Biodiversity Management Plan

Jagersfontein Developments (Pty) Ltd

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EKO•ENVIRONMENTAL

Prepared for:
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1. Introduction

1.1 Background

Natural vegetation is an important component of ecosystems. Some of the vegetation units in a region can be more sensitive than others, usually as a result of a variety of environmental factors and species composition. These units are often associated with water bodies, water transferring bodies or moisture sinks. These systems are always connected to each other through a complex pattern. Degradation of a link in this larger system, e.g. tributary, pan, wetland, usually leads to the degradation of the larger system. Therefore, degradation of such a water related system should be prevented.

Though vegetation may seem to be uniform and low in diversity it may still contain species that are rare and endangered. The occurrence of such a species may render the development unviable. Should such a species be encountered the development should be moved to another location or cease altogether.

South Africa has a large amount of endemic species and in terms of biological diversity ranks third in the world. This has the result that many of the species are rare, highly localised and consequently endangered. It is our duty to protect our diverse natural resources.

The Western Free State contains isolated dolerite capped mesas, butts, hills and ridges. Due to the flat topography these are often prominent landscape features. Due to the topography, hydrology, soil properties, etc. these hills contain vegetation differing markedly from that of the surrounding plains. In this region these hills are often the only landscape features able to sustain trees. Due to the above characteristics of these hills they also sustain a faunal population distinct from that of the surrounding plains. For the above reasons these hills are often considered as sensitive areas.

It is well known that diamond mining operations, especially pertaining to open pit mining, has several detrimental impacts on the environment. These impacts are numerous but the most pronounced impacts are associated with the excavation of large amounts of earth materials, the storage and disposal thereof and the sedimentation associated with it. This usually causes degradation of waterways due to sedimentation as well as the transformation of the vegetation and ecosystem on the site.

The report together with its recommendations and mitigation measures should be used to minimise the impact on the biodiversity of the mining area.

1.2 The value of biodiversity

The diversity of life forms and their interaction with each other and the environment has made Earth a uniquely habitable place for humans. Biodiversity sustains human livelihoods and life itself. Although our dependence on biodiversity has become less tangible and apparent, it remains critically important.

The balancing of atmospheric gases through photosynthesis and carbon sequestration is reliant on biodiversity, while an estimated 40% of the global economy is based on biological products and processes.

Biodiversity is the basis of innumerable environmental services that keep us and the natural environment alive. These services range from the provision of clean water and watershed services to the recycling of nutrients and pollution. These ecosystem services include:

- Soil formation and maintenance of soil fertility.
- Primary production through photosynthesis as the supportive foundation for all life.
- Provision of food, fuel and fibre.
- Provision of shelter and building materials.
- Regulation of water flows and the maintenance of water quality.
- Regulation and purification of atmospheric gases.
- Moderation of climate and weather.
- Detoxification and decomposition of wastes.
- Pollination of plants, including many crops.
- Control of pests and diseases.
- Maintenance of genetic resources.

1.3 Location

The Jagersfontein Diamond Mine is situated immediately south and west of the town of Jagersfontein and borders the town in some areas. The mine can be reached by the R706 Provincial Road from Bloemfontein (approximately 118km). The mining area is approximately 2000 ha in size.

1.4 Brief history of the mine

The Jagersfontein kimberlite pipe was discovered in 1870 by J.J. de Klerk. The farm was subsequently rushed by hundreds of diggers who worked an open pit. Initial challenges included water scarcity, the arid climate, the distance to urban centres, the difficulty of securing food supplies and equipment, the primitive modes of working and insufficient capitol to work claims effectively.

By 1891 the mine was owned by the amalgamated United Diamond Mining and New Jagersfontein Companies. The mine was only acquired by De Beers Consolidated Mines in 1930.

The mine operated on and off (operations ceased during the Anglo Boer War, World War I, and World War II and during the Great Depression) for 99 years and officially closed in 1969. The mine was sold to Jagersfontein Developments (Pty) Ltd in 2010.

1.5 Aims of the Biodiversity Management Plan

- Provide a comprehensive description of the site itself. The description must pertain to the fauna and flora and the varying condition of these aspects over the mining area as impacted by previous as well as current mining activities.

- Conduct a sensitivity analysis of the mining area and compile a sensitivity map (Map 3). The analysis must give information on pristine/degraded areas, areas containing species or vegetation with a high conservation value and areas performing vital ecological functions and services.

- Identify impacts due to previous as well as current mining activity and interpret the transformation and degradation caused by these impacts.

- Recommend mitigation and rehabilitation to improve degraded areas, sustain ecosystem functions on the mining area and promote conservation of biodiversity.

2. Scope

- To describe the environmental setting of the current mining area; as it relates to biodiversity.
- To satisfy the principle objectives and/or criteria relevant to biodiversity.
- To evaluate the present state of the vegetation and ecological functioning of the mining area.
- To identify possible negative impacts that are currently present and those that may develop due to ongoing mining activities.

3. Limitations

- Due to the size of the site and time constraints some species of conservational importance may have been overlooked. However, it is considered that these would occur in pristine areas and would be conserved by default.
- Some of the bulbous species may have been overlooked. Many species have a spring/autumn flowering period.
- Some animal species may not have been observed as a result of their nocturnal and/or shy habits.

4. Description of the environment

4.1 Climate

The town of Jagersfontein receives most of its rainfall from October to March. Temperatures also fluctuate accordingly with December being the hottest month at a mean temperature of 22.6˚C and July being the coldest at a mean temperature of 7.2˚C.

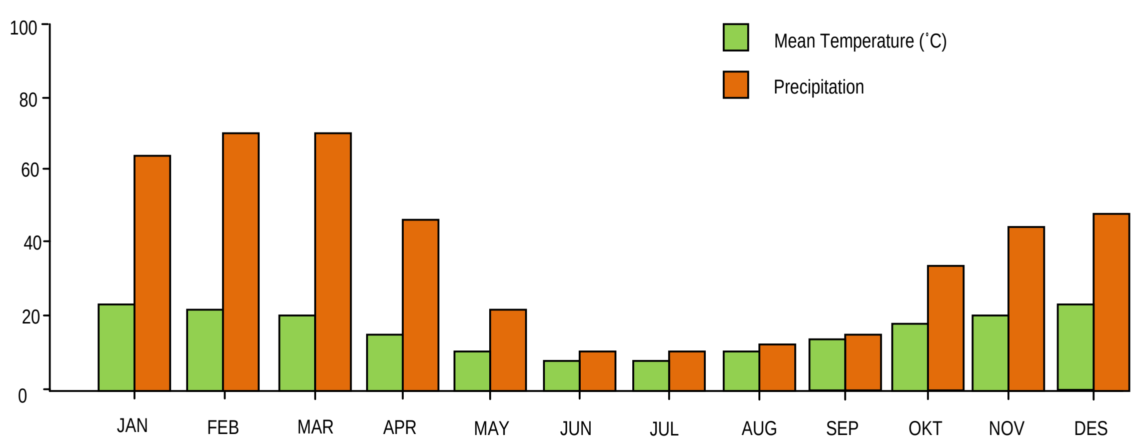

Figure 1: Climate diagram for Jagersfontein illustrating the monthly mean temperatures and precipitation.

As can be seen from the climate diagram February and March have the highest rainfall. The temperature trend follows the rainfall pattern to a large extent.

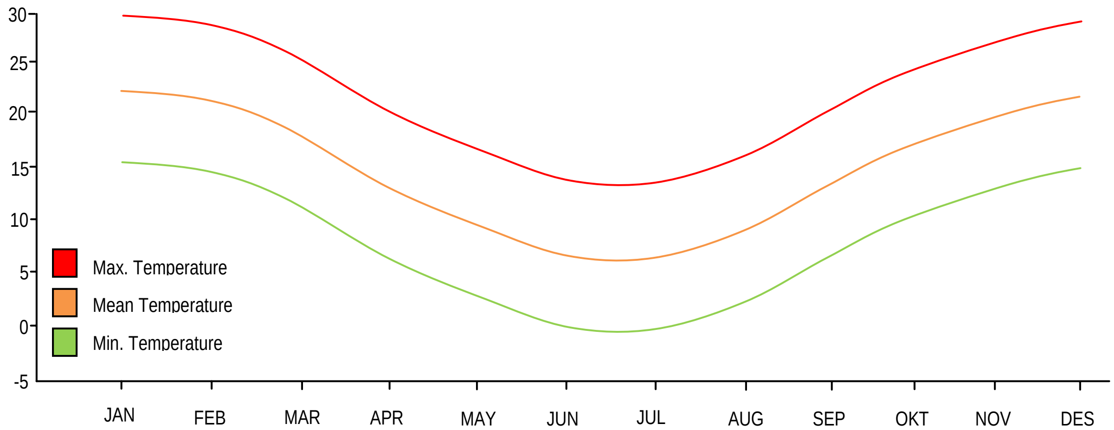

Figure 2: Graph illustrating the monthly maximum and minimum temperatures.

4.2 Geology and Soils

The geology of the area consists of Karoo Supergroup sediments and extensive dolerite sills. The Jagersfontein kimberlite pipe intrudes through these Karoo Supergroup sediments and dolerite intrusive sill complexes. The stratigraphy of the area shows how the local hills preserve the remnants of the dolerite sills. The outcrop of dolerites indicates the NW-SE striking structure, which appears to be a common structural trend in the region.

The soil is described as being dominated by prismacutanic and/or peducotanic horizons, with a mainly red B horizon (code Da46 and Da 104) in the central, lower part of the area and on the flatter dolerite areas. Glenrosa and/or Mispah forms with lime rare or absent occur on the higher ground in the north-eastern and western parts of the area (codes Fb191 and Fb400). On the steeper, rocky slopes in the north-eastern part of the area, soil is thin and is described as miscellaneous (code Ib348).

4.3 Topography, landscape features and surface infrastructure

4.3.1 Natural landscape (Map 2 & 3)

The topography is broken by numerous dolerite capped hills, ridges and plateaus (Map 2). These form prominent features in the landscape. In the mining area several dolerite hills and ridges occur (Map 2). The most prominent of these occur in the western portion of the mining area. These hills are relatively intact and have not been subjected to significant mining impacts. However, several smaller hills occur in the eastern portion of the mining area where impacts have been high (Map 2 & 3). These hills have been degraded by mining activities. These impacts will be further discussed under Historical and Current Impacts.

Areas in between hills and ridges consist of plains (Map 2). These plains are grass dominated with a large component of dwarf karroid shrubs. The dominance of these shrubs differs with the degree of disturbance. Due to the uneven topography these plains commonly contain drainage lines and seasonal streams (Map 3). The seasonal drainage lines and streams as well as the impacts on these will be further discussed under Surface Hydrology and Riparian Vegetation and Historical and Current Impacts.

4.3.2 Landscape features and surface infrastructure associated with mining activities (Map 1)

Mining activities are mostly concentrated within the eastern half of the mining area (Map 1). The mining activity having the largest footprint must surely be the excavated mine dumps. Several separate mine dumps are scattered over the mining area but concentrated in the eastern portion of the mining area. Most of the mine dumps have a steep slope and consequently runoff from the dumps have a high velocity with a high sediment load. This is considered a major impact but will be discussed under Surface Hydrology and Riparian Vegetation and Historical and Current Impacts.

The historic Jagersfontein Kimberlite Pit is substantial in size and forms a prominent feature on the site (Map 1). Over time this grew to a substantial size and depth (19,65 ha size at surface and 250m deep). The pit is of such a size and location that it disrupts the flow of several seasonal streams. The impact that this hole has on the surface hydrology of the area will be discussed under 5.1 Historical Jagersfontein Kimberlite Pit.

The site contains a large slimes dam that has been used and expanded for a prolonged period (Map 1). The slimes dam is currently still in use but will reach its capacity in the near future. The dam causes some impacts such as sediment runoff and existing mine dumps on and along the dam which will be discussed under Historical and Current Impacts.

In between the slimes dam, mine dump and kimberlite pit the processing plant is situated (Map 1). Infrastructure associated with the plant include crushers, processing plant, conveyors, process water dam, workshops, diesel storage tanks, etc.

The mining area contains several artificial dams, many of which were constructed in the late 19th century (Map 1). Due to the age of these dams many have been silted up and cannot contain a large amount of water any more. A large dam, Dam10, is situated near the eastern border of the site. Almost the entire catchment of the mining area drains into this dam (Map 4).

The mining area contains an extensive road network which has been constructed with waste rock. The construction of the majority of these roads did not make ample provision for sufficient drainage (See 5.10 Internal Road Network).

4.4 Vegetation (Map 2)

The vegetation on the site consists of Xhariep Karroid Grassland (Gh 3) and Besemkaree Koppies Shrubland (Gh 4) (Mucina & Rutherford 2006).

Besemkaree Koppies Shrubland (Gh 4) is confined to the dolerite capped hills and ridges on the site (Map 2). These hills are scattered throughout the site but the highest concentration of these occur in the western portion of the site. These hills often from prominent features in the landscape. Due to the topography, hydrology, soil properties, etc. these hills contain vegetation differing markedly from that of the surrounding plains. In this region these hills are often the only landscape features able to sustain trees. Due to the above characteristics of these hills they also sustain a faunal component distinct from that of the surrounding plains. As a result these hills are often considered sensitive as a result of a higher diversity, distinct species composition and prominent visual landscape forms.

The vegetation consists of a strong dominance of shrubs/small trees and grasses. Dominant trees and large shrubs include *Searsia burchellii, S. erosa, S. ciliata, Olea europea* subsp. *africana, Ehretia rigida, Buddleja saligna, Osyris lanceolata, Tarchonanthus minor, Gymnosporia buxiifolia* and *Cussonia paniculata*. This assemblage of species is diverse but all these species are widespread. However, two of these species are protected in the Free State Province. These species are the Wild Olive (*Olea europea* subsp. *africana*) and the Cabbage Tree (*Cussonia paniculata*). These species are common on the hills and rocky ridges on the site but are excluded from the plains habitats. Many of these trees are old and large. These species are considered of moderate conservational importance.

Dominant grasses on the hills and rocky ridges include *Tragus koelerioides, Themeda triandra, Hyperhenia hirta, Cymbopogon plurinodis, Elionurus muticus, Aristida diffusa, Heteropogon contortus, Eustachys paspaloides* and *Pogonathria squarrosa*. These grass species indicate a system in a good condition.

These hills and ridges also contain a high diversity of herbs and dwarf shrubs. Although these species never dominate they are common between grasses, under trees, in rock fissures and other micro habitats occurring on these hills. These species are not listed here as this will not serve any purpose of description. A list of these species can be found in Appendix B.

Exotic weeds and invaders are not common on these hills and this also substantiates the relatively good condition of the vegetation. Weeds that were observed on these hills include *Opuntia ficus-indica, Nicotiana glauca* and *Conyza bonariensis*.

These hills and ridges contain several succulent species. These include *Aloe broomii, A. calviiflora, Chasmatophyllum mustellinum, Crassula corallina* and *Anacampseros filamentosa*. Of these *Aloe broomii, A. claviiflora* and *Anacampseros filamentosa* are protected species. It is not foreseen that these species will be affected by mining activities as long as these hills and ridges are treated as no-go areas.

Xhariep Karroid Grassland (Gh 3) is confined to the plains on the site (Map 2). Due to the scattered hills on the site the plains contain a slight slope over most of the site. Due to these hills and sloped plains, drainage lines and seasonal streams are common on the site. These will be discussed in detail under Surface Hydrology and Riparian Vegetation. The plains are characterised by a strong dominance of grass species with dwarf karroid shrubs common.

The plains are usually devoid of shrubs and trees and this should be the natural condition of the plains. However, during the late 19th century the miners of the Jagersfontein Pit used large portions of the plains to weather the excavated kimberlite before processing. Large areas of these plains still contain kimberlite boulders and small kimberlite heaps litters the plains and strewn boulders are also common on the plains. The plains on the site occur on deep soils with surface rock absent. This is due to the sediment eroded from the surrounding hills being deposited on the plains. The grass dominated vegetation has also adapted to these deep soils devoid of any surface rock. As a consequence of the remaining kimberlite rubble the vegetation has also been altered to some extent. The kimberlite rubble has formed suitable habitat for the establishment of large shrubs and trees as well as dwarf shrubs. Therefore these kimberlite rubble strewn areas have altered the natural species composition and vegetation structure of these plains. The vegetation on large portions of the plains has therefore been altered to some extent by previous dumping of kimberlite rubble, however, since this occurred such a long time ago the vegetation has stabilised and although transformed it is not disturbed.

The diversity of species and growth forms on these plains are much lower than the surrounding hills. This is in part due to the uniform habitat available on the plains. As a consequence the species are few and most possess the same growth form.

Dominant grasses on the plains include *Themeda triandra, Tragus koeleioides, Eragrostis lehmanniana, Cynodon dactylon, Chloris virgata, Aristida congesta* and *Digitaria eriantha*. Many of these species, i.e. *Tragus koeleioides, Eragrostis lehmanniana, Cynodon dactylon, Chloris virgata* and *Aristida congesta*, indicate disturbance and vegetation that is not in a climax stage. This can be attributed to the overgrazing by domestic and introduced game, previous kimberlite strewn rubble and inadequately constructed roadways, these impacts will be discussed in detail under Historical and Current Impacts.

Dwarf karroid shrubs and herbs include *Geigeria fillifolia, Rosenia humilis, Nenax microphylla, Pentzia incana, Lycium horridum, Tallinum caffrum, Hertia pallens Lotononis laxa, Conyza bonariensis, Wahlenbergia nodosa* and *Chrysocoma ciliata*.

Several specimens of small trees have become established on the plains. Although these are not natural to the species composition and vegetation structure of the plains they have established as a result of previous kimberlite rubble weathering done by miners. These tree species include *Diospyros lycioides* and *Searsia pyroides*.

The bulbous species *Brunsvigia radulosa* and *Ammocharis coranica* are rare on the plains. These species are widespread but are protected in the Free State Province and are listed as being of Least Concern under the National Red List. As long as mining activities do not occur on the plains areas in good condition the impact on these species are anticipated to remain low.

4.5 Surface Hydrology and Riparian Vegetation (Map 3, 4 & 5)

As previously mentioned due to the uneven topography and surrounding hills the area contains several drainage lines and seasonal streams (Map 3). These drainage lines and streams have their origins in the surrounding hills (Map 2 & 4). The catchment of these drainage lines and seasonal streams are largely confined to the mining area with only small portions of the catchment occurring outside the mining area to the north and south of the site (Map 4 & 5).

The origin of the drainage lines on the site is situated along the hills and ridges on the site. Surface water drains from the steep slopes of these hills onto the plains. Water flow along the slopes of the hills is fast and only a limited amount of water infiltrates to the groundwater. Therefore the majority of surface water reaches the plains below.

Upon reaching the plains the surface flow slows down considerably as the slope on the plains decrease drastically from that of the hills. The slow flowing surface water infiltrates to the groundwater much more easily. However, a large amount of surface water reaches the low point on the plains. In addition the groundwater movements also follow that of the surface water flow and groundwater amasses at the low point as well. It is at this low point that a drainage line is formed. After periods of high rainfall these drainage lines sustain a substantial baseflow. However, these drainage lines only contain a baseflow for short periods and therefore they are not capable of sustaining a large degree of riparian wetland species. These drainage lines are dominated by riparian and terrestrial grasses. Dominant riparian species include *Digitaria eriantha, Sporobolus fimbriatus* and *Hyperhenia hirta*. Terrestrial grass species include *Eragrostis obtusa, Themeda triandra* and *Ergarostis lehmanniana*. The drainage lines contain a high degree of terrestrial dwarf karroid shrubs and herbs. As can be deduced these drainage lines do not contain a high degree of riparian species. This is primarily due to the short periods of flow and the limited amount of surface flow. However, these drainage lines provide a vital service and must be regarded as sensitive areas.

The sensitivity can be substantiated by the degraded condition of some of the drainage lines on the site. A mining dump is situated near the origin of one of these drainage lines. The increased runoff from this mine dump as well as the increased sediment load has caused severe gully forming of the drainage line. The inadequate construction of roadways and drainage culverts and drains as well as the overgrazing of the vegetation has led to the erosion and gully formation in several other drainage lines on the site. This illustrates the sensitivity and easily degraded nature of these drainage lines. These degraded drainage lines will not rehabilitate easily and their functioning has been impaired.

The drainage lines on the site coalesce into a seasonal stream. This seasonal stream flows from west to east over the site and feeds into Dam 10 near the eastern border of the mining area (Map 1). Almost the entire catchment of this seasonal stream drains into Dam 10 (Map 4). Essentially this dam acts as a sediment trap to the catchment of the seasonal stream. As a consequence the capacity of this dam has been severely decreased due to sedimentation of the dam.

The seasonal stream also contains another dam upstream (Map 1). This dam is very old and may date to the early 20th century. Due to the age and sedimentation of this dam it hardly has any remaining capacity and merely acts as a water flow retarding obstruction.

This seasonal stream is subjected to several severe impacts as caused by the mining activities. Several drainage lines have been obstructed by existing mine dumps and essentially removed from the hydrological flow pattern. Consequently the seasonal stream is starved of this water inflow and several unnatural wetlands have consequently formed. Furthermore sediment runoff from the surrounding mine dumps end up in this seasonal stream and essentially choke the stream. The large amounts of sediment in this stream suffocate plant and animal life and as a result the seasonal stream does not contain a viable ecosystem. A large stone quarry is also situated on the border of the seasonal stream which also disrupts the water flow into this seasonal stream. The roadway that has been constructed over this seasonal stream is broad and culverts are inadequate for sufficient water flow.

The vegetation along the seasonal stream is dominated by sedges, bulrush and riparian grasses. The area where this stream exits the historical dam on the site is dominated by *Agrostis lachnantha, Melilotus alba, Scirpoides dioecus* and *Lobelia thermalis*. *Melilotus alba* (White Sweet Clover) is a serious weed and forms dense stands in this area. This indicates the poor condition of the seasonal stream in this area. The primary causes of this degraded condition are thought to be trampling and overgrazing as well as a large sediment load due to the adjacent large mine dump.

As the seasonal stream flows past the large mine dump the sediment load of the stream is increased drastically. As a consequence the stream is severely degraded in this portion. A small portion of the mine dump is also situated within the seasonal stream and this further transforms and degrades the stream. In this area the main channel of the stream is dominated by *Typha capensis* (Bulrush). The floodplain is dominated by several riparian grass and sedge species with a fair amount of dwarf karroid shrubs also present. Isolated trees are also present. The soil surface is covered by a thick layer of sediment and this causes suffocation of much of the vegetation and aquatic- and soil fauna. As a result the vegetation is in a severely degraded condition and the fauna in this area is very low in diversity.

As the seasonal stream flows east a large dirt roadway crosses the stream. The culverts and drainage underneath this roadway is inadequate to allow drainage of the seasonal stream. In addition to the inadequate drainage the large amounts of sediment as mentioned above cause blocking of the culverts. The culmination of the above causes the water flow to dam up in this area. The condition of the seasonal stream is severely degraded in this area. The area contains only limited vegetation with most of the vegetation suffocated and the faunal component severely degraded.

The stream is severely retarded at the above road crossing. Consequently on the eastern side of the road crossing the stream is starved of water flow and is consequently severely degraded. In addition, extensive areas of dumped screened sand occur in the floodplain of the stream. This also ads high volumes of sediment to the stream and further degrades its condition.

At this point the stream flows into Dam 10. This dam is also of considerable age and due to sedimentation has lost most of its capacity. However, the dam has a positive impact in that it acts as a sediment trap. However, some mine dumps are situated outside the watershed of the dam and these dumps again add sediment to the system.

As the seasonal stream exits the mining area boundary it flows past the Charlesville settlement. This settlement causes further degradation to the stream. Approximately 8km further the stream flows into the Prosesspruit (Map 5). The Prosesspruit is a perennial stream that flows north and after a short distance flows into the Kromellenboogspruit. The Kromellenboogspruit, a larger perennial stream, flows north for some distance and flows into the Riet River. This is a perennial river that flows westwards for a short distance until it is dammed by the Kalkfontein Dam. The Kalkfontein Dam is a large artificial reservoir dam. The dam is situated approximately 34km north west of the site (Map 5).

4.6 Fauna

A large portion of the mining area consists of natural vegetation and two game species have been introduced into this area. These species are Springbok (*Antidorcas marsupialis*) and Blesbok (*Damaliscus dorcas phillipsi*). Although some overgrazing is evident the stocking levels does not seem to exceed the capacity of the area. Having said this, the stocking levels of these game species should be monitored and should be managed accordingly.

The area is also being used for communal stock grazing and this is regarded as a much larger impact. The overgrazing of the domestic stock (cattle, donkey, horses, goat, sheep) is regarded as high in many parts of the site.

The site contains numerous other mammal species that are natural to the region. Several species were observed on the site including Aardvark (*Orycteropus afer*), Steenbok (*Raphicerus campestris*), Cape Hare (*Lepus capensis*) and Smith's Red Rock Rabbit (*Pronolagus rupestris*). Of these species the Aardvark and Smith's Red Rock Rabbit are protected species in the Free State Province. However, as long as the mining footprint is not enlarged significantly the impact on these species is anticipated to remain low.

A single spoor of the Cape Clawless Otter (*Aonyx capensis*) was encountered near a drainage line on the site. Several crab skeletons were also encountered. It is therefore considered likely that this species occurs on the site. However, the species wanders widely and would move from the site as disturbance becomes extensive. The species is listed as being of Least Concern according to the National Red List. The species is protected in the Free State Province.

The watercourses on the site support a very low amount of water birds. This is undoubtedly due to the high sediment load which negatively affects the aquatic fauna. The only water body on the site where water birds were observed was Dam 10 in the seasonal stream. These species include the Spur-winged Goose (*Plectropterus gambensis*), White-faced Duck (*Dendrocygna viduata*) and Yellow-billed Duck (*Anas undulata*). These species are widespread, common and well adapted to disturbed environments.

The site contains numerous Helmeted Guineafowl (*Numida meleagris*) but these are widespread and common and not of a significant concern.

A single specimen of Blue Korhaan (*Eupodotis caerulescens*) was observed on the plains of the site. This species is listed as Near Threatened in the National Red List and is also an endemic to South Africa. However, as long as the mining footprint does not enlarge significantly and does not encroach on the plains areas that are in relatively good condition the impact on the species would remain low.

A pair of Verreaux's (Black) Eagles (*Aquila verreauxii*) inhabits the steep cliffs of the Jagersfontein Kimberlite Pit. This species is widespread and is not regarded as endangered. The species is therefore not considered of significant concern. However, infilling of this pit would negatively affect this species and this impact would be discussed under Historical and Current Impacts.

Several Lesser Kestrels (*Falco naumanni*) were observed on the site. The species is a migrant to South Africa. It is listed as Vulnerable due to sharp declines in numbers at their Western Palearctic breeding grounds. The species utilises South Africa as wintering grounds. As long as mining activities do not expand into the grassland sections in a good condition the impact on this species will remain relatively low. This is because the birds would not forage in the disturbed areas but prefer open grassland in good condition.

5. Historical and Current Impacts

5.1 Historical Jagersfontein Kimberlite Pit (Fig. 35, 36 & 38)(Map 1 & 3)

Due to the surface area and depth of the pit it has several impacts on the environment. The most pronounced impact would be the disruption of drainage patterns and seasonal streams. A significant seasonal stream originates north west of the pit and flows in a south easterly direction. The pit is situated directly in the flow path of this stream. Essentially the stream has been cut off and does no longer form part of the natural drainage pattern. This disruption of the seasonal stream has occurred for at least a century during excavation of this pit. It is considered a significant impact as this amount of surface runoff is lost and flows into the pit where the water recharges the aquifer.

Several drainage lines from the west and south west of the pit has also been disrupted and surface runoff flows into the pit. This is also considered a significant impact.

The pit may also have a significant impact on fauna. The pit may act as a trap whereby numerous species, in particular reptiles, small mammals, amphibians and arachnids, fall into the pit and are killed on impact or succumb to starvation. Most of these species would not be able to survive inside the pit and the habitat inside the pit would not be able to sustain most species. The pit itself cannot be said to form a viable ecosystem. Although the pit sustains a number of species, i.e. Verreaux's Eagles, Rock Hyrax (*Procavia capensis*), the food chain is simple and consists of only a few species.

Infilling of the pit would most probably lead to the Verreaux's Eagles pair to vacate their breeding site. Since there are no suitable habitat nearby the pair would most likely move out of the area. The species is not considered rare or endangered and cannot be regarded as a large concern to the proposed backfilling of the pit.

Recommended Mitigation and Rehabilitation: From an ecological perspective the backfilling of the Jagersfontein Kimberlite Pit is preferred. Although backfilling of the pit is preferred it is unlikely that the drainage patterns would be recovered. A similar kimberlite pit in the town of Kimberley has recently been backfilled in the same manner. In this case the pit was filled to a level leaving the original outline of the pit and was converted into a wetland. This would also be preferred for the Jagersfontein Kimberlite Pit.

Converting the pit into a wetland would serve a much better ecological service. This wetland would serve as habitat for a much larger and viable faunal population.

5.2 Degraded area surrounding Jagersfontein Kimberlite Pit (Fig. 37 & 38)(Map 3)

The area surrounding the kimberlite pit has been subjected to several impacts since the establishment of the mine in the late 19th century. This area still contains excavated rubble, boulders and dilapidated infrastructure. The rubble and rock heaps around the pit form obstructions to water flow and cause damming of surface water flow. Due to the degraded condition of the area several weeds and invader species have become established in this area.

This area is considered severely degraded and the obstructed water flow is considered a large impact as well as the high abundance of exotic species.

Recommended Mitigation and Rehabilitation: If the Jagersfontein Kimberlite Pit is to be filled in and transformed into a wetland the surrounding area must also be rehabilitated. The rubble and boulder heaps must be removed or levelled where applicable. A weed eradication and monitoring programme must be initiated. The weeds and invaders surrounding the pit will degrade the sustainability of the proposed "pit wetland".

5.3 Existing processing plant and associated infrastructure (Fig. 37)(Map 1 & 3)

The processing plant and associated infrastructure, i.e. workshop, is situated in an area that has been previously degraded. This is considered a suitable location for the processing plant and the impacts caused by the plant is therefore kept to a minimum. The drainage patterns where the plant is situated has been severely degraded and consequently damming of water is problematic. To enhance drainage the implementation of V-drains should be investigated.

Recommended Mitigation and Rehabilitation: Improved drainage of the area should be implemented. The implementation of strategic V-drains must be investigated.

5.4 Existing and expanded slimes dam and included mine dumps (Fig. 38)(Map 1 & 3)

The existing slimes dam is of considerable age. Through the mining history of the area the slimes dam has also been used to dump rock waste in. Consequently the slimes dam also contains small mine dumps inside and on top of the dam.

The slimes dam itself acts as a water barrier and disrupts the flow of the natural drainage pattern. Consequently the drainage of the area especially to the west of the dam is problematic and damming of water occurs. Although this drainage pattern has been irreparably degraded by the slimes dam some management of water drainage should still be done.

The largest impact that the slimes dam itself has on the environment are the seepage of water and erosion of the dam walls causing an increased sediment load. The runoff from the dam walls accumulates sediment and these are then transported into the adjacent seasonal stream or deposited along the surroundings of the slimes dam. Although the runoff from the dam walls cannot be regarded as high it still constitutes a moderate impact.

However, the existing mine dumps on the slimes dam and along the borders of the dam have a much higher impact then the slimes dam wall itself. These mine dumps are subjected to high levels of erosion and high runoff rates. Consequently the sediment load from these mine dumps is high. The sediment from these dumps is deposited on the surrounding plains and a large amount of sediment is transported to the adjacent seasonal stream and downstream of the site.

Recommended Mitigation and Rehabilitation: Improved drainage of the area surrounding the slimes dam should be implemented. The implementation of strategic V-drains must be investigated.

Cut-off trenches or berms must be implemented along the walls of the dam to prevent any sediment from entering the natural drainage pattern.

The mine dumps on and surrounding the slimes dam must be removed, processed but must not be replaced on and around the slimes dam. The processed and screened sand from these dumps must either be dumped inside the kimberlite pit or must be dumped at an existing mine dump other than the present. The reason for this is that Dam 10 acts as a sediment trap and this prevents the majority of suspended sediment from being transported downstream. However, these dumps are situated outside the catchment of Dam 10 and consequently all sediment runoff from these dumps are transported downstream and not deposited in Dam 10.

5.5 Mine dumps (Map 1 & 3)

5.5.1 Sediment runoff from mine dumps (Fig. 3, 17, 18, 19, 20, 21, 22, 23, 28, 29, 31, 32)

The most pronounced impact of the mine dumps on the site is the large volumes of sediment being deposited in the streams and drainage lines on the site and downstream of the site.

The mine dumps are not vegetated and creates an unstable surface that is easily eroded. These slopes also contain a steep slope and this increases the instability of the soil surface. During rain events the sediment is liberated and transported downslope. Where the suspended sediment reaches the plains area a large amount of the sediment is deposited. The remaining suspended sediment is transported to the drainage lines and streams on the site. From these watercourses the sediment enters the stream system and is transported downstream.

The impact that this deposited and suspended sediment has is high. The deposited sediments blankets vegetation and smother low growing vegetation. This alters the species composition of the vegetation. The deposited sediment is also not natural as compared to the *in situ* soil and therefore it is not ideal for the establishment of a wide range of species. In stead it is the ideal disturbed environment for the establishment of weeds. As sediment is deposited after each rain event the smaller species and seedlings are covered and consequently perish. It is therefore clear that the sediment has a detrimental affect on the terrestrial vegetation.

A high amount of this sediment is transported into the seasonal stream on the site. Here it has even a higher impact. These seasonal streams have a high diversity of fauna that is activated on a seasonal basis by the advent of rains. This fauna survives times of drought by sheltering inside the soil or as eggs inside the soil. However, the sediment from these mine dumps are exceedingly fine and is not conducive to harbouring life. This diverse aquatic fauna is therefore adversely affected by the sediment deposited within the seasonal stream. A large portion of the aquatic fauna such as a large portion of protozoans, plankton and algae are dependant on sunlight filtering through the waster. As suspended sediment occurs in the stream water the turbidity of the water is increased. This prevents adequate sunlight from reaching the aquatic micro fauna and has a severe impact on the ecosystem of the seasonal streams. As this aquatic fauna forms a crucial role as a primary consumer in the food chain of the stream the fauna of these seasonal streams are severely impaired and absent in many areas.

Recommended Mitigation and Rehabilitation: If the correct mitigation is applied this impact will be kept to a minimum.

A berm and trench should be erected along the boundaries of these mine dumps. These berms should follow the contours around these dumps to ensure efficient functionality. The berm and trench will capture and slow runoff from these dumps. The suspended sediment will settle within the trench and cleaner water will flow over the berm. This will prevent a large amount of sediment being deposited on the plains and in the watercourses.

The large dam at the eastern border of the mine, Dam 10, should be utilised as a sediment trap. This dam currently acts as a sediment trap whereby water flow from the seasonal stream enters the dam, water flow slows, and sediment is deposited. The water then percolates from this dam into the seasonal stream, this water is much cleaner with fewer sediments. This is a good mitigation measure to limit the sediment downstream of the mine. However, there are two factors that contravene this mitigation.

Firstly, the sedimentation of this dam has lead to a large decrease in capacity. Dredging of the dam or increasing the damwall height should be investigated.

Secondly, several mine dumps or portions thereof are situated outside the watershed. The sediment that has been trapped by this dam is essentially just being added again by these dumps outside the watershed of the dam. It is recommended that these dumps be removed, processed and then dumped behind the dam catchment together with an existing dump so as to keep the footprint to a minimum.

A factor playing a large role in the erodability of the mine dumps are the steep slopes as well as the lack of vegetation on these dumps. To rehabilitate the dumps after processing the following must be considered:

- The volume of material post processing will be considerably lower.
- The resulting processed material should preferably be dumped in the Jagersfontein Kimberlite Pit. This would result in the lowest ecological impact.
- If processed material is returned to the original mine dump from where it was sourced it should be replaced with a moderate slope (lower than 50˚).
- Remove all mine dumps outside Dam 10 catchment, process, and replace the resulting processed material with an existing mine dump inside the Dam 10 catchment.
- The dumps may be contoured to reduce erosion.
- Topsoiling of the mine dump to promote plant growth.
- Seedbed preparation to maximise germination and plant establishment.
- Fertilizer application.
- Transplanting suitable species.

5.5.2 Obstruction of watercourses by mine dumps (Fig. 1, 2, 10, 14, 15, 21, 22)(Map 1 & 3)

Several historical mine dumps are placed in the flow path of several drainage lines and seasonal streams. These dumps have affected each drainage line and stream in differing manners but all are considered to have had a high impact on the stream/drainage line.

A dump occurring in the central eastern portion of the mining area is situated within a drainage line. The mine dump is of such a size and orientation that the drainage line is unable to circumvent the dump. As a result a substantial wetland has formed upstream of the dump. This wetland is artificial in nature and is not in a good condition. Downstream of the mine dump the drainage line has caused increased sediment runoff from the dump and this is visible as a sediment plume downstream of the dump. The preferred course of action would be to rehabilitate the drainage line and restore the natural flow pattern of the drainage line.

A mine dump occurring in the western portion of the area is also situated in the flow of a drainage line. A damwall has also been constructed on the western border of this mine dump. As a consequence the surface runoff has formed a substantial artificial dam upstream of the damwall. Downstream of this mine dump the sediment runoff is increased as a result of the drainage line and sediment runoff from the mine dump. This is visible as a sediment plume downstream of the dump. Although it is not considered that the damwall itself contributes a large impact on the drainage line the mine dump and resulting sediment is considered a large impact on the drainage line.

Three mine dumps are situated in the northern portion of the mining area. These mine dumps are situated within or adjacent to minor drainage lines. Although these drainage lines are minor and not distinctive they transport a significant surface water flow. This is substantiated by the large sediment plumes downstream of these mine dumps as well as the dams constructed in the flow channel.

Recommended Mitigation and Rehabilitation: The preferred rehabilitation and mitigation would entail the following:

The mine dumps should be removed, processed and dumped within the Jagersfontein Kimberlite Pit. This will entail the lowest ecological impact and would promote rehabilitation of the currently heavily degraded drainage lines. If these dumps are removed all remaining sediment must be removed as well as those sediments that have accumulated in the drainage lines (sediment plumes). The removal of the dumps should not entail excavation of the virgin soil levels. The areas where the dumps were removed should be monitored to ascertain if the drainage lines are able to function naturally (minimal damming/ponding of drainage lines).

If backfilling of the Jagersfontein Kimberlite Pit is approved these dumps situated in drainage lines should be given preference over other dumps as they have the highest impact and their removal must take priority.

If it is not possible to dump these mine dumps in the pit they should still be removed, processed but not replaced in or alongside these drainage lines. These processed dumps should rather be placed together with the central, largest mine dump as this mine dump is not situated in a drainage lines and this will also enable better management of sediment runoff apposed to the management of several smaller mine dumps.

5.6 Gully erosion of drainage lines in plains areas (Fig. 3)(Map 1 & 3)

Several drainage lines occur in the plains on the mining area in between the dolerite hills. Most of these drainage lines contain a high amount of gully erosion. The erosion is caused and exacerbated by increased runoff from mine dumps and inadequate drainage of roadways. Gully erosion is a process that is not easily remedied and once the onset of gully formation has taken place erosion only progresses.

Recommended Mitigation and Rehabilitation: The most beneficial treatment of the gully would be treatment of the cause. Therefore the placing of processed mine dumps within the Jagersfontein Pit is further encouraged. The correct drainage of roadways and culverts installation would also alleviate gully formation.

Several techniques are available for the rehabilitation of gullies and these are easily obtainable.

5.7 Liberation of dust from mine dumps, processing plant and sand screens

The mine dumps and other processed materials contain amongst others a very fine sediment that is easily liberated. During mining activities this amount of liberated dust is increased.

This dust then settles on the surroundings. Where a large amount of dust settles on the surrounding vegetation the leaf surfaces are covered by the dust. When leaf surfaces become covered in dust the photosynthetic ability and gas exchange of the plants are inhibited. This has a high impact on the immediate surrounding vegetation.

Recommended Mitigation and Rehabilitation: Utilise dust suppression techniques such as water spraying.

5.8 Roadway from processing plant to sand screens (Fig. 21, 22 & 23)(Map 3)

The roadway constructed from the processing plant to the sand screens to the south is broad (approx. 50m) and crosses the seasonal stream on the site. The roadway causes a high impact on this seasonal stream.

This roadway acts as a barrier to water flow. Although the road contains culverts these are not adequate to allow for normal water flow. In addition, due to the high amount of sediments from the mine dumps that end up in the stream the culverts are easily blocked by these large amounts of sediment. The consequence of water flow retardation is damming of water and sediment. Sediment has accumulated to such an extent that most plant species have been excluded from this area.

Recommended Mitigation and Rehabilitation: Adequate culverts should be installed underneath the roadway. This will ensure adequate and natural flow rate of the seasonal stream.

Periodic removal of accumulated sediments to ensure that culverts remain free draining.

5.9 Extensively dumped screened sands (Fig. 23, 24 & 25)

Processed and screened sands are currently being dumped extensively to the south of the seasonal stream. These sand dumps have a high impact on the surroundings but especially on the seasonal stream.

These dumps have a large footprint area. They cause a major obstruction to the natural drainage of the area. Surface runoff follows a south west to north east flowpath. Therefore these sand dumps cause a runoff obstruction. In addition runoff from these dumps accumulates a large amount of fine sediment which is transported into the seasonal stream. This is considered a high impact.

Recommended Mitigation and Rehabilitation: These screened sand dumps must be removed. The sand must preferably be dumped inside the Jagersfontein Kimerlite Pit. This would have the lowest ecological impact.

If this is not possible the sand must be dumped in a heap that has more height but utilises a lower amount of surface area. This will decrease the footprint of the dump and would also allow for better management of sediment runoff. The sand should also not be dumped immediately adjacent to the seasonal stream as this area is considered sensitive and the amount of sediment that is deposited in the stream would decrease if this sand dump is placed further from the seasonal stream.

5.10 Internal road network (Fig. 6, 10, 16, 21, 22 & 23)

The mining area contains an extensive internal road network. These roadways are concentrated around the processing plant, slimes dam and sand screens but several roadways extend into the natural plains areas. These roadways extending into the natural plains are mostly single track dirt roads. The roads have been covered by a layer of crushed kimberlite. It has been indicated by the project company that these kimberlite coverings may still contain diamond deposits. They have indicated that this kimberlite covering will be removed and processed. This will be preferred as it will lead to alleviation of negative impacts caused by these roads.

These roadways are often elevated above the virgin soil level as a result of the kimberlite covering. These roads also do not contain any culverts to allow for drainage. The roads also cross drainage lines at several points. The lack of culverts, the erodable kimberlite covering as well as the elevation of the roadways above the virgin soil levels cause several impacts. The roadways cause ponding of drainage lines and as the kimberlite covering is highly erodable this causes erosion of the roadways, this is particularly evident on the airstrip in the west of the mining area.

Recommended Mitigation and Rehabilitation: As indicated by the project company the kimberlite covering the roadways must be lifted processed and dumped together with other processed materials inside the Jagersfontein Kimberlite Pit or at an existing dump.

After removal of the kimberlite covering the roadway should be level with the virgin soil level, if this is done the installation of culverts will also not be necessary as water flow will no longer be impeded.

Those roadways that become unused as the lifespan of the mine nears its end should be rehabilitated. This must included ripping of the roadways.

The maintenance of the airstrip is currently in progress. The natural drainage should be diverted around this airstrip, i.e. V-drains, to prevent extensive runoff on the airstrip itself. Attenuation berms in the V-drain will also prevent runoff to attain high velocity and consequently high erosive force. The airstrip should preferably not be raised above the virgin soil level. If the airstrip is lifted the installation of culverts underneath the airstrip should be done.

5.11 Historical Kimberlite Weathering Fields (Fig. 39, 40 & 43)

In the early years of mining (late 19th century) the miners would excavate the kimberlite and lay these out in extensive boulder fields to weather before processing it. Many of these fields were left unprocessed and these kimberlite boulder fields are still present today. These kimberlite fields are easily visible and form extensive fields of neatly arranged rows. Although these fields are old and have been left unprocessed for an extensive period these areas are still considered as degraded.

These kimberlite fields are old and through succession they have attained a stable community structure. However, these boulders were lain out on the plains. These plains are characterised by their absence of surface rock as a result of continuous sediment deposition. This is a natural process. The vegetation adapted to these plains is also not adapted to surface rock. As a result the species composition of these kimberlite fields have been altered from the natural state.

Large portions of the mining area contain these kimberlite boulders. These are mostly isolated piles. The extensive kimberlite boulder fields are found in the east of the mining area. From an ecological perspective this area is degraded and should any expansion of mining activities be required this area may be considered most appropriate as it is transformed and in a degraded state.

Recommended Mitigation and Rehabilitation: As this is regarded as a transformed and degraded area it is considered the most preferred area should any mining activities be expanded, e.g. slimes dam. However, this area is also situated outside the catchment of Dam 10 and although no drainage lines are situated within the area any surface runoff from this mining expansion must be managed accordingly to prevent sedimentation of the seasonal stream.

5.12 Existing stone quarry (Fig. 13)

In the centre of the mining area a large stone quarry exists (approx. 80m in diameter). The quarry is expected to be quite old. The quarry is periodically filled with water via surface water runoff. The surface water currently flowing into the quarry would naturally flow into the seasonal stream. The impact that the quarry has is considered moderate.

Recommended Mitigation and Rehabilitation: It is preferred that this quarry be backfilled and covered with a layer of topsoil. The quarry may be filled with screened sand or waste rock as long as a layer of topsoil is spread on top.

5.13 Historical dams and surface runoff drain along hillslope (Fig. 7, 8, 9, 11 & 12)(Map 1)

Several artificial dams/weirs have been constructed in the mining area since the mine opened in the late 19th century. The largest of these occur near the centre of the mining area. This is possibly also the oldest dam. Due to sedimentation these dams have lost most of their capacity. Due to this sedimentation and the age of the dams the vegetation in and along these dams have stabilised and are not in a degraded condition. It can be concluded that these dams do not have a significant detrimental affect on the ecology of the seasonal streams and drainage lines. However, as discussed previously several of these dams also contain mine dumps downstream which do have a high impact on the streams.

The large, old dam as discussed above also contains a very long runoff capturing ditch. This ditch or canal is also of considerably age and must have been constructed near the late 19th century. The canal runs along the footslope of the largest dolerite capped hill in the south west of the mining area. This canal captures all the runoff from the steep slopes of the dolerite capped hill and transports this water to the dam. Due to the age of this canal and the dam this system is no longer functional. The area along the runoff canal has stabilised as a result of its age. Although a limited amount of erosion is still present along this canal the option of removing it would result in degradation of the environment due to erosion along the footslopes.

Recommended Mitigation and Rehabilitation: Due to the age of these dams the initial disturbance that they caused to these streams and drainage lines has long been stabilised. It is considered that the removal and rehabilitation of these dam walls and surface runoff drain would lead to more disturbance and degradation than it would lead to improvement of the environment. Therefore it is considered the better option to leave these dams and surface runoff drain as is.

5.14 Weed Infestation (Fig. 37)

Through the long history of the mine many areas have become degraded as discussed under the previous headings. These degraded areas are highly susceptible to infestation by exotic weeds and invaders. As a result, large areas are dominated by these weeds (refer to Appendix C).

These weeds exclude natural pioneers and prevent the establishment of natural vegetation. Furthermore, these weed dominated areas act as distribution nodes whereby other disturbed areas become infested.

Recommended Mitigation and Rehabilitation:

The implementation of a weed eradication programme is highly recommended (refer to Appendix C). The use of local unschooled labour should be investigated for use in this programme. Eradication must initially concentrate on areas where mining activities have ceased, i.e. around the Jagersfontein Pit, derelict buildings, along water courses, but must eventually include the entire mining area.

Those weeds that are removed must be taken from the area and dumped in the stone quarry or Jagersfontein Pit or can alternatively be taken to the local landfill site.

6. Conclusions

This Biodiversity Management Plan should be used to guide the management of the current ongoing mining activities and any proposed expansion. The proposed recommended mitigation and rehabilitation measures must be taken into consideration and should be used to improve the ecological status of the ecosystem on the site.

The Site Sensitivity Map (Map 3) must also be used as a guideline throughout the operation of the mine and is a crucial tool during any expansion of mining activities.

- The Site Sensitivity Map indicates areas of Very High Sensitivity. These areas consist of the drainage lines and seasonal streams on the site. Impacts on these areas should be prevented and rehabilitation of these areas is a priority.

- Areas of High Sensitivity consist of hills, ridges and surface outcrops. These areas should also be excluded from mining activities.
- Areas of Moderate Sensitivity consist of plains habitat in relatively good condition as well as areas of problematic drainage around the processing plant. The plains areas should preferably be excluded from activities and expansion. The area around the processing plant where the drainage has been degraded and ponding is a common problem should preferably be improved using V-drains.
- Areas of Low Sensitivity consist of areas that contain natural vegetation but have been severely degraded by previous and current mining activities. These areas may be considered for any expansion of mining activities. However, if the Jagersfontein Pit is to be filled and transformed into a wetland the degraded surrounding area should also be rehabilitated to fit the wetland.
- Very Low Sensitivity areas consist primarily of mine dumps, slimes dam and processing plant. These areas are severely degraded to such an extent that rehabilitation to its natural condition is unlikely and considered unfeasible. However, rehabilitation of these areas should still be done to such an extent that these areas do not pose an environmental risk to the surroundings.

The mine dumps occurring on the mining area is considered the largest environmental impact and the rehabilitation of these dumps must be given a high priority.

The backfilling of the Jagersfontein Kimberlite Pit is highly desired as this would mitigate and eliminate several of the impacts associated with the mine dumps as the material would be dumped in the pit after processing.

The seasonal streams, drainage lines and overall drainage pattern on the site are considered to be in a degraded condition. This is primarily due to mining activities especially those impacts associated with the existing mine dumps. The drainage system on the site also forms the headwaters of a tributary of the Prosesspruit which eventually feeds into the Riet River. Therefore any impacts within these headwaters will be propagated downstream of the impact and will also affect downstream water users. This is all the more reason why the seasonal streams and drainage lines on the site should be managed in accordance with this Biodiversity Management Plan and rehabilitation thereof is highly recommended.

It is recommended that rehabilitation commence once activities in an area is completed, i.e. completed processing of a mine dump. It is also recommended that prior to closure an ecologist is consulted to identify areas of priority and possible rehabilitation procedures.

Mining operations should strive to keep environmental impacts to a minimum and must endeavour to improve the ecology, especially pertaining to the drainage systems, on the site.

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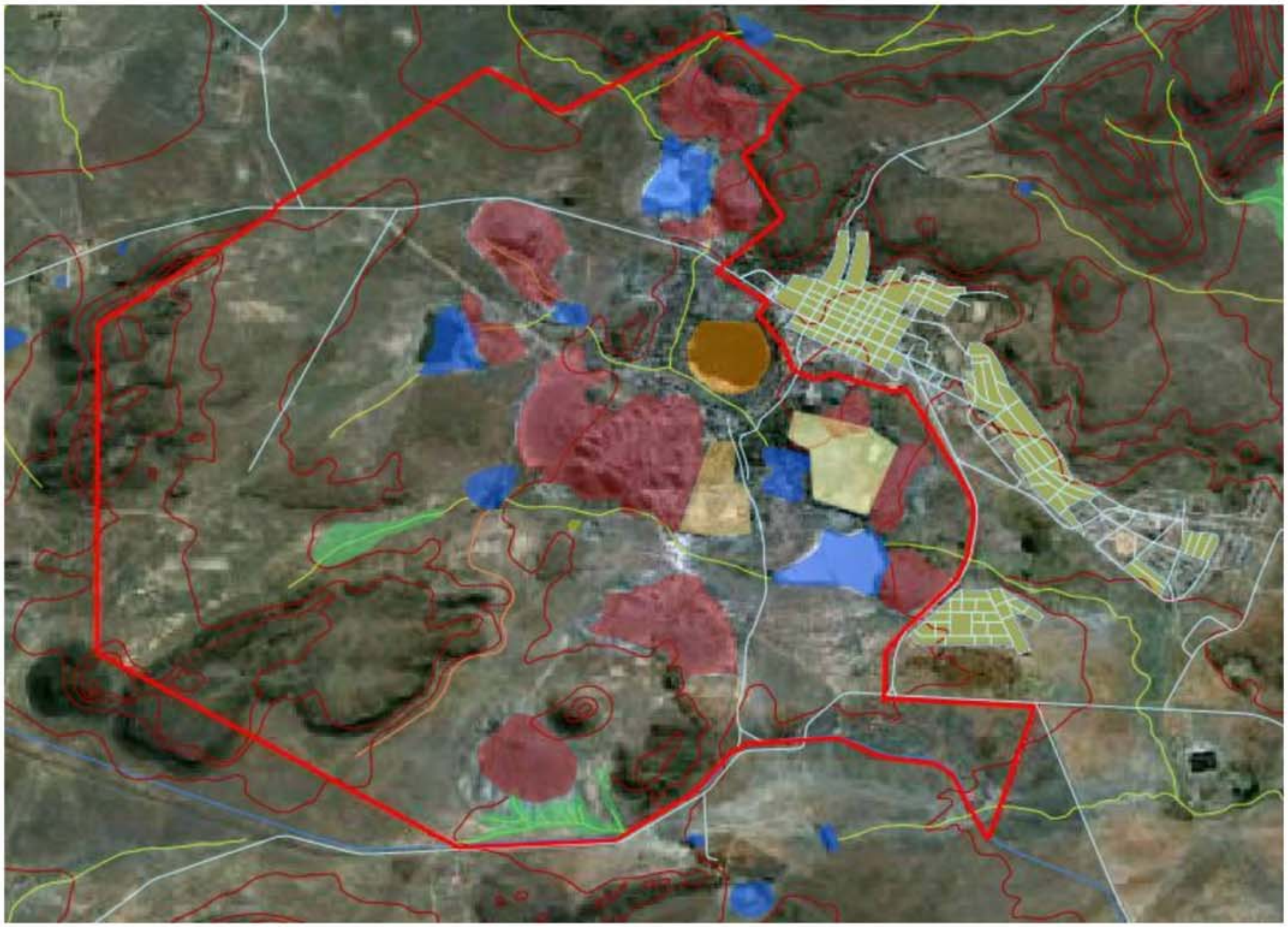
Annexure A: Maps and Site photos

Mining and landscape features of the Jagersfontein Mining Area.



Map 1: Map illustrating the surface features of the Jagersfontein mine as well as surrounding area. Note the Jagersfontein town to the north of the mine.

Preparred for:
Jagersfontein Developments

Legend:

- Streams and Drainage Lines
- Contours
- Roadways
- Historical Water Canal

- Mine Dumps
- Jagersfontein Pit
- Processing Plant
- Slimes Dam
- Artificial Dams
- Erosion Gullies

- Mining Area Boundary

Map Information

Spheroid: WGS 84

Map Design: Quantum GIS

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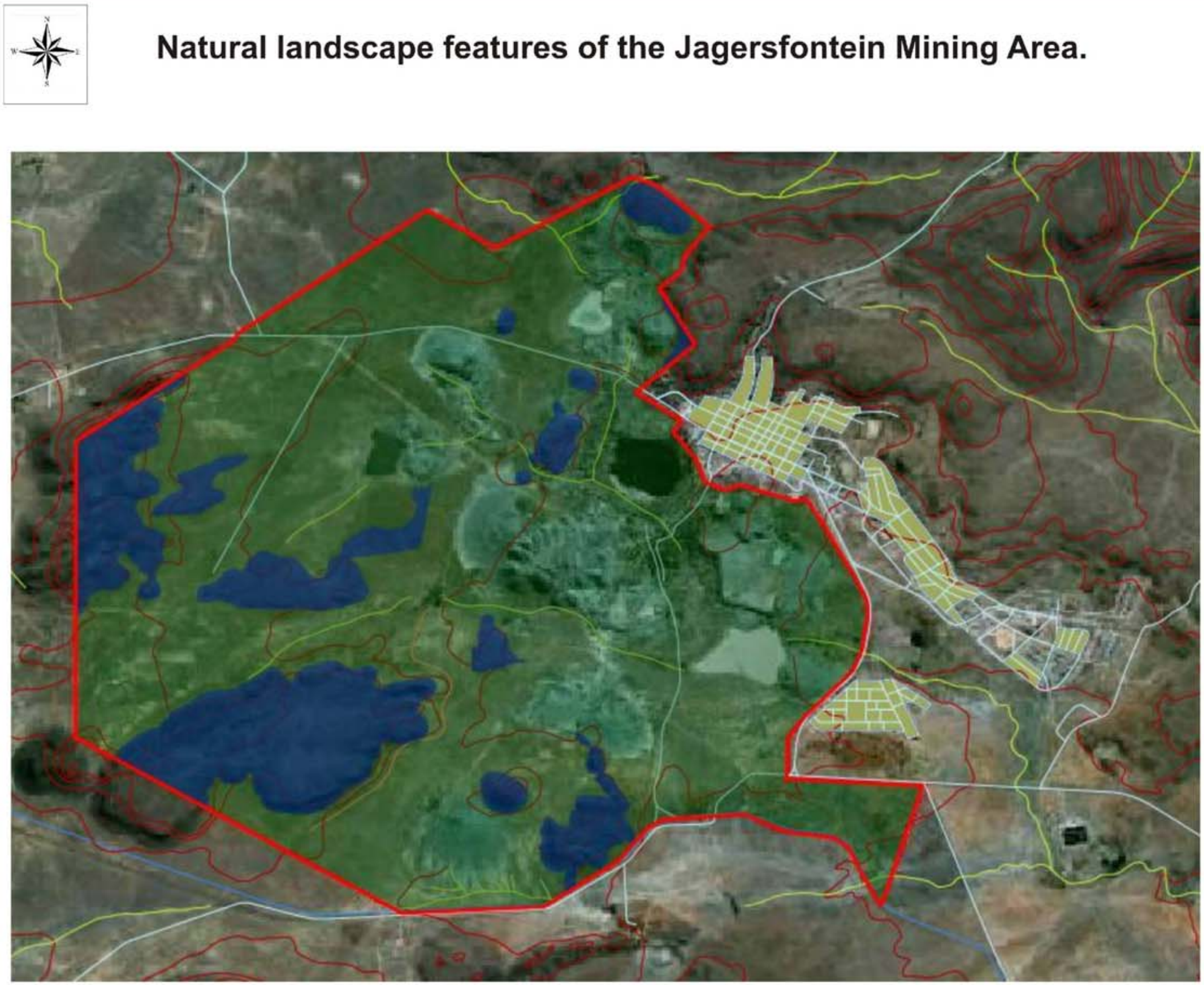
Natural landscape features of the Jagersfontein Mining Area.



Map 2: Map illustrating the Dolerite capped hills, ridges and surface dolerite exposures as well as the plains areas in the Jagersfontein Mining Area. Note that the majority of hills are situated in the west and south of the mining area.

Prepared for:
Jagersfontein Developments

Legend:

- Hills, ridges and surface rock exposures
- Plains
- Mining Area Boundary

Map Information

Spheroid: **WGS 84**

Map Design: Quantum GIS

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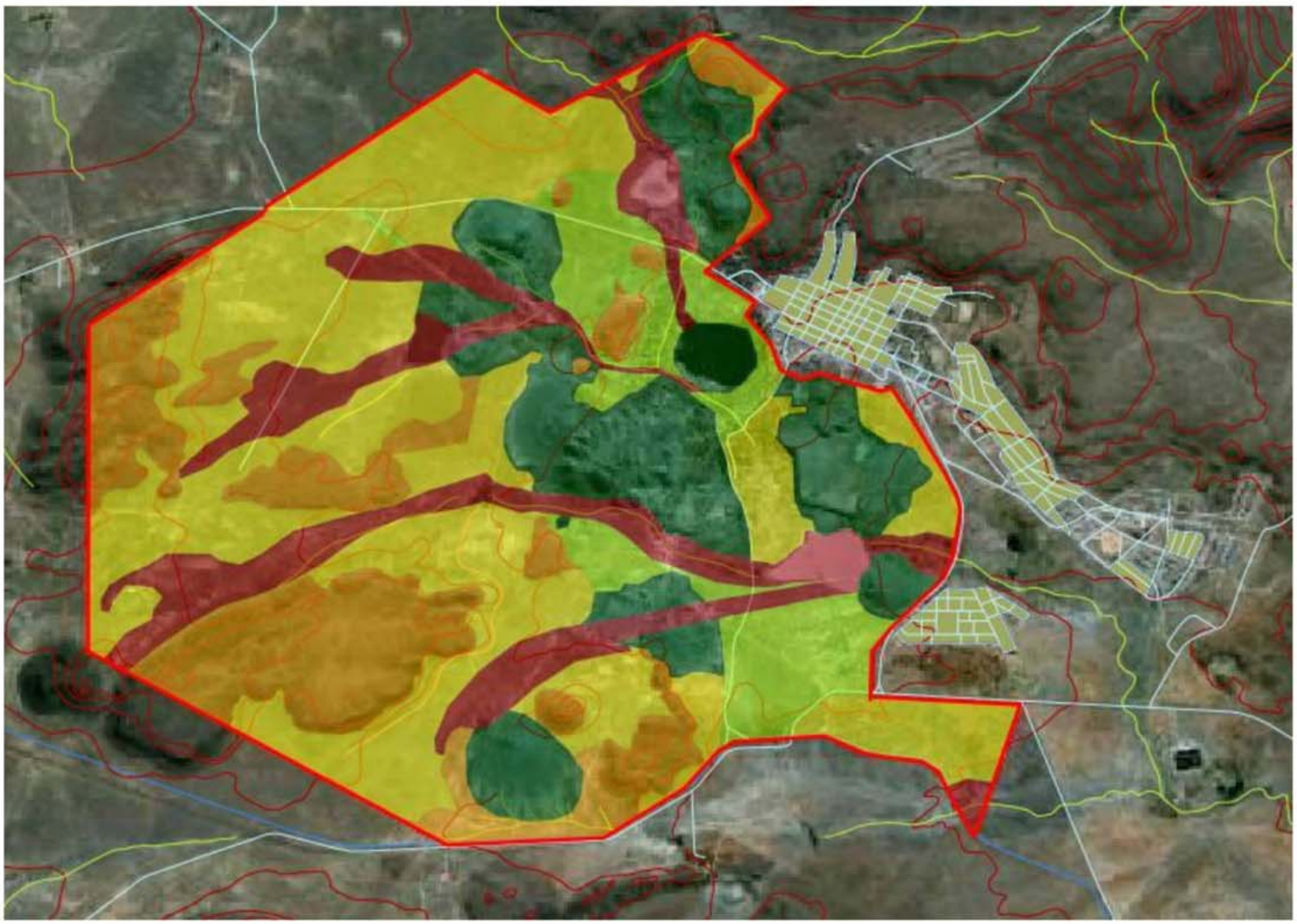
Site Sensitivity Map of the Jagersfontein Mining Area.



Prepared for:
Jagersfontein Developments

Legend:

- Very High Sensitivity
- High Sensitivity
- Moderate Sensitivity
- Low Sensitivity
- Very Low Sensitivity
- Mining Area Boundary

Map Information

Spheroid: WGS 84

Map Design: Quantum GIS

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Map 3: Map illustrating the sensitivity of the ecological features of the Jagersfontein Mining Area. Very High Sensitivity areas consists of streams and drainage lines. High Sensitivity areas consists primarily of hills, ridges and outcrops. Moderate Sensitivity areas consist of natural plains and essential drainage areas. Low Sensitivity areas consist of natural areas that has been severely degraded by mining activities such as kimberlite fields. Very Low Sensitivity areas consist primarily of mine dumps, processing plant and slimes dam.

Approximate watershed of Dam 10 within the mining area, Jagersfontein.

Preparred for:
Jagersfontein Developments

Legend:

- Existing mine dumps
- Approximate Dam 10 watersheds
- Mining Area Boundary

Map Information

Spheroid: **WGS 84**

Map Design: Quantum GIS

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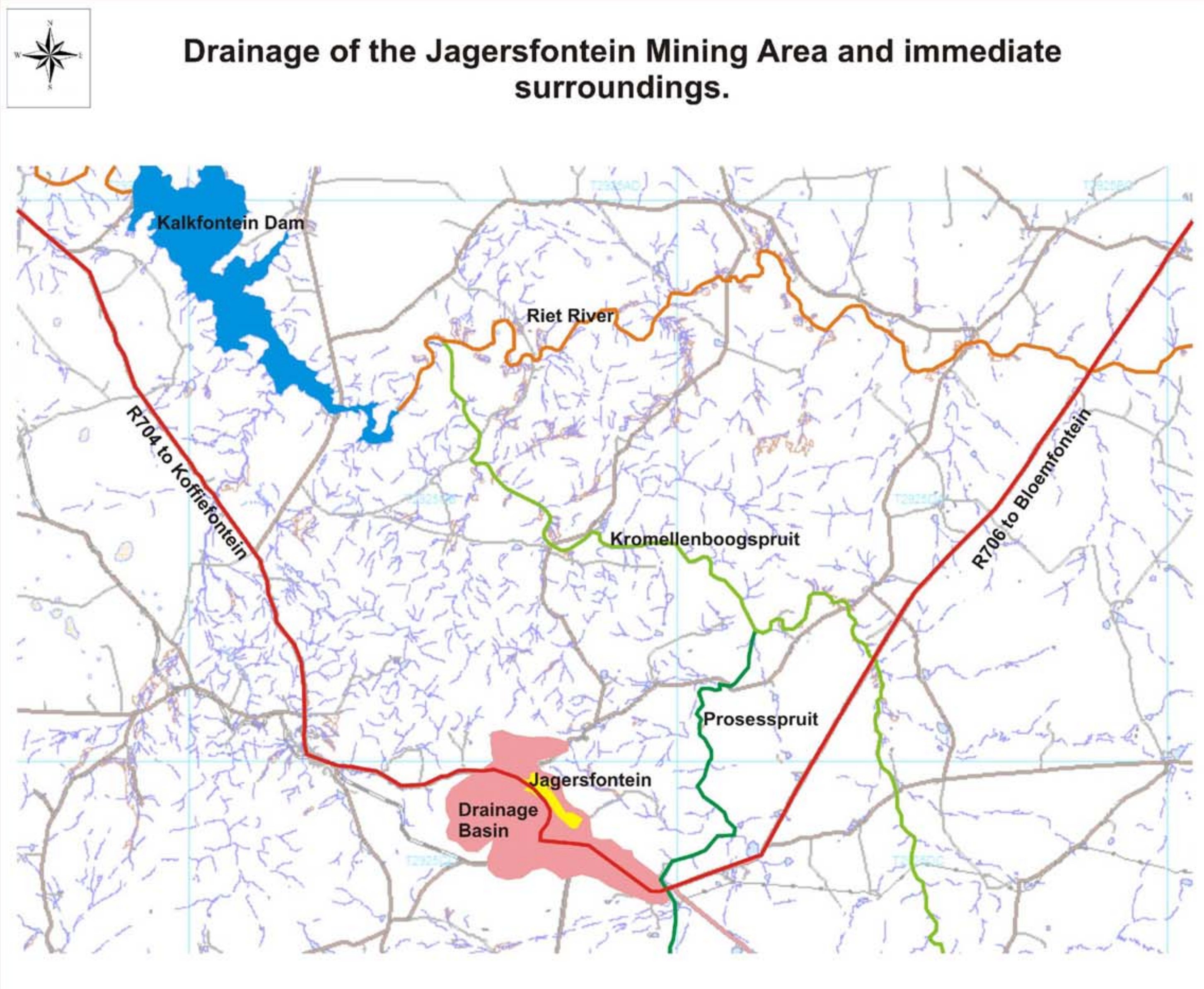
Map 4: Map illustrating the approximate watershed of Dam 10. Although the watershed is only an approximation and not determined using reliable methods it is considered to be fairly accurate representation of the watershed. The aim of this map is to illustrate that several mine dumps or portions of mine dumps are situated outside this watersheds, therefore, the sediment runoff from those dumps will not be trapped by Dam 10 and will consequently enter the downstream watercourses.

Drainage of the Jagersfontein Mining Area and immediate surroundings.



Preparred for:
Jagersfontein Developments

Legend:

- Prosesspruit
- Kromellenboofspruit
- Riet River
- Tarred Road
- Jagersfontein Drainage
- Jagersfontein Town
- Kalkfontein Dam

Map Information

Spheroid: **WGS 84**

Scale: 1:250 000

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Map 5:The drainage pattern and river systems into which the drainage basin on the site feeds into. The drainage system on the site drains into the Prosesspruit from where this stream drains into the Kromellenboogspruit. This stream drains into the Riet River which in turn feeds the Kalkfontein Dam.

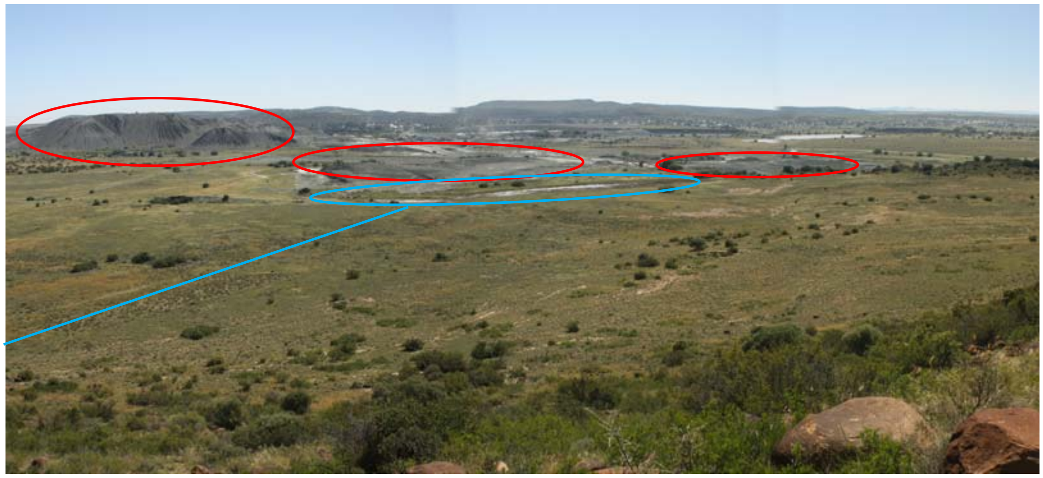


Figure 1: Panorama of mining activities on the site. Visible mine dumps are indicated (red circles). A drainage line flowing from south west has been obstructed by a mine dump and has consequently formed an artificial and degraded wetland. The drainage line and wetland is indicated in blue.

Figure 2: Panorama of the same drainage line as depicted in Fig. 1. The drainage line is indicated in blue.

Figure 3: A close-up of the drainage line as depicted in Fig. 2. The erosion of this drainage line is unnatural and considered a large disturbance. The erosion is caused by increased runoff from a mine dump to the south of the drainage line.

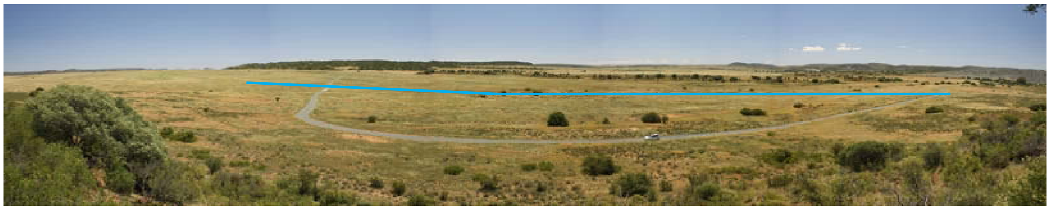


Figure 4: Panorama of another drainage line further west than the one depicted in Fig. 2. The drainage line is indicated in blue.

Figure 5: Close-up of the drainage line depicted in Fig. 4 (indicated by blue line). Note the sheet erosion. The drainage line itself also exhibits moderate gully erosion.

Figure 6: Selection of photographs illustrating areas where the internal road network causes ponding and erosion. This is due to the lack of culverts and the elevation of the roadways above the virgin soil level.

Figure 7: Panorama of the wall of a very old dam on the site. As can be seen the capacity of the dam has severely decreased due to sedimentation over the years.

Figure 8: The surface runoff drain along the slopes of the large southern hill formation in the mining area. The drain was most probably constructed during the late 19th century.

Figure 9: Panorama of the dam situated in the northern corner of the mining area. The dam is subjected to sedimentation by surrounding mine dumps and upon closer inspection a thick layer of mine dump sediment cover the soil layer.

Figure 10: Panorama of an artificial pond adjacent to the dam depicted in Fig. 9. These ponds are a result of disturbance of the natural drainage pattern. This is primarily due to obstructions such as mine dumps, roadways and inadequate drainage in disturbed areas.

Figure 11: Panorama of Dam 10 near the eastern border of the mining area. The dam is quite large but has lost much of its capacity due to sedimentation from mine dump runoff.

Figure 12: Panorama of the inflow of Dam 10. This area is periodically flooded and consists of an extensive wetland (blue figure). This wetland is a result of the dam and would, under natural conditions, be much smaller. The blue arrow indicates the main channel and inflow of the dam.

Figure 13: The large stone quarry situated in the centre of the mining area. The quarry acts as a surface water runoff trap. This is considered a degraded area.

Figure 14: Panorama of the mine sump situated to the south of the processing plant. This is the same dump as depicted in Fig. 1 which obstructs a drainage line and leads to the formation of an artificial wetland (blue figure).

Figure 15: A close-up panorama of the above depicted wetland.

Figure 16: Panorama of the large main, central mine dump as well as a portion of the seasonal stream (stream indicated in blue). A roadway also crosses this seasonal stream.

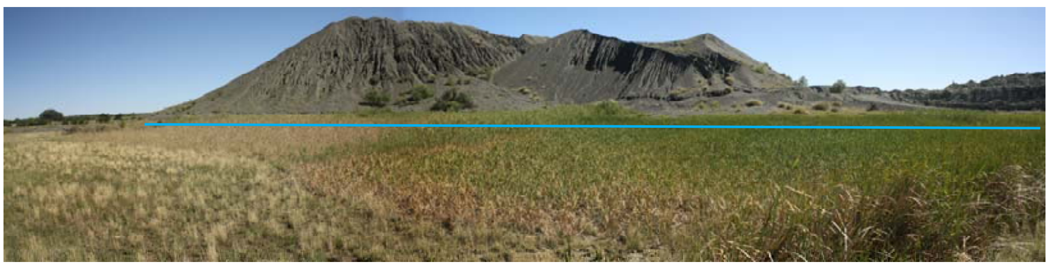


Figure 17: Panorama of the large, main mine dump as well as the seasonal stream (stream indicated by blue line). The dominance of Bulrush (*Typha capensis*) is not natural and is caused by retardation of water flow by road crossings, inadequate culverts, continuous sedimentation and increased runoff from the mine dump.

Figure 18: Panorama of the seasonal stream (blue line). The large main, central dump is located to the left of the stream. Sedimentation of the stream is severe and leads to severe degradation of the stream.

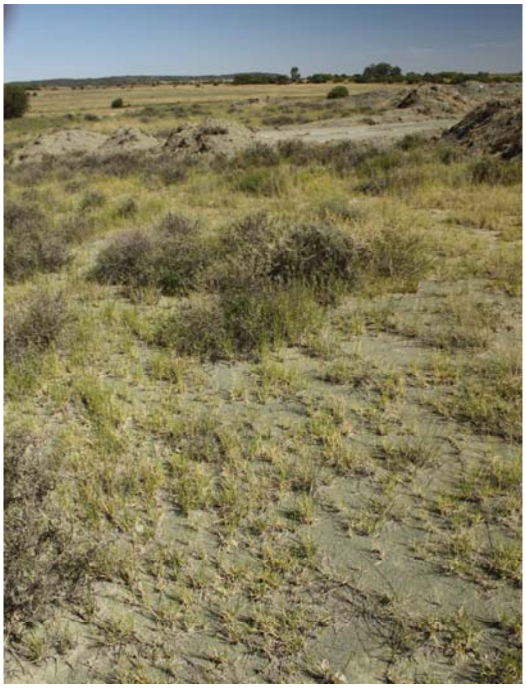


Figure 19: Portion of the floodplain of the seasonal stream. The sediment deposition is clearly visible in the foreground. This leads to severe disturbance including low percentage vegetation cover which is clearly visible.

Figure 20: Another photograph adjacent to the seasonal stream. Sediment deposition is clearly visible. This causes a severe impact and leads to areas where vegetation is excluded as is the case in this picture.

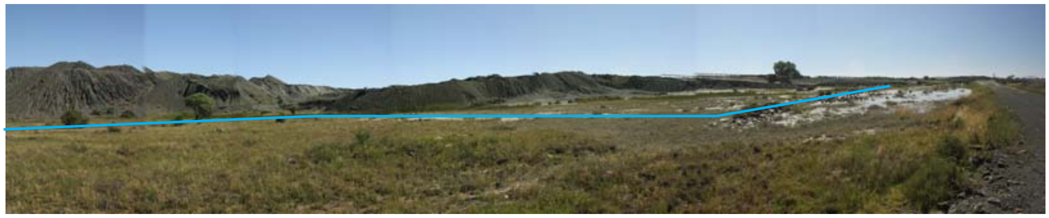


Figure 21: Panorama of a portion of the large main, central dump as well as the seasonal stream on the site (stream indicated in blue). As can be seen the roadways as well as the dumps has caused damming of the seasonal stream; this is unnatural and considered a large impact. Sedimentation of the seasonal stream in this area is also severe as caused by sediment runoff from the mine dump.

Figure 22: Panorama of the area where the seasonal stream is crossed by a wide roadway (stream indicated in blue). The culverts are not adequate and together with sedimentation form the adjacent large main dump the stream is severely degrade in this area. Sedimentation and inadequate culverts have caused damming of the seasonal stream. The deposited sediment forms a thick covering layer and has essentially smothered all plant life.

Figure 23: Panorama of the seasonal stream (blue line) downstream of the main road crossing. Due to flow retardation upstream of the roadway the stream is much smaller and severely degraded due to sedimentation and screened sand dumping.

Figure 24: Extensive screened sand dumping south of the seasonal stream. These sand dumps cause severe disturbance of the adjacent seasonal stream. The sand dumps act as a surface runoff barrier and cause ponding of surface water. The sand dumps also cause severe sedimentation of this stream.

Figure 25: A close-up panorama of the screened sand dumps. The extensive nature of these dumps are evident.

Figure 26: Panorama of the seasonal stream near the eastern border of the mining area.

Figure 27: Panorama of the seasonal stream as it exits the mining area on the eastern border (blue line). The border of the mining area is visible as the fence line. The damwall of Dam 10 is indicated in red. This dam acts as a sediment trap and most of the suspended sediment is deposited in this dam. However, mine dumps outside the catchment of this dam releases sediment into the stream downstream of the dam.

Figure 28: Panorama of the seasonal stream at the R704 road crossing approximately 1,5km east from the border of the mining area. The sediment resulting from the mine is still evident at this site. In addition disturbance caused by the Charlesville settlement adds to the degraded state of this stream.

Figure 29: A close-up of this stream as depicted in Fig. 28. Note that suspended sediment increase turbidity of the water and sediment deposition occurs along the banks (red figure). This area is located approximately 1,5km from the boundary of the mine.

Figure 30: Panorama of the large main, central mine dump as seen from a western perspective.

Figure 31: Panorama of the large main, central mine dump as seen from a north western perspective. Note the thick covering of sediment resulting from the runoff from the mine dumps. This sediment has caused degradation of the vegetation and soil surface. Note the low percentage vegetation cover and low species diversity.

Figure 32: Panorama of a sediment plume of one of the mine dumps. The sediment is quite thick and causes substantial degradation of the natural vegetation.

Figure 33: Close-up panorama of one of the hill slopes in the mining area.

Figure 34: Panorama of one of the hills in the mining area. These hills are considered sensitive areas.

Figure 35: The Jagersfontein Kimberlite Pit.

Figure 36: One of the drainage lines that flows into the Jagersfontein Pit. This drainage line has essentially been cut off from the drainage pattern on the site.

Figure 37: The area surrounding the Jagersfontein Kimberlite Pit as well as the processing plant is severely infested by exotic weeds. Disturbance of this area has occurred over an extended period during previous operation of the mine.

Figure 38: Drainage around the existing slimes dam and Jagersfontein Pit. The drainage pattern in this area has been altered and transformed. It is therefore in a highly degraded condition.

Figure 39: A portion of the historical kimberlite fields on the southern side of Dam 10. These fields are considered to be disturbed areas. The rows of kimberlite boulders are clearly visible.

Figure 40: A portion of the historical kimberlite fields on the northern side of Dam 10. The strewn kimberlite boulders are clearly visible. The vegetation in this area is transformed from the natural but is in a stable condition.

Figure 41: Panorama of the plains in the mining area. The plains are dominated by grass species with a strong dwarf karroid shrub element.

Figure 42: Panorama of the plains in the mining area.

Figure 43: A selection of photographs illustrating the historical dumping of kimberlite boulders to weather. These heaps litter the plains and cause localised disturbance. The vegetation on and around these have been transformed and as is evident from most photographs trees establish on these heaps which is not natural to the plains environment.

Appendix B: Species List

Species indicated with an * are exotic.

Species	Growth form
Hills and Ridges Habitat	
Searsia burcherllii	Small tree
Searsia erosa	Shrub
Searsia ciliata	Low shrub
Olea europea subsp. *africana*	Tree/Protected Species
Ehretia rigida	Large shrub
Buddleja saligna	Tree
Diospyros austro-africana	Shrub
Osyris lanceolata	Large shrub
Tarchonathus minor	Shrub
Gmnosporia buxiifolia	Shrub
Cussonia paniculata	Tree/Protected Species
Salsola calluna	Dwarf Karroid Shrub
Tragus koelerioides	Grass
Themeda triandra	Grass
Hyperhenia hirta	Grass
Amphiglossa triflora	Dwarf Karroid Shrub
Gnidia polycephala	Dwarf Karroid Shrub/Disturbance indicator
Selago densiflora	Dwarf Karroid Shrub
Eriocephalus ericoides	Dwarf Karroid Shrub
Helichrysum zeyheri	Dwarf Karroid Shrub
Indegofera alternans	Creeping Herb
Asparagus striatus	Dwarf Karroid Shrub
Cyperus congestus	Sedge
Gomphocarpus tomentosus	Herb
Cymbopogon plurinodis	Grass
Elionurus muticus	Grass
Pentzia quinquifida	Dwarf Karroid Shrub
Felicia fillifolia	Dwarf Karroid Shrub
Pellaea calemelanos	Fern
Cheilanthes eckloniana	Fern
Jamesbrittenia pinnatifida	Herb
Aristida diffusa	Grass
Chascanum pinnatifidum	Herb
**Opuntia ficus-indica*	Exotic Invader/Succulent
Heteropoogon contortus	Grass
Eustachys paspaloides	Grass
Chasmatophyllum mustellinum	Dwarf Succulent
Crassula corallina	Dwarf Succulent
Solanum tomentosum	Herb/Disturbance Indicator
Anacampseros filamentosa	Dwarf Succulent/Protected

	Species
Eragrostis nindensis	Grass
Gazania krebsiana	Herb
Stachys linearis	Dwarf Shrub
Pogonathria squarrosa	Grass
Selago albida	Dwarf Karroid Shrub
Hermannia vestita	Herb
Asparagus suaveolens	Dwarf Karroid Shrub
Melolobium candicans	Dwarf Karroid Shrub
**Nicotiana glauca*	Exotic Invader
Aloe broomii	Succulent/Protected Species
Aloe claviiflora	Succulent/Protected Species
Lotononis laxa	Herb
**Conyza bonariensis*	Exotic Weed
Ipomoea oenotheroides	Herb
Withania somnifera	Herb
Lantana rugosa	Dwarf Shrub
Phyllanthus maderaspatensis	Herb
Pupalia lappacea	Herb
Plains Habitat	
Themeda triandra	Grass
Tragus koelerioides	Grass
Searsia pyroides	Small Tree
Geigeria fillifolia	Herb
Eragrostis lehmanniana	Grass
Cynodon dactylon	Grass
Chloris virgata	Grass
Aristida congesta	Grass
Rosenia humilis	Dwarf Karroid Shrub
Nenax microphylla	Dwarf Karroid Shrub
Digitaria eriantha	Grass
Diospyros lycioides	Small Tree
Eragrostis obtusa	Grass
Pentzia incana	Dwarf Karroid Shrub
Hertia pallens	Shrub
Wahlenbergia nodosa	Dwarf Karroid Shrub
Chrysocoma ciliata	Dwarf Karroid Shrub
Tallinum caffrum	Geophyte/Succulent
Brunsvigia radulosa	Protected Species/Bulb
Ammocharis coranica	Protected Species/Bulb
Lotononis laxa	Herb
**Conyza bonariensis*	Exotic Weed
Riparian Habitat	
Diospyros lycioides	Small Tree
Digritaria eriantha	Grass
Hyperhenia hirta	Grass

Pentzia incana	Dwarf Karroid Shrub
Hertia pallens	Shrub/Disturbance Indicator
Wahlenbergia nodosa	Dwarf Karroid Shrub
Conyza podocephala	Riparian Herb/Pioneer Species
Eriocephalus spinescens	Dwarf Karroid Shrub
**Oenothera rosea*	Riparian Weed
Agrostis lachnantha	Riparian Grass
Cyperus rotundus	Sedge
Pseudognaphalium luteo-album	Riparian Herb/Pioneer Species
Cyperus marginatus	Sedge
**Cirsium vulgare*	Exotic Invader/Herb
Gomphocarpus fruticosus	Herb/Pioneer Species
Juncus rigidus	Sedge
Helichrysum lucilioides	Riparian Dwarf Shrub
Lycium horridum	Shrub
Midorella resedifolia	Riparian Herb/Pioneer Species
Eragrostis lehmanniana	Grass
Lycium cinerium	Shrub/Floodplain Species
Senecio consanguineus	Riparian Herb/Pioneer Species
Sisymbrium capense	RiparianHerb/Pioneer Species
Rosenia humilis	Dwarf Karroid Shrub
Searsia lancea	Tree
Acacia karroo	Tree
Typha capensis	Bulrush
Panicum coloratum	Riparian Grass
Cyperus indecoris	Sedge
Sporobolus ioclados	Riparian Grass
Themda triandra	Grass
Sporobolus fimbriatus	Riparian Grass
Bulbine abyssinica	Succulent/Bulb
Arctotheca calendula	Herb/Pioneer Species
**Ciclospermum leptophyllum*	Exotic Herb
**Schinus molle*	Exotic Tree
**Eucalyptus camaldulensis*	Exotic Tree
**Melilotus alba*	Exotic Herb
Scirpoides dioecus	Sedge
Jamesbrittenia aurantiaca	Herb
Lobelia thermalis	Creeping Herb
**Bidens bipinnata*	Exotic Weed/Herb
**Datura ferox*	Exotic Weed/Herb
**Xanthium spinosum*	Exotic Weed/Herb
Dimorphotheca zeyheri	Herb/Pioneer Species
**Polygonum aviculare*	Exotic Weed/Herb

**Hordeum murinum*	Exotic Grass
Cyperus laevigatus	Sedge
Wahlenbergia denticulata	Dwarf Karroid Shrub
Cynodon dactylon	Pioneer Grass

Appendix C: Likely invader weed species

It is strongly recommended that a weed eradication programme be initiated. Many areas previously disturbed by mining activities have become heavily infested by weeds and invader species. Additional sources should be consulted to confirm invader weed species as well as the best method to eradicate them.

According to the Conservation of Agricultural Resources Act, No. 43 of 1983 any Category 1 declared plants must be controlled by the land user on whose land such plants are growing.

Cirsium vulgare
Scotch Thistle/Skotse Dissel

Type: Weed
Category: 1

Mechanical removal is effective to control this weed. Cutting should be done below soil level and no leaves should remain.

Xanthium spinosum
Spiny Cocklebur/Boetebos

Type: Weed
Category: 1

Mechanical removal by hand is effective to control this weed.

Several chemicals have also been registered for control: amitrole/simazine, bromoxynil, metribuzin, MCPA-K and 2,4-D(A).

Xanthium strumarium
Large cocklebur/Kankerroos

Type: Weed
Category: 1

Mechanical removal by hand is effective to control this weed. Cutting is not recommended as this leads to re-sprouting.

Several chemicals have also been registered for control: bromoxynil, metribuzin, cyanazine/atrazine, bendioxide, MCPB, MCPA-K and 2,4-D(A), (T), (I).

Opuntia spp.
Prickly Pear

Type: Weed
Category: 1

Mechanical control is effective for single specimens. All parts of the plant must be removed and burned.

Chemical is most effective control method. Monosodium methanearsonate (MSMA) and glyphostae must be injected into the stem as concentrated solutions.

Argemone ochroleuca
Mexican Poppy

Type: Weed
Category: 1

Mechanical removal by hand is effective against this weed.

Several chemicals have also been registered for control: 2, 4-D, 2, 4-DB, dicamba, diuron, fluroxypyr, hexazinone, isoproturon, karbutilate, MCPA, picloram and terbutryn.

Solanum eleagnifolium
Silver-leaf Bitter Apple/Satansbos

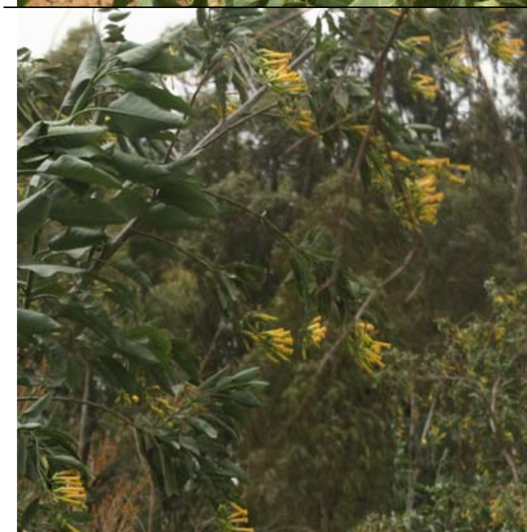
Type: Weed
Category: 1

Chemical control is most effective for control of this weed. Garlon 4 (triclopyr) is the only registered herbicide for control.

Datura ferox
Large thorn-apple

Type: Weed
Category: 1

Mechanical removal by hand is effective for this weed.



Nicotiana glauca
Wild Tobacco/Tabakboom

Type: Weed
Category: 1

Hand pull or dig out young seedlings.

Cut large plants and treat the stump with 2,4,5-T herbecide.

Melilotus alba
White Sweet Clover/Witstinkklawer

Type: Weed
Category: None

Mechanical control is most effective. Pulling and cutting must be carried out over consecutive years until the seedbank is exhausted.

Appendix D: Protected species on the site

Protected species on the site may not be limited to these species. The aim of this appendix is to provide a preliminary list of protected species occurring in the mining area that must be considered when expansion of any mining activities take place, i.e. slimes dam. Additional sources should be consulted to confirm the presence of protected species.

Adromischus trigynus
Klein Plakkie/Pig's Ears

Not Protected

National Red List Status: Least Concern (LC)

Method: Transplant if found on site proposed for expansion.

Occurring on exposed dolerite ridges.

Aloe broomii
Berg Aalwyn/Mountain Aloe

Protected Species

National Red List Status: Least Concern (LC)

Method: Transplant if found on site proposed for expansion.

Occurring on dolerite hills, outcrops and plains. Several specimen occur near the southernmost mine dump.

Aloe claviiflora
Canon Aloe/Kraal Aalwyn

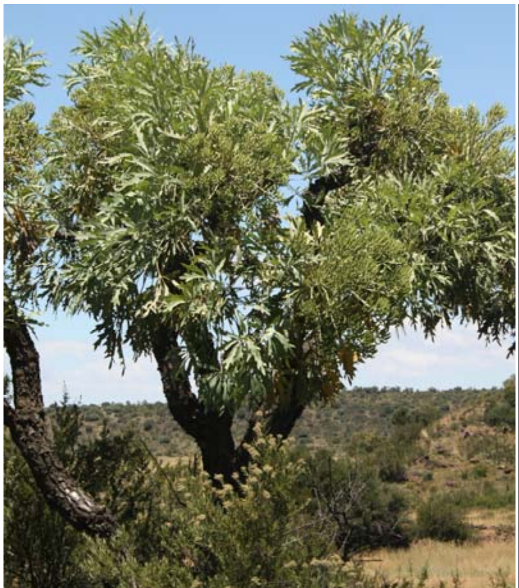
Protected Species

National Red List Status: Least Concern (LC)

Method: Transplant if found on site proposed for expansion.

Occurring on dolerite hills and outcrops.

	*Arachnoidea fillamentosa* Haaskos/Boesmansuring Protected Species National Red List Status: Least Concern (LC) Method: Transplant if found on site proposed for expansion. Occurring on exposed dolerite ridges.
	*Brunsvigia radulosa* Candelabra Flower/Kandelaar Lelie/Maart Blom Protected Species National Red List Status: Least Concern (LC) Method: Transplant if found on site proposed for expansion. Sporadically found on the plains.
	*Ammocharis coranica* Ground Lily/Seeroogblom Protected Species National Red List Status: Least Concern (LC) Method: Transplant if found on site proposed for expansion. Sporadically found on the plains.



Cussonia paniculata
Cabbage Tree/Kiepersol

Protected Species

National Red List Status: Least Concern (LC)

Method: Obtain permit to remove.

Occurring only on dolerite hills. Therefore unlikely that it will be affected by mining.

Olea europea subsp. *africana*
Olienhout/Wild Olive

Protected species

National Red List Status: Least Concern (LC)

Method: Obtain permit to remove.

Occurring only on dolerite hills. Therefore unlikely that it will be affected by mining.