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AN ECOLOGICAL IMPACT ASSESSMENT AND WETLAND / RIPARIAN DELINEATION FOR THE PROPOSED GLENCORE KROONDAL MINE RESIDUE EXPANSION PROJECT, NORTHWEST PROVINCE

Prepared for: **Glencore Operations South Africa (Pty) Ltd**

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Conducted on behalf of:

Glencore Operations SA (Pty) Ltd

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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 take into account, 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.

_____

SIGNATURE OF SPECIALIST

Notations and terms

Alien vegetation Plants that do not occur naturally within the area but have been introduced either intentionally or unintentionally. Vegetation species that originate from outside of the borders of the biome - usually international in origin.

Anthropogenic: of human creation

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.

Biome A broad ecological unit representing major life zones of large natural areas – defined mainly by vegetation structure and climate.

Biota: living things; plants, animals, bacteria

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

Ecologically sensitive ecosystem: One where relatively even minor disturbances may result in substantial and significant changes.

Ecoregion An ecoregion is a "recurring pattern of ecosystems associated with characteristic combinations of soil and landform that characterise that region".

Ecosystems: Include living (e.g., plants, animals) and non-living (e.g., minerals, soil, water) components, which can be defined in terms of distinguishing characteristics (e.g., a wetland ecosystem, a freshwater ecosystem, a terrestrial ecosystem, a forest ecosystem, etc.).

Endemic or range-restricted species or ecosystem: One whose distribution is confined to a particular and often very limited geographical region.

Environment: Broadly covers our surroundings and the characteristics of those surroundings that influence our health and wellbeing. That is, the environment includes all living organisms (plants, animals and other life), the

physical environment (land, water and air), as well as social, economic and cultural conditions. Sometimes we speak of 'the natural environment' and 'the built environment', to differentiate between natural and man-made systems.

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.

Habitat: The place or type of site where an organism or population naturally occurs.

Indigenous vegetation Vegetation occurring naturally within a defined area.

Protected species or ecosystem: One that is protected by law from activities and land 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.

Soil horizons: layers of soil that have fairly 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).

Species: A group of plants, animals, micro-organisms or other living organisms that are morphologically similar; that share inheritance from common ancestry; or whose genes are so similar that they can breed together and produce fertile offspring.

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 being made up of all or some of the following units: crest (1), scarp (2), midslope (3), footslope (4) and valley bottom (5).

Threatened species or ecosystem: Species/ Ecosystems that are at risk of going extinct in its natural range. It may be 'critically endangered' at extremely high risk, 'endangered' at very high risk, or 'vulnerable' at high risk. Species or ecosystems at low or no risk are not 'threatened' and fall into the 'near threatened' or 'least concern' categories.

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

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1 ASSIGNMENT

Exigo Sustainability (Pty) Ltd was appointed by Glencore Operations South Africa (Pty) Ltd to conduct an EIA phase study on the ecological components (fauna and flora) and wetlands for 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.

This report will include a detailed impact assessment of the proposed mine residue expansion infrastructure on the biodiversity, as well as wetland assessments of drainage and wetland crossings.

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, promulgated in terms of Section 24 (5) of NEMA and Chapter 4 of the National Water Act, Act 36 of 1998 Section 21 (c) and (i).

The assignment is interpreted as follows: Compile an ecological study on the flora (vegetation units), fauna and general ecology of the site and determine the potential impacts of the proposed development on the fauna and flora of the area as well as any wetlands and propose mitigation measures. The study will be done according to guidelines and criteria set by the North West Department of Rural, Environment and Agricultural Development (NW DREAD) for biodiversity studies and the Department of Water and Sanitation (DWS) for wetland assessments. To compile this, the following had to be done:

2 INFORMATION SOURCES

The following information sources were obtained:

1. All relevant topographical maps, aerial photographs and information (previous studies and environmental databases) related to the ecological and wetland components in the study area;
2. Requirements regarding the fauna and flora survey as requested by NW DREAD;
3. Requirements regarding the wetland functionality assessment as stipulated in the following guidelines:
    a. A practical field procedure for identification and delineation of wetlands and riparian areas (Department of Water and Forestry (DWAF) now Deparment of water and Sanitation (DWS), 2006);
    b. National Wetland Classification System for South Africa (SANBI, 2009);
4. Legislation pertaining to the biodiversity and wetlands of the study area as relevant;
5. Red data species list from the South African National Biodiversity Institute (SANBI).

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 during the course of 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.

This Act also embraces all three fields of environmental concern namely: resource conservation and exploitation; pollution control and waste management; and land-use planning and development. The environmental management principles include the duty of care for wetlands and special attention is given to management and planning procedures.

2.1.2 Conservation of Agricultural Resources Act (Act No. 43 of 1983) (CARA)

This Act regulates the utilization and protection of wetlands, soil conservation and all matters relating thereto; control and prevention of veld fires, control of weeds and invader plants, the prevention of water pollution resulting from farming practices and losses in biodiversity.

2.1.3 National Environmental Management Biodiversity Act (Act 10 0f 2004) (NEMBA)

The following aspects of the NEMBA (2004) are important to consider in the compilation of an ecological report. It:

- Lists ecosystems that are threatened or in need of national protection;
- Links to Integrated Environmental Management processes;
- Must be taken into account in EMPs and IDPs;
- The Minister may make regulations to reduce the threats to listed ecosystems.

2.1.4 The National Forest Act (Act 84 of 1998) (NFA)

The National Forest Act:

- Promotes the sustainable management and development of forests for the benefit of all;
- Creates the conditions necessary to restructure forestry in State Forests;
- Provide special measures for the protection of certain forests and protected trees;

- Promotes the sustainable use of forests for environmental, economic, educational, recreational, cultural, health and spiritual purposes;
- Promotes community forestry.

2.1.5 The National Water Act (Act No. 36 of 1998) (NWA)

Chapter 4 of the National Water Act, Act 36 of 1998 specifies that:

"In general, a water use must be licensed unless it is listed in Schedule I, is an existing lawful use, is permissible under a general authorisation, or if a responsible authority waives the need for a licence. The Minister may limit the amount of water which a responsible authority may allocate. In making regulations the Minister may differentiate between different water resources, classes of water resources and geographical areas."

In section 21 of the NWA, water uses which are applicable to the proposed project, are listed as follows:

c. Impeding or diverting the flow of water in a watercourse;

i. Altering the bed, banks, course or characteristics of a watercourse.

General Notice 509 as published in the Government Gazette 40229 of 2016 as it relates to the NWA (Act 36 of 1998) states the following:

In accordance with GN 509 of 2016, a regulated area of a watercourse for Section 21(c) and 21(i) of the NWA, 1998 is defined as:

- The outer edge of the 1 in 100-year flood line and/or delineated riparian habitat, whichever is the greatest distance, measured from the middle of the watercourse of a river, spring, natural channel, lake or dam;
- In the absence of a determined 1 in 100-year flood line or riparian area the area within 100 m from the edge of a watercourse where the edge of the watercourse is the first identifiable annual bank fill flood bench; or
- A 500 m radius from the delineated boundary (extent) of any wetland or pan.

This notice should be read together with the Risk Assessment provisions in the General Authorisation Notice in Relation to Section 21.

2.2 TERMS OF REFERENCE

2.2.1 Objectives

1. The primary aim of this project is to investigate options for enhancing and / or maintaining biodiversity to mitigate the impact of the proposed development and related infrastructure with the overall objective of preventing further loss of biodiversity. The end product would be a tool for promoting and lobbying for the recognition of the importance of species habitat

and habitat conservation. Options available to maintain the current level of floral diversity include:

a. Protection of native vegetation restored elsewhere in return for unavoidable clearing;

b. Minimisation of habitat fragmentation;

c. Minimisation of any threats to the native flora and fauna and their habitats during the construction and operational phases of the development and;

d. Rehabilitation to establish plant communities / landscaping that will provide future habitat values.

2. To produce a clear and agreed species and habitat priorities for conservation actions. This includes the following:

   i. Determine the potential ecological impacts and actions the development will have on the biodiversity on a species and habitat level;

   ii. Conduct a risk analyses of the impacts identified to determine the significance of the impacts on the fauna and flora of the study area;

   iii. Protection and enhancement of vegetation / habitats of high conservation value;

   iv. The retention of a substantial amount of native vegetation / habitat of adequate size and configuration to promote the conservation of the existing flora communities;

   v. The retention and / or creation of vegetation links, wildlife corridors and vegetation buffers wherever possible, subject to the appropriate bush fire risk management; and

   vi. The protection of water quality in the locality so as not to threaten native aquatic flora that rely on the watercourse for survival.

3. Provide recommendations on the ecological mitigation measures to be implemented by the developer and the way forward;

4. Delineate wetlands and riparian areas on site according to the guidelines of the DWS;

5. Determine the Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS) of all wetlands and riparian areas along the proposed bulk water supply pipeline at the crossings.

2.2.2 Scope

1. Detailed flora survey – in each vegetation type/plant community on site:
   a. After studying the aerial photographs identify specific areas to be surveyed and

confirm location by making use of a Geographical Positioning System (GPS).

b. Conduct a site visit and list the plant species (trees, shrubs, grasses, succulents and other herbaceous species of special interest) present for plant community and ecosystem delimitation.

c. Identify potential red data plant species, possible encroacher species, medicinal plants of value and exotic plant species.

d. Indicate suitable plant species that can be used for the landscaping around the proposed development.

2. Plant community delimitation and description
    a. Process data (vegetation and habitat classification) to determine vegetation types on an ecological basis.

    b. Describe the habitat and vegetation.

3. Fauna scoping
    a. List the potential fauna (mammal species, red data birds, reptiles, amphibians, invertebrates) present linked to the specific potential habitats that occur as identified in the vegetation survey.

    b. Analyse the data and identify potential red data fauna species, as well as other endemic or protected species of importance.

    c. Indicate species mitigation measures and management measures to be implemented to prevent any negative impacts on the fauna of the area.

4. Delineate all wetlands and water courses and assess the wetland and / or riparian functionality of the crossings along the proposed bulk water supply development to specific guidelines and methodology.

5. General
    a. Identify and describe ecologically sensitive areas. Create a sensitivity map to indicate specific sensitive areas based on various environmental parameters such as natural vegetation in a good condition, rockiness, slopes, flood lines etc.

    b. Identify problem areas in need of special treatment or management, e.g., bush encroachment, erosion, degraded areas, reclamation areas.

    c. Make recommendations, impact ratings and risk assessments for each specific impact.

2.2.3 Limitations and assumptions

- To obtain a comprehensive understanding of the dynamics of the flora and fauna 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, and this biodiversity study was conducted over one season, i.e., the end of the summer season of May 2019, as per the minimum requirements for biodiversity studies;

- 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 vegetation units, as well as general observations, aerial photograph analysis, generic data and a desktop analysis;
- This report focuses only on the wetlands at the proposed development footprints and road and conveyor crossing. Other wetland areas further away from the proposed development was not assessed.

Thus, even though it might be assumed that survey findings are representative of the ecosystem of the project area, it should be stated that the possibility exists that individual plants or animal species might have been missed due to the nature of the terrain. Therefore, maintaining due cognisance of the integrity and accuracy of the ecological survey, it should be stated that the ecological resources identified during the study do not necessarily represent all the ecological resources present on the property.

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

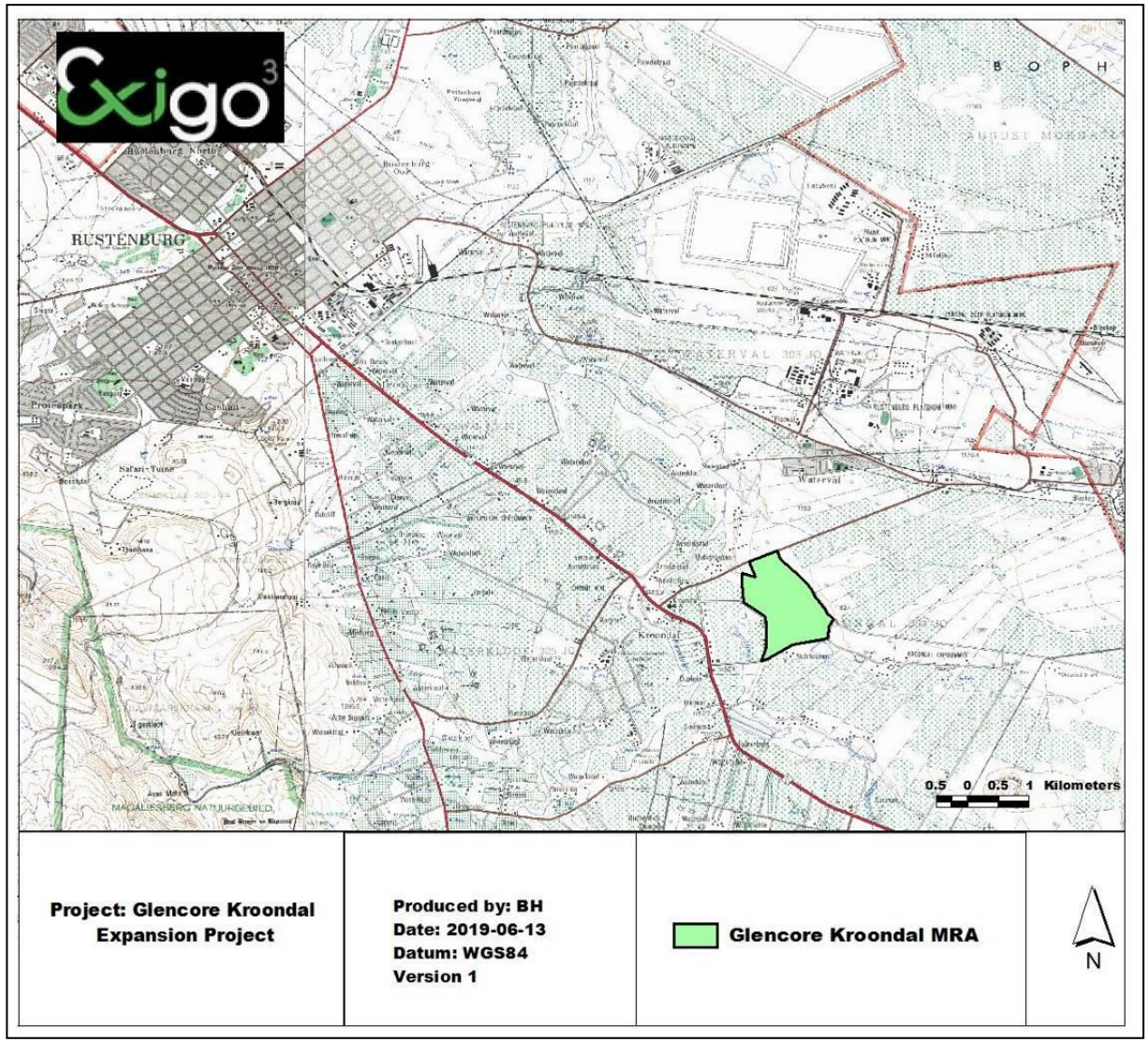


Figure 1. Regional Location Map

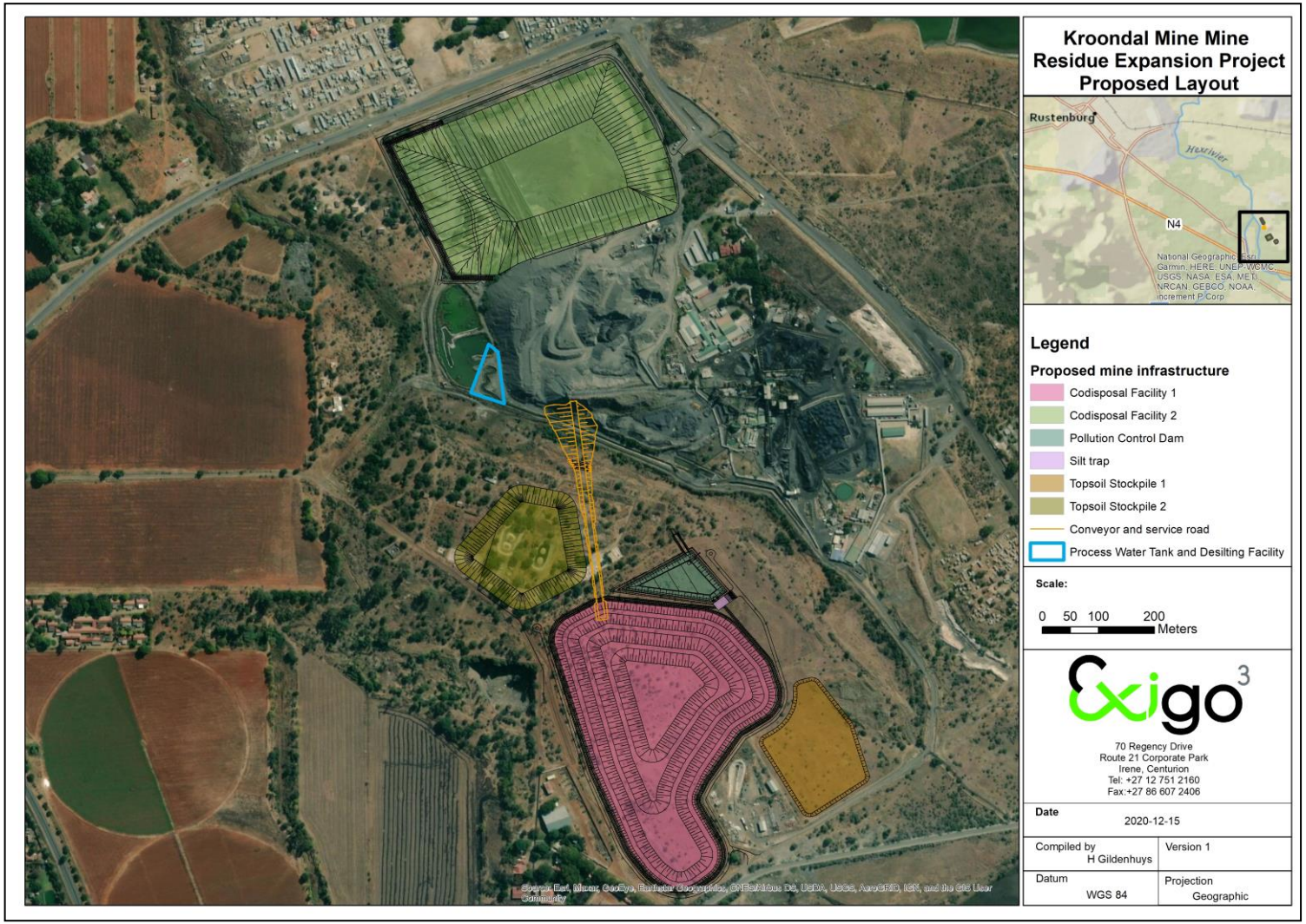


Figure 2. Satellite image showing the project area (Google Pro, 2010) and proposed activities

3.2 CLIMATE

Climate in the broad sense is a major determinant of the geographical distribution of species and vegetation types. However, on a smaller scale, the microclimate, which is greatly influenced by local topography, is also important. Within areas, the local conditions of temperature, light, humidity and moisture vary greatly, and it is these factors which play an important role in the production and survival of plants (Tainton, 1981). The climate for the region can be described as warm-temperate. In terrestrial environments, limitations related to water availability are always important to plants and plant communities. The spatial and temporal distribution of rainfall is very complex and has great effects on the productivity, distribution and life forms of the major terrestrial biomes (Barbour et al. 1987).

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 night time 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.

4 METHODS

4.1 VEGETATION SURVEY

Two basic methods were used during the vegetation survey:

- Line transects were walked along the proposed development footprint areas to record the plant species present. Rare and threatened plant species and any botanically sensitive sites or habitats were searched for in the various vegetation units.
- The Braun-Blanquet survey technique to describe plant communities as ecological units was also used for this study. It allows for the mapping of vegetation and the comparison of the data with similar studies in the area.

The vegetation survey was conducted on site during May 2019. The vegetation was in a moderate to good condition and most species could be identified. No further surveys were necessary considering that the area received sufficient precipitation during the wet season to allow for the identification of most plants in the study area.

4.1.1 Data recorded:

Plant names used in this report are in accordance with Arnold & De Wet (1993), except for a few newly revised species. A list of all plant species present, including trees, shrubs, grasses, forbs, geophytes and succulents were compiled. All identifiable plant species were listed. Notes were additionally made of any other features that might have an ecological influence as well as potential fauna habitat that might occur.

4.1.2 Red data species

A species list of the red data species previously recorded in the vicinity of the proposed development was obtained from the South African Biodiversity Institute (SANBI), South Africa as classified by the IUCN red data list categories.

4.1.3 Protected trees

A species list of the protected tree species was obtained from the Department of Forestry. These trees are listed by the NFA (Act 84 of 1998) as protected.

4.1.4 Data processing

A classification of vegetation data was done to identify, describe and map vegetation types. The descriptions of the vegetation units include the tree, shrub and herbaceous layers.

Conservation priority of each vegetation unit was assessed by evaluating the plant species composition in terms of the present knowledge of the vegetation of the Gauteng Province, as well as the represented vegetation types in the area.

The following four conservation priority categories were used for each vegetation unit:

- High: Ecologically sensitive and valuable land with high species richness that should be conserved, and no development allowed.
- Medium: Land that should be conserved but on which low impact development could be considered with the provision of mitigation measures.
- Medium-low: Land that has some conservation value but on which development could be considered with limited impact on the vegetation / ecosystem. It is recommended that certain sections of the vegetation be maintained.
- Low: Land that has little conservation value and that could be considered for developed with little to no impact on the vegetation / ecosystem.

4.2 FAUNA SURVEY

The fauna survey was conducted as follows:

- A site survey was done to identify potential habitats after identifying the vegetation units. Fauna observed on site or any specific indication of species was noted as confirmed in the species lists.
- A scoping survey was then conducted by comparing the habitat types identified with the preferred habitats of species occurring in the area.

4.2.1 Data recorded:

A list of all species of fauna and their status as observed on the site or that could potentially occur on the site. Notes were made of any specific sensitive or specialized habitats that occur on the site.

4.2.2 Red data species lists

A species list of the red data species of the different faunal classes was obtained from the following references:

- Red Data Book of the Mammals of South Africa (Friedman & Daly, 2004)
- The Atlas of the Southern African Birds - digital data on quarter degree grid data (Avian Demography Unit, University of Cape Town)
- Atlas and red data book of the frogs of South Africa, Lesotho and Swaziland (Minter et al. 2004)
- South African Red Data Book – Reptiles and Amphibians. National Scientific Programmes Report no. 151;

4.2.3 Data processing

A comparison of the habitats (vegetation units) occurring in the area was made to the preferred habitats of the faunal species. In addition to species observed on the site, lists of the potential mammal, bird, reptile, amphibian and insect species were compiled and mitigating measures recommended if needed.

4.3 WETLAND DELINEATION AND CLASSIFICATION

The National Water Act, Act 36 of 1998, defines wetlands as follows:

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

Wetlands were delineated according to the delineation procedure given in "A Practical Field Procedure for the Identification and Delineation of Wetlands and Riparian Areas" (DWAF, 2003).

Wetland indicators are divided into different unit indicators which need to be given consideration in the delineation of wetlands (Figure 3). The outer edge of the temporary zone requires the delineator to take the following specific indicators into account:

- The terrain unit indicator helps to identify those parts of the landscape where wetlands are more likely to occur.
- The Soil Form Indicator identifies the soil forms, as defined by Macvicar (1991), which are associated with prolonged and frequent saturation.
- The Soil Wetness Indicator identifies the morphological "signatures" developed in the soil profile because of prolonged and frequent saturation.
- The Vegetation Indicator identifies hydrophilic vegetation associated with frequently saturated soils.

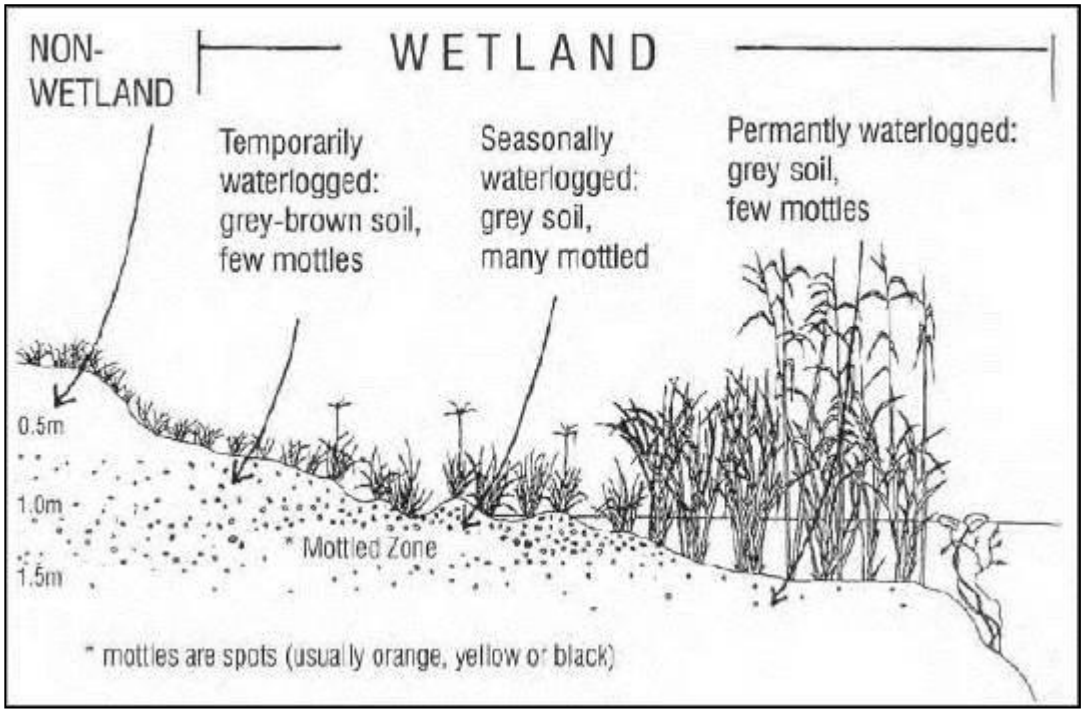


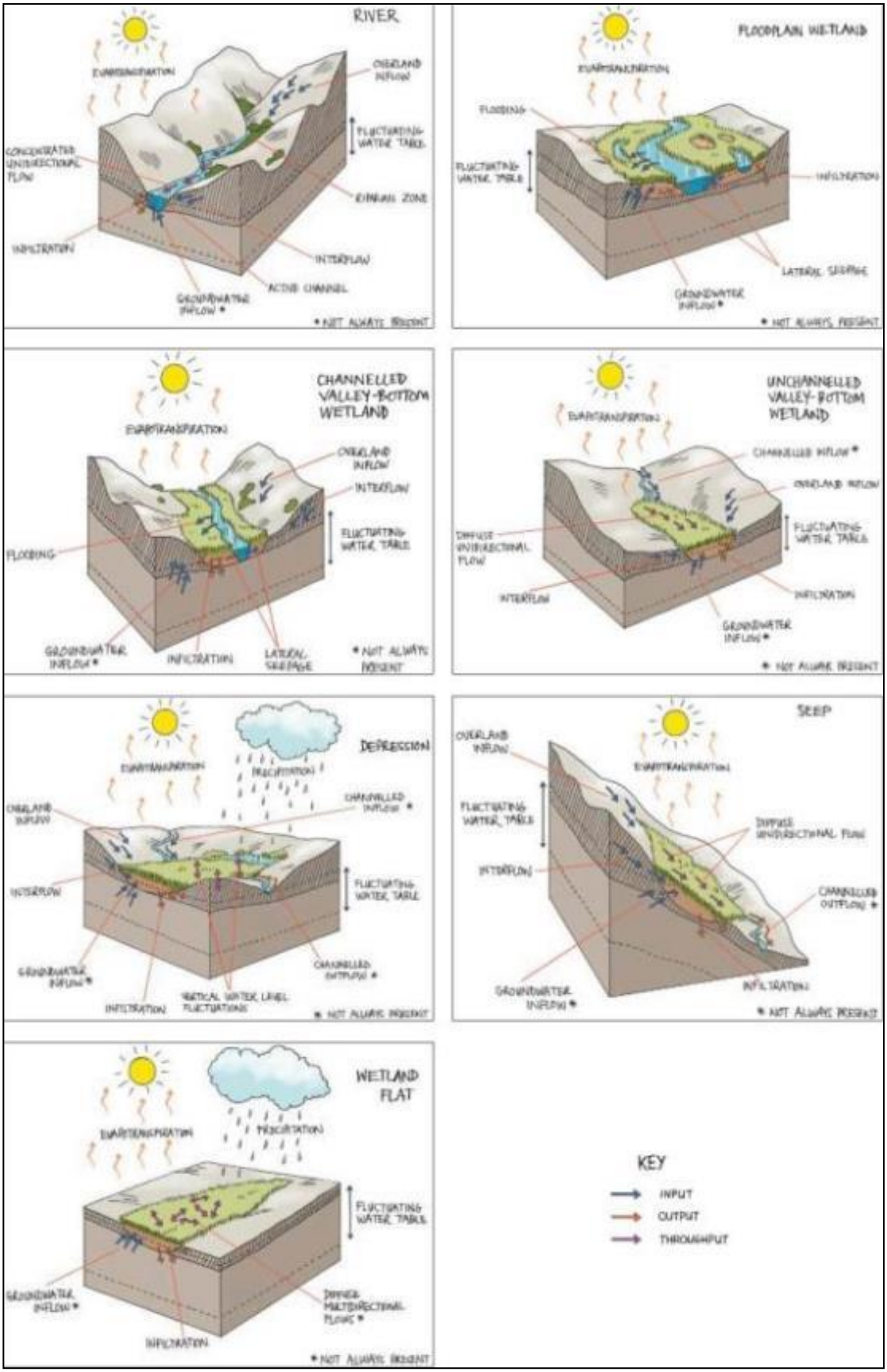
Figure 3. A cross section through a wetland showing how the soil form indicators and vegetation changes from the centre to the edge of the wetland (adapted from Kotze, 1996)

4.4 WETLAND CLASSIFICATION

The study area was sub-divided into transects and the soil profile was examined for signs of wetness within 50 cm of the surface using a hand auger along transects. The wetland boundaries were then determined by the positions of augered holes that showed signs of wetness as well as by the presence or absence of hydrophilic vegetation. The wetlands were subsequently classified according to their hydro-geomorphic setting based on the system proposed in the National Wetland Classification System (Table 2) (SANBI, 2009).

Furthermore, because of alluvial deposits being visible from the air, aerial photography was also used to assist in determining the extent of deposits, as well as the vegetation line indicating a difference in species composition or more vigorous growth. The aerial photographs were used to guide on-screen delineation of wetlands in ArcView GIS 3.3.

Table 2. Wetland Unit types based on hydrogeomorphic characteristics (Adapted from Kotze *et al.* 2005)



4.5 RIPARIAN DELINEATION AND CLASSIFICATION

Riparian areas often associated with streams or drainage lines are also important to protect due to the followings ecological and hydrological functions that it performs (DWAF, 2003):

- Stabilize stream banks;
- Store water and aid in flood attenuation;
- Improve water quality by trapping nutrients and sediment;
- Maintain natural water temperature for aquatic species;
- Provide shelter and food for avifauna and other animals;
- Provide corridors for movement and migration of different species; and
- Act as a buffer between aquatic ecosystems and adjacent land uses.

The riparian areas have their own unique set of indicators. DWAF (2003) states that to classify an area as a riparian area it must have one or more of the following attributes:

- Are associated with a watercourse;
- Contain distinctively different plant species than adjacent areas; and contain species like adjacent areas but exhibiting more vigorous or robust growth forms; and
- May have alluvial soils.

The delineation process requires that the following be considered:

- Topography associated with the watercourse (figure 4);
- Vegetation (figure 5); and
- Alluvial soils and deposited material.

Many riparian areas display wetland indicators and should be classified as wetlands. However, other riparian areas are not saturated long enough or often enough to develop wetland characteristics, but also perform a few important functions, which need to be safeguarded. In these areas alluvial deposits can predominate and/or the water table is too deep for most of the year to produce hydromorphic features in the top 50cm of the soil profile. These conditions do not support vegetation typically adapted to life in saturated soil and it is therefore important to delineate these riparian areas in addition to wetlands. Riparian areas commonly reflect the high-energy conditions associated with the water flowing in a water channel, whereas wetlands generally display more diffuse flow and are lower energy environments.

The general approach for delineating riparian areas in the field is to identify the active channel or the lowest part of the river course. Most likely cues like water with associated emergent

vegetation, sedges and reeds or alluvial soil and bedrock will be visible. From this point some topographic units like sandbars, active channel bank, flood benches and macro-channel bank with associated riparian vegetation will be identifiable. The next step would be to proceed upwards towards the macro-channel bank, taking note of alluvial soil, topographic units and vegetation indicators. The outer boundary will be the point on the edge of the macro channel bank where there is a distinct difference between the riparian and terrestrial vegetation. In some cases where riparian vegetation is unrecognisable, because of land-use activities, indicators like alluvial material and topographical units can still be used to visualize the edge of a riparian area. If you are adjacent to a watercourse, it is also important to check for the presence of riparian indicators. The riparian areas were identified using the following information:

- Topographical maps: Riparian areas normally occur within the flood area of a river or stream.
- Aerial photographs: As a result of alluvial deposits being visible from the air, aerial photography can assist in determining the extent of deposits, as well as the vegetation line indicating a difference in species composition or more vigorous growth.

A combination of the abovementioned indicators was used during the field survey that was conducted during May 2019 to identify the indicator plant species, soil types and specific topography related to the wetland areas. The outer boundaries were then recorded using a Global Positioning System (GPS). Riparian areas were mapped by means of the computer programme Arcview 3.3.

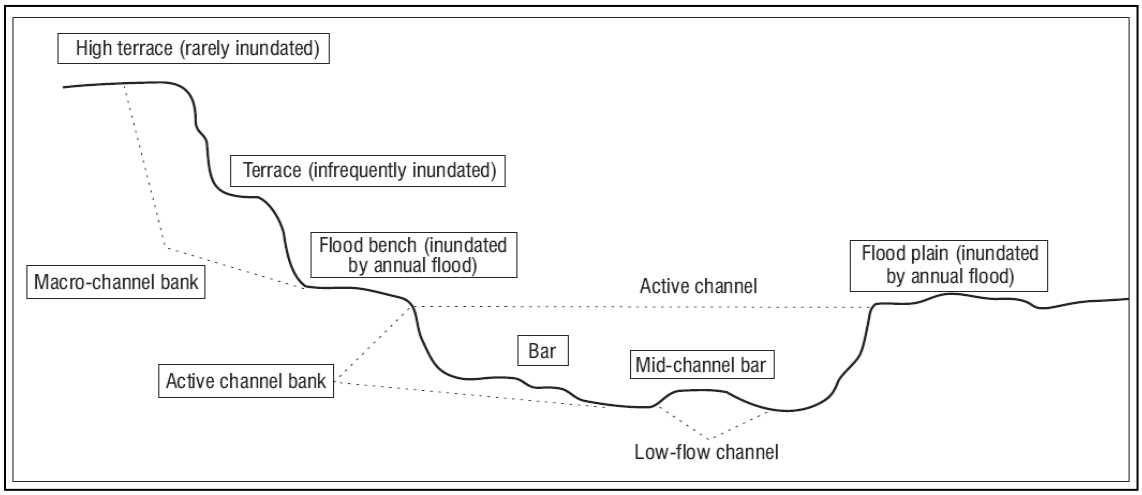


Figure 4. Cross section of topography associated with a channel and floodplains

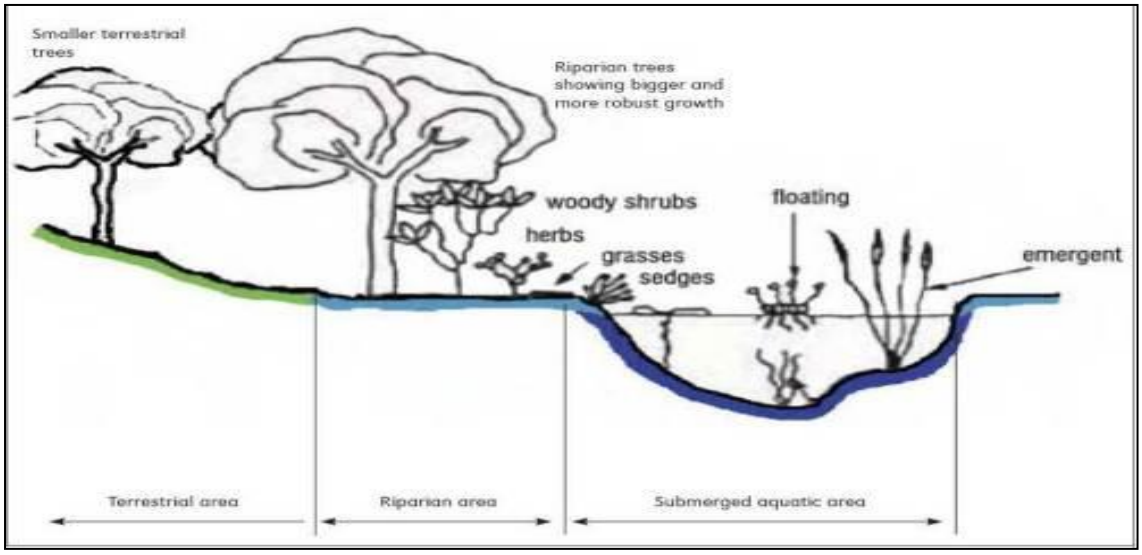


Figure 5. Typical cross section of a river channel displaying riparian habitat (Department of Water Affairs (DWA), 2003)

4.6 WETLAND INTEGRITY ASSESSMENTS

4.6.1 Present Ecological Status (PES) of wetlands

The Present Ecological State (PES) assessment of the wetlands within the study area was undertaken to determine the extent of departure of the wetlands from a natural state or reference condition. This method is based on the modified Habitat Integrity approach (Table 3) developed by Kleynhans (1999). Anthropogenic modification of the criteria and its attributes can have an impact on the ecological integrity of a wetland.

Table 3. Habitat integrity assessment criteria for wetlands (Adapted from DWAF, 2003)

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

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

Scoring guidelines per attribute: natural, unmodified = 5; Largely natural = 4, Moderately modified = 3; largely modified = 2; seriously modified = 1; Critically modified = 0.

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

For this study, the scoring system as described in the document "Resource Directed Measures for Protection of Water Resources, Volume 4. Wetland Ecosystems" (DWAF, 1999) was applied for the determination of the PES (Table 4).

Two tools have recently been developed to facilitate the derivation of scores to reflect the present ecological sate, namely the Index of Habitat Integrity (IHI) Department of Water and Sanitation (DWS), 2007, and Wet-Health, developed by Macfarlane et al., 2008. Both these tools have limitations in that they were developed primarily to assess conditions of floodplain and valley bottom wetlands and Hill slope seepage wetlands linked to drainage lines. The former tool was developed to provide a rapid assessment of the PES specifically for application in reserve studies, while the latter tool was developed to support the Working for Wetlands program. The objective of the latter tool was to provide a semi quantitative assessment of the state of wetland prior to rehabilitation, and one post rehabilitation to demonstrate "improvement". The intention in defining the health category (PES) of a wetland is to provide an indication of the current "condition" of a wetland to inform a management class. The latter provides the guidelines that inform water quality and quantity required to maintain or improve the quality of the water resource.

The PES or health of wetlands has only been applied to the "natural" wetlands, i.e., those that have developed naturally as a consequence of the presence of water. Wetlands are rated on a scale of A to F, with A being a natural wetland and F being a completely modified and disturbed wetland (Table 4). The Wet-Health assesses the following four factors that influence the "health" or condition of wetlands and in this application floodplains and river channels associated with the site:

- Hydrology;

- Geomorphology;
- Vegetation; and ideally
- Water quality.

The Present Ecological Status Class (PESC) of the wetlands was based on the available information for each of the criteria listed in Table 3 and the mean score determined for each wetland (Table 4). This approach assumes that extensive degradation of any of the wetland attributes may determine the PESC (DWAF, 2003).

Table 4. Present Ecological Status Class Descriptions

CLASS	CLASS BOUNDARY	CLASS DESCRIPTION
A	>4	**Unmodified, natural;** • The resource base reserve has not been decreased; • The resource capability has not been exploited
B	>3 and <=4	**Largely natural with few modifications**; • The resource base reserve has been decreased to a small extent; • A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.
C	>2 and <=3	**Moderately modified**; • The resource base reserve has been decreased to a moderate extent. • A change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.
D	2	**Largely modified**; • The resource base reserve has been decreased to a large extent. • Large changes in natural habitat, biota and basic ecosystem functions have occurred.
E	>0 and <2	**Seriously modified**; • The resource base reserve has been seriously decreased and regularly exceeds the resource base; • The loss of natural habitat, biota and basic ecosystem functions is extensive.
F	0	**Critically modified**; • The resource base reserve has been critically decreased and permanently exceeds the resource base; • Modifications have reached a critical level and the resource has been modified completely with an almost total loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.

4.6.2 Ecological Importance and Sensitivity (EIS)

The Ecological Importance and Sensitivity (EIS) assessment was conducted according to the

guidelines as discussed by DWAF (1999). Here DWAF defines "ecological importance" of a water resource as an expression of its importance to the maintenance of ecological diversity and function on local and wider scales. "Ecological sensitivity", according to DWAF (1999), is the system's ability to resist disturbance and its capability to recover from disturbance once it has occurred.

In the method outlined by DWAF a series of determinants for EIS are assessed for the wetlands on a scale of 0 to 4 (Table 5). The median of the determinants is used to determine the EIS of the wetland unit (Table 6).

Table 5. Criteria for assessing the Ecological Importance and Sensitivity of Wetlands

Determinant
PRIMARY DETERMINANTS
1. Rare & Endangered Species
2. Populations of Unique Species
3. Species/taxon Richness
4. Diversity of Habitat Types or Features
5. Migration route/breeding and feeding site for wetland species
6. Sensitivity to Changes in the Natural Hydrological Regime
7. Sensitivity to Water Quality Changes
8. Flood Storage, Energy Dissipation & Particulate/Element Removal
MODIFYING DETERMINANTS
9. Protected Status
10. Ecological Integrity

Score guideline Very high = 4; High = 3, Moderate = 2; Marginal/Low = 1; None = 0

Confidence rating Very high confidence = 4; High confidence = 3; Moderate confidence = 2; Marginal/low confidence = 1

Table 6. Ecological Importance and Sensitivity Classes

Ecological Importance and Sensitivity Category (EIS)	**Range of Median**
Very high Wetlands that are considered ecologically important and sensitive on a national or even international level. The biodiversity of these wetlands is usually very sensitive to flow and habitat modifications. They play a major role in moderating the quantity and quality of water of major rivers.	>3 and <=4
High Wetlands that are ecologically important and sensitive. The biodiversity of these wetlands may be sensitive to flow and habitat modifications. They play a role in moderating the quantity and quality of water of major rivers.	>2 and <=3
Moderate Wetlands that are ecologically important and sensitive on a provincial or local scale. The biodiversity of these Wetlands is not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water of major rivers.	>1 and <=2
Low/marginal Wetlands that are not ecologically important and sensitive at any scale. The biodiversity of these Wetlands is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water of major rivers.	>0 and <=1

4.7 SENSITIVITY ASSESSMENT

The ecological sensitivity of any piece of land is based on its inherent ecosystem service and overall preservation of biodiversity.

4.7.1 Ecological function

The ecological function relates to the degree of ecological connectivity between systems within a landscape matrix. Therefore, systems with a high degree of landscape connectivity amongst one another are perceived to be more sensitive and will be those contributing to ecosystem service (e.g., wetlands) or overall preservation of biodiversity.

4.7.2 Conservation importance

Conservation importance relates to species diversity, endemism (unique species or unique processes) and the high occurrence of threatened and protected species or ecosystems protected by legislation.

4.7.3 Sensitivity scale

- High – sensitive ecosystem with either low inherent resistance or low resilience towards disturbance factors or highly dynamic systems considered being important for the maintenance of ecosystem integrity. Most of these systems represent ecosystems with high connectivity with other important ecological systems or with high species diversity and usually provide suitable habitat for a few threatened or rare species. These areas should be protected;
- Medium – These are slightly modified systems which occur along gradients of disturbances of low-medium intensity with some degree of connectivity with other ecological systems or ecosystems with intermediate levels of species diversity but may include potential ephemeral habitat for threatened species;
- Low – Degraded and highly disturbed / transformed systems with little ecological function and which are generally very poor in species diversity.

4.8 IMPACT RATING ASSESSMENT MATRIX

An impact can be defined as any change in the physical-chemical, biological, cultural and/or socio-economic environmental system that can be attributed to human activities related to alternatives under study for meeting a project need.

The significance of the impacts will be determined through a synthesis of the criteria below (Plomp, 2004):

Probability. This describes the likelihood of the impact occurring:

- Improbable: The possibility of the impact occurring is very low, due to the circumstances, design or experience.
- Probable: There is a probability that the impact will occur to the extent that provision must be made, therefore.
- Highly Probable: It is most likely that the impact will occur at some stage of the development.
- Definite: The impact will take place regardless of any prevention plans, and there can only be relied on mitigation actions or contingency plans to contain the effect.

Duration. The lifetime of the impact:

- Short term: The impact will either disappear with mitigation or will be mitigated through natural processes in a time span shorter than any of the phases.
- Medium term: The impact will last up to the end of the phases, where after it will be negated.
- Long term: The impact will last for the entire operational phase of the project but will be mitigated by direct human action or by natural processes thereafter.
- Permanent: Impact that will be non-transitory. Mitigation either by man or natural processes will not occur in such a way or in such a time span that the impact can be considered transient.

Scale. The physical and spatial size of the impact:

- Local: The impacted area extends only as far as the activity, e.g., footprint.
- Site: The impact could affect the whole, or a measurable portion of the above-mentioned properties.
- Regional: The impact could affect the area including the neighbouring areas.

Magnitude/ Severity. Does the impact destroy the environment, or alter its function:

- Low: The impact alters the affected environment in such a way that natural processes are not affected.
- Medium: The affected environment is altered, but functions and processes continue in a modified way.
- High: Function or process of the affected environment is disturbed to the extent where it temporarily or permanently ceases.

Significance. This is an indication of the importance of the impact in terms of both physical extent

and time scale, and therefore indicates the level of mitigation required:

- Negligible: The impact is non-existent or unsubstantial and is of no or little importance to any stakeholder and can be ignored.
- Low: The impact is limited in extent, has low to medium intensity; whatever its probability of occurrence is, the impact will not have a material effect on the decision and is likely to require management intervention with increased costs.
- Moderate: The impact is of importance to one or more stakeholders, and its intensity will be medium or high; therefore, the impact may materially affect the decision, and management intervention will be required.
- High: The impact could render development options controversial or the project unacceptable if it cannot be reduced to acceptable levels; and/or the cost of management intervention will be a significant factor in mitigation.

The following weights will be assigned to each attribute:

Aspect	Description	Weight
Probability	Improbable	1
	Probable	2
	Highly Probable	4
	Definite	5
Duration	Short term	1
	Medium term	3
	Long term	4
	Permanent	5
Scale	Local	1
	Site	2
	Regional	3
Magnitude/Severity	Low	2
	Medium	6
	High	8
Significance	**Sum (Duration, Scale, Magnitude) x Probability**	
	Negligible	<20
	Low	<40
	Moderate	<60
	High	>60

The significance of each activity will be rated without mitigation measures and with mitigation

measures for the development.

The mitigation effect of each impact will be indicated without and with mitigation measures as follows:

- Can be reversed
- Can be avoided, managed or mitigated
- May cause irreplaceable loss of resources

5 RESULTS: ECOLOGICAL ASSESSMENT

5.1 VEGETATION

5.1.1 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.

5.1.2 Vegetation types

5.1.2.1 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), Searsia 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*

5.1.3 Vegetation Units

The proposed development sites occur on slightly undulating plains and flat plains with a non –perennial river and wetland bisecting the area including the proposed wetland crossings of the conveyor and road. The farms surrounding this farm are primarily used for mining, small-scale subsistence crop cultivation and rural developments.

Vegetation units were identified according to plant species composition, previous land-use, soil types and topography. The state of the vegetation of the proposed mining sites varies from being natural to completely degraded. The farms are currently zoned for mining.

The vegetation communities identified in the area are classified as physiographic physiognomic units, where physiognomic refers to the outer appearance of the vegetation, and physiographic refers to the position of the plant communities in the landscape. The physiographic-physiognomic units will be referred to as vegetation units in the following sections. These vegetation units are divided in terms of the topographical differences, previous land-use and soil differences that had the most definitive influence on the vegetation units. Each unit is described in terms of its characteristics. A species list is included in the Photographic Guide at the end of the document.

The broad classification is done for each of the proposed infrastructure areas as follows:

1. Secondary old fields
    - Degraded *Vachellia tortilis – Dichrostachys cinerea – Ziziphus mucronata* woodland;
    - Degraded *Ischaemum fasciculatum - Vachellia nilotica* secondary old fields;
2. Alien invasive bushclumps
3. Hydrological features:
    - River and riparian woodland;

- Valleybottom wetland with channel;
- Man-made dam (Depression)
- Stormwater canal

4. Exposed areas associated with mining infrastructure

The vegetation units as identified during site visits, databases and aerial imagery are indicated in Figure 6.

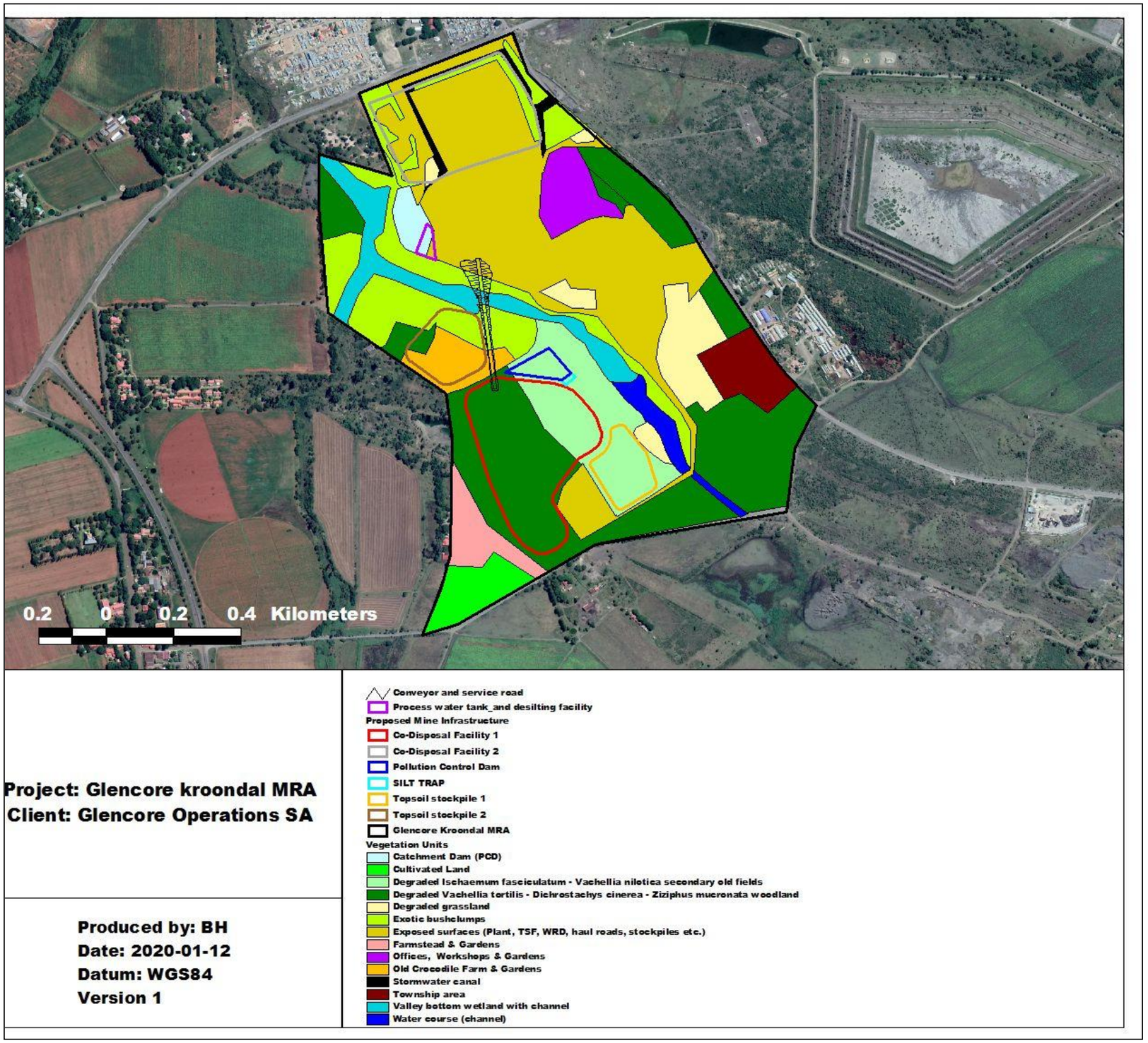


Figure 6. Vegetation Map of the project area for the proposed development footprint area.

5.1.3.1 Secondary Old fields

The secondary old fields occur to the east of the old crocodile farm and represent the proposed footprint area for the new CDF, stockpiles and PCD. When cultivated fields are left fallow, it results in a landscape mosaic of patches of secondary vegetation varying in age and dominated by various grass species (Moll, 1965). Different stages of succession occur in the old fields, and Wildi (2002) described how dynamic these systems are over time and space. The outer successional stage of old fields (as observed on site) only starts after several years of abandonment when woody species start to invade. These secondary old fields are usually dominated by species such as *Dichrostachys cinerea, Vachellia tortilis* and *Ziziphus mucronata*. In the project area, two variations of the secondary old fields occur according to the soil type.

The Degraded *Vachellia tortilis – Dichrostachys cinerea – Ziziphus mucronata* woodland occur on red clayey soils and forms open woodland, while the Degraded *Ischaemum fasciculatum - Vachellia nilotica* secondary old fields can be classified as open grassland with scattered woody species on black, vertic clay soils.

The state of the vegetation is indicated in photograph 1 and 2, while the characteristics of the variations of this vegetation unit are summarized in Table 7.

Table 7. Botanical analysis and characteristics of the vegetation associated with the *Vachellia karroo* woodland in the study area

	***Vachellia tortilis – Dichrostachys cinerea – Ziziphus mucronata* woodland**	***Ischaemum fasciculatum - Vachellia nilotica* grassland**
State of the vegetation:	Open microphyllous woodland in a state of succession	Grassland with scattered microphyllous trees
Conservation priority	Medium-low	Medium
Characteristics	Open savanna woodland on red apedal soils	Grassland with scattered trees on vertic, black clay soils
Dominant plant species	*Vachellia tortilis, Dichrostachys cinerea, Ziziphus mucronata*	*Ischaemum fasciculatum, Vachellia nilotica, Brachiaria nigropedata*
Density of woody layer	Trees: 2-5% (avg. height: 3-6m) Shrubs:5-10% (avg. height: 1-2m)	Trees: <1% (avg. height: 3-6m) Shrubs:1-2% (avg. height: 1-2m)
Density of herbaceous layer	Grasses: 50-60% (avg. height: 0.8m) Forbs: <1 (avg. height: 0.5m)	Grasses: 70-80% (avg. height: 0.8m) Forbs: <1 (avg. height: 0.5m)
Sensitivity	Medium-low	Medium
Red data species	None observed	None observed
Protected tree species (DAFF)	None observed	None observed

The following specific recommendations for the vegetation unit regarding the proposed development

should be adhered to:

- The vegetation unit is classified as having a Medium and Medium-low Sensitivity due to being in a state of succession. The old fields on the black, clayey soils are more sensitive due to the soil type having a high risk of erosion;
- The development of the mining infrastructure can be supported in the area with mitigation measures implemented where necessary, especially with regards to the proximity to the Sandspruit.

Photograph 1. *Ischaemum fasciculatum* - *Vachellia nilotica* secondary old fields in the project area

Photograph 2. Degraded *Vachellia tortilis – Dichrostachys cinerea – Ziziphus mucronata* woodland in the project area

5.1.3.2 Alien invasive bushclumps

The areas surrounding the silt dumping areas from the pollution control dam (PCD) on which the new WRD is proposed, is largely dominated by alien invasive stands dominated by species such as *Tecoma stans, Leucacena leucocephala, Lantana* and *Solanum mauritianum,* with only isolated indigenous trees such as *Vachellia karroo* and *Ziziphus mucronata* scattered in between the dense alien stands. The state of the vegetation is indicated in photograph 3 and location in between the silt dumps in photograph 4, while the characteristics of the vegetation unit are summarized in Table 8.

Table 8. Botanical analysis and characteristics of degraded bushveld

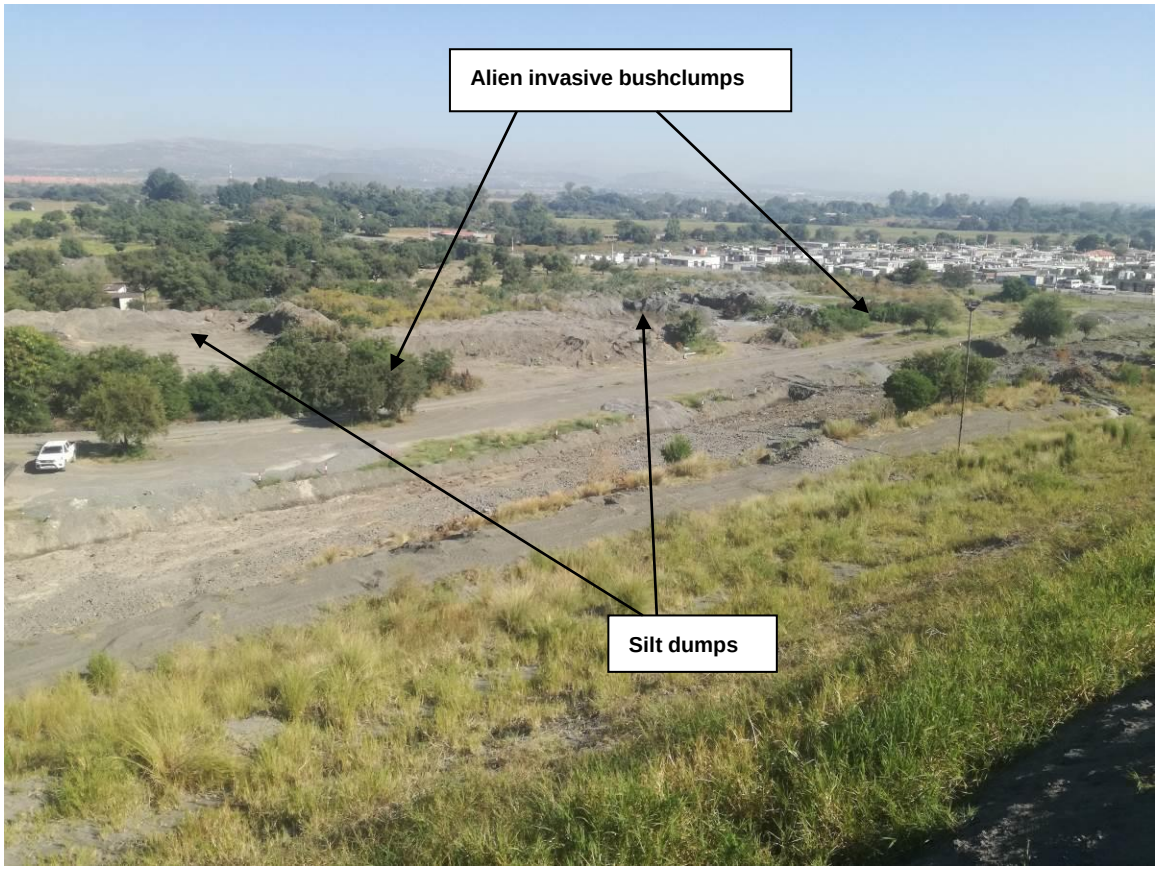
State of the vegetation:	Degraded
Need for rehabilitation	High
Conservation priority	Low
Soils & Geology	Mostly silt dumps, with a small section on red apedal soils of the Hutton soil form derived from shale / mudstone
Density of woody layer	Trees: 2-5% (avg. height: 3-6m) Shrubs: 30-40% (avg. height: 1-2m)
Density of herbaceous layer	Grasses: 10-20% (avg. height: 0.5m) Forbs: 5-10% (avg. height: 0.3m)

Sensitivity	Low
Dominant plant species	*Tecoma stans, Leucacena leucocephala, Lantana* and *Solanum mauritianum*
Red data species	None observed
Protected tree species (DAFF)	None observed

The following specific recommendations and conclusions were made for this vegetation unit:

- The degraded variation of this vegetation unit is classified as having a Low Sensitivity due to the high density of alien invasive shrubs in the area. Unlimited development of the WRD can be supported in this area.

Photograph 3. State of the degraded alien invasive bushclumps



Photograph 4. Location of the alien invasive bushclumps surrounding the silt (sludge) dumps

5.1.3.3 Degraded grassland

The degraded grassland represents a small area adjacent to the offices and haul road at the new WRD site. The area is characterised by the grass species *Cynodon dactylon, Aristida congesta, Melinis repens* and *Sporobolus africanus*, while the area also became invaded by various alien invasive species such as *Ricinus communis, Bidens pilosa* and *Tagetes minuta*. The state of the vegetation and location is indicated in photograph 5, while the characteristics of the variations of this vegetation unit are summarized in Table 9.

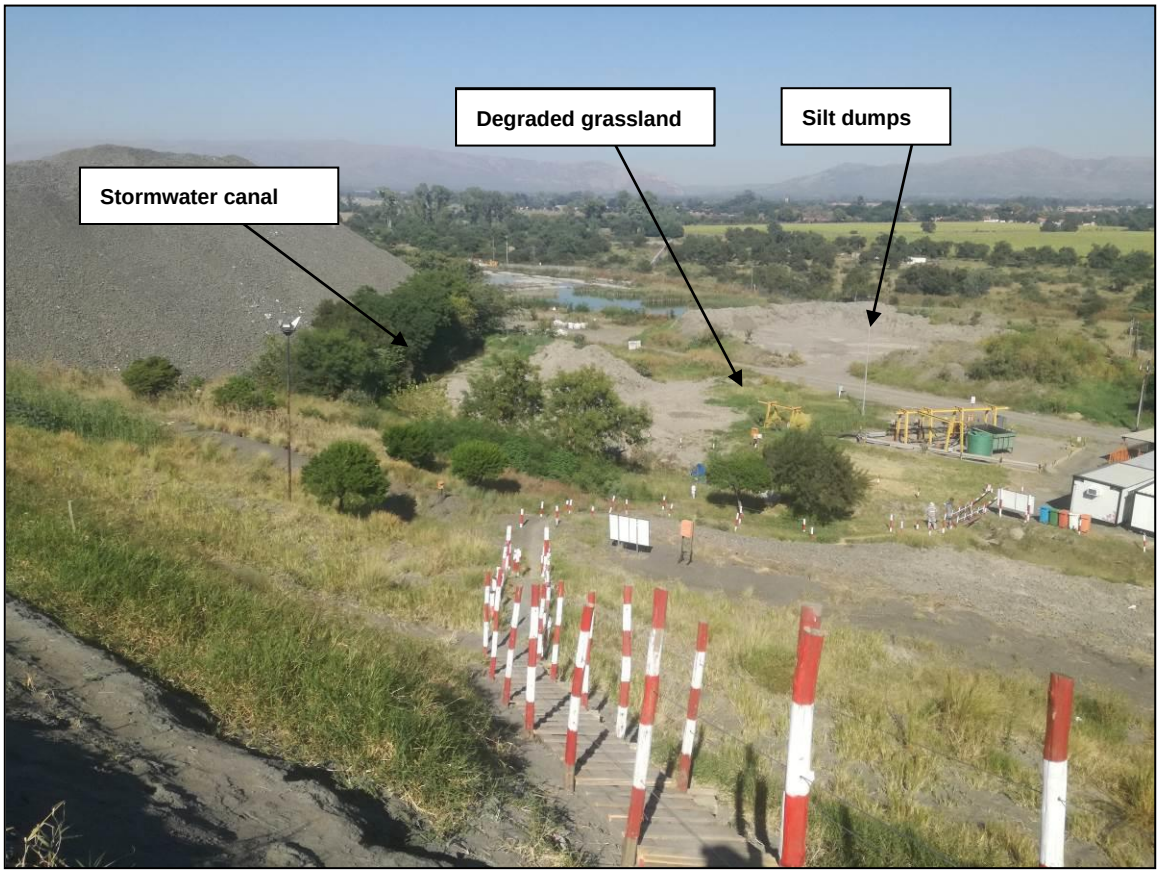
Table 9. Botanical analysis and characteristics of degraded grassland

State of the vegetation:	Degraded
Need for rehabilitation	High
Conservation priority	Low
Soils & Geology	Red apedal soils of the Hutton soil form derived from mudstone / shale
Density of woody layer	Trees: <1% (avg. height: 3-6m) Shrubs: <1% (avg. height: 1-2m)
Density of herbaceous layer	Grasses: 40-50% (avg. height: 0.5m) Forbs: 2-5% (avg. height: 0.3m)
Sensitivity	Low

Dominant plant species	
Red data species	None observed
Protected tree species (DAFF)	None observed

The following specific recommendations and conclusions were made for this vegetation unit:

- The degraded variation of this vegetation unit is classified as having a Low Sensitivity due to the high density of pioneer grasses and alien invasive weeds in the area. The development in this area is highly suitable.



Photograph 5. Degraded grassland and other aspects in the proposed western section of the new WRD site

5.1.3.4 Drainage features

The drainage features near the proposed mining infrastructure on site are valleybottom wetland with channel, river with riparian woodland (largely modified), offstream man-made dam (PCD) as well as stormwater canals.

5.1.3.4.1 Valleybottom wetland with channel

The Sandspruit and its tributary from the south are classified as a Valley bottom wetland with a channel. Valley bottom wetlands are classified as low-lying, gently sloped areas that receive water from an upstream channel and/or form adjacent hillslopes, not subject to periodic over-bank flooding by a river

channel. Surface water in the valley bottom wetlands of the study area flows only seasonally, although the channels are in most cases perennial.

One type of valley bottom wetlands is associated with the study area as classified by Sanbi (2009) namely channelled valley bottom wetlands (Photograph 6). A channelled valley-bottom wetland is classified as a mostly flat valley-bottom wetland dissected by and typically elevated above a channel. Dominant water inputs to these areas are typically from the channel, either as surface flow resulting from overtopping of the channel bank/s or as interflow, or from adjacent valley-side slopes (as overland flow or interflow). Water generally moves through the wetland as diffuse surface flow, although occasional, short-lived concentrated flows are possible during flooding events. Small depressional areas within a channelled valley-bottom wetland can result in the temporary containment and storage of water within the wetland. Water generally exits in the form of diffuse surface flow and interflow, with the infiltration and evaporation of water from these wetlands also being potentially significant (particularly from depressional areas). The hydrodynamic nature of channelled valley-bottom wetlands is characterised by bidirectional horizontal flow, with limited vertical fluctuations in depressional areas (SANBI, 2009).

The vegetation structure of the valley bottom wetlands varies from the actual channels being closed grassland in certain areas, to a sandy riverbed with alluvial sand and conglomerates along the riverbanks. The drainage channels that from part of the channelled valley bottom wetlands is mostly non-perennial.

The most abundant and most conspicuous plant species is hygrophilous grasses such as *Sporobolus africanus, Paspalum dilatatum, Andropogon eucomis, Hyparrhenia tamba, Eragrostis gummiflua* and *Setaria sphacelata*. Other plants associated with valley bottom channels are *Cyperus sexangularis, Schoenoplectus corymbosus* and *Typha capensis*.

Unfortunately, the valley bottom wetlands provide a distribution route for weeds and invading trees (Photograph 7). Many of the usual weeds were recorded together with *Tecoma stands, Solanum mauritianum, Leucacena leucocephala, Xanthium strumarium*, *Datura stramonium* and *Flaveria bidentis*. Weeds and invaders should be removed, as well as destruction of such plants in a safe place and manner.

Photograph 6. Sandspruit to the north of the proposed CDF and PCD where the conveyor and road will cross the wetland

Photograph 7. Alien invasive species along the banks of the Sandspruit

5.1.3.4.2 Channels (water courses) and riparian woodland (including stormwater canal)

The modified canals represent river channels and are classified as channels or water courses. A Channel (river, including the banks) can be described as follows: an open conduit with clearly defined margins that (i) continuously or periodically contains flowing water, or (ii) forms a connecting link between two water bodies. Dominant water sources include concentrated surface flow from upstream channels and tributaries, diffuse surface flow or interflow, and/or groundwater flow. Water moves through the system as concentrated flow and usually exits as such but can exit as diffuse surface flow because of a sudden change in gradient. Unidirectional channel-contained horizontal flow characterises the hydrodynamic nature of these units. Note that, for purposes of the classification system, channels generally refer to rivers or streams (including those that have been canalised) that are subject to concentrated flow on a continuous basis or periodically during flooding, as opposed to being characterised by diffuse flow. As a result of the erosive forces associated with concentrated flow, channels characteristically have relatively obvious active channel banks. At Level 4A of the classification system, the entire active channel (including wetlands occurring on the banks, i.e., in the riparian zone) is treated as a unit.

No vegetation grows in the channel itself other than the edges of the channel where sedges (Cyperaceae spp) and hygrophilous grasses (*Sporobolus africanus, Setaria sphacelata*) grow.

The substrate in the channel is composed of sediment with smaller pebbles and some areas where large rocks occur along the banks. The modified section of the valley bottom wetland to the west of the culverts represents a water course rather than a wetland area due to the area previously being part of the opencast mining area (Photograph 4).

In the case of the major channel, the riparian woodland of the area is mostly sparse with species such as *Searsia lancea* and *Vachellia karroo* documented. Most of the riparian woodland has been removed by local communities and the herbaceous component is poorly developed along the riverbanks due to overgrazing by the livestock of the local communities and dominated by species such as *Sporobolus africanus* and *Cynodon dactylon*.

Photograph 8. Modified section of a valley bottom representing a river

5.1.3.4.3 Man-made dam (depression)

The Pollution Control Dam (PCD) represents a man-made dam also classified as a depression (Photograph 9). A depression is classified as a landform with closed elevation contours that increases in depth from the perimeter to a central area of greatest depth, and within which water typically accumulates. Dominant water sources are precipitation, ground water discharge, interflow and (diffuse or concentrated) overland flow. For 'depressions with channelled inflow', concentrated overland flow is typically a major source of water for the wetland, whereas this is not the case for 'depressions without channelled inflow'. Dominant hydrodynamics are (primarily seasonal) vertical fluctuations. Depressions may be flat-bottomed (in which case they are often referred to as 'pans') or round bottomed (in which case they are often referred to as 'basins') and may have any combination of inlets and outlets or lack them completely.

The vegetation associated with depressions is mostly reeds, sedges and bulrushes depending on the depth of the water and the substrate. Species such as *Typha capensis, Phragmites australis, Schoenoplectus corymbosus, Ludwigia stolonifer* and *Leersia hexandra* mostly grow along the shallow edges of the dam in the project area on a muddy substrate.

Photograph 9. Pollution Control Dam (PCD) representing a man-made depression in the project area

The following specific recommendations for the wetland areas should be adhered to for the hydrological features on site;

- The vegetation associated with the water courses that forms part of the floodline area in the project area has a high sensitivity with a high conservation priority. The man-made features have a Medium (PCD dam) and Low Sensitivity (stormwater canals);
- A detailed rehabilitation and riverine management plan should be developed by a wetland specialist in collaboration with a civil engineer;
- Any development activities that would include crossing of drainage channels by the tailings pipeline and upgrade of the road would need a water license application to DWS. The location where the road cross the drainage channels or bisect riparian woodland (within 32 m of a water course) should be on the least sensitive areas. The site should preferably be indicated by an ecologist after consultation by the engineers;
- Riparian areas: DWS has stipulated specific guidelines for the identification of such areas in a guide. These are sensitive areas and prime examples of such areas are the riparian woodland areas associated with the major drainage channels in the area. A survey and delineation of the drainage systems and wetlands in the area was conducted as part of a detailed ecological survey. The predicted impact of the development activities will be significant and strict mitigation measures should be addressed as part of the construction phase to ensure limited impacts on the drainage channels and riparian woodland;
- The following aspects should be considered as part of the layout of the proposed development

activities on the drainage channels:

- Identify areas of historic or potential vulnerability, such as geologically unstable materials or areas subject to flooding.
- Avoid problematic areas and avoid construction locations on the layout in areas of high natural hazard risk, such as landslides, rock-fall areas, steep slopes (over 60-70%), wet areas, saturated soils, etc.
- Avoid or minimize construction in narrow canyon bottoms or on flood plains of rivers that will inevitably be inundated during major storm events.
- Minimize changes to natural drainage patterns and crossings to drainages. Drainage crossings are potentially problematic, so they must be well designed. Changes to natural drainage patterns or channels often result in either environmental damage or failures.
- Perform scheduled maintenance to be prepared for storms. Ensure that culverts have their maximum capacity, ditches are cleaned, and that channels are free of debris and brush than can plug structures.
- Typically keep cut and fill slopes as flat as possible and well covered (stabilized) with vegetation to minimize slumping as well as minimize surface erosion. Well-cemented but highly erosive soils may best resist surface erosion with near-vertical slopes that minimize the surface area exposed to erosion.
- Use deep-rooted vegetation for biotechnical stabilization on slopes. Use a mixture of good ground cover plus deep-rooted vegetative species, preferably native species, to minimize deep-seated mass instability as well as offer surface erosion control protection.
- Locate roads crossings on narrow sections of rivers and in areas of bedrock where possible. Avoid fine, deep alluvial deposits (of fine sand and silt) that are scour susceptible and problematic, or which otherwise require costly foundations.
- Place retaining structures, foundations, and slope stabilization measures into bedrock or firm, in-place material with good bearing capacity to minimize undermining, rather than placing these structures on shallow colluvial soil or on loose fill material.

5.1.3.5 Exposed areas associated with mining infrastructure

The mining areas (including shafts, infrastructure, TSF, WRD, Plant and all cleared land) and haul roads represent zero sensitivity degraded areas characterised only by landscaping areas, a few pioneer grasses and exotic weeds. No further description of these degraded areas was considered necessary. The location of the areas is indicated in the vegetation map.

5.2 RECOMMENDATIONS & MANAGEMENT STRATEGIES FOR FLORA

South Africa has been recognized as having remarkable plant diversity with high levels of endemism. The major threats to plants in the study area are urban expansion, non-sustainable harvesting, collecting, overgrazing/browsing, mining and agriculture. The objective of this section was to compile a list of plant species for which there is conservation concern. This included threatened, rare, declining, protected and endemic species.

5.2.1 Species of conservation concern

Species of conservation concern are species that have a high conservation importance in terms of preserving South Africa's high floristic diversity and include not only threatened species, but also those classified in the categories Extinct in the Wild (EW), Regionally Extinct (RE), Near Threatened (NT), Critically Rare, Rare, Declining and Data Deficient – Insufficient Information (DDD). It should also be noted that not all species listed as protected are threatened or vice versa. A list of SCC plant species previously recorded in the study area in which the proposed development is planned was obtained from the Plants of Southern Africa (POSA) database of SANBI. Figure 7 indicates the classification system used by Sanbi for SCC:

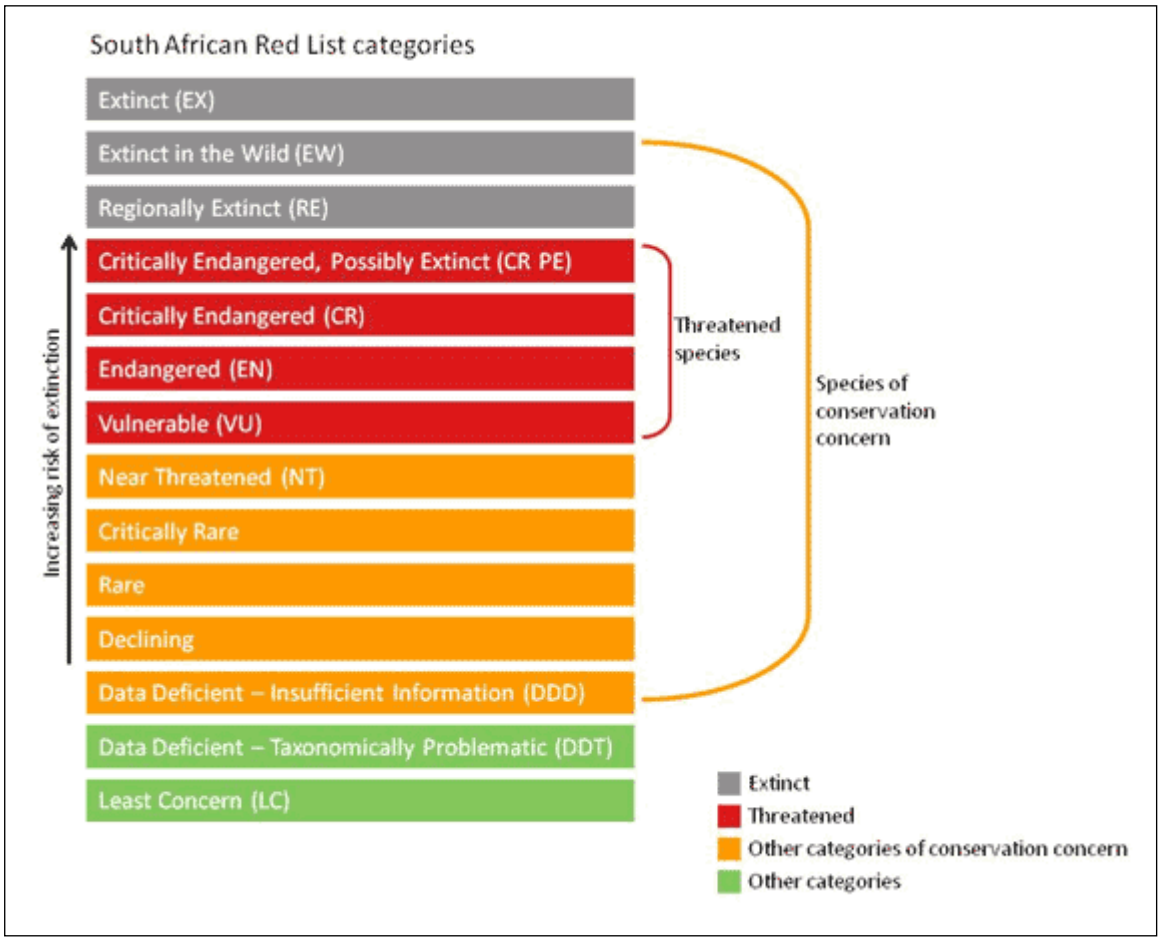


Figure 7. South African red list categories indicating the categories to be used for Species of Conservation Concern

A list of red data plant species previously recorded in the study area in which the proposed development is planned was obtained from the Plants of Southern Africa (POSA) database of SANBI. The following red data species are listed for the specific Quarter Degree Grid Square (QDS) (Table 10).

Table 10. Red data species potentially occurring in the project area according to the POSA database

Family	Common Name	Species	Threat status
Myrothamnaceae	*Resurrection Plant*	*Myrothamnus flabellifolius*	Data Deficient

None of this species was documented during the surveys considering that the habitat is completely different.

5.2.2 Protected Plants (LEMA)

Plant species are also protected according to the Northwest Nature Conservation ordinance. According to this Act, no person may pick, import, export, transport, possess, cultivate or trade in a specimen of a specially protected or protected plant species. The Appendices to the Act provide an extensive list of species that are protected. After a detailed survey of the vegetation surrounding the site, it was concluded that none of the listed species potentially occurred on the proposed development sites.

5.2.3 Protected tree species (NFA)

The National Forest Act (no.84 of 1998: National Forest Act, 1998) provides a list of tree species that are considered important in a South African perspective because of scarcity, high utilization, common value, etc. In terms of the National Forest Act of 1998, these tree species may not be cut, disturbed, damaged, destroyed and their products may not be possessed, collected, removed, transported, exported, donated, purchased or sold – except under license granted by DWAF (or a delegated authority). Obtaining relevant permits are therefore required prior to any impact on these individuals. Taking cognizance of the data obtained from the field surveys of the direct surrounding, it was concluded that no protected trees occurred on the proposed development sites.

5.2.4 Invasive alien species

Invasive alien plants pose a direct threat not only to South Africa's biological diversity, but also to water security, the ecological functioning of natural systems and the productive use of land. They intensify the impact of fires and floods and increase soil erosion. Of the estimated 9000 plants introduced to this country, 198 are currently classified as being invasive. It is estimated that these plants cover about 10% of the country and the problem is growing at an exponential rate.

The Alien and Invasive Species Regulations (GNR 599 of 2014) are stipulated as part of the National Environmental Management: Biodiversity Act (10/2004). The regulation listed a total of 559 alien species as invasive and further 560 species are listed as prohibited and may not be introduced into South Africa. Below is a brief explanation of the four categories of Invasive Alien Plants as per the regulation.

- Category 1a: Invasive species requiring compulsory control. Remove and destroy. Any specimens

of Category 1a listed species need, by law, to be eradicated from the environment. No permits will be issued.

- Category 1b: Invasive species requiring compulsory control as part of an invasive species control programme. Remove and destroy. These plants are deemed to have such a high invasive potential that infestations can qualify to be placed under a government sponsored invasive species management programme. No permits will be issued.
- Category 2: Invasive species regulated by area. A demarcation permit is required to import, possess, grow, breed, move, sell, buy or accept as a gift any plants listed as Category 2 plants. No permits will be issued for Category 2 plants to exist in riparian zones.
- Category 3: Invasive species regulated by activity. An individual plant permit is required to undertake any of the following restricted activities (import, possess, grow, breed, move, sell, buy or accept as a gift) involving a Category 3 species. No permits will be issued for Cat 3 plants to exist in riparian zones.

The following alien invasives and exotic plant species were recorded on the site and surroundings during the surveys as stipulated in the Alien and Invasive Species Regulations (GNR 599 of 2014) (Table 11):

Table 11. List of exotic plant species of the study area

Species	Category
Argemone ochroleuca	1b
Cereus jamacaru	1b
Conyza albida / Conyza bonariensis	1b
Datura stramonium	1b
Eucalyptus camaldulensis	1b
Ipomoea purpurea	1b
Jacaranda mimosifolia	2
Laggera decurrens	1b
Lantana camara	1b
Leucacena leucacephala	2
Melia azedarach	1b
Morus alba	2
Nicotiana glauca	1b
Opuntia ficus-indica	1b
Ricinus communis	2
Sesbania bispinosa	1b
Solanum mauritianum	1b
Tamarisk chinensis	1b

Species	Category
Tecoma stans	1b
Tithonia rotundifolia	1b
Verbena brasiliensis	1b
Xanthium strumarium	1b

6 FAUNAL ASSESSMENT

6.1 OVERVIEW

A healthy environment is inhabited by animals that vary from micro-organisms to the birds and mammals. The species composition and diversity are often parameters taken into consideration when determining the state of the environment. A comprehensive survey of all animals is a time-consuming task that will take a long time and several specialists to conduct. The alternative approach to such a study is to do a desktop study from existing databases and conduct a site visit to verify the habitat requirements and condition of the habitat. If any rare or endangered species are discovered in the desktop study that will be negatively influenced by the proposed development, specialist surveys will be conducted.

6.1.1 Fauna habitats of the project area

The number of mammal species supported by a plant community depends on several factors like the primary production, seasonal availability of resources, floral heterogeneity, diversity of plant structure, nature of the substratum and previous history (Delany, 1982). Each mammal species has a particular niche, which can be regarded as the sum of all ecological requirements of a species namely food, space, shelter and physical conditions. Mills & Hes (1997) stated that the distribution and abundance of animal species does not rigorously follow that of plant communities or biomes. Instead, mammal species seem to have certain preferences for a specific habitat type (Skinner & Smithers, 1990). Several authors have shown this preference of mammals to certain habitats through analysis (Beardall et al. 1984; Ben-Shahar, 1991; Dekker et al. 1996).

A survey was conducted during May 2019 to identify specific fauna habitats, and to compare these habitats with habitat preferences of the different fauna groups (birds, mammals, reptiles, amphibians) occurring in the quarter degree grid. The area represents degraded grassland, alien bushclumps, microphyllous woodland and riverine habitats (including riparian woodland and open water) with a diverse vegetation structure and height class. A detailed species list for the fauna of the area is included in Appendix C, D and E.

During the site visits mammals, birds, reptiles, and amphibians were identified by visual sightings through random transect walks. In addition, mammals were also recognized as present by means of spoor, droppings, burrows or roosting sites.

The regional fauna has been studied extensively and is known to exhibit many unique features. The area has been settled for many centuries, and the fauna is usually considered impoverished due to the degradation caused by mining activities, built-up land and other man-induced impacts. There are four main faunal habitat types present on the site that might be impacted on by the proposed project.

Four major fauna habitats were observed in the area namely:

- Exotic bushclumps;
- Microphyllous woodland;
- Degraded grassland;
- Riverine habitat

6.1.2 Background

A previous study conducted by NSS (2015) for the Kroondal Mine revealed the following on site:

- Five mammal species;
- Sixty Five bird species;
- One frog; and
- Ten dragonfly species.

MammalMap (2015) lists 27 species for the Quarter Degree Square (QDS) 2527CB covering the study area. Species observed on site include Single-striped Mouse, Scrub Hare, Common Mole-rat, Multimammate Mouse and Water Mongoose (NSS, 2015).

Mine shafts in the vicinity may provide suitable habitat for a few bat species (NSS, 2015).

Of the 400 regionally occurring bird species 331 have been recorded during SABAP 1 & 2 (2015) surveys in the QDS (2627DB) and pentad (2540_2715) covering Kroondal. Most of these species are likely to have been recorded at more significant habitat features in the area and only some 225 species are likely to occur on site. During all visits to Kroondal NSS has recorded 65 species.

Kroondal is likely to receive a mixed compliment of bird species from bank nesting species to waterbirds, bushveld and garden birds. The steep-sided tailings and stockpile slopes in the south-east provide suitable nesting habitat for certain kingfishers, bee-eaters, martins and swifts. Currently these cuttings host a population of White-fronted Bee-eaters. The various small artificial dams with their dense marginal vegetation provide suitable habitat for a few waterbird species such as crakes, rails, coots, ducks, herons and warblers.

Of the 70 regionally occurring reptile species 31 have been recorded during atlassing projects in the QDS (ReptileMap, 2015) and 37 are considered likely to occur on site based on distribution and the availability of suitable habitat. During the 2015 site visits three species were detected namely variable skink and rock monitor (NSS, 2015). Nile crocodile is not a species that, under normal circumstances would be expected to occur. However, a large crocodile breeding facility borders Kroondal to the south-east and it is entirely possible that escapees may utilise the various waterbodies on site and indeed there have been reports of and individual wandering onto site in

the past (NSS, 2015).

Of the 24 regionally occurring frog species 12 species have been recorded during atlassing surveys in the QDS (FrogMap, 2015) but 14 are considered likely to occur on site based on distribution and the availability of suitable habitat. One frog species was recorded during the NSS site visit the Eastern Olive Toad. (NSS, 2015).

6.1.2.1 Mammals

Large mammals that occurred historically at the site are mainly restricted to game reserves and national parks in the area. This loss of large species on the private land that forms part of the project area means that the mammal diversity on these sites is far from its original natural state not only in terms of species richness but also with regards to functional roles in the ecosystem.

Mammals are sensitive to disturbances and habitat destruction and degradation and as such the anticipated species diversity of the study area would be low. Settlement areas have negated the possibility of encountering any medium to large mammals. The presence of feral dogs and cats as well as poaching activities, poses a threat to the presence of mammals on sites. The mammals are mostly represented by generalised species such as rodents, scrub hares and smaller antelope (steenbok, common duiker) that will move through the area while foraging. The proximity of the informal settlements does however place constant pressure on these mammal populations and many of these populations will eventually disappear from the area completely. The natural habitats associated with the area will still support populations of herbivores such as duiker and steenbok

Most of the habitat types are degraded and fragmented, although the habitat will still be utilized by small mammals such as rodents still intact. Therefore, the expected mammalian richness on these areas is considered low, especially for the more degraded areas. Antelope species such as duiker still roam this small area (dung, spoor identified) and are not restricted by game fences. Smaller mammal species such as honey badgers and serval can become habituated to anthropogenic influences, while other species will rather move away from the construction activities and will seldom use the area. Many of the bat species of conservation concern in the project area are cave-dependant for roosting or alternatively could inhabit the mine shafts on site. Any individuals that utilize the proposed new infrastructure area would therefore either be foraging or migrating and would not be affected by the localized loss of habitat due to the development. The dominant species composition therefore comprises of widespread taxa with unspecialised life history traits.

Most mammal species are highly mobile and will move away during construction. The impact will also be low if one compares the footprint of the development and the overall range of individual species. It is therefore considered highly unlikely that any mammal species that still occur in the

area will be affected negatively by the development of the mining infrastructure, although mitigation measures should be enforced. The connectivity1 of the project site to the remainder of the larger area is poor due to other developments, roads, agriculture and mining activities. The most important corridors that need to be preserved for free-roaming mammal species in the larger area include Sandspruit and its tributary. The only area where these areas will be impacted is at the crossing of the pipeline or indirect impacts associated with construction and operational activities. The use of trapping techniques was not deemed necessary due to the degraded state of the natural environment.

6.1.2.2 Birds (avifauna)

Three major bird habitat systems were identified within the borders of the study site, including the woodland, degraded grassland and riverine habitats.

Most bird species identified within the study area are common species known to nest within or utilise the degraded grassland, riparian woodland and microphyllous woodland habitat in the region and may be either permanently or occasionally present within the study area. According to Birdlife South Africa, the study area falls inside the Magaliesberg Important Bird Area (IBA), although in terms of habitat the site is not typical of the Magaliesberg habitat type for avifauna.

Microphyllous woodland usually supports much higher bird numbers compared to the broadleaved woodlands. The ground cover between the trees consists of mainly short grasses interspersed with shrubs (Barnes, 1998). The plains area where the proposed CDF, PCD and stockpiles is planned, represents microphyllous woodland and supports many smaller bird species such as Ashy Tit, Pied Babbler, Kalahari Robin, Burntnecked Eremomela, Desert Barred Warbler, Marico Flycatcher, PiritBatis, Crimsonbreasted Shrike, Longtailed Shrike, Threestreaked Tchagra, Great Sparrow, Whitebrowed Sparrowweaver, Scalyfeathered Finch, Violeteared Waxbill and Blackcheeked Waxbill.

In general terms the open grassland patches in between the microphyllous woodland could attract the Secretarybird, White-bellied Korhaans, and White Stork and Abdim's Stork. However, the proximity to various residential areas and informal settlements means that disturbance levels in these areas are likely to be high due to humans, and hunting by dogs, and therefore the potential to find these species in the area are considered very low. The low reporting for these species is evidence of the impact that the surrounding communities are having on the birds that would, under optimum conditions, inhabit these open areas. The grassland patches are also a favourite foraging area for non-Red Data game birds such as Swainson's Spurfowl and Helmeted Guineafowl. This in turn could attract large because of both the presence and accessibility of prey.

1 C**onnectivity (habitat connectivity)** - Allowing for the conservation or maintenance of continuous or connected habitats, to preserve movements and exchanges associated with the habitat.

Many habitat generalist species utilize this habitat type predominantly for foraging and hunting purposes. The disturbances of the topsoil layers also very often allow for greater foraging for insectivorous species. The farmland habitat type, however, is not a habitat type that is relied upon by any avifaunal species for survival.

The conservation status of many of the bird species that are dependent on riverine areas reflects the critical status of wetlands or rivers nationally, with many having already been destroyed. The Sandpsruit is in a degraded state, therefore the probability of finding any red data species in this area was considered low.

6.1.2.3 Herpetofauna (Reptiles and Amphibians)

There is a potential presence of some toads and sand frogs in the non-perennial river on site, as they only need temporary pools for reproduction and the riverine area may provide suitable habitat. Amphibian species potentially occurring in the area include Common River Frog, Natal Sand Frog, Gutteral Toad, Raucous Toad and Bubbling Kassina. These species are non-threatened and widespread species, and as such the development will not have any impact on amphibian conservation within the region.

Reptile species such as the southern rock python, the black mamba, puff adder, snouted cobra boomslang, vine snake, spotted bush snake and several members of the green snakes (Philothamnus spp.) is expected to occur in the larger area, although the potential to find these species in the project area is low due to the anthropogenic influences. The general habitat type for reptiles consists of open to very dense bushveld, with limited available habitat for diurnally active and sit-and-wait predators, such as terrestrial skinks and other reptiles. Arboreal species are the more prominent components of the local herpetofauna in the woodland areas outside the fenced mining area.

A few baby crocodiles were observed in the Catchment Dam and the Silt Trap of the Kroondal Mine. The crocodiles hatched from eggs that were left behind when the adjacent Crocodile Farm was abandoned recently. The small crocodiles need to be removed from the area by a crocodile specialist.

6.1.3 Red data species

According to the existing databases and field survey the following number of fauna species included in the IUCN red data lists can potentially be found in the study area (Table 12):

Table 12. Red data list of potential fauna for the study area

English Name	Conservation Status	Probability of occurrence
MAMMALS		
Brown Hyena	Near Threatened	Low

English Name	Conservation Status	Probability of occurrence
Serval	Near Threatened	Low
Tsessebe	Vulnerable	Zero – restricted to game reserves
Sable antelope	Vulnerable	Zero – restricted to game reserves
Leopard	Vulnerable	Low
BIRDS		
Korhaan, Southern Black	Vulnerable	Low
Kingfisher, Half-collared	Near Threatened	Low
Eagle, Tawny	Endangered	Medium
Eagle, Verreauxs'	Vulnerable	Low
Stork, Abdim's	Near Threatened	Low
Stork, Black	Vulnerable	Low
Roller, European	Near Threatened	Medium
Korhaan, White-bellied	Vulnerable	Low
Falcon, Lanner	Vulnerable	Low
Vulture, White-backed	Endangered	Low
Vulture, Cape	Endangered	Low
Duck, Maccoa	Near Threatened	Low
Eagle, Martial	Endangered	Low
Secretarybird	Vulnerable	Low
Owl, African Grass	Vulnerable	Low
HERPETOFAUNA		
Crocodile	Vulnerable	Confirmed

The following impacts might occur during the mining phases on the fauna populations of the area:

- Destruction/permanent loss of individuals of rare, endangered, endemic and/or protected species through habitat loss or fragmentation.
- Disturbance of remnant terrestrial wild mammal, avian, amphibian and insect fauna would probably occur through physical habitat destruction, noise, traffic and movement of people.
- Potential increase in feral animals and impact on indigenous fauna e.g., cats, rats.
- Illegal hunting or disturbance.

The following management measures are proposed regarding the conservation of these and other fauna which might occur on the property:

- The mining development would not have a significant impact on the above-mentioned red data fauna since adequate and natural habitat/vegetation would be available on the peripheral grassland, woodland and riverine areas outside the study area. The most probable habitat to find any of the red data species in the study area would be in the more natural riverine areas, where little or no disturbances form humans or livestock

occur at a regular interval. Most of the site do not represent suitable habitat considering the anthropogenic influences in the area and the degraded state of the vegetation in general. Fauna will therefore rather move away from the area and utilize adjacent, more natural areas. The importance to preserve the riverine habitat should still be considered a high priority though;

- The removal of vegetation should be confined to the footprints of the developments. This will be on small sections in relation to the total available surrounding habitat for fauna. Development also will not influence the natural feeding and movement patterns of the existing fauna in the area.
- If one considers the habitat descriptions of the red data species, most of them are not directly threatened by habitat loss. The impact of development on the red data species would therefore be less than predicted.
- The protection of different habitat types in the area will be important to ensure the survival of the different animals due to each species' individual needs and requirements. Sufficient natural corridor sections should be protected around the proposed development footprints to allow fauna to move freely between the different vegetation units on the property. The rivers represent highly sensitive areas in the area and mitigation measures should be implemented to ensure that the habitats are protected.
- The taller (>3m) indigenous trees within this area also provide resting/perching sites for larger birds like vultures, birds of prey, arboreal reptiles and mammals that might occur/pass through the area and should preferably be preserved. These larger trees should be protected as far as possible and be incorporated into the proposed road developments development. The removal of large dead trees is also not advised as these trees also provide smaller habitats for the mentioned bat species as well as rodents. The grass layer on the other hand also provides a valuable food source (insects, reptiles, small mammals that occur in/on the grass layer) for fauna.
- A monitoring programme needs to be implemented by a specialist if any rare species are confirmed on the property.

The following practical recommendations with regards to the fauna of the area apply with regards to the construction of the road development:

- Where trenches pose a risk to animal safety, they should be adequately cordoned off to prevent animals falling in and getting trapped and/or injured. This could be prevented by the constant excavating and backfilling of trenches during construction.
- No animals may be poached. Many animals are protected by law and poaching, or other

interference could result in a fine or jail term.

- Do not feed any wild animals on site.
- Poisons for the control of problem animals should rather be avoided since the wrong use thereof can have disastrous consequences for the raptors occurring in the area. The use of poisons for the control of rats, mice or other vermin should only be used after approval from an ecologist.
- Roads in the area should be designed without vertical pavements to allow for the movement of small mammals. Culverts underneath the road at the drainage crossing could provide easy migration of smaller fauna.

Monitoring of the environmental aspects is recommended for the future phases of the proposed development should the authorities approve the application. The monitoring phase would ensure that negative impacts on the fauna and flora of the area are limited to a minimum during the construction phase.

7 WETLANDS / WATER COURSES OF THE PROJECT AREA

7.1 DELINEATION

DWAF (2003) states that to classify an area as a wetland it must have one or more of the following attributes:

- Hydromorphic soils that exhibit features characteristic of prolonged saturation;
- The presence of hydrophytes (even if only infrequently);
- A shallow water table that results in saturation at or near the surface, leading to the development of anaerobic conditions in the top 50cm of the soil.

The delineation map is indicated in Figure 6 as part of the vegetation map. The identification of the water courses was done according to the aerial photograph and a field survey where the topography of the landscape and vegetation were used to delineate the water course or riparian zone.

Three types of hydrological systems were identified on site as follows:

- Valleybottom wetland with channel
- Exorheic depression (artificial dam);
- River & riparian woodland (including stormwater canals)

Detailed descriptions of these ecosystems are included as part of the vegetation unit descriptions (Section 4.1.3.4).

7.2 WETLAND INTEGRITY ASSESSMENTS

In determining the integrity of the water courses, the condition of the site and the indirect and direct disturbances is considered. The embankments, roads, alien invasive vegetation species, littering etc. was considered in determining the PES and EIS of these wetland units at the crossing. Appendix F and G indicate the scores for the PES and EIS respectively.

Evidence was observed on site of transformation of the floristic characteristics of the site. Impacting activities which may have altered the expected floristic composition include alien infestation, impoundment and road development crossings.

Table 13 indicate the PES and EIS as determined for this crossing. The secondary roads, impoundments and alien invasion had a definite impact on downstream areas.

Table 13. Present Ecological State and Ecological Importance & Sensitivity of the wetland and riparian systems on the proposed development site

Wetland	PES	EIS
Sandpsruit & tributary	Class D Largely modified	Low

The Sandspruit and its tributary are classified as having a 'Largely Modified' PES, due to the impacts on the ecosystem by erosion, sedimentation, alien species invasion and water pollution from upstream activities. This wetland system has a 'Low' EIS and is ecologically important and sensitive on a local scale. The biodiversity of these wetlands may be sensitive to flow and habitat modifications. They play a role in moderating the quantity and quality of water of major rivers.

7.3 STATEMENT ON HYDRPEDOLOGY OF 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 (Zimpande Research Collaborative, 2021).

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 (Zimpande Research Collaborative, 2021).

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 (Zimpande Research Collaborative, 2021).

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 (Zimpande Research Collaborative, 2021).

8 DISCUSSION OF IMPACTS ON FLORA AND FAUNA FOR DIFFERENT MINING PHASES

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 (CDFs);
- Pollution Control Dam (PCD);
- Topsoil stockpiles;
- Silt dam;
- Support infrastructure. (e.g., conveyor, access road etc.)

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:

- Obtaining of flora species permits (if relevant);
- Avoidance of sensitive habitats through identification of alternatives;

No specific direct impacts will occur on the fauna and flora of the area.

8.2 CONSTRUCTIONAL PHASE

The development and start-up of the mining operations covers the period when considerable changes take place as the mine infrastructure are constructed. The most immediate impacts are disruptions and disturbances to flora communities due to site clearance for construction of the CDFs, PCD, stockpiles, silt dam and support infrastructure (conveyor, roads etc.). 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 proposed Glencore Kroondal Mine Residue expansion project:

- The construction phase of the mining development will result in loss of and damage to natural habitats if the vegetation is cleared for the development of infrastructure (CDFs and laydown areas for the stockpiles). Rehabilitation of some areas would be possible but there is likely to be long-term damage in large areas. Most habitat destruction will be

caused during the construction phase. Vegetation communities are likely to be impacted on a very small spatial scale in comparison to the extent of the vegetation communities' total area in the region;

- The mining development will inevitably result in natural movement patterns being disrupted and, to a varying degree depending on how different species react to these barriers will result in the fragmentation of natural populations. The fencing of the mining area and construction of mining infrastructure will have a large, significant impact in fragmenting the habitats on and around the site.
- The construction activities associated with the mining developments may result in widespread soil disturbance and is usually associated with accelerated soil erosion. Soil erosion 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 flora;
- Construction work of the magnitude contemplated for the proposed development will always carry a substantial risk of soil and water pollution, with large construction vehicles contributing substantially due to oil and fuel spillages. 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 the flora of the site;
- The environmental impacts of wind-borne dust, gases and particulates from the construction activities associated with the proposed development will have an impact on the vegetation of the area when dust settles on plant material reducing the amount of light reaching the chlorophyll in the leaves, thereby reducing photosynthesis, which in turn reduces plant productivity, growth and recruitment;
- Continued movement of personnel and vehicles on and off the site during the construction phase, as well as occasional delivery of materials required for maintenance, will result in a risk of importation of alien species. Vehicles often transport many seeds and some may be of invader species, which may become established along the road, especially where the area is disturbed. The construction almost certainly carries by far the greatest risk of alien invasive species being imported to the site, and the high levels of habitat disturbance also provide the greatest opportunities for such species to establish themselves, since most indigenous species are less tolerant of disturbance. The biggest risk is that seeds of noxious plants may be carried onto the site along with materials that have been stockpiled elsewhere at already invaded sites.
- Disturbance of remnant terrestrial wild mammal, avian, amphibian and insect fauna would probably occur through physical habitat destruction, noise, traffic and movement

of people. The impact of the construction would be MODERATE considering that animals would move away from the area, while some ground-burrowing species such as moles and reptiles might be killed in the process. There are however no specific red data species that would be critically impacted on by the constructional phase.

- Potential increase in feral animals and impact on indigenous fauna e.g., cats, rats.
- Illegal hunting or disturbance.
- Operation or disturbance during breeding season can precipitate long-term cumulative effect on populations.

The following impacts on the flora and fauna apply to both the Glencore Kroondal Mine Residue Expansion Project for the various components during the construction phase:

8.2.1 Co-Disposal Facilities, Pollution Control Dam, topsoil stockpiles and Silt Trap

- **Activity 1:** Vegetation clearing
- **Related impacts**
    - Habitat destruction or disturbance to ecosystems leading to reduction in the overall extent of a particular habitat;
    - Fragmentation of fauna habitats;
    - Potential establishment and spread of declared weeds and alien invader plants
- **Activity 2:** Topsoil and subsoil stripping
- **Related impacts**
    - Increased Soil erosion and sedimentation;
    - Habitat degradation due to dust;
- **Activity 3: Vehicle movement**
    - Spillages of harmful substances to the ecosystem;
    - Habitat degradation due to dust;
    - Road mortalities of fauna

8.2.2 Support infrastructure

- **Activity 1:** Vegetation clearing
- **Related impacts**
    - Habitat destruction or disturbance to ecosystems leading to reduction in the overall extent of a particular habitat;
    - Fragmentation of fauna habitats;
    - Potential establishment and spread of declared weeds and alien invader plants

- Impacts on drainage regime at wetland / riverine crossings

- **Activity 2:** Topsoil and subsoil stripping
  - Increased Soil erosion and sedimentation;
  - Habitat degradation due to dust;
- **Activity 3: Vehicle movement during construction of surface infrastructure**
  - Spillages of harmful substances to the ecosystem;
  - Habitat degradation due to dust;
  - Road mortalities of fauna

8.2.3 Cumulative Impact

The cumulative impacts associated with the construction phase are the same as discussed above for the different mining components. The rating will be higher compared to the individual component ratings as the landscape scarring of are permanent features affecting the species diversity and composition of the general vegetation patterns of the study area.

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:

- Processing of ore in the processing plant;
- Storage of tailings and 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;

- Water storage facilities;
- Hazardous waste storage and disposal.

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

- The operational phase of the mine will have a very low impact on the vegetation of the proposed mining development site. Considering that most infrastructure (plant etc.) have already been constructed during this mining phase, the only impacts that might create habitat disturbance or loss of plant communities might be loss of plant communities and flora species of significance on the laydown areas of the waste rock and stockpiles that used to represent natural vegetation communities;
- The spread of alien invasive plants on site is more intense during the operational phase of the mine due to the movement of vehicles over an extended area on and from the site, causing a higher risk of potentially spreading the seeds or vegetative material from invasive species. Although construction creates the suitable conditions for establishment of invasive species, the operational phase certainly carries by far the greatest risk of alien invasive species being spread through the area and even through the wetland systems to the greater region. This risk is further influenced by increased run-off as a result of exposed areas and hardened surfaces created during the construction phase of the mine;
- The increased hardened surfaces around infrastructure and exposed areas created alongside the roads and additional surface areas created on the slopes of the stockpiles and waste rock dumps will have a definite impact on the potential erosion of exposed areas that will eventually cause sedimentation in the wetlands and streams of the area. Soil erosion 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 flora;
- During the operational phase heavy machinery and vehicles as well as sewage and domestic waste would be the main contributors to potential pollution problems;
- The impact of the operational phase of the mine relates more to the habitat loss of fauna because of specific mining activities. Furthermore, developments can threaten migration routes or flight paths because of noise and dust pollution. Cumulative impact of illegal collecting, road kills or power line related deaths reduce population viability in the long-term. Some mining related habitats also favour species leading to un-natural competition with endemic fauna. Much of the impacts of the fauna related to the construction phase of the mining development also apply to the operational phase of the mine.

The following impacts on the flora and fauna apply to both the Glencore Kroondal Mine Residue

Expansion Project for the various components during the operational phase:

8.3.1 Co-Disposal Facilities, Pollution Control Dam, topsoil stockpiles and Silt Trap

- **Activity 1: Stockpiling of residue deposits**
- **Related impacts**
    - Habitat destruction or disturbance to ecosystems leading to reduction in the overall extent of a particular habitat;
    - Fragmentation of fauna habitats;
    - Potential establishment and spread of declared weeds and alien invader plants;
    - Spillages of harmful substances to the ecosystem;
    - Increased Soil erosion and sedimentation (increased runoff from laydown areas);
    - Habitat degradation due to dust.
- **Activity 2: Materials handling and storage**
    - Spillages of harmful substances to the ecosystem;
    - Habitat degradation due to dust;
    - Road mortalities of fauna
- **Activity 3: Disposal of tailings:**
    - Spillages of harmful substances to the ecosystem.

8.3.2 Support infrastructure

- **Activity 1: Materials handling and storage**
    - Spillages of harmful substances to the ecosystem;
    - Habitat degradation due to dust;
    - Road mortalities of fauna
- **Activity 2: Storm water management:**
    - Increased Soil erosion and sedimentation.
- **Activity 3: Vehicle movement during construction of surface infrastructure, access road and bridges**
    - Spillages of harmful substances to the ecosystem;
    - Habitat degradation due to dust;
    - Road mortalities of fauna

8.3.3 Cumulative Impact

The cumulative impacts associated with the operational phase are the same as discussed above

for the different mining components. The rating will be higher compared to the individual component ratings, especially if one considers that water extraction and dust pollution will be increased through the operation of the mines. This will contribute to a loss of diversity and species composition over the larger area of the Vegetation Type. Cumulative effects only become critical if there are no other suitable habitats in the adjacent areas.

8.4 DECOMMISION PHASE

This 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 only major impacts on the vegetation during this phase would be the potential increased invasion of alien species and weeds on the cleared areas, while the risks of spreading fires will also still exist. Otherwise, there should be no further negative impact on surrounding vegetation during decommissioning.

8.4.1 Co-Disposal Facilities, Pollution Control Dam, topsoil stockpiles and Silt Trap

- **Activity 1: Demolition of mining infrastructure**
- **Related impacts**
    - Potential establishment and spread of declared weeds and alien invader plants;
    - Spillages of harmful substances to the ecosystem;
    - Habitat degradation due to dust;
    - Road mortalities of fauna

8.4.2 Support infrastructure

- **Activity 1: Demolition of mining infrastructure**
- **Related impacts**
    - Potential establishment and spread of declared weeds and alien invader plants;
    - Spillages of harmful substances to the ecosystem;
    - Habitat degradation due to dust;
    - Road mortalities of fauna

8.4.3 Cumulative Impact

The cumulative impacts associated with the decommissioning phase are the same as discussed above for the different mining components. The rating will be slightly higher compared to the individual component ratings.

8.5 CLOSURE PHASE

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 from stockpiles for rehabilitation;
- Rehabilitation of the CDFs, PCD and silt trap;
- Seeding of ripped and rehabilitated surfaces;

Amongst the more pronounced post-closure impacts on flora are landscape scarring in the form of unrehabilitated mine facilities, discard dumps as well as continuing environmental damage from wind-blown dusts and the dispersal of contaminated solid waste. If mitigation measures are correctly implemented there should be not be any further significant impact on the surrounding natural vegetation after closure though.

The following impacts are associated with the closure phase of the mine:

- 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 replacement. The poor soil cover associated with the cleared areas, stockpiles and WRD 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 wetlands and rivers during the closure phase, compared to the other phases;
- 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 as a result of concurrent rehabilitation;
- Dust generation can temporarily increase during closure phases of the mine. This is due to rehabilitation activities. During this phase, the impacts should last for a short period. The impact of dust on the vegetation will however be at a reduced intensity during the closure phase compared to the construction and operational phases of the mine because of the rehabilitation measures. The revegetation of exposed areas will play a major role in this regard.
- The control of alien invasive species will be more pertinent during the closure phase of the mine and the risk of spreading is therefore reduced. Although the movement of vehicles on site during rehabilitation will still have a potential impact on the spreading of

alien invasive species, the intensity of spread of alien invasive plants on site is more INTENSE during the operational phase of the mine due to the movement of vehicles over an extended area on and from the site, causing a higher risk of potentially spreading the seeds or vegetative material from invasive species;

- The impact on fauna mortality will continue during the closure phase because of rehabilitation activities on site.

8.5.1 CDFs, PCD and silt trap

- **Activity 1: Rehabilitation**
- **Related impacts**
    - Positive impact through habitat improvement in rehabilitated areas;
    - Potential establishment and spread of declared weeds and alien invader plants;
    - Spillages of harmful substances to the ecosystem;
    - Habitat degradation due to dust;
    - Road mortalities of fauna

8.5.2 Support infrastructure

- **Related impacts**
    - Positive impact through habitat improvement in rehabilitated areas;
    - Potential establishment and spread of declared weeds and alien invader plants;
    - Spillages of harmful substances to the ecosystem;
    - Habitat degradation due to dust;
    - Road mortalities of fauna

8.5.3 Cumulative Impact

The cumulative impacts associated with the closure phase are the same as discussed above for the different mining components. The rating will be slightly higher compared to the individual component ratings, although much lower compared to the other phases of the development. The impacts associated with the rehabilitation of the mining sites are positive considering that the rehabilitated land will improve habitats in the area, even though it still represents degraded land.

9 QUANTITATIVE IMPACT ASSESSMENT

Table 14 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 14. Quantitative impact assessment for the various mining components and mining phases

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	Eradication of protected trees / flora through permit application	**WOM**	**Negative**	Definite	5	Short term	1	Local	1	Low	2	20	Negligible	Apply and obtain permits from DAFF 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	Low	2	16	Negligible		Can be reversed
Construction Phase																
2	Habitat destruction / fragmentation of fauna habitats	Clearing of vegetation for construction of infrastructure (including roads and conveyor through wetlands), causing direct habitat destruction / fragmentation of terrestrial and wetland habitats	**WOM**	Negative	Definite	5	Permanent	5	Local	1	High	8	70	High	Refer to Table 15	May cause irreplaceable loss of resources
			WM	Negative	Definite	5	Permanent	5	Local	1	Medium	6	60	Moderate		Can be avoided, managed or mitigated
3	Soil erosion and sedimentation	Topsoil & subsoil stripping, exposure of soils, ore and rock to wind and rain during construction causing erosion and sedimentation	**WOM**	Negative	Definite	5	Long term	4	Site	2	Medium	6	60	Moderate	Refer to Table 15	May cause irreplaceable loss of resources
			WM	Negative	Highly Probable	4	Long term	4	Local	1	Low	2	28	Low		Can be avoided, managed or mitigated
4	Spreading and establishment of alien invasive species	Vegetation clearing / vehicle movement	**WOM**	Negative	Highly Probable	4	Permanent	5	Site	2	High	8	60	Moderate	Refer to Table 15	May cause irreplaceable loss of resources
			WM	Negative	Highly Probable	4	Long term	4	Site	2	Low	2	32	Low		Can be reversed
5	Habitat degradation due to dust	Vegetation clearing / vehicle movement	**WOM**	Negative	Definite	5	Long term	4	Regional	3	High	8	75	High	Refer to Table 15	May cause irreplaceable loss of resources
			WM	Negative	Definite	5	Long term	4	Site	2	Medium	6	60	Moderate		Can be reversed
6	Spillages of harmful substances	Heavy machinery and vehicle movement on site	**WOM**	Negative	Probable	2	Long term	4	Regional	3	Medium	6	26	Low	Refer to Table 15	May cause irreplaceable loss of resources
			WM	Negative	Probable	2	Long term	4	Site	2	Low	2	16	Negligible		Can be reversed
7	Road mortalities of fauna / impact of human activities on site	Heavy machinery and vehicle movement on site; Construction of infrastructure, roads etc. on site	**WOM**	Negative	Highly Probable	4	Long term	4	Regional	3	Medium	6	52	Moderate	Refer to Table 15	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
8	Impediment of flow patterns	Clearing of vegetation for pipeline construction through wetlands and water courses	**WOM**	Negative	Definite	5	Permanent	5	Local	1	Medium	6	60	Moderate	Refer to Table 15	May cause irreplaceable loss of resources
			WM	Negative	Highly Probable	4	Long term	4	Local	1	Low	2	28	Low		Can be avoided, managed or mitigated
Operational Phase																
9	Habitat destruction / fragmentation of fauna habitats	Storage of tailings and disposal of Waste rock on CDF, laydown areas of stockpiles	**WOM**	Negative	Definite	5	Permanent	5	Local	1	Medium	6	60	Moderate	Refer to Table 15	May cause irreplaceable loss of resources
			WM	Negative	Highly Probable	4	Long term	4	Local	1	Low	2	28	Low	Refer to Table 15	Can be avoided, managed or mitigated
10	Soil erosion and sedimentation	Increased hardened surfaces around infrastructure and exposed areas around laydown areas of CDFs and stockpiles	**WOM**	Negative	Definite	5	Long term	4	Site	2	High	8	70	High	Refer to Table 15	May cause irreplaceable loss of resources
			WM	Negative	Highly Probable	4	Long term	4	Site	2	Medium	6	48	Moderate	Refer to Table 15	Can be avoided, managed or mitigated
11	Spreading and establishment of alien invasive species	Heavy machinery and vehicle movement on site	**WOM**	Negative	Highly Probable	4	Permanent	5	Site	2	Medium	6	52	Moderate	Refer to Table 15	May cause irreplaceable loss of resources
			WM	Negative	Highly Probable	4	Long term	4	Site	2	Low	2	32	Low	Refer to Table 15	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
12	Habitat degradation due to dust	Heavy machinery and vehicle movement on site	**WOM**	Negative	Definite	5	Long term	4	Regional	3	High	8	75	High	Refer to Table 15	May cause irreplaceable loss of resources
			WM	Negative	Definite	5	Medium term	3	Site	2	Medium	6	55	Moderate	Refer to Table 15	Can be reversed
13	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 Table 15	May cause irreplaceable loss of resources
			WM	Negative	Probable	2	Medium term	3	Site	2	Low	2	14	Negligible	Refer to Table 15	Can be reversed
13	Road mortalities of fauna / impact of human activities on site	Heavy machinery and vehicle movement on site; workers accommodated on site causing poaching, wood collection, fires etc.	**WOM**	Negative	Highly Probable	4	Long term	4	Regional	3	Medium	6	52	Moderate	Refer to Table 15	May cause irreplaceable loss of resources
			WM	Negative	Probable	2	Medium term	3	Site	2	Low	2	14	Negligible	Refer to Table 15	Can be avoided, managed or mitigated
Closure and Decommissioning Phase																
14	Improvement of habitat through revegetation / succession over time	Rehabilitation of mining site	**WOM**	Positive	Highly Probable	4	Long term	4	Local	1	Low	2	28	Low	Refer to Table 15	Can be avoided, managed or mitigated
			WM	Positive	Definite	5	Permanent	5	Local	1	Medium	6	60	Moderate	Refer to Table 15	Can be reversed
15	Soil erosion and sedimentation	Demolition of mining infrastructure / Cessation of mining / rehabilitation of mining site	**WOM**	Negative	Highly Probable	4	Long term	4	Site	2	Medium	6	48	Moderate	Refer to Table 15	May cause irreplaceable loss of resources
			WM	Negative	Probable	2	Medium term	3	Local	1	Low	2	12	Negligible	Refer to Table 15	Can be avoided, managed or mitigated
16	Spreading and establishment of alien invasive species	Demolition of mining infrastructure / Cessation of mining / rehabilitation of mining site	**WOM**	Negative	Highly Probable	4	Long term	4	Site	2	Medium	6	48	Moderate	Refer to Table 15	May cause irreplaceable loss of resources
			WM	Negative	Probable	2	Medium term	3	Site	2	Low	2	14	Negligible	Refer to Table 15	Can be reversed
17	Habitat degradation due to dust	Demolition of mining infrastructure / Cessation of mining / rehabilitation of mining site / vehicle movement on site	**WOM**	Negative	Highly Probable	4	Long term	4	Site	2	High	8	56	Moderate	Refer to Table 15	May cause irreplaceable loss of resources
			WM	Negative	Probable	2	Medium term	3	Site	2	Medium	6	22	Low	Refer to Table 15	Can be reversed
18	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 Table 15	May cause irreplaceable loss of resources
			WM	Negative	Probable	2	Short term	1	Site	2	Low	2	10	Negligible	Refer to Table 15	Can be avoided, managed or mitigated
19	Road mortalities of fauna / impact of human activities on site	Heavy machinery and vehicle movement on site	**WOM**	Negative	Highly Probable	4	Long term	4	Regional	3	Medium	6	52	Moderate	Refer to Table 15	May cause irreplaceable loss of resources
			WM	Negative	Probable	2	Medium term	3	Site	2	Low	2	14	Negligible	Refer to Table 15	Can be avoided, managed or mitigated
Post-Closure Phase																
20	Improvement of habitat through revegetation / succession over time	Natural Successional processes	**WOM**	Positive	Highly Probable	4	Long term	4	Local	1	Low	2	28	Low	Refer to Table 15	Can be avoided, managed or mitigated
			WM	Positive	Definite	5	Permanent	5	Local	1	Medium	6	60	Moderate	Refer to Table 15	Can be reversed
21	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 Table 15	May cause irreplaceable loss of resources
			WM	Negative	Probable	2	Short term	1	Local	1	Low	2	8	Negligible	Refer to Table 15	Can be avoided, managed or mitigated
22	Spreading and establishment of alien invasive species	Exposed surfaces / poor monitoring of revegetation on site	**WOM**	Negative	Highly Probable	4	Medium term	3	Site	2	Medium	6	44	Moderate	Refer to Table 15	May cause irreplaceable loss of resources
			WM	Negative	Probable	2	Short term	1	Local	1	Low	2	8	Negligible	Refer to Table 15	Can be avoided, managed or mitigated

10 ECOLOGICAL 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 15 below.

Table 15. Ecological 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
Construction Phase									
Support infrastructure, CDF, PCD. Stockpiles and silt trap	Clearing of vegetation	Fauna & Flora	Habitat destruction	NEMA Regulation 543 Section 32 NEMBA Section 56 (1), 57 (1), 57 (2) and 57 (4) Northwest Nature Conservation Ordinance (1983)	• Prevent edge effects • Keep mining development footprint restricted to layout plans • To limit the habitat loss due to the increase of the mining footprint	Keep mining development footprint restricted to layout plans	• The removal of the isolated indigenous trees and shrubs should only occur on the construction footprint area of the development and not over the larger area. Where possible, vegetation should be retained in between infrastructural elements associated with the project; • Conduct flora species search and rescue efforts before ground clearing begins in order to reduce negative impacts on species of concern; • Remove and relocate any plants of botanical or ecological significance as indicated by the ecologist or Mine Environmental Control Officer (ECO); • ; • Construction should preferably take place in winter to reduce disturbance to breeding fauna and flowering flora; • Vegetation to be removed as it becomes necessary – do not clear the entire footprint simultaneously; • Clearly demarcate the entire development footprint prior to initial site clearance and prevent construction personnel from leaving the demarcated area; • Monitoring should be implemented during the construction activities to ensure that minimal impact is caused to the flora of the area; • The Mine ECO should advise the construction team in all relevant matters to ensure minimum destruction and damage to the environment. The Mine ECO should enforce any measures that he/she deem necessary. Regular environmental training should be provided to construction workers to ensure the protection of the habitat, fauna and flora and their sensitivity to conservation; • Where trenches pose a risk to animal safety, they should be adequately cordoned off to prevent animals falling in and getting trapped and/or injured. This could be prevented by the constant excavating and backfilling of trenches during construction. • Poisons for the control of problem animals should rather be avoided since the wrong use thereof can have disastrous consequences for the raptors occurring in the area. Poisons for the control of rats, mice or other vermin should only be used after approval from an ecologist.	Continuous	Contractor / ECO
Support infrastructure, CDF, PCD. Stockpiles and silt trap	Clearing of vegetation	Fauna	Habitat fragmentation	NEMA Regulation 543 Section 32 NEMBA Section 56 (1), 57 (1), 57 (2) and 57 (4) Northwest Nature Conservation Ordinance (1983)	• To limit the impact on wildlife habitat • To limit the loss in carrying capacity • To prevent negative impact on fauna populations through infrastructure development	Keep mining development footprint restricted to layout plans	• Use existing facilities (e.g., access roads, parking lots, graded areas) to the extent possible to minimize the amount of new disturbance. • Ensure protection of important resources by establishing protective buffers to exclude unintentional disturbance. All possible efforts must be made to ensure as little disturbance as possible to the sensitive habitats such as ravines and moist grassland pockets during construction. • During construction, sensitive habitats 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. • Construction activities must remain within defined construction areas and the road servitudes. No construction / disturbance will occur outside these areas	Continuous	Contractor / ECO
Support infrastructure, CDF, PCD. Stockpiles and silt trap	Topsoil & subsoil stripping	Fauna & Flora	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	• 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	Continuous	Contractor / ECO

Components	Activity	Aspect	Impact	Legal requirements	Objectives	Performance criteria	Mitigation Measures	Time frame	Responsible person
							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;		
Support infrastructure, CDF, PCD. Stockpiles and silt trap	Heavy machinery & vehicle movement on site	Fauna & Flora	Spillages	National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008) Section 11(1)	• To prevent contamination of flora 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	• 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	Continuous	Contractor / ECO
Support infrastructure, CDF, PCD. Stockpiles and silt trap			Road mortalities of fauna	NEMBA Section 56 (1), 57 (1), 57 (2) and 57 (4) NEMA Regulation 543 Section 32	Prevent fauna mortalities because of vehicle movement	Control of vehicle speed Control of vehicle movement	• More fauna is normally killed the faster vehicles travel. A speed limit should be enforced as determined by the mine environmental manager. It can be considered to install speed bumps in sections where the speed limit tends to be disobeyed. (Speed limits will also lessen the probability of road accidents and their negative consequences). • Travelling at night should be avoided or limited as much as possible. No travelling at night should be allowed without approval by site manager; • Lights should be positioned 5m from the roads or paved areas.	Continuous	Contractor / ECO
Support infrastructure, CDF, PCD. Stockpiles and silt trap	Vegetation clearing, topsoil & subsoil stripping, vehicle movement on site	Flora	Potential establishment and spread of declared weeds and alien invader plants	Alien and Invasive Species Regulations (GNR 599 of 2014) as part of the National Environmental Management: Biodiversity Act (10/2004)	To implement an alien invasive eradication programme to manage and control alien species on the mine	Prevent and control of spreading and establishment of alien invasive species on the mining area and larger region	• Control involves killing the alien invasive plants present, killing the seedlings which emerge, and establishing and managing an alternative plant cover to limit re-growth and re-invasion. The control of these species should even begin prior to the construction phase considering that small populations of the AIS occur around the sites; • Institute strict control over materials brought onto site, which should be inspected for seeds of noxious plants and steps taken to eradicate these before transport to the site. Routinely fumigate or spray all materials with appropriate low-residual herbicides prior to transport to site or in a quarantine area on site. The contractor is responsible for the control of weeds and invader plants within the construction site for the duration of the construction phase; • Rehabilitate disturbed areas as quickly as possible to reduce the area where invasive species would be at a strong advantage and most easily able to establish; • Institute a monitoring programme to detect alien invasive species early, before they become established and, in the case of weeds, before the release of seeds; • Institute an eradication/control programme for early intervention if invasive species are detected, so that their spread to surrounding natural ecosystems can be prevented; • A detailed plan should be developed for control of noxious weeds and invasive plants that could colonize the area because of new surface disturbance activities at the site. The plan should address monitoring, weed identification, the way weeds spread, and methods for treating infestations.	Continuous	Contractor / ECO
Support infrastructure, CDF, PCD. Stockpiles and silt trap	Vegetation Clearing, Vehicle movement on site	Flora & Fauna	Habitat degradation due to dust	National Environmental Management Air Quality Act 39 of 2004 Section 32	• To reduce dust emission levels to acceptable norms in terms of aesthetics, health and annoyance • To implement a dust monitoring programme which will enable the mine to	To limit exposure to sensitive receptors resulting from dust and fumes from, mine vehicles and transportation systems and windborne dust from surface working	• Daily dampening of dust areas or other dust suppression methods such as dust-aside or more environmentally friendly methods. • Re-vegetation of impacted areas is to be conducted on an on-going basis. • Place dust generating activities where maximum protection can be obtained from natural features. • Locating dust generating activities where prevailing winds will blow dust away from users. • Minimize the need to transport and handle materials by placing	Continuous	Contractor / ECO

Components	Activity	Aspect	Impact	Legal requirements	Objectives	Performance criteria	Mitigation Measures	Time frame	Responsible person
					determine the impacts associated with its activities • To manage the operations in such a way as to ensure that the impact on the air quality is prevented and reduced.		adequate storage facilities close to processing areas. • Minimize the re-handling of material which obviously has cost benefits as well. • Exposed material should be protected from the wind by keeping it within voids or protecting them by topographical features where possible. • Reduce the drop heights wherever practicable. • Protect activities from wind by erecting a screen or using a natural barrier. • All roads on site should be dampened or treated with a binding agent. • The general vehicle speed should be restricted as there is a direct relationship between the speed and vehicle entrained emissions. • Monitoring, modelling and emission measurements should be regarded as complementary components in any integrated approach to exposure assessment or determining compliance against air quality criteria.		
Support infrastructure – conveyor and road crossing	Clearing of vegetation / conveyor and road construction	Wetlands / water courses	Impediment of natural flow	NEMA Regulation 543 Section 32 NEMBA Section 56 (1), 57 (1), 57 (2) and 57 (4) National Water Act Section 21 C and I	• Prevent edge effects • Keep pipeline footprint restricted to layout plans • To limit the habitat loss due to the increase of the mining footprint	Keep development footprint restricted to layout plans	• Unless authorised by this licence, access and haul roads must not encroach into the extent of the watercourse(s) • No structures to be placed within the 1:100-year floodline and/or the delineated riparian areas unless authorised in this licence • Appropriate design and mitigation measures must be developed and implemented to minimise impacts on the natural flow regime of the watercourse i.e., through placement of structures/supports and to minimise turbulent flow in the watercourse • The diversion and impeding structures may not restrict river flows by reducing the overall river width or obstructing river flow. Any watercourse crossing must minimise its impacts on the watercourse and must be assessed and documented as such and be available for review • The indiscriminate use of machinery within the in-stream and riparian habitat will lead to compaction of soils and vegetation and must therefore be strictly controlled • The clear incision of the banks of the Sandspruit indicates that this feature is highly erodible. The installation of energy dissipating structures, such as gabion wingwalls, to protect the banks of the drainage line where the conveyor crossing is proposed is required as recommended by the submitted reports • Perform scheduled maintenance to be prepared for storms. Ensure that culverts have their maximum capacity, ditches are cleaned, and that channels are free of debris and brush than can plug structures. • Work in rivers, streams and riparian zones should preferably be done during the low flow season; • The construction camp must be located outside the extent of the watercourse(s) and must be recovered and removed within one (1) month after construction has been completed • During the construction phase vehicles must not be allowed to indiscriminately drive through any wetland areas. • Indigenous riparian vegetation, including dead trees, outside the limits of disturbance indicated in the site plans must not be removed from the area	Continuous	Contractor / ECO
OPERATIONAL PHASE									
Support infrastructure, CDF, PCD. Stockpiles and silt trap	Laydown areas of stockpiles and CDF	Flora	Habitat destruction	NEMA Regulation 543 Section 32 NEMBA Section 56 (1), 57 (1), 57 (2) and 57 (4) NEMA Regulation 543 Section 32 Northwest Nature Conservation Ordinance (1983)	Refer to Construction Phase objectives	Refer to Construction Phase criteria	• Final profile lines of rehabilitated areas must fit in with the character of the topography in the area. • Concurrent rehabilitation should occur during the operational phase on all exposed areas created by construction as well as roads, stockpiles and WRD. Only indigenous species should be used for rehabilitation. The following programmes should be implemented as part of the operational phase of the mine: o Concurrent rehabilitation programme o Alien invasive programme o Fire management programme o Educational and training programme on the conservation and ecological systems • Refer to mitigation measures needed during the operational phase that are like the mitigation measures for impacts during the	Continuous	Contractor / ECO

Components	Activity	Aspect	Impact	Legal requirements	Objectives	Performance criteria	Mitigation Measures	Time frame	Responsible person
							construction phase.		
	Laydown areas of stockpiles and CDF	Fauna	Fragmentation of fauna habitats	NEMA Regulation 543 Section 32 NEMBA Section 56 (1), 57 (1), 57 (2) and 57 (4) NEMA Regulation 543 Section 32 Northwest Nature Conservation Ordinance (1983)	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.	Continuous	Contractor / ECO
	Laydown areas of stockpiles and CDF	Flora	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 CDFs and stockpiles, materials handling and transportation, crushing and stockpiling	Flora	Spillages of harmful substances to the ecosystem;	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
	Laydown areas of CDFs and stockpiles, materials handling and transportation, crushing and stockpiling	Fauna	Road mortalities of fauna	NEMBA Section 56 (1), 57 (1), 57 (2) and 57 (4) NEMA Regulation 543 Section 32 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.	Continuous	Contractor / ECO

Components	Activity	Aspect	Impact	Legal requirements	Objectives	Performance criteria	Mitigation Measures	Time frame	Responsible person
	Laydown areas of CDFs and stockpiles, materials handling and transportation, crushing and stockpiling	Flora & Fauna	Habitat degradation due to dust;	National Environmental Management Air Quality Act 39 of 2004 Section 32	Refer to Construction Phase objectives	Refer to Construction Phase criteria	• Daily dampening of dust areas. • Re-vegetation of mined areas is to be conducted on an ongoing basis. • Dust fallout monitoring to be conducted according to the requirements of the legislation. • Place dust generating activities where maximum protection can be obtained from natural features. • Locating dust generating activities where prevailing winds will blow dust away from users. • Minimize the need to transport and handle materials by placing adequate storage facilities close to processing areas. • Exposed material should be protected from the wind by keeping it within voids or protecting them by topographical features where possible. • Reduce the drop heights wherever practicable. • Protect activities from wind by erecting a screen or using a natural barrier. • Fine spray or fog suppression can also be used in loading bays. • All roads on site should be dampened or treated with a binding agent. • The general vehicle speed should be restricted as there is a direct relationship between the speed and vehicle entrained emissions. • Monitoring, modelling and emission measurements should be regarded as complementary components in any integrated approach to exposure assessment or determining compliance against air quality criteria • 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 stockpiles and CDFs	Flora	Potential establishment and spread of declared weeds and alien invader plants	Alien and Invasive Species Regulations (GNR 599 of 2014) as part of the National Environmental Management: Biodiversity Act (10/2004)	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		Ecologist / ECO
DECOMMISSIONING PHASE									
Support infrastructure, CDF, PCD. Stockpiles and silt trap	Cessation of mining Demolition of mining infrastructure	Flora	Potential establishment and spread of declared weeds and alien invader plants	Alien and Invasive Species Regulations (GNR 599 of 2014) as part of the National Environmental Management: Biodiversity Act (10/2004)	Refer to Construction Phase objectives	Refer to Construction Phase criteria	To leave all affected areas in a safe condition Refer to mitigation measures for the construction phase needed during the decommissioning phase that are similar	Continuous	Ecologist / ECO
	Demolition of mining infrastructure	Fauna & Flora	Habitat degradation due to dust;	National Environmental Management Air Quality Act 39 of 2004 Section 32	Refer to Construction Phase objectives	Refer to Construction Phase criteria	Refer to mitigation measures for the construction phase needed during the decommissioning phase that are similar	Continuous	Contractor / ECO
	Demolition of mining infrastructure	Fauna	Road mortalities of fauna	NEMBA Section 56 (1), 57 (1), 57 (2) and 57 (4) NEMA Regulation 543 Section 32	Refer to Construction Phase objectives	Refer to Construction Phase criteria	Refer to mitigation measures for the construction phase needed during the decommissioning phase that are similar	Continuous	Contractor / ECO
	Demolition of mining infrastructure	Fauna & Flora	Spillages of harmful substances to the ecosystem;	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 phase needed during the decommissioning phase that are similar	Continuous	Contractor / ECO
CLOSURE PHASE & POST CLOSURE PHASES									
Support infrastructure, CDF, PCD. Stockpiles and silt trap	Rehabilitation	Fauna & Flora	Improvement of habitat 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	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.	Continuous	Ecologist / ECO

Components	Activity	Aspect	Impact	Legal requirements	Objectives	Performance criteria	Mitigation Measures	Time frame	Responsible person
					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		• 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.		
	Rehabilitation	Flora	Potential establishment and spread of declared weeds and alien invader plants	Alien and Invasive Species Regulations (GNR 599 of 2014) as part of the National Environmental Management: Biodiversity Act (10/2004)	Refer to Construction Phase objectives	Refer to Construction Phase criteria	• Monitor and manage invader species and alien species on the rehabilitated land until the natural vegetation can outperform the invaders or aliens.	Continuous	Contractor / ECO
	Rehabilitation	Fauna & Flora	Habitat degradation due to dust;	National Environmental Management Air Quality Act 39 of 2004 Section 32	To comply to all the necessary post closure air quality objectives	Refer to Construction Phase criteria	Refer to mitigation measures for the construction phase needed during the closure phase that are relevant	Continuous	Contractor / ECO
	Rehabilitation	Fauna	Road mortalities of fauna	NEMBA Section 56 (1), 57 (1), 57 (2) and 57 (4) NEMA Regulation 543 Section 32	Refer to Construction Phase objectives	Refer to Construction Phase criteria	Refer to mitigation measures for the construction phase needed during the closure phase that are relevant	Continuous	Contractor / ECO
	Rehabilitation	Fauna & Flora	Spillages of harmful substances to the ecosystem;	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 phase needed during the closure phase that are relevant	Continuous	Contractor / ECO

11 SENSITIVITY ANALYSIS AND CONSERVATION ANALYSIS TOOLS

There are several assessments for South Africa as a whole, as well as on provincial levels that allow for detailed conservation planning as well as meeting biodiversity targets for the country's variety of ecosystems. These guides are essential to consult for development projects and will form an important part of the sensitivity analysis. Areas earmarked for conservation in the future, or that are essential to meet biodiversity and conservation targets should not be developed and have a high sensitivity as they are necessary for overall functioning. In addition, sensitivity analysis in the field based in much finer scale data can be used to ground truth the larger scale assessments and put it into a more localised context.

11.1 CRITICAL BIODIVERSITY & ECOLOGICAL SUPPORT AREAS OF THE PROJECT AREA

The purpose of the Northwest Conservation Plan is to develop the spatial component of a bioregional plan (i.e., map of Critical Biodiversity Areas (CBA) and associated land-use guidelines).

The Northwest Conservation Plan categories for the proposed mining area are presented in Figure 8. The following can be concluded regarding developments:

The mining project is in the following areas:

- The proposed mining expansion areas is located in CBA 2 areas.

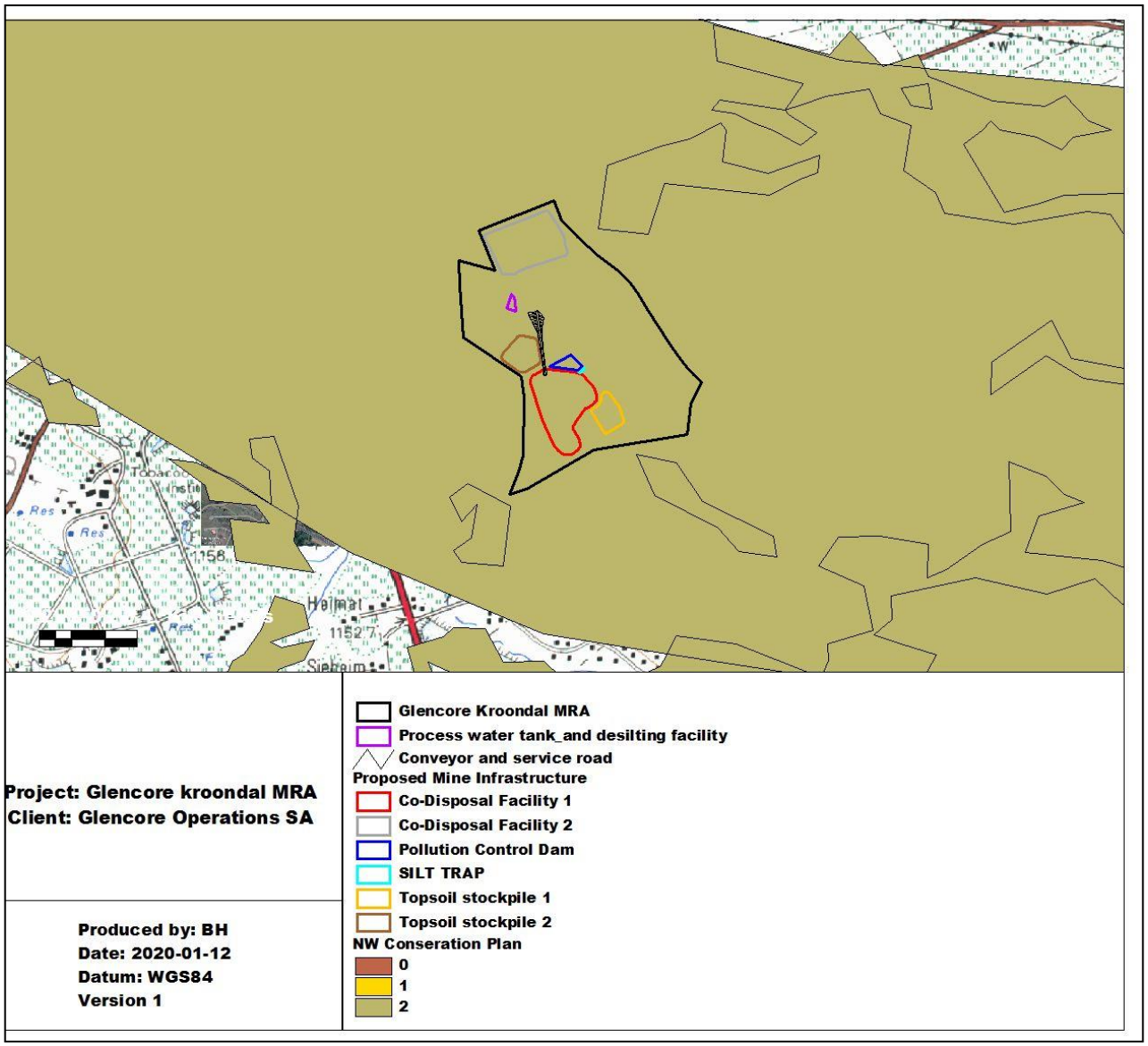


Figure 8. Terrestrial CBA areas of the study area (2014)

11.2 PROTECTED AREAS NETWORK AND NATIONAL PROTECTED AREAS EXPANSION STRATEGY (NPAES)

Officially protected areas, either provincially or nationally that occur close to a project site could have consequences as far as impacts on these areas are concerned. For the proposed development site and associated infrastructure however, the Magaliesberg Protected Environment and Kgaswane Nature Reserve is located to the south and south-west of the project area (Figure 9). These areas are located approximately 8 km south-west and south of the project area.

The NPAES are areas designated for future incorporation into existing protected areas (both National and informal protected areas). These areas are large, mostly intact areas required to meet biodiversity targets, and suitable for protection. They may not necessarily be proclaimed as protected areas in the future and are a broad scale planning tool allowing for better development and conservation planning. The project area is not linked to any NPAES, although the area to the south of the Magaliesberg is earmarked for future expansion of this area (Figure 9).

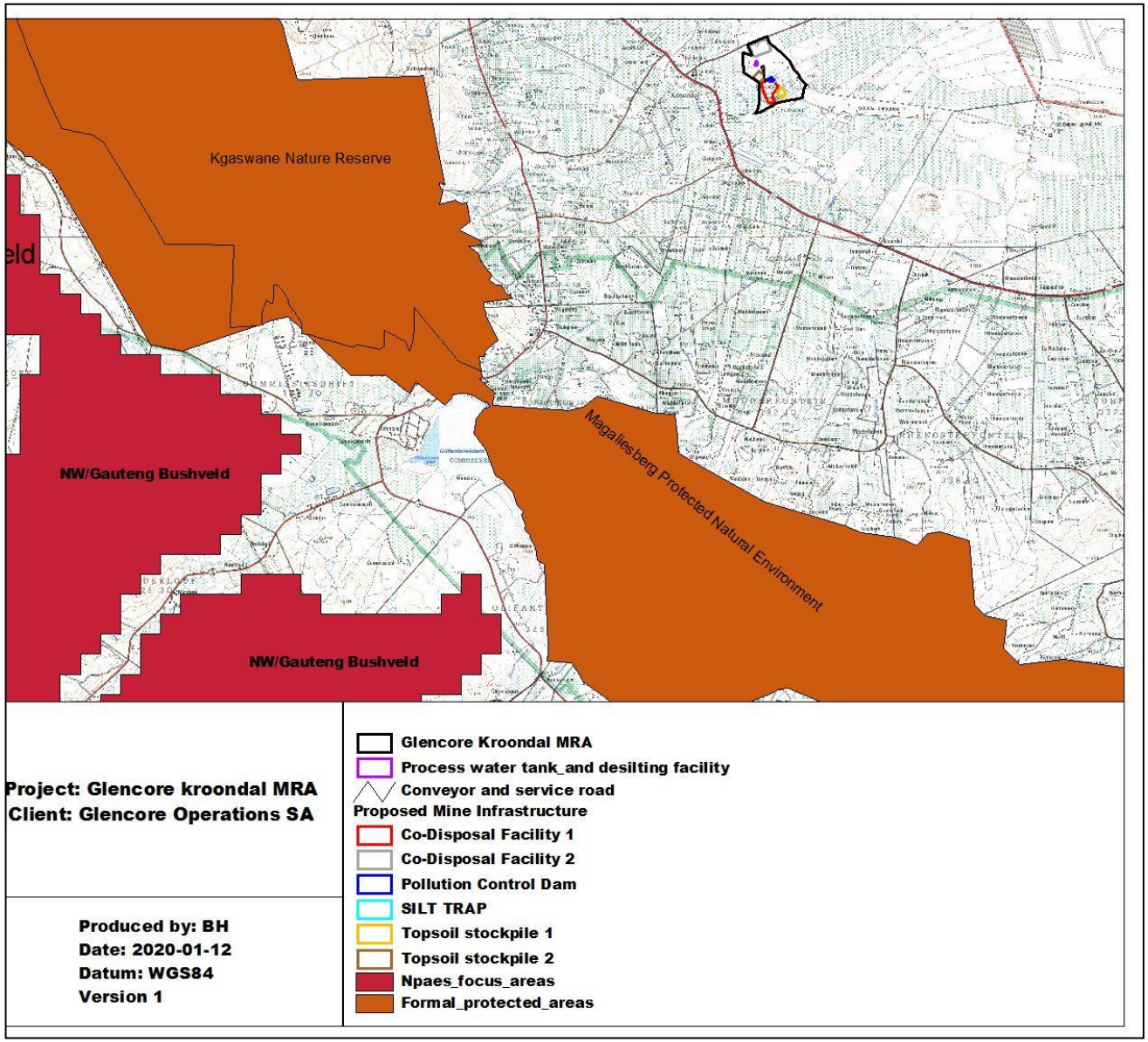


Figure 9. Protected areas in proximity to the project area.

11.3 IMPORTANT BIRD AREAS

An Important Bird Area (IBA) is an area recognized as being globally important habitat for the conservation of bird populations. Currently there are about 10,000 IBAs worldwide. At present, South Africa has 124 IBA's, covering over 14 million hectares of habitat for our threatened, endemic and congregatory birds. Yet only million hectares of the total land surface covered by our IBA's legally protected. The BirdLife SA IBA programme continues a programme of stewardship which will ultimately achieve formal protection (Birdlife, 2013).

The Magaliesberg IBA is located within the project area, although the actual Magaliesberg habitat is not represented on site (Figure 10).

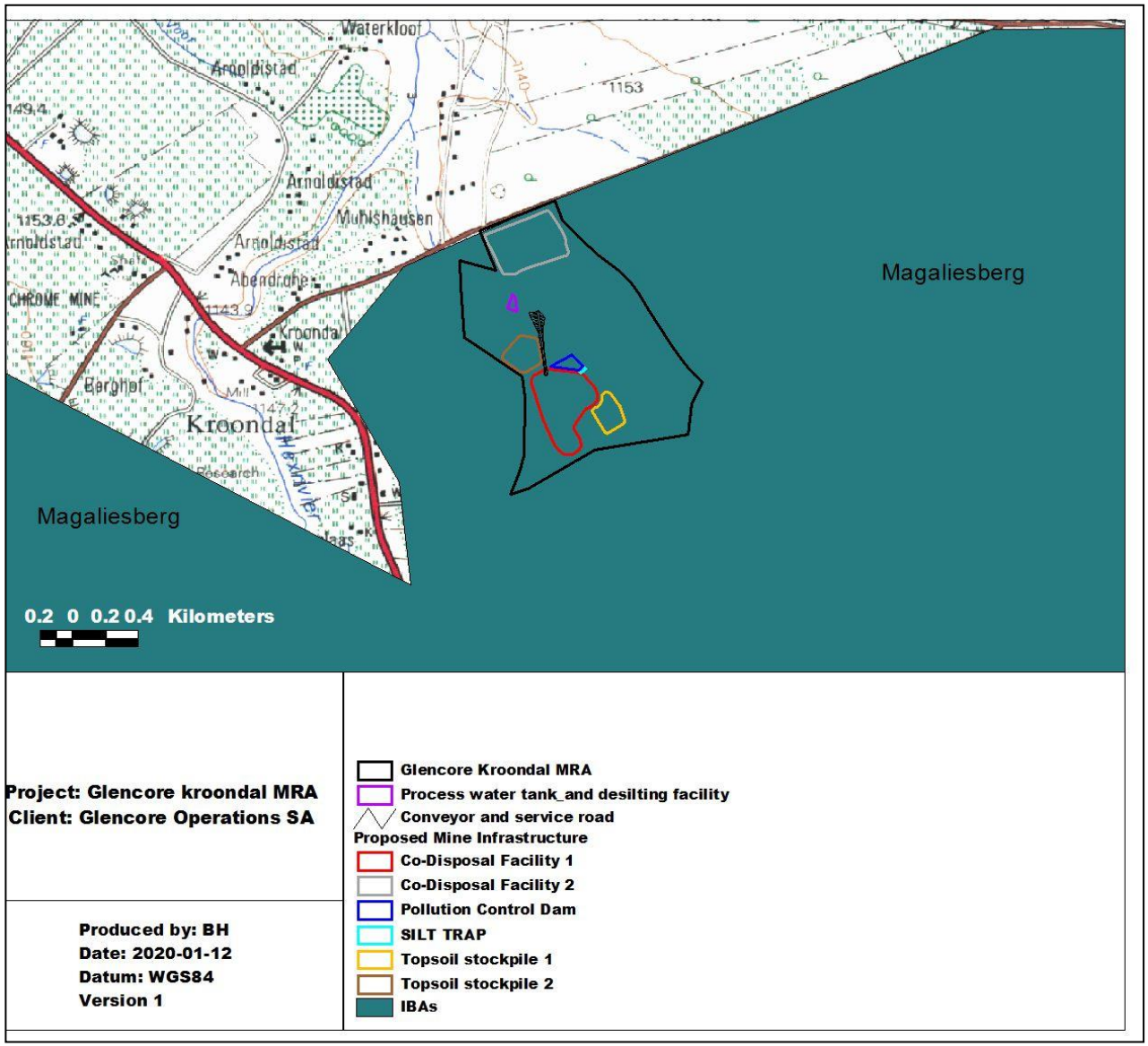


Figure 10. Location of the project area in relation to IBAs

11.4 NATIONALLY THREATENED ECOSYSTEMS

The list of national Threatened Ecosystems has been gazetted (NEM:BA: National list of ecosystems that are threatened and in need of protection) and result in several implications in terms of development within these areas. Four basic principles were established for the identification of threatened ecosystems. These include:

- The approach must be explicit and repeatable;
- The approach must be target driven and systematic, especially for threatened ecosystems;
- The approach must follow the same logic as the IUCN approach to listing threatened species, whereby a number of criteria are developed, and an ecosystem is listed based on its highest-ranking criterion; and
- The identification of ecosystems to be listed must be based on scientifically credible, practical and simple criteria, which must translate into spatially explicit identification of ecosystems.

Areas were delineated based on as fine a scale as possible and are defined by one of several assessments: These areas are essential for conservation of the country's ecosystems as well as meeting conservation targets. The Marikana Thornveld vegetation type is a listed threatened vegetation type located within the project area.

11.5 ECOLOGICAL SENSITIVITY CLASSES

Following the ecological surveys, the classification of the study area into different sensitivity classes and development zones was based on information collected at various levels on different environmental characteristics. Factors which determined sensitivity classes were as follows:

- Presence, density and potential impact of development on rare, endemic and protected plant species;
- Conservation status of vegetation units;
- Soil types, soil depth and soil clay content;
- Previous land-use;
- State of the vegetation in general as indicated by indicator species.

Below included is the sensitivity map for the different areas (Figure 11). Only criteria applicable to the specific vegetation units were used to determine the sensitivity of the specific unit.

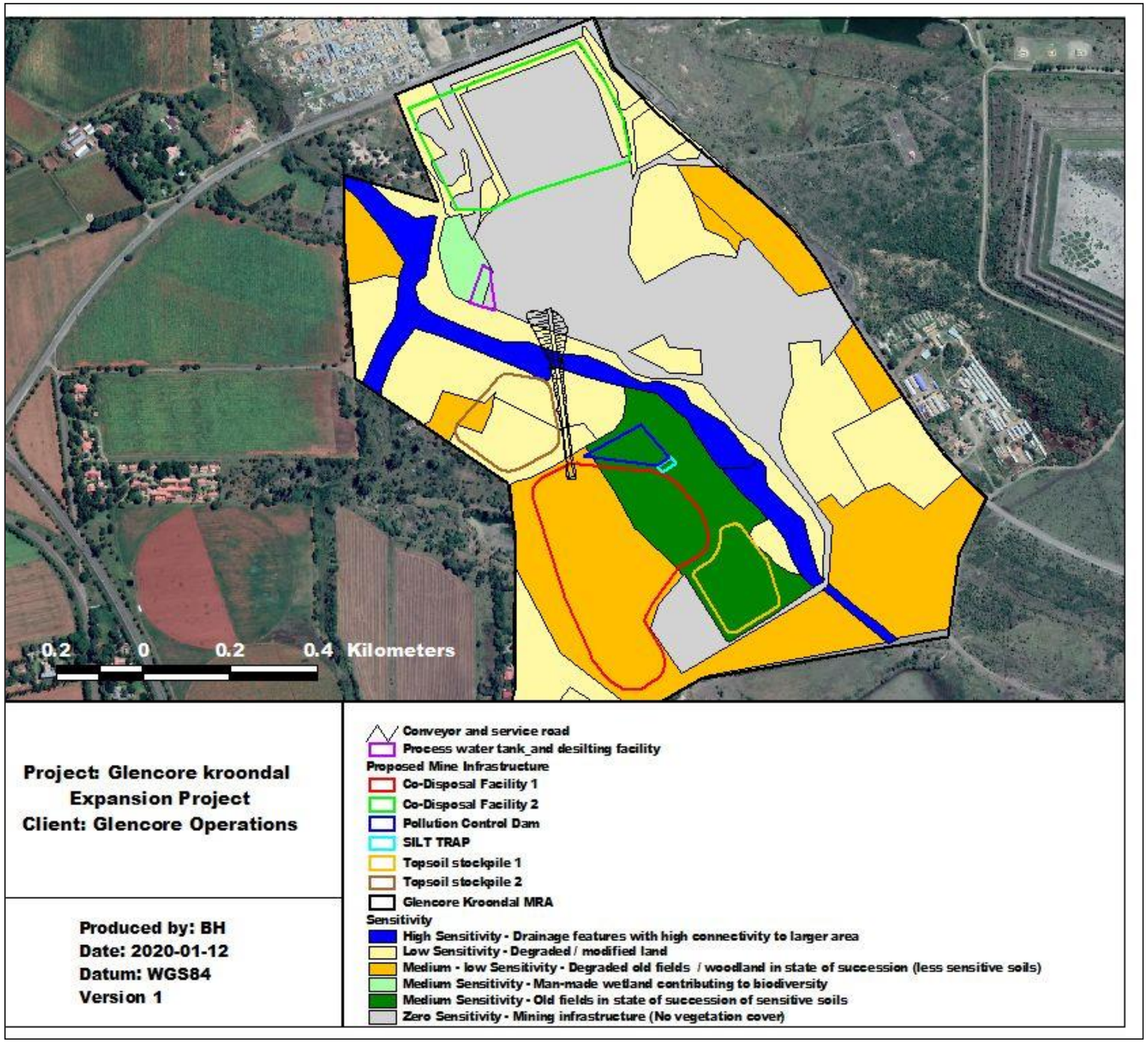


Figure 11. Sensitivity Map of the project area for the proposed Mining Infrastructure sites.

12 MANAGEMENT STRATEGY FOR THE WETLANDS AND RIVERS

12.1 CONSTRAINTS AND OPPORTUNITIES OF THE EXISTING ENVIRONMENT

The existing environment presents a few constraints and opportunities which have been considered in the development of the recommendations for the site as part of the proposed development.

12.1.1 Constraints

- Pollution of the streams, wetlands and groundwater. Stormwater runoff contains a few potentially harmful pollutants, including fuels and oils, lead, etc.
- Increased stormwater runoff: The construction of hardened surfaces on the property will lead to an increase in the quantity of runoff flowing across the site.
- Loss of surface and subsurface water recharge to groundwater: Any loss of seep or stream habitat, or condition, could interfere with the natural recharge of subsurface water resources. In addition, if natural surface runoff is diverted away from houses on the site, this might interfere with subsurface drainage across the site.
- Increased erosion and sedimentation: Runoff from residential areas can lead to increased mobilisation of fine sediments during rain and storm events.
- Increased disturbance of aquatic fauna and flora: The proximity of homes to the wetland corridor will lead to an increase in disturbance in the form of noise, light, pets and physical disturbance from trampling.
- Introduction of alien invasives.

12.1.2 Opportunities

- Opportunity to manage and monitor the wetlands effectively and thereby increasing knowledge base on the specific wetlands of the area.

12.1.3 Management Strategies

12.1.3.1 Stormwater Management: The Sustainable Drainage System (SuDS)

Hardened surfaces and other aspects related to mining developments reduce the natural permeability characteristics of land by replacing free draining surfaces with impermeable surfaces, typically drained by pipes and/or canals. This also results in the general loss of vegetation, biodiversity and amenity.

It is widely recognised that developments impact negatively on natural drainage systems in several ways, including:

- Reduced permeability of catchment areas by introduction of impervious surfaces such as streets. This results in increased catchment runoff volumes.

- The introduction of efficient stormwater drainage results in reduced catchment response times with concomitant increased downstream flow peaks.
- Manipulation of groundwater tables, which can have severe effects on wetland functioning and the survival of many terrestrial plant communities.
- Alteration to the natural flow regimes in river systems resulting in both geomorphologic (e.g., channel / bank erosion) and aquatic ecosystem changes over time.
- Deteriorating water quality because of industrial fallout, fertilisers and other pollutants that are conveyed by stormwater systems directly to receiving water bodies, without any attempt to ameliorate enroute.

These guidelines require greater cognisance to be taken of natural hydrological patterns and systems in the development of stormwater management systems and that the potential negative impacts highlighted above are reduced as far as is practically possible. This is illustrated by means of Figures 12 to 14 below, depicting both the traditional and recommended approaches to stormwater management within the urban context.

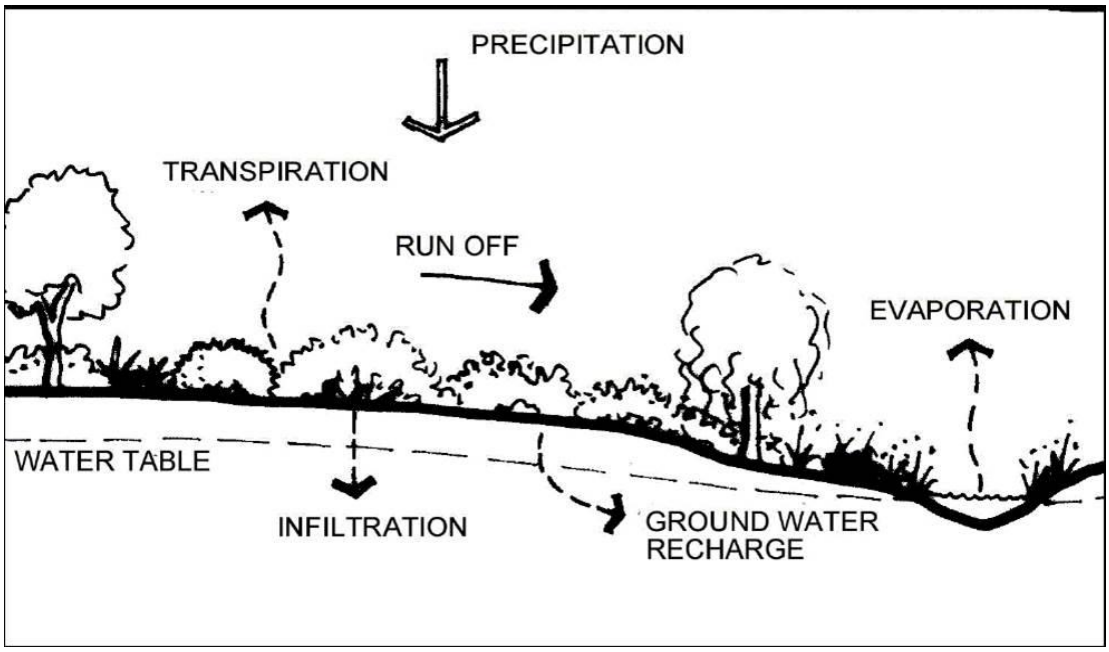


Figure 12. Natural hydrological system

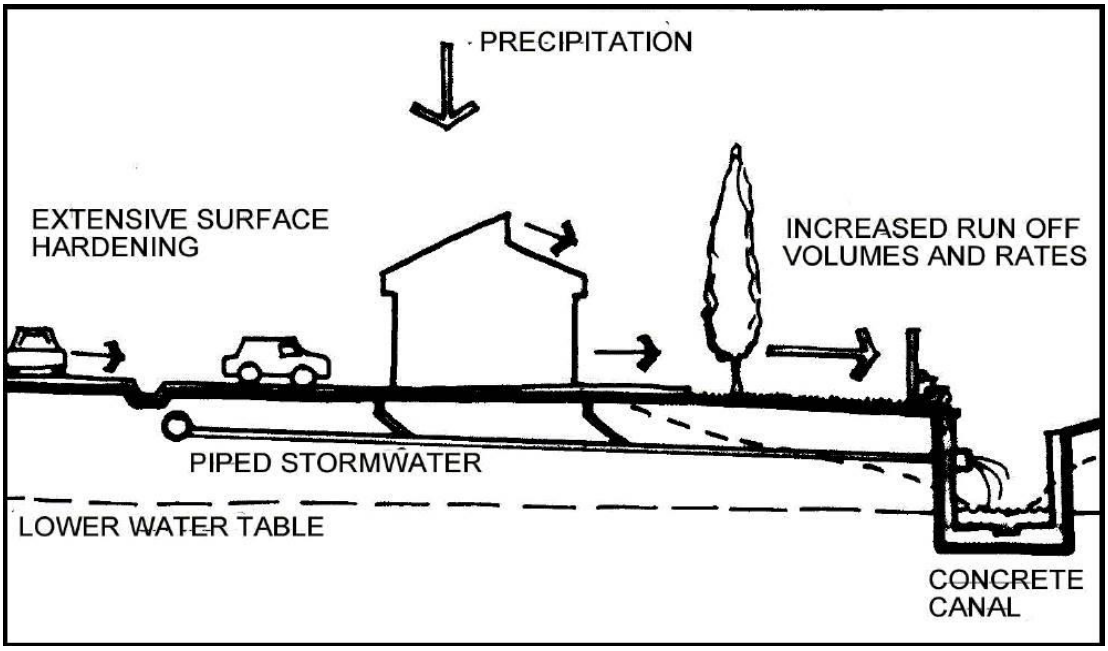


Figure 13. Stormwater management approach with little concern for natural environment

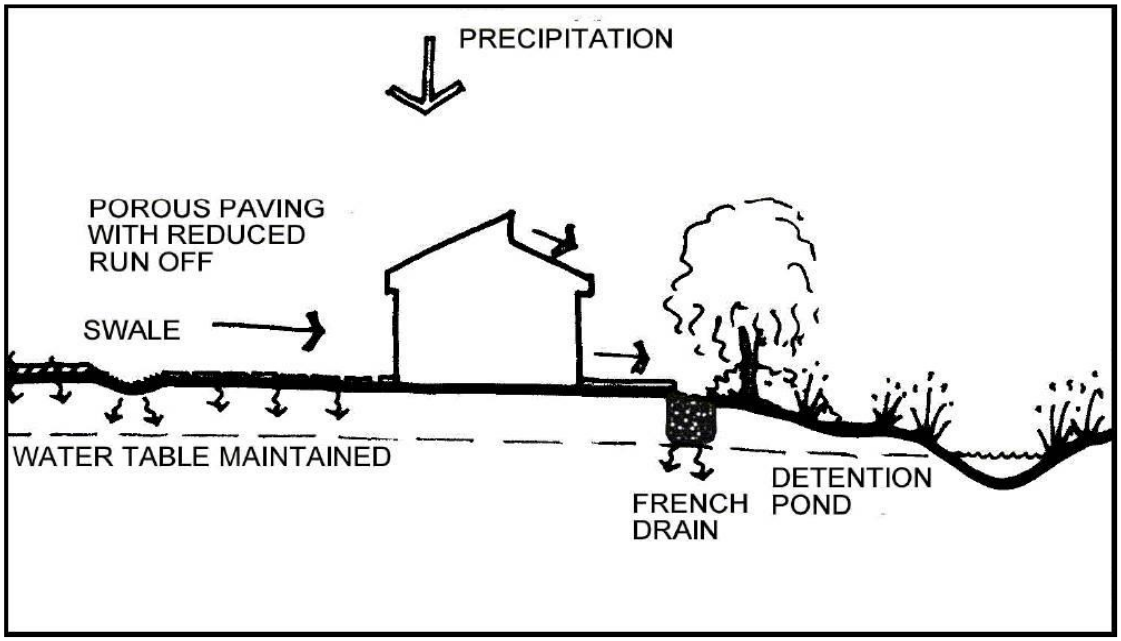


Figure 14. Responsible approach to stormwater management

Stormwater management objectives should include the following:

- Minimise the Threat of Flooding: This remains a key objective of any stormwater management system. However, the challenge when contemplating design of stormwater management systems is to consider the following:
- To mimic pre-development responses to storms
    - To reduce the volume of runoff by promoting infiltration
    - To reduce the peak flows and increase the time-to-peak through detaining the

runoff and releasing it at a gradual rate

- Where necessary, to construct means to contain flood waters and safely convey them out of the urban area

- Protection of Receiving Water Bodies: Receiving water bodies include the following:
    - Rivers / streams;
    - Groundwater;
    - Wetlands.

- It should be noted that the "receiving water body" is not necessarily the system into which stormwater is discharged directly but can also be a natural system located further downstream in the catchment. Every endeavour should be made to achieve the following as far as possible:
- Maintain natural flow regimes and seasonality
- Prevent deterioration in water quality
- Prevent erosion or sedimentation of natural wetlands or rivers
- Preserve natural river channels, wetlands and vegetation, and preclude engineering interventions that may alter their physical and ecological characteristics.

The need to design appropriate stormwater management systems for new developments should be an opportunity to preserve or, if possible, improve natural freshwater ecosystems that have suffered degradation because of past activities, and in some cases, to create additional freshwater habitats that will contribute to the availability of appropriate, high quality river and wetland habitat that mimics the natural condition.

- Promote Multi-Functional Use of Stormwater Management Systems: Resources such as land and water are becoming increasingly scarce and multiple uses of these must be strived for. Stormwater systems provide a wide range of opportunities for multi-functionality.
- Development of Sustainable Environments: Developers should think beyond their short-term involvement with the project and consider the sustainability of the stormwater management system that is to be implemented. All relevant factors that will impact on future operation and maintenance should be considered. Maintenance requirements should be minimised as far as possible to maximise the available local authority funding, personnel and equipment. Responsibilities for maintenance must be resolved with the relevant local authority department at an early stage of the design. The possibility of developing public/private partnerships should be explored with local authorities (e.g., division of funding of capital versus maintenance costs between public and private sectors). Environmental policies such as promoting the use of locally indigenous vegetation in planting programmes will also reduce the long-term maintenance

requirements of the development.

Conventional drainage systems are generally focused on eliminating local flood nuisances and ignore the water quality, amenity, and biodiversity. Sustainable drainage systems (SuDS) aim to mimic the natural hydrological cycle thereby improving water quality, preserving biodiversity, and enhancing amenity. The result is a more sustainable and liveable city.

The key objectives of the SuDS approach are the effective management of stormwater runoff quantity, quality and the associated amenity and biodiversity as described by the hierarchy below (Figure 15) where each level contributes to an improved, more sustainable drainage system.

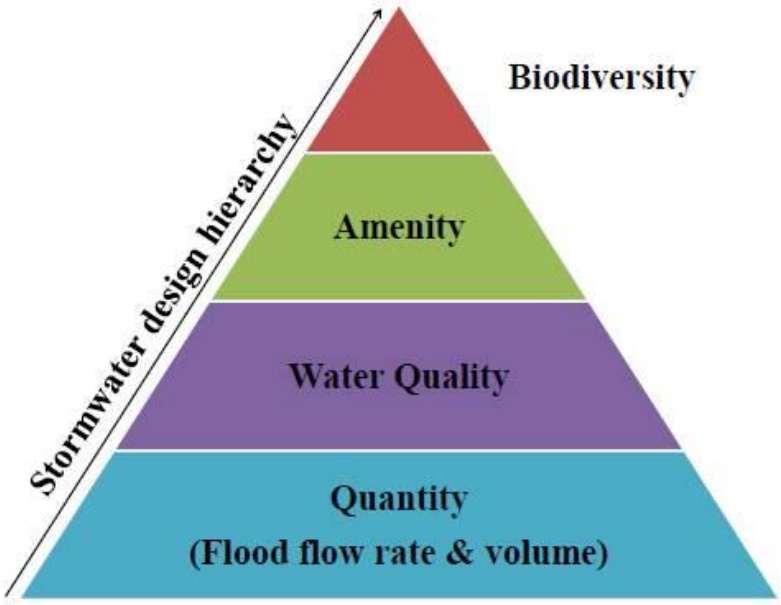


Figure 15. Stormwater design hierarchy of the SuDS

Treatment trains are critical in designing an effective SuDS scheme. The SuDS Treatment Train starts with good housekeeping before moving on to source controls, local controls and regional controls. SuDS controls should be used sequentially to optimally treat stormwater runoff. Good Housekeeping ensures that as much as possible is done to minimise the release of pollutants – such as solid waste – into the environment where it may subsequently be transported by stormwater.

Source controls manage stormwater runoff as close to its source as possible, usually on site. Typical SuDS options include green roofs, rainwater harvesting, permeable pavements and soakaways.

Local Controls manage stormwater runoff in the local area, typically within the road reserves and around infrastructure. Typical SuDS options include bio-retention areas, filter strips, infiltration trenches, sand filters and swales.

Regional Controls manage the combined stormwater runoff from several developments. Typical SuDS

options include constructed wetlands, detention ponds and retention ponds.

These aspects and specific management practices that can be considered for implementation for the developments is indicated in Table 16.

Table 16 SuDS conceptual design matrix

		Quantity					Quality						Amenity		Biodiversity	Costing		
		Rainwater harvesting	Infiltration	Detention	Conveyance	Long-term storage	Sedimentation	Filtration	Adsorption	Biodegradation	Plant-uptake	Nitrification	Recreational benefits	Aesthetic enhancement	Habitat provision	Land take	Capital	Operation and maintenance
Source controls	Green roofs	S	×	P	×	×	P	P	P	P	P	P	Y	Y	Y	×	L/M	M
	Rainwater Harvesting	P	×	S	×	P	PR	×	×	×	×	×	×	×	N	L	M/H	M
	Soakaways	S	P	S	×	×	PR	P	P	P	×	×	×	×	N	×	M	L
	Permeable pavements	S	P/S	P/S	S	×	×	P	P	S	×	×	Y	Y	N	×	L/M	L
Local controls	Filter strips	×	S	S	P	×	P	P	P	P	S	S	Y	Y	Y	H	L	L
	Swales	×	S	S	P	×	S	P	P	S	S	S	×	Y	Y	M	L	M
	Infiltration trenches	S	P	S	×	×	PR	P	P	S	×	S	×	×	N	L	L/M	M
	Bio-retention areas	S	P	P/S	×	×	P	P	P	P	P	P	×	Y	Y	M	M	M
	Sand filters	S	S	P	×	×	S	P	P	S	×	×	×	×	N	L	L/M	M
Regional controls	Detention ponds	×	S	P	×	×	P	×	×	×	×	×	Y	Y	Y	H	L	L
	Retention ponds	P	S	P	×	P	S	S	S	P	P	P	Y	Y	Y	H	M	M
	Constructed wetlands	S	S	P	×	P	S	S	P	P	P	P	Y	Y	Y	H	H	L/M
		Primary process (P) Secondary process (S) Pre-treatment Required (PR) Not applicable (×)											Provides amenity/habitat (Y) Does not provide amenity/habitat (N)			High (H) Medium (M) Low (L)		

1. SEMCOG, 2008, *Low Impact Development Manual for Michigan: A Design Guide for Implementers and Reviewers*, Southeast Michigan Council of Governments, Michigan 2. Woods-Ballard B., Kellagher R., Martin P., Jefferies C., Bray R. and Shaffer P (2007). *The SUDS Manual*. CIRIA 697. London. 3.Wilson S., Bray R. and Cooper P. (2004) *Sustainable drainage systems: Hydraulic, structural and water quality advice*. CIRIA C609. London.

There are circumstances where SuDS may be unsafe; for example, where there is a serious risk of contamination resulting from point or non-point sources. These risks should be taken into consideration in the design and precautions taken. Table 16 highlights pollutants that may be found in stormwater. The potential risks of each pollutant on a site need to be assessed. This is especially important in the case of pathogens where stormwater facilities are open to the public.

Table 17. Potential stormwater pollutants and impacts that needs to be assessed and monitored during the development phases

Pollutant Group	Pollutant	Impacts
Nutrients	Nitrogen & phosphorus	Excessive nutrients result in eutrophication. It is commonly associated with algal plumes, reduced clarity resulting in decreased bio-diversity
Sediments	Suspended & settable solids	Increased turbidity, sedimentation, smothering of aquatic plant and animal life
Organic material	Plant litter	Increased nutrients & sediment.
Pathogens	Bacteria, viruses & protazoa	Public health risk. contaminated recreational areas. Decreased economic value of natural recreational areas
Hydrocarbons	Oils, grease & others	Polluted water may become toxic. Aquatic life becomes toxic due to bioaccumulation. Decrease of biodiversity
Metals	Lead, copper, zinc and others	Polluted water may become toxic. Aquatic life becomes toxic due to bioaccumulation. Decrease of biodiversity
Toxic chemicals	Pesticides & insecticides	Polluted water may become toxic. Aquatic life becomes toxic due to bioaccumulation. Decrease of biodiversity
Solids	Debris & rubbish	Threat to wildlife. Aesthetic appeal decreased

12.1.3.2 Erosion control and rehabilitation

Erosion control will need to be undertaken to ensure the successful landscape and rehabilitation of the site. Specific soil management practices need to be implemented to prevent erosion and sedimentation as stipulated below:

During the construction phase the clearing of the site will leave the soil exposed and this can cause erosion. The following list provides a guide to preventing erosion on construction sites:

- Programming: Install erosion control measures before construction commences. Schedule construction activities to minimize land disturbance.
- Land clearing: minimize the extent and duration of land clearing.
- Stormwater and run-off systems: install temporary drains and minimize concentrated water flows. Control stormwater velocity where necessary with temporary energy dissipater structures. Divert run-off around trench excavations or disturbed areas.
- Rehabilitation: revegetate or stabilize 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.

- Services: coordinate the provision of site services to minimize disturbance.
- Stockpiles: locate stockpiles away from concentrated flows and divert run-off around them.

12.1.3.3 Prevention of sedimentation

Erosion is likely to occur on site, with sediment export being an inevitable risk. Measures must be employed to capture sediment and reduce the amount of sediment that leaves the site. The generation of dust, litter and debris need to be minimized. A regular site maintenance schedule needs to be introduced. Sediment control devices need to be installed to capture mobilized sediment. The following sediment control devices are suggested:

- Grass filter strips: it encourages sediment to settle as water passes over a vegetated area.
- Sediment filters: use materials such as fine mesh or geo-fabric to filter run-off prior to discharge.
- Sediment traps: temporary sedimentation basins.
- Drop inlet filters: e.g., hay bales and silt fences, which prevent sediment entry into the drainage system.

12.1.3.4 Pollution prevention

Stored material that has been poorly located or left unprotected can be a source of pollutants. The following measures need to be taken to prevent pollution to the wetland:

- Stockpile location: locate stockpiles and material storage 30m or more away from drainage lines and identified wetland habitat.
- Stockpile construction: minimize the number and size of stockpiles. Construct stockpiles with a height to width ratio of less than 2:1. Surround unstabilised stockpiles and batters with silt fences or drainage systems that will collect and treat uncontaminated water.
- Stockpile maintenance: cover any stored material to protect it from rainfall. Mulch, roughen and grass seeding can be used on any batter or topsoil stockpile that is to be maintained for longer than 28 days.

12.1.3.5 Littering prevention

Uncontrolled littering can be a source of pollution to the wetland. The following measures need to be taken to mitigate against littering in wetlands:

- Litter storage and housekeeping: maintain a high standard of housekeeping. Store all litter carefully so it cannot be washed or blown into the stormwater drainage systems.

- Rubbish bins: provide bins for construction workers and staff at appropriate location, particularly where food is consumed.
- Daily site clean-up: clean-up site of all litter daily.
- Rubbish disposal: dispose of scrap materials (e.g., off-cuts and scrap machinery components) in a responsible manner.

12.1.3.6 Building activity associated impacts

Dust concrete, solvents, steel fillings, fuel and other wastes are all produced during building construction and can cause impacts to the wetlands. Take the following mitigation measures:

- Materials storage: store building materials under cover or in contained areas.
- Site cleaning: clean the repair or construction site daily. Do not use water for cleaning the site.
- Leakage containment and treatment: ensure that oil, fuel or solvent leakages cannot enter the stormwater system.
- Temporary filters: fit temporary inlet pit filters near wash-down areas to prevent pollutant entry into the drainage system.

13 IMPACT STATEMENT AND VIABILITY OF MINING PROJECT

The proposed mining activities that form part of the Glencore Kroondal Mine Residue Expansion Project will impact on the flora and fauna of the area. The following can be concluded with regards to the impacts:

- Vegetation clearing and topsoil stripping will have the most definite and permanent direct negative impact on the flora and fauna of the area during the construction phase of the mining expansion infrastructure. The clearance will eradicate all vegetation and displace fauna that will migrate to neighbouring areas;
- The laydown areas of CDFs and stockpiles during the operational phase of the mine will have a direct, negative impact on the vegetation and fauna habitats, although considering the degraded state of the area in general it can be considered as less than anticipated;
- The indirect impacts such as soil erosion, fauna mortalities, spillages and establishment of alien invasive species are relevant for all mining phases, although with strict implemented of the mitigation measures and action plans for the various components, the impacts can be minimized;
- Considering the cumulative impacts of the mining phases on the fauna and flora of the area, it can be concluded that the current state of the vegetation and fauna habitats, will cause some negative impacts, although the implementation of a rehabilitation and revegetation plan will allow the vegetation to recover over time and the fauna to return to the area;
- The mining development can be considered as viable, although strict mitigation and monitoring will need to be implemented throughout all the mining phases to ensure the impacts are kept to a minimum.

14 CONCLUSION

All aspects of the environment, especially living organisms, are vulnerable to disturbance of their habitat. The mining activities will completely modify the natural vegetation and faunal habitats. The importance of monitoring, rehabilitation and implementation of mitigation processes to prevent negative impacts on the environment during and after the closure phases of the mines should be considered a VERY HIGH priority. Any negative impacts created by such actions and processes will ultimately scar the environment and negatively impact on the ecosystem both on a local and global scale. The project area consists of sensitive drainage features, microphyllous woodland, exotic bushclumps and degraded grassland. The riverine woodland provides corridors and feeding and breeding areas for red data and other birds, reptiles and amphibians, even though impacts are considered to be low to medium. Many features of the study area contribute to its ecological sensitivity and it is recommended to be considered during the environmental impact process. Provided that the mitigation measures and recommendations are adhered to as stated in the report, the development of the mining expansion sites (CDFs, PCD, stockpiles, silt trap and associated infrastructure) can be supported, although under strict conditions with regards to monitoring, rehabilitation and management measures.

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APPENDIX A. PLANT SPECIES IN QDS

Family	Species	IUCN	Ecology
Euphorbiaceae	*Acalypha glabrata*	LC	Indigenous
Crassulaceae	*Adromischus umbraticola*		Indigenous; Endemic
Lamiaceae	*Aeollanthus buchnerianus*	LC	Indigenous
Rubiaceae	*Afrocanthium gilfillanii*	LC	Indigenous
Loranthaceae	*Agelanthus natalitius*		Indigenous
Apiaceae	*Alepidea setifera*	LC	Indigenous
Poaceae	*Alloteropsis semialata*	LC	Indigenous
Asphodelaceae	*Aloe greatheadii*	LC	Indigenous
Cyatheaceae	*Alsophila dregei*	LC	Indigenous
Anacampserotaceae	*Anacampseros subnuda*		Indigenous
Apocynaceae	*Ancylobotrys capensis*	LC	Indigenous
Poaceae	*Andropogon chinensis*	LC	Indigenous
Bryaceae	*Anomobryum julaceum*		Indigenous
Melastomataceae	*Antherotoma debilis*	LC	Indigenous
Rubiaceae	*Anthospermum hispidulum*	LC	Indigenous
Icacinaceae	*Apodytes dimidiata*	LC	Indigenous
Iridaceae	*Aristea angolensis*	LC	Indigenous
Poaceae	*Aristida aequiglumis*	LC	Indigenous
Poaceae	*Aristida congesta*	LC	Indigenous
Poaceae	*Aristida junciformis*	LC	Indigenous
Poaceae	*Aristida spectabilis*	LC	Indigenous
Poaceae	*Aristida stipitata*	LC	Indigenous
Poaceae	*Arundinella nepalensis*	LC	Indigenous
Cyperaceae	*Ascolepis capensis*	LC	Indigenous
Asparagaceae	*Asparagus angusticladus*	LC	Indigenous
Aspleniaceae	*Asplenium friesiorum*	LC	Indigenous
Aspleniaceae	*Asplenium inaequilaterale*	LC	Indigenous
Aytoniaceae	*Asterella bachmannii*		Indigenous
Aytoniaceae	*Asterella muscicola*		Indigenous
Asteraceae	*Athrixia elata*	LC	Indigenous
Polytrichaceae	*Atrichum androgynum*		Indigenous
Iridaceae	*Babiana bainesii*	LC	Indigenous
Pottiaceae	*Barbula eubryum*		Indigenous
Acanthaceae	*Barleria pretoriensis*	LC	Indigenous; Endemic
Asteraceae	*Berkheya carlinopsis*	LC	Indigenous; Endemic
Asteraceae	*Berkheya seminivea*	LC	Indigenous; Endemic
Apiaceae	*Berula repanda*	LC	Indigenous
Blechnaceae	*Blechnum attenuatum*		Indigenous
Blechnaceae	*Blechnum punctulatum*		Indigenous
Bryaceae	*Brachymenium acuminatum*		Indigenous
Bryaceae	*Bryum apiculatum*		Indigenous

Family	Species	IUCN	Ecology
Bryaceae	*Bryum argenteum*		Indigenous
Bryaceae	*Bryum pycnophyllum*		Indigenous
Scrophulariaceae	*Buddleja saligna*	LC	Indigenous
Scrophulariaceae	*Buddleja salviifolia*	LC	Indigenous
Cyperaceae	*Bulbostylis burchellii*	LC	Indigenous
Cyperaceae	*Bulbostylis contexta*	LC	Indigenous
Fabaceae	*Burkea africana*	LC	Indigenous
Burmanniaceae	*Burmannia madagascariensis*		Indigenous
Leucobryaceae	*Campylopus introflexus*		Indigenous
Leucobryaceae	*Campylopus pyriformis*		Indigenous
Leucobryaceae	*Campylopus sp.*		
Rubiaceae	*Canthium suberosum*	LC	Indigenous
Apocynaceae	*Carissa bispinosa*	LC	Indigenous
Scrophulariaceae	*Chaenostoma leve*	LC	Indigenous
Pteridaceae	*Cheilanthes hirta*	LC	Indigenous
Pteridaceae	*Cheilanthes viridis*	LC	Indigenous
Amaranthaceae	*Chenopodium schraderianum*		notIndigenous; Naturalised
Thelypteridaceae	*Christella gueinziana*		Indigenous
Ranunculaceae	*Clematis brachiata*	LC	Indigenous
Cleomaceae	*Cleome maculata*	LC	Indigenous
Cleomaceae	*Cleome monophylla*	LC	Indigenous
Euphorbiaceae	*Clutia pulchella*	LC	Indigenous; Endemic
Euphorbiaceae	*Clutia pulchella*	LC	Indigenous
Cucurbitaceae	*Coccinia adoensis*	LC	Indigenous
Combretaceae	*Combretum molle*	LC	Indigenous
Commelinaceae	*Commelina africana*	LC	Indigenous
Commelinaceae	*Commelina africana*	LC	Indigenous
Commelinaceae	*Commelina modesta*	LC	Indigenous
Crassulaceae	*Cotyledon orbiculata*	LC	Indigenous
Acanthaceae	*Crabbea angustifolia*		Indigenous; Endemic
Crassulaceae	*Crassula setulosa*	NE	Indigenous; Endemic
Crassulaceae	*Crassula swaziensis*		Indigenous
Linderniaceae	*Craterostigma wilmsii*	LC	Indigenous; Endemic
Fabaceae	*Crotalaria sphaerocarpa*	LC	Indigenous
Euphorbiaceae	*Croton gratissimus*	LC	Indigenous
Cucurbitaceae	*Cucumis melo*	LC	Indigenous
Araliaceae	*Cussonia transvaalensis*		Indigenous; Endemic
Poaceae	*Cymbopogon marginatus*	LC	Indigenous
Orchidaceae	*Cynorkis kassneriana*	LC	Indigenous
Cyperaceae	*Cyperus cyperoides*	LC	Indigenous
Cyperaceae	*Cyperus leptocladus*	LC	Indigenous
Cyperaceae	*Cyperus margaritaceus*	LC	Indigenous
Lobeliaceae	*Cyphia stenopetala*	LC	Indigenous

Family	Species	IUCN	Ecology
Aizoaceae	*Delosperma sp.*		
Asteraceae	*Dicoma anomala*	LC	Indigenous
Asteraceae	*Dicoma anomala*		Indigenous
Asteraceae	*Dicoma anomala*	LC	Indigenous
Poaceae	*Diheteropogon amplectens*	LC	Indigenous
Ebenaceae	*Diospyros lycioides*		Indigenous
Ebenaceae	*Diospyros lycioides*		Indigenous
Ditrichaceae	*Ditrichum difficile*		Indigenous
Malvaceae	*Dombeya rotundifolia*	LC	Indigenous
Salicaceae	*Dovyalis zeyheri*	LC	Indigenous
Hyacinthaceae	*Drimia altissima*		Indigenous
Droseraceae	*Drosera collinsiae*	LC	Indigenous
Dumortieraceae	*Dumortiera hirsuta*		Indigenous
Rubiaceae	*Empogona lanceolata*		Indigenous; Endemic
Onagraceae	*Epilobium hirsutum*	LC	Indigenous
Onagraceae	*Epilobium salignum*	LC	Indigenous
Poaceae	*Eragrostis acraea*	LC	Indigenous
Poaceae	*Eragrostis curvula*	LC	Indigenous
Poaceae	*Eragrostis gummiflua*	LC	Indigenous
Poaceae	*Eragrostis racemosa*	LC	Indigenous
Poaceae	*Eragrostis sclerantha*	LC	Indigenous
Poaceae	*Eragrostis stapfii*	LC	Indigenous
Poaceae	*Eragrostis superba*	LC	Indigenous
Ericaceae	*Erica woodii*	LC	Indigenous
Fabaceae	*Eriosema cordatum*	LC	Indigenous
Fabaceae	*Eriosema squarrosum*	LC	Indigenous
Hyacinthaceae	*Eucomis montana*		Indigenous
Orchidaceae	*Eulophia streptopetala*	LC	Indigenous
Fabroniaceae	*Fabronia pilifera*		Indigenous
Rubiaceae	*Fadogia homblei*	LC	Indigenous
Proteaceae	*Faurea saligna*	LC	Indigenous
Moraceae	*Ficus ingens*		Indigenous
Moraceae	*Ficus thonningii*		Indigenous
Fissidentaceae	*Fissidens bryoides*		Indigenous
Fissidentaceae	*Fissidens curvatus*		Indigenous
Fissidentaceae	*Fissidens ovatus*		Indigenous
Fissidentaceae	*Fissidens plumosus*		Indigenous
Fissidentaceae	*Fissidens rufescens*		Indigenous
Fissidentaceae	*Fissidens sciophyllus*		Indigenous
Fissidentaceae	*Fissidens sp.*		
Commelinaceae	*Floscopa glomerata*	LC	Indigenous
Fossombroniaceae	*Fossombronia crispa*		Indigenous
Fossombroniaceae	*Fossombronia gemmifera*		Indigenous

Family	Species	IUCN	Ecology
Fossombroniaceae	*Fossombronia straussiana*		Indigenous
Iridaceae	*Freesia grandiflora*	LC	Indigenous
Aizoaceae	*Frithia pulchra*	LC	Indigenous; Endemic
Cyperaceae	*Fuirena stricta*	LC	Indigenous
Funariaceae	*Funaria hygrometrica*		Indigenous
Funariaceae	*Funaria rottleri*		Indigenous
Asteraceae	*Geigeria burkei*	NE	Indigenous
Colchicaceae	*Gloriosa modesta*		Indigenous
Thymelaeaceae	*Gnidia sericocephala*		Indigenous
Apocynaceae	*Gomphocarpus glaucophyllus*	LC	Indigenous
Celastraceae	*Gymnosporia buxifolia*	LC	Indigenous
Celastraceae	*Gymnosporia polyacantha*	LC	Indigenous; Endemic
Celastraceae	*Gymnosporia tenuispina*	LC	Indigenous
Amaryllidaceae	*Haemanthus humilis*	LC	Indigenous
Orobanchaceae	*Harveya pumila*	LC	Indigenous
Asteraceae	*Helichrysum acutatum*	LC	Indigenous
Asteraceae	*Helichrysum aureonitens*	LC	Indigenous
Asteraceae	*Helichrysum callicomum*	LC	Indigenous
Asteraceae	*Helichrysum cerastioides*		Indigenous
Asteraceae	*Helichrysum cerastioides*	LC	Indigenous
Asteraceae	*Helichrysum epapposum*	LC	Indigenous
Asteraceae	*Helichrysum kraussii*	LC	Indigenous
Asteraceae	*Helichrysum lepidissimum*	LC	Indigenous
Asteraceae	*Helichrysum mundtii*	LC	Indigenous
Asteraceae	*Helichrysum nudifolium*	LC	Indigenous
Asteraceae	*Helichrysum rugulosum*	LC	Indigenous
Asteraceae	*Helichrysum setosum*	LC	Indigenous
Malvaceae	*Hermannia burkei*	LC	Indigenous
Malvaceae	*Hermannia floribunda*	LC	Indigenous
Malvaceae	*Hermannia lancifolia*	LC	Indigenous; Endemic
Iridaceae	*Hesperantha coccinea*	LC	Indigenous
Malvaceae	*Hibiscus sp.*		
Apocynaceae	*Huernia transvaalensis*	LC	Indigenous; Endemic
Aquifoliaceae	*Ilex mitis*	LC	Indigenous
Fabaceae	*Indigastrum burkeanum*	LC	Indigenous
Fabaceae	*Indigofera arrecta*	LC	Indigenous
Fabaceae	*Indigofera melanadenia*	LC	Indigenous
Convolvulaceae	*Ipomoea magnusiana*	LC	Indigenous
Poaceae	*Ischaemum fasciculatum*	LC	Indigenous
Cyperaceae	*Isolepis fluitans*	LC	Indigenous
Acanthaceae	*Justicia betonica*		Indigenous
Crassulaceae	*Kalanchoe lanceolata*		Indigenous
Aizoaceae	*Khadia acutipetala*	LC	Indigenous; Endemic

Family	Species	IUCN	Ecology
Achariaceae	*Kiggelaria africana*	LC	Indigenous
Asphodelaceae	*Kniphofia ensifolia*	LC	Indigenous
Thymelaeaceae	*Lasiosiphon caffer*	LC	Indigenous
Hyacinthaceae	*Ledebouria atrobrunnea*		Indigenous; Endemic
Hyacinthaceae	*Ledebouria ovatifolia*		Indigenous; Endemic
Poaceae	*Leersia hexandra*	LC	Indigenous
Leskeaceae	*Lindbergia haplocladioides*		Indigenous
Leskeaceae	*Lindbergia sp.*		
Orchidaceae	*Liparis bowkeri*	LC	Indigenous
Cyperaceae	*Lipocarpha chinensis*	LC	Indigenous
Verbenaceae	*Lippia javanica*		Indigenous
Fabaceae	*Listia heterophylla*	LC	Indigenous
Lophiocarpaceae	*Lophiocarpus tenuissimus*	LC	Indigenous
Lophocoleaceae	*Lophocolea sp.*		
Asteraceae	*Lopholaena coriifolia*	LC	Indigenous
Poaceae	*Loudetia simplex*	LC	Indigenous
Aytoniaceae	*Mannia capensis*		Indigenous
Celastraceae	*Maytenus undata*	LC	Indigenous
Malvaceae	*Melhania acuminata*	LC	Indigenous
Sapotaceae	*Mimusops zeyheri*	LC	Indigenous
Anemiaceae	*Mohria vestita*	LC	Indigenous
Poaceae	*Monocymbium ceresiiforme*	LC	Indigenous
Lobeliaceae	*Monopsis decipiens*	LC	Indigenous
Geraniaceae	*Monsonia angustifolia*	LC	Indigenous
Myricaceae	*Morella pilulifera*		Indigenous
Fabaceae	*Mundulea sericea*	LC	Indigenous
Myrothamnaceae	*Myrothamnus flabellifolius*	DD	Indigenous
Myrsinaceae	*Myrsine africana*	LC	Indigenous
Myrsinaceae	*Myrsine pillansii*	LC	Indigenous
Celastraceae	*Mystroxylon aethiopicum*	LC	Indigenous; Endemic
Asteraceae	*Nidorella hottentotica*	LC	Indigenous
Stilbaceae	*Nuxia congesta*	LC	Indigenous
Urticaceae	*Obetia tenax*		Indigenous
Ochnaceae	*Ochna holstii*	LC	Indigenous
Ochnaceae	*Ochna pretoriensis*	LC	Indigenous
Ochnaceae	*Ochna pulchra*	LC	Indigenous
Calymperaceae	*Octoblepharum albidum*		Indigenous
Rubiaceae	*Oldenlandia herbacea*	LC	Indigenous
Rubiaceae	*Oldenlandia tenella*	LC	Indigenous
Oleaceae	*Olea capensis*	LC	Indigenous
Oleaceae	*Olea europaea*		Indigenous
Oleandraceae	*Oleandra distenta*	LC	Indigenous
Asteraceae	*Oocephala staehelinoides*		Indigenous; Endemic

Family	Species	IUCN	Ecology
Ophioglossaceae	*Ophioglossum polyphyllum*	LC	Indigenous
Apocynaceae	*Orbea lutea*	LC	Indigenous
Osmundaceae	*Osmunda regalis*	LC	Indigenous
Santalaceae	*Osyris lanceolata*	LC	Indigenous
Rubiaceae	*Otiophora calycophylla*	LC	Indigenous; Endemic
Anacardiaceae	*Ozoroa paniculosa*	LC	Indigenous
Anacardiaceae	*Ozoroa paniculosa*	LC	Indigenous
Rubiaceae	*Pachystigma macrocalyx*	LC	Indigenous
Poaceae	*Panicum natalense*	LC	Indigenous
Poaceae	*Paspalum urvillei*	NE	notIndigenous; Naturalised
Rubiaceae	*Pavetta zeyheri*	LC	Indigenous
Malvaceae	*Pavonia clathrata*	LC	Indigenous
Fabaceae	*Pearsonia sessilifolia*	LC	Indigenous
Fabaceae	*Pearsonia uniflora*	LC	Indigenous
Geraniaceae	*Pelargonium luridum*	LC	Indigenous
Poaceae	*Pennisetum macrourum*	LC	Indigenous
Apocynaceae	*Pentarrhinum insipidum*	LC	Indigenous
Piperaceae	*Peperomia tetraphylla*		Indigenous
Cucurbitaceae	*Peponium caledonicum*	LC	Indigenous
Polygonaceae	*Persicaria madagascariensis*		Indigenous
Bartramiaceae	*Philonotis dregeana*		Indigenous
Bartramiaceae	*Philonotis hastata*		Indigenous
Rhamnaceae	*Phylica paniculata*		Indigenous
Pittosporaceae	*Pittosporum viridiflorum*	LC	Indigenous
Pteridaceae	*Pityrogramma argentea*	LC	Indigenous
Aytoniaceae	*Plagiochasma rupestre*		Indigenous
Aytoniaceae	*Plagiochasma rupestre*		Indigenous
Lamiaceae	*Plectranthus aliciae*	LC	Indigenous; Endemic
Lamiaceae	*Plectranthus hereroensis*	LC	Indigenous
Lamiaceae	*Plectranthus ramosior*	LC	Indigenous; Endemic
Poaceae	*Pogonarthria squarrosa*	LC	Indigenous
Polytrichaceae	*Pogonatum capense*		Indigenous
Caryophyllaceae	*Pollichia campestris*		Indigenous
Asteraceae	*Polydora poskeana*	LC	Indigenous
Polygalaceae	*Polygala hottentotta*	LC	Indigenous
Polygalaceae	*Polygala rehmannii*	LC	Indigenous
Polytrichaceae	*Polytrichum commune*		Indigenous
Portulacaceae	*Portulaca grandiflora*		Indigenous; Endemic
Portulacaceae	*Portulaca quadrifida*		Indigenous
Urticaceae	*Pouzolzia mixta*		Indigenous
Proteaceae	*Protea caffra*	LC	Indigenous
Proteaceae	*Protea caffra*		Indigenous
Proteaceae	*Protea welwitschii*	LC	Indigenous

Family	Species	IUCN	Ecology
Pteridaceae	*Pteris friesii*	LC	Indigenous
Pteridaceae	*Pteris vittata*	LC	Indigenous
Celastraceae	*Pterocelastrus echinatus*	LC	Indigenous
Lamiaceae	*Pycnostachys reticulata*	LC	Indigenous
Racopilaceae	*Racopilum capense*		Indigenous
Apocynaceae	*Raphionacme velutina*	LC	Indigenous
Vitaceae	*Rhoicissus tridentata*		Indigenous
Fabaceae	*Rhynchosia confusa*	NE	Indigenous
Fabaceae	*Rhynchosia hirsuta*	LC	Indigenous
Fabaceae	*Rhynchosia totta*		Indigenous
Ricciaceae	*Riccia albolimbata*		Indigenous
Ricciaceae	*Riccia atropurpurea*		Indigenous
Ricciaceae	*Riccia cavernosa*		Indigenous
Ricciaceae	*Riccia crystallina*		Indigenous
Ricciaceae	*Riccia okahandjana*		Indigenous
Ricciaceae	*Riccia volkii*		Indigenous
Bryaceae	*Rosulabryum capillare*		Indigenous
Rubiaceae	*Rothmannia capensis*	LC	Indigenous
Rosaceae	*Rubus cuneifolius*		notIndigenous; Naturalised; Invasive
Celastraceae	*Salacia rehmannii*	LC	Indigenous; Endemic
Poaceae	*Schizachyrium jeffreysii*	LC	Indigenous
Poaceae	*Schizachyrium sanguineum*	LC	Indigenous
Hyacinthaceae	*Schizocarphus nervosus*		Indigenous
Cyperaceae	*Schoenoplectus brachyceras*	LC	Indigenous
Salicaceae	*Scolopia mundii*	LC	Indigenous
Anacardiaceae	*Searsia discolor*		Indigenous
Anacardiaceae	*Searsia magalismontana*		Indigenous
Anacardiaceae	*Searsia pyroides*		Indigenous
Anacardiaceae	*Searsia rigida*		Indigenous
Gentianaceae	*Sebaea bojeri*	LC	Indigenous
Selaginellaceae	*Selaginella dregei*		Indigenous
Sematophyllaceae	*Sematophyllum brachycarpum*		Indigenous
Sematophyllaceae	*Sematophyllum sphaeropyxis*		Indigenous
Asteraceae	*Senecio othonniflorus*	LC	Indigenous
Asteraceae	*Senecio pleistocephalus*	LC	Indigenous
Fabaceae	*Senegalia caffra*	LC	Indigenous
Fabaceae	*Senna occidentalis*	NE	notIndigenous; Naturalised; Invasive
Poaceae	*Setaria sphacelata*	LC	Indigenous
Malvaceae	*Sida dregei*	LC	Indigenous
Solanaceae	*Solanum giganteum*	LC	Indigenous
Sphagnaceae	*Sphagnum capense*		Indigenous
Sphagnaceae	*Sphagnum truncatum*		Indigenous
Fabaceae	*Sphenostylis angustifolia*	LC	Indigenous

Family	Species	IUCN	Ecology
Poaceae	*Sporobolus congoensis*	LC	Indigenous
Poaceae	*Sporobolus pectinatus*	LC	Indigenous; Endemic
Orobanchaceae	*Striga bilabiata*	LC	Indigenous
Orobanchaceae	*Striga gesnerioides*	LC	Indigenous
Loganiaceae	*Strychnos usambarensis*	LC	Indigenous
Pallaviciniaceae	*Symphyogyna brasiliensis*		Indigenous
Pallaviciniaceae	*Symphyogyna podophylla*		Indigenous
Pottiaceae	*Syntrichia laevipila*		Indigenous
Anacampserotaceae	*Talinum caffrum*		Indigenous
Targioniaceae	*Targionia hypophylla*		Indigenous
Thelypteridaceae	*Thelypteris confluens*	LC	Indigenous
Santalaceae	*Thesium magalismontanum*	LC	Indigenous; Endemic
Santalaceae	*Thesium resedoides*	LC	Indigenous
Santalaceae	*Thesium sp.*		
Pottiaceae	*Tortella xanthocarpa*		Indigenous
Poaceae	*Trachypogon spicatus*	LC	Indigenous
Cannabaceae	*Trema orientalis*	LC	Indigenous
Bruchiaceae	*Trematodon intermedius*		Indigenous
Bruchiaceae	*Trematodon longicollis*		Indigenous
Malpighiaceae	*Triaspis glaucophylla*	LC	Indigenous; Endemic
Poaceae	*Tricholaena monachne*	LC	Indigenous
Poaceae	*Trichoneura grandiglumis*	LC	Indigenous
Pottiaceae	*Trichostomum brachydontium*		Indigenous
Malvaceae	*Triumfetta pilosa*	LC	Indigenous
Asteraceae	*Ursinia nana*	LC	Indigenous
Asteraceae	*Ursinia sp.*		
Lentibulariaceae	*Utricularia welwitschii*	LC	Indigenous
Fabaceae	*Vachellia nilotica*	LC	Indigenous
Valerianaceae	*Valeriana capensis*	LC	Indigenous
Santalaceae	*Viscum verrucosum*		Indigenous
Campanulaceae	*Wahlenbergia denticulata*	LC	Indigenous
Campanulaceae	*Wahlenbergia lycopodioides*	LC	Indigenous
Campanulaceae	*Wahlenbergia magaliesbergensis*	LC	Indigenous; Endemic
Pottiaceae	*Weissia latiuscula*		Indigenous
Convolvulaceae	*Xenostegia tridentata*		Indigenous
Velloziaceae	*Xerophyta viscosa*		Indigenous; Endemic
Xyridaceae	*Xyris congensis*		Indigenous
Scrophulariaceae	*Zaluzianskya elongata*	LC	Indigenous
Rutaceae	*Zanthoxylum capense*	LC	Indigenous

APPENDIX B. PLANT SPECIES FOUND ON SITE

Plant species lists for site
Woody species
Celtis africana
Dichrostachys cinerea
Jacaranda mimosifolia
Melia azedarach
Morus alba
Schotia brachypetala
Senegalia galpinni
Senegalia sieberiana
Solanum mauritianum
Tecoma stans
Vachellia karroo
Vachellia nilotica
Vachellia tortilis
Vachellia xanthophloea
Ziziphus mucronata
Grass species
Aristida congesta
Aristida stipitata
Botriochloa insculpta
Brachiaria deflexa
Chloris virgata
Cymbopogon pisposchilli
Cynodon dactylon
Digitaria eriantha
Enneapogon cenchroides
Enneapogon scoparius
Eragrostis curvula
Eragrostis viscosa
Heteropogon contortus
Hyparrhenia hirta
Hyperthelia dissoluta
Ishaemum fasciculatum
Melinis repens
Panicum coloratum
Panicum maximum
Pogonarthria squarrosa
Sporobolus africanus
Tragus bertertranonianus
Urochloa mosambicense
Forbs and succulents
Guilulemnia densa
Amaranthus hybridus

Plant species lists for site
Cereus jamacaru
Chenopodium album
Convolvulis sagittatus
Conyza bionariensis
Cyperus sexangularis
Datura oligotrocha
Datura stramonium
Dicerocarium eriocaprum
Flaveria bidentis
Gomphocarpus fruticosus
Gomphrena celasoides
Harrissia spp.
Kalanchoe paniculata
Laggera decurrens
Lantana rugose
Lippia javanica
Malva parvifolia
Nidorella anomala
Opuntia ficus indica
Pellaea calomelanos
Rhoicissus tridentata
Schkuria pinnata
Schoenoplectus corymbosus
Sida cordifolia
Solanum panduriforme
Stoebe vulgaris
Tagetes minuta
Tithonia rotundifolia *Aloe marlothii*
Vigna vexillata
Zansevieria hyacinthoides
Tapinanthus spp.
Tribulis terrestris
Vernonia oligocephala
Zinnia peruviana

APPENDIX C. BIRD SPECIES LIST FOR QDS

Common_name	***Taxon_name***
Ostrich, Common	*Struthio camelus*
Grebe, Great Crested	*Podiceps cristatus*
Grebe, Little	*Tachybaptus ruficollis*
Cormorant, White-breasted	*Phalacrocorax carbo*
Cormorant, Reed	*Phalacrocorax africanus*
Darter, African	*Anhinga rufa*
Heron, Grey	*Ardea cinerea*
Heron, Black-headed	*Ardea melanocephala*
Heron, Goliath	*Ardea goliath*
Heron, Purple	*Ardea purpurea*
Egret, Great	*Egretta alba*
Egret, Little	*Egretta garzetta*
Egret, Yellow-billed	*Egretta intermedia*
Egret, Cattle	*Bubulcus ibis*
Heron, Squacco	*Ardeola ralloides*
Heron, Green-backed	*Butorides striata*
Heron, Black	*Egretta ardesiaca*
Bittern, Dwarf	*Ixobrychus sturmii*
Bittern, Little	*Ixobrychus minutus*
Night-Heron, Black-crowned	*Nycticorax nycticorax*
Hamerkop, Hamerkop	*Scopus umbretta*
Stork, Abdim's	*Ciconia abdimii*
Stork, Black	*Ciconia nigra*
Stork, White	*Ciconia ciconia*
Ibis, African Sacred	*Threskiornis aethiopicus*
Ibis, Glossy	*Plegadis falcinellus*
Ibis, Hadeda	*Bostrychia hagedash*
Spoonbill, African	*Platalea alba*
Goose, Spur-winged	*Plectropterus gambensis*
Goose, Egyptian	*Alopochen aegyptiacus*
Shelduck, South African	*Tadorna cana*
Duck, Knob-billed	*Sarkidiornis melanotos*
Shoveler, Cape	*Anas smithii*
Duck, African Black	*Anas sparsa*
Duck, Yellow-billed	*Anas undulata*
Teal, Red-billed	*Anas erythrorhyncha*
Teal, Cape	*Anas capensis*
Duck, White-faced	*Dendrocygna viduata*
Pochard, Southern	*Netta erythrophthalma*
Duck, Maccoa	*Oxyura maccoa*
Duck, White-backed	*Thalassornis leuconotus*

Common_name	***Taxon_name***
Secretarybird, Secretarybird	*Sagittarius serpentarius*
Vulture, Cape	*Gyps coprotheres*
Vulture, White-backed	*Gyps africanus*
Falcon, Peregrine	*Falco peregrinus*
Falcon, Lanner	*Falco biarmicus*
Falcon, Amur	*Falco amurensis*
Kestrel, Rock	*Falco rupicolus*
Kestrel, Lesser	*Falco naumanni*
Hawk, African Cuckoo	*Aviceda cuculoides*
Kite, Yellow-billed	*Milvus aegyptius*
Kite, Black-shouldered	*Elanus caeruleus*
Honey-buzzard, European	*Pernis apivorus*
Eagle, Verreaux's	*Aquila verreauxii*
Eagle, Tawny	*Aquila rapax*
Eagle, Wahlberg's	*Aquila wahlbergi*
Eagle, Long-crested	*Lophaetus occipitalis*
Eagle, Martial	*Polemaetus bellicosus*
Buzzard, Lizard	*Kaupifalco monogrammicus*
Snake-eagle, Brown	*Circaetus cinereus*
Snake-eagle, Black-chested	*Circaetus pectoralis*
Fish-eagle, African	*Haliaeetus vocifer*
Buzzard, Jackal	*Buteo rufofuscus*
Buzzard, Steppe	*Buteo vulpinus*
Sparrowhawk, Rufous-chested	*Accipiter rufiventris*
Sparrowhawk, Ovambo	*Accipiter ovampensis*
Sparrowhawk, Little	*Accipiter minullus*
Sparrowhawk, Black	*Accipiter melanoleucus*
Shikra, Shikra	*Accipiter badius*
Goshawk, Gabar	*Melierax gabar*
Harrier-Hawk, African	*Polyboroides typus*
Osprey, Osprey	*Pandion haliaetus*
Francolin, Coqui	*Peliperdix coqui*
Francolin, Crested	*Dendroperdix sephaena*
Francolin, Red-winged	*Scleroptila levaillantii*
Francolin, Orange River	*Scleroptila levaillantoides*
Spurfowl, Natal	*Pternistis natalensis*
Spurfowl, Swainson's	*Pternistis swainsonii*
Quail, Common	*Coturnix coturnix*
Guineafowl, Helmeted	*Numida meleagris*
Rail, African	*Rallus caerulescens*
Crake, Black	*Amaurornis flavirostris*
Flufftail, Red-chested	*Sarothrura rufa*
Swamphen, African Purple	*Porphyrio madagascariensis*

Common_name	***Taxon_name***
Moorhen, Common	*Gallinula chloropus*
Coot, Red-knobbed	*Fulica cristata*
Korhaan, White-bellied	*Eupodotis senegalensis*
Jacana, African	*Actophilornis africanus*
Plover, Kittlitz's	*Charadrius pecuarius*
Plover, Three-banded	*Charadrius tricollaris*
Lapwing, Crowned	*Vanellus coronatus*
Lapwing, Blacksmith	*Vanellus armatus*
Lapwing, African Wattled	*Vanellus senegallus*
Snipe, African	*Gallinago nigripennis*
Stint, Little	*Calidris minuta*
Sandpiper, Common	*Actitis hypoleucos*
Greenshank, Common	*Tringa nebularia*
Sandpiper, Wood	*Tringa glareola*
Stilt, Black-winged	*Himantopus himantopus*
Thick-knee, Spotted	*Burhinus capensis*
Courser, Temminck's	*Cursorius temminckii*
Courser, Bronze-winged	*Rhinoptilus chalcopterus*
Gull, Grey-headed	*Larus cirrocephalus*
Tern, Whiskered	*Chlidonias hybrida*
Pigeon, Speckled	*Columba guinea*
Olive-pigeon, African	*Columba arquatrix*
Dove, Red-eyed	*Streptopelia semitorquata*
Turtle-dove, Cape	*Streptopelia capicola*
Dove, Laughing	*Streptopelia senegalensis*
Dove, Namaqua	*Oena capensis*
Wood-dove, Emerald-spotted	*Turtur chalcospilos*
Green-pigeon, African	*Treron calvus*
Go-away-bird, Grey	*Corythaixoides concolor*
Cuckoo, Red-chested	*Cuculus solitarius*
Cuckoo, Black	*Cuculus clamosus*
Cuckoo, Great Spotted	*Clamator glandarius*
Cuckoo, Levaillant's	*Clamator levaillantii*
Cuckoo, Jacobin	*Clamator jacobinus*
Cuckoo, Klaas's	*Chrysococcyx klaas*
Cuckoo, Diderick	*Chrysococcyx caprius*
Owl, Barn	*Tyto alba*
Grass-owl, African	*Tyto capensis*
Owl, Marsh	*Asio capensis*
Scops-owl, African	*Otus senegalensis*
Scops-owl, Southern White-faced	*Ptilopsus granti*
Owlet, Pearl-spotted	*Glaucidium perlatum*
Eagle-owl, Cape	*Bubo capensis*

Common_name	***Taxon_name***
Eagle-owl, Spotted	*Bubo africanus*
Nightjar, Rufous-cheeked	*Caprimulgus rufigena*
Nightjar, Fiery-necked	*Caprimulgus pectoralis*
Nightjar, Freckled	*Caprimulgus tristigma*
Swift, Common	*Apus apus*
Swift, African Black	*Apus barbatus*
Swift, White-rumped	*Apus caffer*
Swift, Horus	*Apus horus*
Swift, Little	*Apus affinis*
Swift, Alpine	*Tachymarptis melba*
Palm-swift, African	*Cypsiurus parvus*
Mousebird, Speckled	*Colius striatus*
Mousebird, White-backed	*Colius colius*
Mousebird, Red-faced	*Urocolius indicus*
Kingfisher, Pied	*Ceryle rudis*
Kingfisher, Giant	*Megaceryle maximus*
Kingfisher, Half-collared	*Alcedo semitorquata*
Kingfisher, Malachite	*Alcedo cristata*
Pygmy-Kingfisher, African	*Ispidina picta*
Kingfisher, Woodland	*Halcyon senegalensis*
Kingfisher, Brown-hooded	*Halcyon albiventris*
Kingfisher, Striped	*Halcyon chelicuti*
Bee-eater, European	*Merops apiaster*
Bee-eater, White-fronted	*Merops bullockoides*
Bee-eater, Little	*Merops pusillus*
Bee-eater, Swallow-tailed	*Merops hirundineus*
Roller, European	*Coracias garrulus*
Roller, Lilac-breasted	*Coracias caudatus*
Roller, Purple	*Coracias naevius*
Hoopoe, African	*Upupa africana*
Wood-hoopoe, Green	*Phoeniculus purpureus*
Hornbill, African Grey	*Tockus nasutus*
Hornbill, Southern Yellow-billed	*Tockus leucomelas*
Barbet, Black-collared	*Lybius torquatus*
Barbet, Acacia Pied	*Tricholaema leucomelas*
Tinkerbird, Yellow-fronted	*Pogoniulus chrysoconus*
Barbet, Crested	*Trachyphonus vaillantii*
Honeyguide, Greater	*Indicator indicator*
Honeyguide, Lesser	*Indicator minor*
Honeybird, Brown-backed	*Prodotiscus regulus*
Woodpecker, Golden-tailed	*Campethera abingoni*
Woodpecker, Cardinal	*Dendropicos fuscescens*
Woodpecker, Bearded	*Dendropicos namaquus*

Common_name	***Taxon_name***
Wryneck, Red-throated	*Jynx ruficollis*
Lark, Rufous-naped	*Mirafra africana*
Lark, Sabota	*Calendulauda sabota*
Lark, Flappet	*Mirafra rufocinnamomea*
Lark, Spike-heeled	*Chersomanes albofasciata*
Sparrowlark, Grey-backed	*Eremopterix verticalis*
Lark, Red-capped	*Calandrella cinerea*
Swallow, Barn	*Hirundo rustica*
Swallow, White-throated	*Hirundo albigularis*
Swallow, Pearl-breasted	*Hirundo dimidiata*
Swallow, Red-breasted	*Hirundo semirufa*
Swallow, Greater Striped	*Hirundo cucullata*
Swallow, Lesser Striped	*Hirundo abyssinica*
Cliff-swallow, South African	*Hirundo spilodera*
Martin, Rock	*Hirundo fuligula*
House-martin, Common	*Delichon urbicum*
Martin, Sand	*Riparia riparia*
Martin, Brown-throated	*Riparia paludicola*
Martin, Banded	*Riparia cincta*
Cuckoo-shrike, Black	*Campephaga flava*
Tit, Ashy	*Parus cinerascens*
Drongo, Fork-tailed	*Dicrurus adsimilis*
Oriole, Black-headed	*Oriolus larvatus*
Crow, Pied	*Corvus albus*
Crow, Cape	*Corvus capensis*
Tit, Southern Black	*Parus niger*
Babbler, Arrow-marked	*Turdoides jardineii*
Bulbul, African Red-eyed	*Pycnonotus nigricans*
Bulbul, Dark-capped	*Pycnonotus tricolor*
Thrush, Kurrichane	*Turdus libonyanus*
Thrush, Groundscraper	*Psophocichla litsipsirupa*
Rock-thrush, Cape	*Monticola rupestris*
Rock-thrush, Short-toed	*Monticola brevipes*
Wheatear, Mountain	*Oenanthe monticola*
Wheatear, Capped	*Oenanthe pileata*
Chat, Familiar	*Cercomela familiaris*
Cliff-chat, Mocking	*Thamnolaea cinnamomeiventris*
Chat, Anteating	*Myrmecocichla formicivora*
Stonechat, African	*Saxicola torquatus*
Robin-chat, Cape	*Cossypha caffra*
Robin-chat, White-throated	*Cossypha humeralis*
Scrub-robin, Kalahari	*Cercotrichas paena*
Scrub-robin, White-browed	*Cercotrichas leucophrys*

Common_name	***Taxon_name***
Warbler, Garden	*Sylvia borin*
Warbler, Icterine	*Hippolais icterina*
Warbler, Willow	*Phylloscopus trochilus*
Eremomela, Yellow-bellied	*Eremomela icteropygialis*
Eremomela, Burnt-necked	*Eremomela usticollis*
Reed-warbler, Great	*Acrocephalus arundinaceus*
Swamp-warbler, Lesser	*Acrocephalus gracilirostris*
Reed-warbler, African	*Acrocephalus baeticatus*
Warbler, Marsh	*Acrocephalus palustris*
Warbler, Sedge	*Acrocephalus schoenobaenus*
Rush-warbler, Little	*Bradypterus baboecala*
Wren-warbler, Barred	*Calamonastes fasciolatus*
Grassbird, Cape	*Sphenoeacus afer*
Crombec, Long-billed	*Sylvietta rufescens*
Apalis, Bar-throated	*Apalis thoracica*
Camaroptera, Grey-backed	*Camaroptera brevicaudata*
Cisticola, Zitting	*Cisticola juncidis*
Cisticola, Desert	*Cisticola aridulus*
Cisticola, Cloud	*Cisticola textrix*
Cisticola, Wing-snapping	*Cisticola ayresii*
Neddicky, Neddicky	*Cisticola fulvicapilla*
Cisticola, Wailing	*Cisticola lais*
Cisticola, Rattling	*Cisticola chiniana*
Cisticola, Levaillant's	*Cisticola tinniens*
Cisticola, Lazy	*Cisticola aberrans*
Prinia, Tawny-flanked	*Prinia subflava*
Prinia, Black-chested	*Prinia flavicans*
Flycatcher, Spotted	*Muscicapa striata*
Tit-flycatcher, Grey	*Myioparus plumbeus*
Tit-babbler, Chestnut-vented	*Parisoma subcaeruleum*
Flycatcher, Marico	*Bradornis mariquensis*
Flycatcher, Pale	*Bradornis pallidus*
Flycatcher, Southern Black	*Melaenornis pammelaina*
Flycatcher, Fiscal	*Sigelus silens*
Batis, Chinspot	*Batis molitor*
Flycatcher, Fairy	*Stenostira scita*
Paradise-flycatcher, African	*Terpsiphone viridis*
Wagtail, African Pied	*Motacilla aguimp*
Wagtail, Cape	*Motacilla capensis*
Wagtail, Yellow	*Motacilla flava*
Pipit, African	*Anthus cinnamomeus*
Pipit, Long-billed	*Anthus similis*
Pipit, Plain-backed	*Anthus leucophrys*

Common_name	***Taxon_name***
Pipit, Buffy	*Anthus vaalensis*
Pipit, Striped	*Anthus lineiventris*
Longclaw, Cape	*Macronyx capensis*
Shrike, Lesser Grey	*Lanius minor*
Fiscal, Common (Southern)	*Lanius collaris*
Shrike, Red-backed	*Lanius collurio*
Boubou, Southern	*Laniarius ferrugineus*
Shrike, Crimson-breasted	*Laniarius atrococcineus*
Puffback, Black-backed	*Dryoscopus cubla*
Tchagra, Brown-crowned	*Tchagra australis*
Tchagra, Black-crowned	*Tchagra senegalus*
Bush-shrike, Orange-breasted	*Telophorus sulfureopectus*
Bokmakierie, Bokmakierie	*Telophorus zeylonus*
Bush-shrike, Grey-headed	*Malaconotus blanchoti*
Shrike, Magpie	*Urolestes melanoleucus*
Helmet-shrike, White-crested	*Prionops plumatus*
Brubru, Brubru	*Nilaus afer*
Myna, Common	*Acridotheres tristis*
Starling, Wattled	*Creatophora cinerea*
Starling, Violet-backed	*Cinnyricinclus leucogaster*
Starling, Cape Glossy	*Lamprotornis nitens*
Starling, Red-winged	*Onychognathus morio*
Starling, Pied	*Spreo bicolor*
Oxpecker, Red-billed	*Buphagus erythrorhynchus*
Sunbird, Malachite	*Nectarinia famosa*
Sunbird, Marico	*Cinnyris mariquensis*
Sunbird, Greater Double-collared	*Cinnyris afer*
Sunbird, White-bellied	*Cinnyris talatala*
Sunbird, Amethyst	*Chalcomitra amethystina*
Sparrow-weaver, White-browed	*Plocepasser mahali*
Sparrow, House	*Passer domesticus*
Sparrow, Cape	*Passer melanurus*
Petronia, Yellow-throated	*Petronia superciliaris*
Finch, Scaly-feathered	*Sporopipes squamifrons*
Masked-weaver, Lesser	*Ploceus intermedius*
Weaver, Red-headed	*Anaplectes rubriceps*
Weaver, Village	*Ploceus cucullatus*
Weaver, Cape	*Ploceus capensis*
Masked-weaver, Southern	*Ploceus velatus*
Weaver, Thick-billed	*Amblyospiza albifrons*
Quelea, Red-billed	*Quelea quelea*
Bishop, Southern Red	*Euplectes orix*
Bishop, Yellow-crowned	*Euplectes afer*

Common_name	***Taxon_name***
Widowbird, Red-collared	*Euplectes ardens*
Widowbird, White-winged	*Euplectes albonotatus*
Widowbird, Long-tailed	*Euplectes progne*
Finch, Red-headed	*Amadina erythrocephala*
Finch, Cut-throat	*Amadina fasciata*
Mannikin, Bronze	*Spermestes cucullatus*
Waxbill, Swee	*Coccopygia melanotis*
Pytilia, Green-winged	*Pytilia melba*
Firefinch, African	*Lagonosticta rubricata*
Firefinch, Jameson's	*Lagonosticta rhodopareia*
Firefinch, Red-billed	*Lagonosticta senegala*
Waxbill, Orange-breasted	*Amandava subflava*
Waxbill, Blue	*Uraeginthus angolensis*
Waxbill, Violet-eared	*Granatina granatina*
Waxbill, Black-faced	*Estrilda erythronotos*
Waxbill, Common	*Estrilda astrild*
Quailfinch, African	*Ortygospiza atricollis*
Whydah, Pin-tailed	*Vidua macroura*
Whydah, Shaft-tailed	*Vidua regia*
Indigobird, Dusky	*Vidua funerea*
Indigobird, Purple	*Vidua purpurascens*
Indigobird, Village	*Vidua chalybeata*
Paradise-whydah, Long-tailed	*Vidua paradisaea*
Finch, Cuckoo	*Anomalospiza imberbis*
Canary, Yellow-fronted	*Crithagra mozambicus*
Canary, Black-throated	*Crithagra atrogularis*
Canary, Yellow	*Crithagra flaviventris*
Seedeater, Streaky-headed	*Crithagra gularis*
Bunting, Lark-like	*Emberiza impetuani*
Bunting, Cinnamon-breasted	*Emberiza tahapisi*
Bunting, Cape	*Emberiza capensis*
Bunting, Golden-breasted	*Emberiza flaviventris*
Dove, Rock	*Columba livia*
Duck, Mallard	*Anas platyrhynchos*
Peacock, Common	*Pavo cristatus*
Korhaan, Northern Black	*Afrotis afraoides*
Thrush, Karoo	*Turdus smithi*
White-eye, Orange River	*Zosterops pallidus*
White-eye, Cape	*Zosterops virens*
Lark, Eastern Clapper	*Mirafra fasciolata*
Lark, Eastern Long-billed	*Certhilauda semitorquata*
Hornbill, Red-billed	*Tockus erythrorhynchus*
Coucal, Burchell's	*Centropus burchellii*

Common_name	***Taxon_name***
Korhaan, Southern Black	*Afrotis afra*
Sparrow, Southern Grey-headed	*Passer diffusus*
Goose, Domestic	*Anser anser*
Duck, Hybrid Mallard	*Anas hybrid*

APPENDIX D MAMMAL SPECIES LIST FOR QDS

Family	Scientific name	Common name	Red list
Bovidae	*Aepyceros melampus*	Impala	Least Concern
Bovidae	*Alcelaphus buselaphus*	Red hartebeest	
Bovidae	*Antidorcas marsupialis*	Springbok	Least Concern (2016)
Bovidae	*Connochaetes taurinus taurinus*	Blue wildebeest	Least Concern (2016)
Bovidae	*Damaliscus lunatus lunatus*	(Southern African) Tsessebe	Vulnerable (2016)
Bovidae	*Damaliscus pygargus phillipsi*	Blesbok	Least Concern (2016)
Bovidae	*Hippotragus niger niger*	Sable antelope	Vulnerable (2016)
Bovidae	*Kobus ellipsiprymnus ellipsiprymnus*	Waterbuc k	Least Concern (2016)
Bovidae	*Oreotragus oreotragus*	Klipspringer	Least Concern (2016)
Bovidae	*Oryx gazella*	Gemsbok	Least Concern (2016)
Bovidae	*Redunca fulvorufula*	Mountain Reedbuck	Least Concern
Bovidae	*Sylvicapra grimmia*	Grey duiker	Least Concern (2016)

Family	Scientific name	Common name	Red list
Bovidae	*Syncerus caffer*	African Buffalo	Least Concern
Bovidae	*Taurotragus oryx*	Common Eland	Least Concern (2016)
Bovidae	*Tragelaphus angasii*	Nyala	Least Concern (2016)
Bovidae	*Tragelaphus scriptus*	Bushbuck	Least Concern
Bovidae	*Tragelaphus strepsiceros*	Greater Kudu	Least Concern (2016)
Canidae	*Canis mesomelas*	Black-backed Jackal	Least Concern (2016)
Cercopithecidae	*Chlorocebus pygerythrus*	Vervet Monkey	Least Concern (2016)
Cercopithecidae	*Papio ursinus*	Chacma Baboon	Least Concern (2016)
Emballonuridae	*Taphozous (Taphozous) mauritianus*	Mauritian Tomb Bat	Least Concern
Equidae	*Equus quagga*	Plains Zebra	Least Concern (2016)
Felidae	*Caracal caracal*	Caracal	Least Concern (2016)
Felidae	*Leptailurus serval*	Serval	Near Threatened (2016)
Felidae	*Panthera pardus*	Leopard	Vulnerable (2016)
Giraffidae	*Giraffa camelopardalis camelopardalis*	Giraffe	Least Concern
Herpestidae	*Atilax paludinosus*	Marsh Mongoose	Least Concern (2016)
Herpestidae	*Herpestes sanguineus*	Slender Mongoose	Least Concern (2016)
Hyaenidae	*Hyaena brunnea*	Brown Hyena	Near Threatened
Hystricidae	*Hystrix africaeaustralis*	Cape Porcupine	Least Concern
Leporidae	*Lepus saxatilis*	Scrub Hare	Least Concern
Leporidae	*Pronolagus randensis*	Jameson's Red Rock Hare	Least Concern (2016)
Macroscelididae	*Elephantulus myurus*	Eastern Rock Elephant Shrew	Least Concern (2016)
Muridae	*Aethomys ineptus*	Tete Veld Aethomys	Least Concern (2016)
Muridae	*Aethomys namaquensis*	Namaqua Rock Mouse	Least Concern
Muridae	*Lemniscomys rosalia*	Single-Striped Lemniscomys	Least Concern (2016)
Muridae	*Mastomys sp.*	Multimammate Mice	
Muridae	*Rhabdomys pumilio*	Xeric Four-striped Grass Rat	Least Concern (2016)
Mustelidae	*Mellivora capensis*	Honey Badger	Least Concern (2016)
Orycteropodidae	*Orycteropus afer*	Aardvark	Least Concern (2016)
Procaviidae	*Procavia capensis*	Cape Rock Hyrax	Least Concern (2016)
Sciuridae	*Paraxerus cepapi*	Tree squirrel	Least Concern (2016)
Suidae	*Phacochoerus africanus*	Common Warthog	Least Concern (2016)
Vespertilionidae	*Scotophilus dinganii*	Yellow-bellied House Bat	Least Concern (2016)

APPENDIX E HERPETOFAUNA LIST FOR QDS

Reptiles

Family	Scientific name	Common name	Red list
Agamidae	*Acanthocercus atricollis*	Southern Tree Agama	Least Concern (SARCA 2014)
Agamidae	*Agama atra*	Southern Rock Agama	Least Concern (SARCA 2014)
Chamaeleonidae	*Chamaeleo dilepis*	Common Flap-neck Chameleon	Least Concern (SARCA 2014)
Colubridae	*Crotaphopeltis hotamboeia*	Red-lipped Snake	Least Concern (SARCA 2014)
Colubridae	*Philothamnus natalensis occidentalis*	Western Natal Green Snake	Least Concern (SARCA 2014)
Colubridae	*Telescopus semiannulatus semiannulatus*	Eastern Tiger Snake	Least Concern (SARCA 2014)
Cordylidae	*Cordylus vittifer*	Common Girdled Lizard	Least Concern (SARCA 2014)
Gekkonidae	*Lygodactylus capensis capensis*	Common Dwarf Gecko	Least Concern (SARCA 2014)
Gekkonidae	*Pachydactylus affinis*	Transvaal Gecko	Least Concern (SARCA 2014)
Gerrhosauridae	*Gerrhosaurus flavigularis*	Yellow-throated Plated Lizard	Least Concern (SARCA 2014)
Lamprophiidae	*Lycodonomorphus rufulus*	Brown Water Snake	Least Concern (SARCA 2014)
Lamprophiidae	*Psammophis brevirostris*	Short-snouted Grass Snake	Least Concern (SARCA 2014)
Scincidae	*Mochlus sundevallii*	Sundevall's Writhing Skink	Least Concern (SARCA 2014)
Scincidae	*Panaspis wahlbergi*	Wahlberg's Snake-eyed Skink	Least Concern (SARCA 2014)
Scincidae	*Trachylepis capensis*	Cape Skink	Least Concern (SARCA 2014)
Scincidae	*Trachylepis punctatissima*	Speckled Rock Skink	Least Concern (SARCA 2014)
Scincidae	*Trachylepis varia sensu lato*	Common Variable Skink Complex	Least Concern (SARCA 2014)
Testudinidae	*Kinixys lobatsiana*	Lobatse Hinged Tortoise	Least Concern (SARCA 2014)

Amphibians

Family	Scientific name	Common name	Red list
Bufonidae	*Poyntonophrynus fenoulheti*	Northern Pygmy Toad	Least Concern
Bufonidae	*Schismaderma carens*	Red Toad	Least Concern
Bufonidae	*Sclerophrys capensis*	Raucous Toad	Least Concern
Bufonidae	*Sclerophrys gutturalis*	Guttural Toad	Least Concern
Bufonidae	*Sclerophrys poweri*	Power's Toad	Least Concern
Hyperoliidae	*Kassina senegalensis*	Bubbling Kassina	Least Concern
Phrynobatrachidae	*Phrynobatrachus natalensis*	Snoring Puddle Frog	Least Concern
Pipidae	*Xenopus laevis*	Common Platanna	Least Concern
Pyxicephalidae	*Amietia delalandii*	Delalande's River Frog	Least Concern
Pyxicephalidae	*Amietia poyntoni*	Poynton's River Frog	Not evaluated
Pyxicephalidae	*Cacosternum boettgeri*	Common Caco	Least Concern
Pyxicephalidae	*Tomopterna cryptotis*	Tremelo Sand Frog	Least Concern
Pyxicephalidae	*Tomopterna natalensis*	Natal Sand Frog	Least Concern

APPENDIX F PES SCORES OF THE WETLANDS ON SITE

Criteria and Attributes	Relevance	Sandspruit & tributary
Flow Modification	Consequence of abstraction, regulation by impoundments or increased runoff from human settlements or agricultural land. Changes in flow regime (timing, duration, frequency), volumes, velocity which affect inundation of wetland habitats resulting in floristic changes or incorrect cues to biota. Abstraction of groundwater flows to the wetland.	1
Permanent Inundation	Consequence of impoundment resulting in destruction of natural wetland habitat and cues for wetland biota.	2
Water Quality Modification	From point or diffuse sources. Measure directly by laboratory analysis or assessed indirectly from upstream agricultural activities, human settlements and industrial activities. Aggravated by volumetric decrease in flow delivered to the wetland.	1
Sediment Load Modification	Consequence of reduction due to entrapment by impoundments or increase due to land use practices such as overgrazing. Cause of unnatural rates of erosion, accretion or infilling of wetlands and change in habitats.	2
Canalisation	Results in desiccation or changes to inundation patterns of wetland and thus changes in habitats. River diversions or drainage.	3
Topographic Alteration	Consequence of infilling, ploughing, dykes, trampling, bridges, roads, railway lines and other substrate disruptive activities which reduce or changes wetland habitat directly in inundation patterns.	2
Terrestrial Encroachment	Consequence of desiccation of wetland and encroachment of terrestrial plant species due to changes in hydrology or geomorphology. Change from wetland to terrestrial habitat and loss of wetland functions.	3
Indigenous Vegetation Removal	Transformation of habitat for farming, grazing or firewood collection affecting wildlife habitat and flow attenuation functions, organic matter inputs and in increases potential for erosion.	2
Invasive Plant Encroachment	Affects habitat characteristics through changes in community structure and water quality changes (oxygen reduction and shading).	2
Alien Fauna	Presence of alien fauna affecting faunal community structure	2
Over utilisation of Biota	Overgrazing, overfishing, etc.	2
Total		22
Mean		2
Category		**Class D**
Ecological Management Class		**Largely Modified**

Scoring guidelines per attribute: natural, unmodified = 5; Largely natural = 4, Moderately modified = 3; largely modified = 2; seriously modified = 1; Critically modified = 0.

APPENDIX G EIS SCORES OF THE WETLANDS ON SITE

Determinant	
PRIMARY DETERMINANTS	
1. Rare & Endangered Species	0
2. Populations of Unique Species	0
3. Species/taxon Richness	1
4. Diversity of Habitat Types or Features	1
5. Migration route/breeding and feeding site for wetland species	1
6. Sensitivity to Changes in the Natural Hydrological Regime	1
7. Sensitivity to Water Quality Changes	1
8. Flood Storage, Energy Dissipation & Particulate/Element Removal	3
MODIFYING DETERMINANTS	
9. Protected Status	0
10. Ecological Integrity	1
TOTAL*	9
MEDIAN	0.9
OVERALL ECOLOGICAL SENSITIVITY AND IMPORTANCE	**Low**