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Rehabilitation Plan for alluvial diamond mining operations at Rooipoort on the farms Zandplaats 102/5, Vogelstruis Pan 101/0, Vogelstruis Pan 98/0, Bergplaats 100/0 and Klipfontein 99/0 near Schmidtsdrif, Northern Cape Province.

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DECLARATION OF INDEPENDENCE

DPR Ecologists and Environmental Services is an independent company and has no financial, personal or other interest in the proposed project, apart from fair remuneration for work performed in the delivery of ecological services. There are no circumstances that compromise the objectivity of the study.

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<tr><td>Report Version</td><td colspan="3">Final 1.0</td></tr>
<tr><td>Title</td><td colspan="3">Rehabilitation Plan for alluvial diamond mining operations at Rooipoort on the farms Zandplaats 102/5, Vogelstruis Pan 101/0, Vogelstruis Pan 98/0, Bergplaats 100/0 and Klipfontein 99/0 near Schmidtsdrif, Northern Cape Province.</td></tr>
<tr><td>Author</td><td>DP van Rensburg (Pr.Sci.Nat)</td><td></td><td>Aug’18</td></tr>
</table>

Table of contents

Rehabilitation Plan

1. Introduction

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.

Some vegetation units perform vital functions in the larger ecosystem. 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.

South Africa's water resources have become a major concern in recent times. As a water scarce country we need to manage our water resources sustainably in order to maintain a viable resource for the community as well as to preserve the biodiversity of the system. Thus, it should be clear that we need to protect our water resources so that we may be able to utilise this renewable resource sustainably. Areas that are regarded as crucial to maintain healthy water resources include wetlands, streams as well as the overall catchment of a river system.

In order to better manage our water resources several guidelines and research sources have been developed. Amongst these are the National Freshwater Ecosystem Priority Areas for South Africa 2011 (NFEPA).

It is well known that diamond mining operations, especially pertaining to alluvial 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. It is therefore also important to ensure preservation of the terrestrial environment in order to prevent sedimentation of watercourses.

The proposed mining development entails alluvial diamond mining within the study area and includes sensitive areas such as wetlands and watercourses (Map 3). The study area consists of the farms Zandplaats 102/5, Vogelstruis Pan 101/0, Vogelstruis Pan 98/0, Bergplaats 100/0 and Klipfontein 99/0. Mining will mostly take place on Zandplaats 102/5, Bergplaats 100/0 and Klipfontein 99/0 whilst the eastern portion of Vogelstruis Pan 101 and almost the entire Vogelstruis Pan 98 will for the time being not be subjected to mining. The study area is located on the eastern banks of the Vaal River with the portions where mining will mostly take place covering 25 000 ha (Map 1). Almost the entire study area still consists of natural vegetation. Mining will include the terrestrial environment, watercourses as well as the bed and banks of the Vaal River. The mining operations is therefore anticipated to have several impacts on the terrestrial habitat and watercourses and it will be necessary to apply comprehensive rehabilitation measures to ensure that the post mining environment closely resembles the natural condition of the site.

2. Scope and limitations

- To incorporate existing information on the condition of the site in order to rehabilitate the site to similar conditions as is currently the case.
- To recommend suitable rehabilitation measures in order to rehabilitate the site to a close to current condition.

2.1 Slope and topography

- Recommend rehabilitation to ensure the current topography and slope is re-instated at the site.
- Recommend measures to maintain topography and slope.
- Recommend suitable measures to ensure erosion is kept to a minimum.

2.2 Terrestrial Vegetation

- Recommend suitable plant species occurring in surrounding natural areas in order to rehabilitate the terrestrial vegetation at the site to close to current conditions.
- Recommend propagation and planting techniques to ensure adequate establishment of terrestrial vegetation.

2.2 Riparian Vegetation

- Recommend suitable plant species occurring in surrounding natural areas in order to rehabilitate the riparian vegetation at the site to close to current conditions.
- Recommend propagation and planting techniques to ensure adequate establishment of riparian vegetation.

2.3 Limitations

Recommended rehabilitation measures may not be successful in many instances as the flow patterns and plant succession functioning is complex. In order to ensure successful rehabilitation, constant and comprehensive monitoring should be done and where rehabilitation measures are considered to be inadequate the rehabilitation plan should be amended.

3. Background Information

3.1 The receiving environment and current condition

3.1.1 Terrestrial environment

The proposed mining development entails alluvial diamond mining within the study area and includes sensitive areas such as wetlands and watercourses (Map 3). The study area consists of the farms Zandplaats 102/5, Vogelstruis Pan 101/0, Vogelstruis Pan 98/0, Bergplaats 100/0 and Klipfontein 99/0. Mining will mostly take place on Zandplaats 102/5, Bergplaats 100/0 and Klipfontein 99/0 whilst the eastern portion of Vogelstruis Pan 101 and almost the entire Vogelstruis Pan 98 will for the time being not be subjected to mining. The study area is also situated in its entirety within the Rooipoort Nature Reserve. The study area is located on the eastern banks of the Vaal River to the east of the town of Schmidtsdrif and approximately 60 km to the west of Kimberley. The extent of the study is approximately 40 000 ha with the portions where mining will mostly take place covering 25 000 ha (Map 1).

Almost the entire study area still consists of natural vegetation although portions along the western border, especially along the floodplain of the Vaal River, where current and previous mining has occurred. Previously mined areas are being rehabilitated and seems able to restore a significant manner of ecological function. The majority of the study however remains natural and the ecological function is largely intact. The study area is situated within the Savanna Biome and therefore contains a well-developed tree layer with grass and dwarf shrub understorey. The tree layer may be quite dense in areas but varies from open to closed. Areas with low or no tree cover also occur in the north eastern portion of the study area. These areas are dominated by grassland. Small portions dominated by dwarf karroid shrubs are also present although in small extent. The region is considered to have a low rainfall and forms part of an arid area.

The study area contains a varied topography also due to the large size of the area. Topography includes relatively flat plains with uneven and rocky terrain in the central portion of the study area with a high amount of ridges and hills. Altitude varies from 1009 m to 1150 m and should illustrate that topography varies considerably over the study area. The majority of the study area contains a gradual slope toward the river except for hills and ridges where the slope can become quite steep. The general slope of the study area is toward the Vaal River. Where a gradual slope occurs such as in the south and north of the study area, watercourses are few. There is a definite increase in drainage lines closer to the river as the slope increases and flood sediments promote the formation of drainage lines. Uneven terrain such as occur in the central portion of the sturdy area contains a high amount of watercourses (Map 3). The north eastern portion contains a very low slope and deep sandy soils. In this area watercourses are largely absent although a few drainage lines and pans occur. The floodplain of the Vaal River can also become quite extensive in areas of the study area.

A detailed ecological study of the major plant communities was conducted for the Rooipoort Nature Reserve which includes the study area for the proposed mining operations by Bezuidenhout (2009). These fifteen communities consist of:

1. *Schmidtia pappophoroides - Themeda triandra* Grassland
2. *Schmidtia pappophoroides - Acacia erioloba* Woodland
3. *Tarchonanthus camphoratus* Shrubland
    3.1 *Eragrostis lehmanniana - Tarchonanthus camphoratus* Shrubland

    3.2 *Ziziphus mucronata - Tarchonanthus camphoratus* Shrubland
4. *Acacia mellifera -Acacia tortilis* Shrubland
5. *Acacia mellifera* Shrubland
    5.1 *Tarchonanthus camphoratus - Acacia mellifera* Shrubland
    5.2 *Digitaria eriantha - Rhigozum obovatum* Shrubland
    5.3 *Heteropogon contortus - Tarchonanthus camphoratus* Shrubland
6. *Diospyros lycioides* Woodland
    6.1 *Diospyros lycioides - Acacia karroo* Woodland
    6.2 *Salsola rabieana - Diospyros lycioides* Shrubland
7. *Pentzia globosa - Eragrostis truncata* Forbland
8. *Eragrostis bicolor* Grassland
    8.1 *Salsola rabieana - Eragrostis bicolor* Grassland
    8.2 *Osteospermum species - Eragrostis bicolor* Grassland
9. *Cynodon dactylon - Sporobolus ioclados* Grassland
10. *Scirpus species - Diplachne fusca* Grassland

The topography of the study area can divide it into roughly three separate areas (Map 2). The **south western portion** of the study area consists of an undulating plain with soils varying from shallow to deep and a relatively high percentage surface rock in most areas. The **central and south eastern portion** of the study area is dominated by uneven, rocky terrain with shallow soils and high percentage surface rock dominated by andesitic lava. The **northern and eastern portion** of the study area contains a relatively flat area which contains areas of much deeper sandy soils but also shallow soils with high percentage calcrete. The northern and southern portions with several similarities and the central, rocky area being more distinct.

South western portion

The south western portion of the study area has an undulating but relatively uniform topography. Different habitats and vegetation communities are however varied and contain four different communities which are mostly separated on the basis of soil and percentage rock cover (Map 2).

The overall diversity of species is not considered high and the occurrence of protected, rare or endangered species are limited to a few species. This portion of the study area does not contain a significant amount of protected species although a few do occur. The floodplain and southern areas with deep sands contain scattered specimens of the protected Camel Thorn Tree (*Vachellia erioloba*). Another protected tree but which occurs as scattered specimens in more rocky areas is the Shepherds Tree (*Boscia albitrunca*). These trees are protected under the National Forests (NFA) Act No 84 of 1998. Where these trees will be affected by mining operations it will not be possible to transplant them and they will require removal. As a result it is recommended that these trees be avoided as far as possible and where they require removal the necessary permits be obtained to do so. Other protected species Include the geophyte, *Lapeirousia plicata*, and succulents, *Orbea sp.* and *Titanopsis calcarea*. These species transplant easily and it is therefore recommended that prior to mining taking place in an area that permits be obtained to transplant them to areas where they will remain unaffected.

This portion of the study area does not contain a high amount of watercourses though several smaller drainage lines as well as one significant stream drain this portion (Map 3). The majority drain toward the Vaal River although a few smaller drainage lines also drain toward the south and east of the study area. A small pan area was also observed in the eastern section of this area.

Recently mined areas occur within the floodplain portion of the area. The natural topography has largely been re-instated in this area and an indigenous vegetation layer has succeeded in establishing. It is important that these areas be monitored closely and continuously in order to document the success/failure of rehabilitation which will aid greatly in improving or maintaining rehabilitation techniques.

In terms of terrestrial ecology this portion of the study area does not contain any elements of exceptionally high conservation value (Map 2). The area consists predominately of natural vegetation in a good condition but with a relatively low diversity of species and unique habitats absent. A few protected species were identified and these are of some conservation value and recommended mitigation should be applied for these.

Figure 1: Areas with deeper sandy soils are clearly devoid of surface rock, a sparse grass layer, well-developed shrub layer, with scattered trees are clearly visible.

Figure 2: View of another portion of this area where the tree/shrub canopy cover is much higher. Note again an increase in superficial calcrete.

Central and south eastern portion

The central portion of the study area consists of very uneven, rocky and mountainous terrain but with a relatively uniform vegetation structure and species composition (Map 2). Despite this the diversity of species is somewhat higher than the surrounding plains and the occurrence of protected species are also somewhat higher.

As mentioned above this portion of the study area contains numerous protected species. They are mostly scattered over this portion and not confined to specific colonies or habitats. The quartzite ridge does contain a few protected species confined to it. Two protected tree/shrub species occur namely *Boscia albitrunca* and *Nymania capensis*. Where these trees will be affected by mining operations it will not be possible to transplant them and they will require removal. As a result it is recommended that these trees be avoided as far as possible and where they require removal the necessary permits be obtained to do so. Other protected species consists mostly of succulent and geophytic species which transplant relatively easily. These include *Oxalis sp., Haemanthus humilis, Freesia andersoninae, Moraea polystachya, Mestoklema tuberosum, Ruschia sp., Orbea sp.*, *Boophone distichia, Dianthus micropetalus, Anacampseros filamentosa* and *Babiana hypogaea*. It is therefore recommended that prior to mining taking place in an area that permits be obtained to transplant them to areas where they will remain unaffected.

The mountainous portion of the study area contains a higher species diversity than the surrounding plains portion and likewise a higher number of protected species. This, coupled with the varied topography and high amount of watercourses, including drainage lines, gives the mountainous portion of the study area a high sensitivity (Map 2 & 3). As a result of the above any mining taking place in this portion should be approach with the necessary caution, implementing comprehensive mitigation and a high level of rehabilitation. The low, quartzite ridge in this portion also contains a unique species assemblage different from the surrounding area and represents a unique geological outcrop which is considered to provide this area with a very high level of sensitivity.

In terms of terrestrial ecology this central portion of the study area does not contain elements of exceptionally high conservation value although the combination of a varied topography, higher species diversity and occurrence of protected species and presence of high amounts of watercourses provide it with a high level of sensitivity (Map 2). Furthermore, the low quartzite ridge is considered a unique habitat with unique species assemblage and therefore a very high level of sensitivity. This ridge should be excluded from mining activities. Numerous protected species occur and although none are listed as rare or endangered they still retain a significant conservation value and recommended mitigation should be applied for these.

Figure 3: Panorama of the hills in the central portion of the area. Note the relatively dense canopy cover dominated by *Senegalia melifera*.

Northern and eastern portion

The northern and eastern portion of the study area has a relatively flat to slightly undulating topography and is relatively uniform (Map 2). However, the portion still contains varied vegetation communities which are mostly coupled to soil conditions and percentage rock cover.

The overall diversity of species is considered relatively low with the north eastern area having a visibly low species diversity while the south western area contains a somewhat higher species diversity though still not significant. This portion of the study area contains the lowest amount of protected species. The sandy soils of north eastern area of this portion contains relatively high amount of the protected Camel Thorn Tree (*Vachellia erioloba*). This species is protected under the National Forests (NFA) Act No 84 of 1998. Where these trees will be affected by mining operations it will not be possible to transplant them and they will require removal. As a result it is recommended that these trees be avoided as far as possible and where they require removal the necessary permits be obtained to do so. The only other protected species observed was *Orbea sp*. This succulent species transplants easily and it is therefore recommended that prior to mining taking place in an area that permits be obtained to transplant them to areas where they will remain unaffected.

This portion of the study area does not contain a high amount of watercourses though a few large streams are present and several unique wetland systems are also present (Map 3). These are considered to have a very high conservation value. Furthermore, the Vaal River and associated floodplain and backwaters also occur on the western border of this portion and will also have a high conservation value.

No mining has taken place in this portion which does increase its conservation value somewhat as a natural area in almost pristine condition.

In terms of terrestrial ecology this portion of the study area does not contain any elements of exceptionally high conservation value (Map 2). The area consists predominately of natural vegetation in a good condition but with a relatively low diversity of species and unique habitats absent. A few protected species were identified and these are of some conservation value and recommended mitigation should be applied for these.

Figure 4: View of the northern portion within the study area. Note an open tree layer with large specimens of *V. erioloba*, a dense, well-developed grass layer and scattered shrubs.

Figure 5: Panorama of the south western area in this portion. Note the high percentage of surface calcrete covering. A sparse grass layer and dense shrub layer is evident.

3.1.2 Watercourses and wetlands

The study area consists of the entire diamond mining area and contains floodplains, seasonal streams, pans, wetland areas and numerous drainage lines especially the areas closer to the Vaal River (Map 3).

All of the watercourses within the interior of the study area which will be affected by the mining operations are seasonal but mostly ephemeral in nature. Seasonal, and especially ephemeral, systems are still poorly understood and their functioning is markedly different from perennial systems. The interior of study area contains a high amount of drainage lines and seasonal streams which increase in number in proximity to the Vaal River. The uneven rocky terrain in the central and south western portion of the study area also contain a high amount of drainage lines as a result of the undulating terrain. The north eastern and south western portions of the study area with a lower slope gradient contain much less watercourses although several are still present in these areas. All of the streams and drainage lines has their origin within the study area. Vegetation along the streams area readily identified as riparian vegetation. Tree species along the streams are characteristic of watercourses in these arid areas. These species include *Vachellia karroo* (Sweetthorn), *Ziziphus mucronata* (Buffalo Thorn), S*earsia lancea* (Karree) and *Diospyros lycioides* (Bluebush). Indicators of wetland conditions increase with proximity to the river as the amount of runoff increases. Due to the arid climate and limited runoff the volume of water transport is low and not conducive to the formation of wetland conditions. Furthermore, these watercourses are characterised by flash flooding after heavy rainfall by which a relatively large amount of water is transported through these systems in a relatively short period. However, the larger stream system and in close proximity to the Vaal River do contain wetland conditions as a result of the increased water volumes and lower gradient leading to prolonged soil saturation and formation of wetland conditions. Where the larger streams mouth into the Vaal River, especially those in the central rocky portion, they form extensive alluvial fans which form part of the floodplain of the river. Here the silty soils cause significant gulley erosion which is natural in occurrence and forms part of the floodplain. As the stream exits the rocky terrain into the alluvial fan, the slope gradient is decreased to almost flat, water flow slows considerably and sediments in suspension is deposited, forming the alluvial fan. The slowdown in water flow also causes it to fan out and take on a form similar to a delta. The vegetation within the main channel of watercourses in the interior of the study area varies over their length as well as between them. This is due to the difference in slope, catchment size, pools, etc, within and between the watercourses. Although differing, all of the vegetation consist of riparian species of grasses and sedges which support the presence of a watercourse. The streams are easily identifiable and distinguished from the surrounding terrestrial habitats by the presence of riparian trees and wetland species such as sedges and riparian grasses. The above description should give a general idea of the functioning of the watercourses in the interior of the study area and should also serve to indicate that although they may seem small and flow only occur sporadically they still have a complex functioning which provides several unique ecosystem services. They should consequently still be considered as sensitive systems which may be easily altered or affected by activities associated with the proposed mining activities.

The Vaal River form the western border of the study area and will also form part of the mining area (Map 1 – 3). This is an extensive length of the river situated in the study area, approximately 30 km. The Vaal River, though well known to be degraded and modified, still performs several vital ecosystem services as well as services rendered to downstream users.

The floodplain and banks of the river is relatively uniform along the length of the study area though smaller portions with differing and, in some areas, rather unique riparian habitats occurring. Two distinct backwater systems are also associated with the river in the northern portion. These are represented by two separate, longitudinal systems situated parallel to the river and in close proximity to it (approximately 300 meters) and within the floodplain. The vegetation is dominated by a grass layer with the dwarf shrub, *Salsola rabieana*, also abundant. Trees and shrubs are largely absent. These areas contain a few Facultative- and one Obligate Wetland species. These areas are being considered as highly sensitive and especially the northern wetland area containing the outflow system. These areas still form part of the floodplain of the Vaal River and will play a vital role in terms of flooding and the functioning of the floodplain. They are also considered a more uncommon type of wetland system, further increasing their conservation value.

River systems can be divided into different riparian zones within the lateral section of the system. These zones are as follows:

The marginal zone is the lowest zone and is always present in river systems while the other two zones may not always be present. The zone is situated from the water level at low flow, if present, up to the features that are hydrologically activated for the most of the year (Figure 6 & 7). The marginal zone within the Vaal River as it occurs within the study area is well defined and easily identifiable by the presence of a dense riparian and sedge layer which are inundated on an annual nature. These marginal areas may be quite extensive in many areas where they constitute a perennial wetland area. These areas are predominately consisting of alluvial deposits on the outside of the river bends and the inflows of tributary streams. The majority of this zone seems to be largely natural although the opposite bank has been affected by mining in close proximity to the marginal zone.

The lower zone is characterised by seasonal features and extends from the marginal zone up to an area of marked elevation. This area may be accompanied by a change in species distribution patterns. The lower zone consists of geomorphic features that are activated on a seasonal basis (Figure 6 & 7). The lower zone along the Vaal River can also be clearly defined and is easily visible as a definite and steep increase in slope over a short distance where after it levels off into the upper zone. The lower zone is inundated infrequently and only during larger flooding events. In small sections of the river and especially where the marginal zone is extensive the lower zone extends over a larger distance and the increase in slope and elevation is more gradual. The boundary between the zones in these areas are more difficult to discern. It is also clearly defined by a grass layer often dominated by *Cynodon dactylon*. This can also be explained by the flooding of the lower zone. Large-scale flooding has a disturbance effect whereby vegetation is removed and allows for vegetation to re-establish through an ongoing cycle which is well known in river systems. Trees are also being affected most by flooding due to their increased volume presented to floods. Grasses, sedges and the like growth forms are much better adapted to flooding and able to withstand being uprooted to a much better degree. As a result the marginal and lower zones contain almost no trees whereas the upper zone is dominated by trees. The lower zone is largely natural within the study area.

The upper zone is characterised by ephemeral features as well as the presence of both riparian and terrestrial species. The zone extends from the lower zone to the riparian corridor. The upper zone contains geomorphic features that are hydrologically activated on an ephemeral basis (Figure 6 & 7). The upper zone along the Vaal River is clearly visible as a decrease in slope and an increase in the woodland component. The tree species are able to attain height and age due to the deep root systems still able to access the higher moisture levels and as flood disturbance in the upper zone is much less the trees are allowed to grow old without being removed by flood damage. The riparian tree species within the upper zone is dominated by *Vachellia karroo* (Sweetthorn), *Ziziphus mucronata* (Buffalo Thorn) and *Diospyros lycioides* (Bluebush) which then also indicate the border of the upper zone.

The upper zone consists of the *Diospyros lycioides* - *Acacia karroo* Woodland vegetation community (Bezuidenhout 2009). The description of the vegetation community accurately coincides with the upper zone of the river. The community is described as a well-developed tree layer up to 9 m tall, a shrub component up to 3 m tall and an understorey dominated by pioneer herbaceous species. The diagnostic tree species include *Vachellia karroo, Combretum erythrophyllum, Searsia lancea* and *Salix mucronata*. Other woody species include *Ziziphus mucronata* and *Diospyros lycioides*. The pioneer herbaceous layer is dominated by *Setaria verticillata, Cynodon dactylon, Ariplex semibaccata* and the exotic weeds *Argemone ochroleuca* and *Datura stramonium*.

The floodplain of the Vaal River can be extensive in areas, especially the southern portion of the study area. Here the floodplain is associated with the *Salsola rabieana* - *Diospyros lycioides* Shrubland vegetation community (Bezuidenhout 2009). The description of the vegetation community accurately coincides with the upper zone and floodplain of the Vaal River. Characteristic species of the community include the grasses *Chloris virgata, Panicum coloratum, Eragrostis lehmanniana* and *Aristida congesta* and the dwarf shrubs *Pentzia globosa* and *Salsola rabieana*. A tree/shrub layer is also present and consists of *Ziziphus mucronata* and *Diospyros lycioides*.

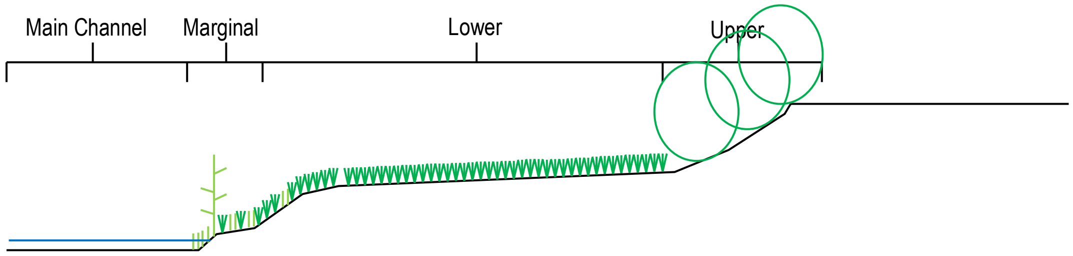


Figure 6: Illustration showing the different riparian zones of the Vaal River in the study area.

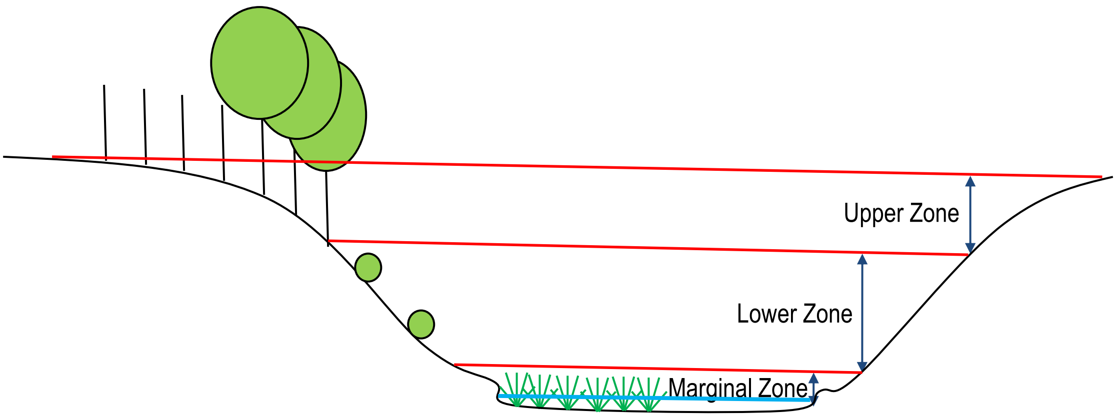


Figure 7: Illustration showing the different riparian zones of the of Vaal River in the study area. This is the situation over the majority of the section in the study area. Note the narrow marginal zone and steep lower zone.

Two large pans occur in the south eastern portion of the study area (Map 2 & 3). The larger of the two is named Hoffman's Pan situated along the southern border of the study area. The other, smaller though still large pan is situated to the north of Hoffman's Pan. The pans are situated along the eastern side of a rocky ridge which also drains into these pans by means of numerous small drainage lines. The Hoffman's Pan has a length of approximately 3.5 km with the pan to its north approximately 1 km in length. It should be evident that both are of exceptionally large size. These pans are flat-bottomed with their interiors mostly devoid of vegetation, relatively deep soils and without prominent surface stone. The floodplain or shore of these pans is quite extensive along their eastern borders. Here the vegetation is dominated by a short grass layer and karroid component represented by dwarf karroid shrubs. The extensive shore portion along the pan's eastern border do not contain any wetland conditions but still form part of the pans and are therefore also included within the border of the delineated wetland systems. The hydrological regime of these pans are considered to be ephemeral and will only contain surface water after exceptional rainfall. These pans and their shore is considered to be rather unique systems, largely as a result of their extensive size and are considered to be highly sensitive.

Figure 8: View of the central portion of the Hoffman's Pan. Due to the vast extent of the pan the shape and characteristics of the pan is not easily visible.

The northern portion of the study area consists of a relatively flat topography with the result that it contains few watercourses. However, a few are still present, especially one large stream draining the interior of this portion. Due to the flat topography areas of ponding is easily formed. As a result of this, wetland areas have formed in and around the main channel of this stream system (Map 3). These areas are mostly flat, without a channel, and contain a relatively dense vegetation layer dominated by hygrophilous grasses and sedges. The central portions of these wetland areas may also be devoid of vegetation. Obligate wetland vegetation is prominent and soil samples also indicate clear wetland conditions occurring. These wetland areas are considered to have a seasonal regime and will contain surface water on a seasonal basis. These areas are also considered to be relatively unique, especially wetland areas adjacent to the quartzite outcrops along the western tributary of this large stream. Consequently these wetland areas are considered to be highly sensitive and of high conservation value.

Figure 9: View of one of the flat wetland areas situated within the large seasonal stream.

In close proximity to the above described wetland areas but considered a separate system is a very unique artesian fountain which seems to be entirely of natural origin (Map 3). Systems such as this is exceptionally rare and considered highly unique. The fountain originates within a quartzite outcrop and flows down a gentle slope into a small natural rocky depression from where it overflows to the south into a sandy area. The extent of this entire fountain is no more than 1 hectare. During the survey surface water was present and a constant flow was also still present indicating that this fountain is a perennial system and provides a watersource throughout the year.

Figure 10: View of the rock pool formed by the fountain.

The section of the Vaal River within the study area is considered to be moderately modified by several impacts. The flood dynamics of the river has been altered to a large degree by the construction of large dams upstream. The construction of large containment dams such as the Bloemhof- and Vaal Dams has influenced the frequency and magnitude of flooding which is part of the natural system. As a result thereof the flooding of the floodplain within the upper zone does no longer take place at the same regular intervals and magnitude. The floodplain within the upper zone of the river is now more dependent on surface runoff. Extensive alluvial diamond mining takes place in several areas upstream and downstream of the site. This occurs within the catchment as well as the riparian zone. This will undoubtedly contribute to the sediment load of the river. Historical delving for alluvial diamonds has also taken place along the river and in many instances in the main channel. Although not extensive these areas has permanently altered the geomorphology of the river and will undoubtedly also have had an effect on sediment and flow dynamics. The impact of historical mining has diminished to some extent as the environment rehabilitates itself although the change in topography and morphology is not rehabilitatable through succession of the environment itself. Historical mining within the catchment has also occurred and the impact considered high since no rehabilitation was undertaken in those days. Shallow excavations and rock heaps are common in upstream areas. Centre-pivot irrigation takes place along the river in upstream and downstream areas and may be extensive in some areas. This will impact on the river as a result of fertiliser runoff and enrichment, pesticides and other impacts associated with commercial irrigation. The study area is utilised for game farming and consequently the impacts associated with this is relatively low. However, it was noted that overgrazing was relatively high in many areas and here trampling is also significant. This was especially prevalent in and around pan systems. Areas used for gaining access to the river was also noted to contain high levels of trampling. Adjacent and upstream areas are also utilised for domestic stock grazing which will have some impact on the sediment load of the river.

The Vaal River and its associated floodplains are considered a fifth order watercourse. This is also due to the Vaal River being a large lowland river. The quaternary catchment of this area is C92A and C92B. The largest impact on the study area is the construction of large upstream containment dams in the Vaal River. These impacts alter flooding regime and the functioning and habitat of the river and floodplains. An Index of Habitat Integrity (IHI) was conducted along the Vaal River within the study area. The results of the IHI indicated that the Vaal River has an Inseam IHI of category C: Moderately Modified and Riparian IHI of category C/D: Moderately to Largely Modified. This is largely due to the change in flooding regime and disturbance/transformation of the habitat. The Vaal River and associated wetlands and floodplains are considered to be somewhat altered and degraded by historical and current impacts.

The watercourses and wetlands within the interior of the study area has been subjected to several impacts of which the majority is of small magnitude although alluvial diamond mining operations is considered a significant impact. Grazing and browsing by introduced game is the most widespread impact but is not considered to have a high impact. However, grazing was noted to be considerable especially around the pan systems including the Hoffman's Pan. Coupled with this was also high levels of trampling in these areas. Furthermore, along dirt tracks which afford game much easier access routes, trampling was also significant. This was also noted along access routes and game paths to the Vaal River. The above impact will cause a decrease in vegetation cover, disturbance of the soil surface and consequent increased erosion and sediment loads in watercourses. However, as stated this impact is still considered relatively low. The study area contains a dirt road network which also often cross streams, drainage lines and wetland areas including pans. These act as flow barriers and alter the flow regime of the watercourses they also alter the bed and banks to a low degree and act as sediment and nutrient traps. Furthermore, dirt tracks, especially those in uneven, rocky terrain are subjected to higher levels of erosion and this was also evident in many areas. This will contribute to an increased sediment load in watercourses. The most significant impact which has affected watercourses in the study area is however the current alluvial diamond mining operations. Up to now the watercourses and wetland areas has been excluded from mining and a buffer of 30 meters has been afforded to these areas. Despite this their catchment has been transformed and disturbed and will undoubtedly affect the watercourses. Mining removes the natural vegetation cover, disturbs the soil surface and consequently causes mobilisation of sediments. The effect on watercourses is an increase in erosion and a significant increase in the sediment load. This will in turn also affect the Vaal River. Furthermore, disturbance causes conditions susceptible to the establishment of exotic weeds and consequently the watercourses also contain a higher percentage exotic weeds. Rehabilitation however seems to be affective and the impacts as discussed above should be of limited duration.

The watercourses and wetlands within the interior of the study area is considered to be affected by relatively few impacts and consequently still in a relatively natural condition. The most widespread impact associated with the landuse is overgrazing, -browsing and trampling by game though this is not considered a high impact. Current mining operations are however considered to have a significant impact. An Index of Habitat Integrity (IHI) was conducted for these watercourses within the study area. The results of the IHI indicated that the watercourses in the interior of the study area has an Instream IHI of category B: Largely Natural and Riparian IHI of category B: Largely Natural. This is considered accurate since they are located in their entirety in a natural area with few impacts. Current mining has not yet affected a large proportion of watercourses and is therefore not yet considered to have decreased the condition of watercourses significantly.

3.2 Proposed mining method

The various identified mining sites, demarcated by an extensive prospecting programme conducted by De Beers, will be mined by conventional open cast alluvial mining methods.

All of the gravel resources on Rooipoort will be mined using the strip mining method, which utilises excavators, front-end loaders and dumper trucks.

The areas to be mined will be surveyed and a survey base line will be established across the working area of each resource. 100m X 200m strips will be demarcated for each of the deposits (M5, M6 and L2) which will be mined. The width of these cuts will probably not be 100 m as it becomes difficult to clear overburden over such a large area. One block at a time will be opened for each deposit, but three blocks will be open at any given time. One block will be stripped of overburden, gravel will be removed from a second block and a third block will be backfilled and rehabilitated. Any topsoil from these blocks will be removed and stockpiled on the high ground side of the excavation. Overburden will also be removed and kept separate from the topsoil. The landowner permits the applicant to have a maximum of 6 ha of voids open at any given time.

The gravels will be extracted from each block using a 70 ton excavator. The gravels will be transported to the Dense Medium Separator (DMS) plant by haul trucks where it will be screened through rotary barrel screens to <75mm. The remaining <75mm material will be scrubbed and screened to -32mm, +2mm, whereafter it will be processed through the DMS plant and the final recovery section. The DMS units have been reduced from 4 units to only 2 units with the addition of the Bourevestnik Plant (BV). The BV plant is an X-Ray machine treating -50 mm to +5 mm material and uses little water making the plant water. The BV only uses water for cooling purposes and will top-up a small volume of water every hour. This is minimal.

Once processed, the plant tailings and oversize material will be hauled back to the excavation and backfilled into the same trench from which it was extracted. This will be performed by the haul trucks that were used to transport the gravels from the excavation site to the Plant.

Figure 11 indicates the process and the products produced by the process. During the processing of the material, the grits and fine material will continuously be pumped to the First Cut on site. The First Cut was designed to allow the suspended fine material to settle in the first pond. Water will flow through a stone diversion between the two ponds. Clean water will be pumped from the second pond back to the PWD to be re-used in the process plant or for dust suppression. When the mining in the area is completed the First Cut will be left to dry and will be backfilled with oversized material, overburden and soil. The overburden and topsoil will be replaced to the voids to cover the backfilled dry fine gravel and plant gravels.

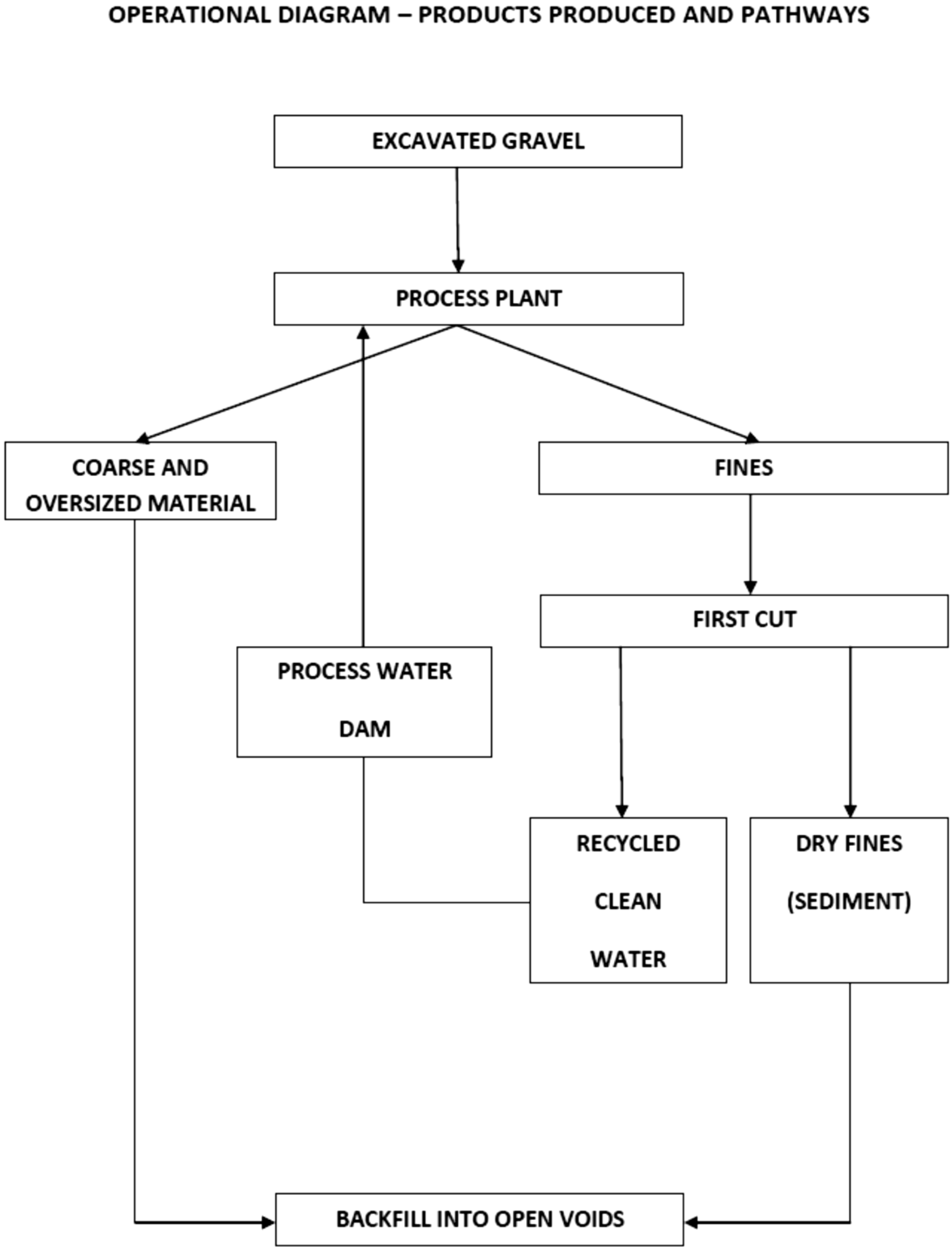


Figure 11: Diagram illustrating the mining process.

Aspects of the mining process pertaining to rehabilitation:

- Opened voids will be backfilled after the excavation of the gravel with gravel processed in the plant and overburden. After backfilling, the pit will be covered with topsoil to ensure that natural vegetation re-establishes. The First Cut will be rehabilitated with the fine material suspended in water from the processing plant which settles in the void. When the void is full the fine material will be left to dry after which it will be covered with the overburden and topsoil excavated from that void.

- Infrastructure (i.e. plant, workshop, offices, etc.) will be taken down and removed from the current mining area to be re-established on another portion of the mining right area where future mining will occur. The disturbed areas will be rehabilitated by removing all waste products from the site, ensuring that there are no contaminated soils and pollution. All compacted areas will be ripped and/or ploughed. These areas include roads which will not be used, surfaces where plant and workshop were established and all office sites.
- Pumps used for abstraction of water from the Vaal River will be removed and installed at a new location where the new process plant will be established. Borehole pumps will also be removed and taken to new boreholes at the new plant (if any). The previously used boreholes will not be closed as it might be used by future landowners. It can also be included into a groundwater monitoring plan.

4. Rehabilitation plan

4.1 Rehabilitation of terrestrial vegetation

Although the rehabilitation plan will focus on the rehabilitation of watercourses and riparian vegetation the surrounding terrestrial environment forms part of the catchment of these water systems and will therefore also affect them if rehabilitation is not adequately implemented.

The terrestrial environment provides runoff which feeds the watercourses in the study area. The topography, substrate and shape of the terrestrial environment therefore determine the runoff patterns and influences the flow volumes within watercourses. It is therefore important to re-instate the natural topography as far as possible during rehabilitation. This can be done by surveying the portion proposed for mining prior to excavation and determining the slope, topography and profile of the landscape. A comprehensive photographic record should also be taken prior to mining commencing which will enable comparison with the rehabilitated topography. It is also important that this be done by using fixed point photography whereby several fixed points are marked and used for consecutive comparisons.

Re-establishing the natural topography is important but the establishment of vegetation is still dependant on a suitable substrate. This should be done by the correct backfilling of materials. Replacing of topsoil should be the last phase of backfilling. When clearing the natural vegetation this should be stored together with the topsoil as this material will also aid in supplementing the seedbank, contributing to mulching and supply slow-release organic nutrients. Were rocky surface covering or bedrock is present on the soil surface this should still be retained as topsoil since a seedbank will still be present and will allow the re-instatement of a similar habitat.

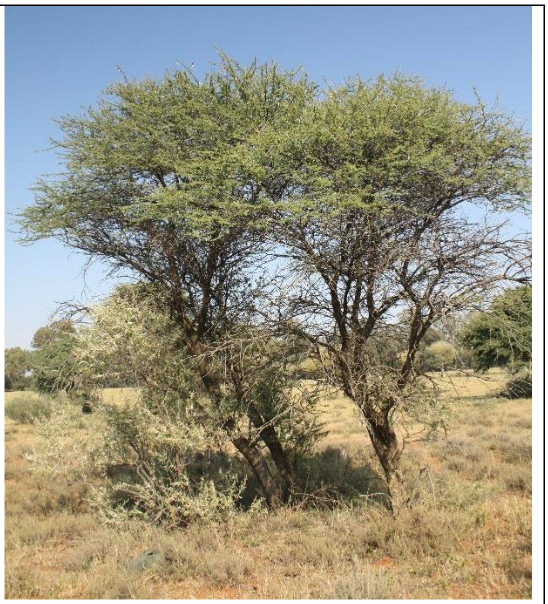
Once a topography and soil surface resembling the natural condition has been re-established the establishing of an indigenous vegetation layer resembling the natural condition can be attempted. It is also important to record the natural vegetation structure and species assemblage prior to mining. This can be obtained with 20 m x 20 m sampling plots using the Braun-Blanquet sampling method; a simple ecological method easily utilised to record vegetation structure and species composition. It is recommended that this be done for approximately every 20 hectares and within each vegetation community as identified by Bezuidenhout (2011).

It is recommended that the grass, herb and dwarf shrub layer re-establish by itself, i.e. without supplemented propagation or planting techniques. This will allow for a natural and genetically similar vegetation layer establishing. Should this be found inadequate it can be supplemented by harvesting grass seeds from adjacent areas and spreading these over the rehabilitated area. Numerous commercially available grass harvesters are available for this. The introduction of commercially available seed is not recommended as these are normally of exotic grass species, artificially manipulated by selective breeding and therefore not representative of the genetic diversity in the naturally occurring vegetation. This will also likely modify the natural species composition of the area.

The tree and shrub layer should also be allowed to establish by itself. However, a shrub/tree layer forms part of the climax stage of succession and will therefore take a much longer period to establish. It is therefore recommended that the shrub/tree layer be supplemented by establishing saplings during rehabilitation. This will require the establishment of a small nursery area at the site and propagation of these species. The following should form part of this process:

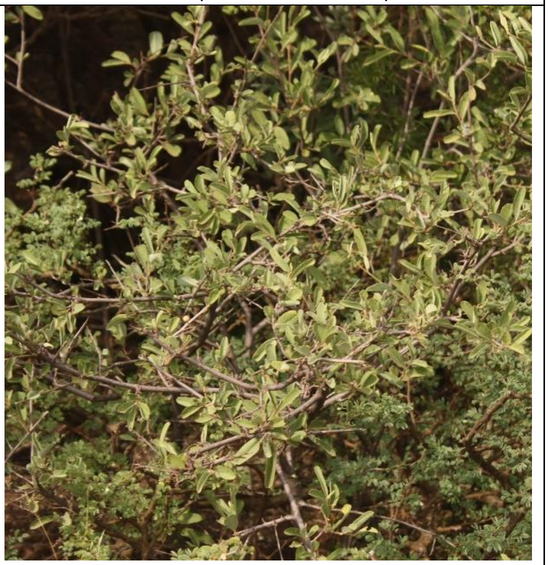
- Harvesting of shrub/tree seeds in the study area to ensure a genetically pure population.
- Establish a nursery area including a shaded propagation area, unshaded hardening off area and easy access to a watering point.
- Germination of seeds in planting bags and propagation of shrubs/trees past the seedling stage.
- Planting and establishing of saplings in the rehabilitated area.
- Initial watering of saplings.
- Monitoring of successful establishment.

Vachellia erioloba (Camel Thorn)



Vachellia tortilis (Umbrella Thorn)

Senegalia mellifera (Black Thorn)



Grewia flava (Velvet Raisin Bush)

 *Tarchonanthus camphoratus* (Vaalbos/Camphor Bush)	 *Boscia albitrunca* (Shepherds Tree)
 *Ehretia rigida* (Puzzle Bush)	 *Ziziphus mucronata* (Buffalo Thorn)

Figure 12: Terrestrial trees recommended for propagation.

Monitoring of sapling establishment is crucial and should record the success of sapling establishment and long-term feasibility. Should monitoring indicate that browsing of and destruction of saplings by game is high the protection of saplings by fencing/caging should be considered.

Monitoring and eradication of exotic weeds and invaders is also essential to successful establishment of a natural vegetation layer. This will be discussed in greater detail in the following sections.

In summary the following process is recommended for successful re-establishment of a natural vegetation layer:

Prior to mining operations commencing

- Document the natural topography by means of surveying and fixed-point photography.
- Document the natural vegetation structure and species composition by 20 m x 20m Braun-Blanquet sample plots.

During mining operations

- Correct clearing and preservation of the natural vegetation material and topsoil layers.

During the rehabilitation process

- Correct backfilling process and replacement of the topsoil layer and remaining vegetation material.
- Re-instating of the natural topography as far as possible.
- Allow natural vegetation layer to establish and supplement by seed harvested in adjacent areas if necessary.
- Propagate and establish saplings of shrubs/trees in the rehabilitated areas.
- Monitor and eradicate exotic weeds and invaders where they establish.
- Implement a comprehensive monitoring plan to document rehabilitation success and proposed amendment of rehabilitation techniques where necessary.

4.2 Rehabilitation of affected watercourses

Mining operations will also include watercourses within the interior of the study area as well as the Vaal River. This will have a high impact and will therefore require comprehensive rehabilitation in order to re-establishing similar functioning watercourses. As already mentioned the functioning of watercourses is dependant on the functioning of the catchment, i.e. the catchment drains into the watercourse and determined its flow and flooding regime. Mining within the catchment will therefore affect the watercourses.

As a result of the connection between the watercourses and the catchment feeding into them it is highly recommended that mining not take place within the watercourse and catchment at the same time. It is rather recommended that the catchment be mined first, then rehabilitated until a manner of natural vegetation has established and only then watercourses should be mined where desired. A buffer of 30 meters from watercourses is recommended whilst the catchment is being mined. Mining in the catchment will mobilise sediments and clear the vegetation layer which will increase the sediment load in watercourses significantly. As long as they are unmodified they will be able to manage this increase to some extent. However, if they are mined at the same time as the catchment the increased sediment load will have an unacceptably high impact and will also affect the Vaal River into which these flow.

The Vaal River, especially the banks and areas where alluvial fans occur, will also be subjected to mining. As above it is strongly recommended that the catchment and watercourses in the study area not be mined at the same time as the Vaal River for the same reasons. As a result, it is recommended that the catchment first be mined, rehabilitated to a point where the soil surface stabilises and a manner of natural vegetation cover establishes and only then desired watercourses be mined. Mined watercourses should then be rehabilitated up to a point that the bed and banks become stabilised and a manner of riparian vegetation establish. This will decrease the mobilisation of sediments. The placement of transverse rocky berms within mined watercourses should also be considered to prevent sediments from being washed into the Vaal River. This will also stem gully erosion to some extent. Thereafter the Vaal River and associated alluvial fans should be mined. If this method of mining is undertaken the accumulation of impacts will also be decreased.

The recommended mining order can be summarised as follows (Figure 13):

- Mine the catchment in the interior of the study area and rehabilitate (blue).
- Mine the smaller watercourses within the interior of the study area and rehabilitate (red).

- Mine the bed and banks of the Vaal River and associated alluvial fans and rehabilitate (green).

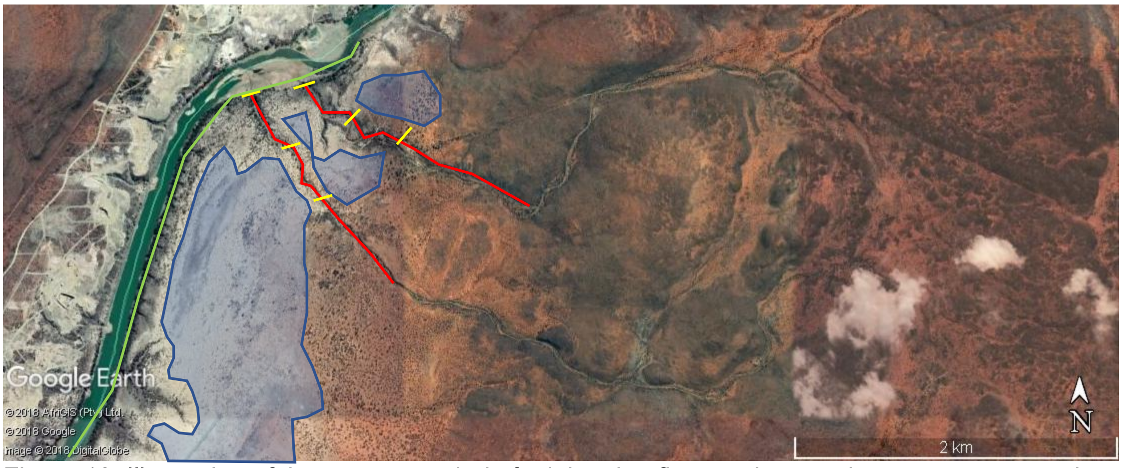


Figure 13: Illustration of the recommended of mining, i.e. first catchment, then watercourses, then the Vaal River (Google Earth 2018). Blue indicates catchment, red watercourses, yellow transverse berms and green the Vaal River.

4.2.1 Slope, topography and erosion

Mining and excavation of ore will alter the topography of the banks of watercourses. Rehabilitation should endeavour to re-instate the current topography as far as possible. In order to rehabilitate the topography sufficiently it is necessary to document the current topography prior to mining. This should be done by keeping a comprehensive photographic record of the site prior to mining. A photographic record should also be updated during mining and during the rehabilitation phase in order to measure the relative success of the rehabilitation of the topography/geomorphology. Other tools which may aid in rehabilitating the topography include surveyed contours of the sites. Despite the steep slopes of many of the affected watercourses, especially the Vaal River, it is still recommended to re-instate these steep slopes in spite of the fact that this will promote erosion in order to re-instate the natural topography as far as possible.

Re-instating of the topography should be done using the correct backfilling of materials. The excavations should be filled with tailings and then overburden. Overburden should be placed on top of the tailings. Replacing of topsoil should be the last phase of backfilling.

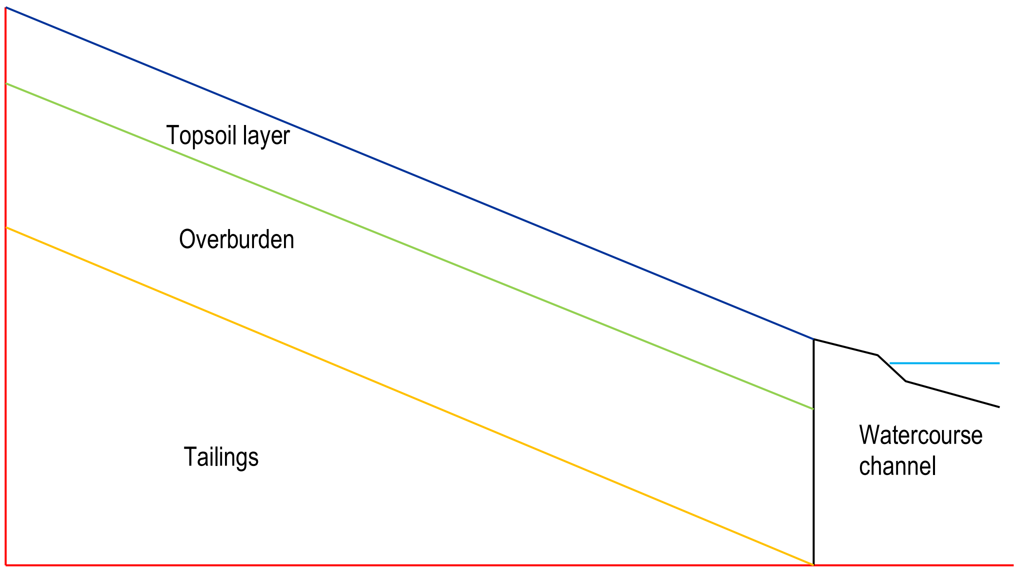


Figure 14: Illustration of the sequence of material layers during rehabilitation.

Due to the steep slopes of the affected watercourses it is recommended that comprehensive erosion measures be implemented in order to stabilise the banks and prevent sediments from being washed downstream and into the Vaal River.

The topsoil layer should be compacted to some degree but the uppermost layer should be scarified to ensure healthy plant growth. The integrity of the topsoil should be well protected and should form the basis of erosion control.

Protection of the topsoil layer and prevention of erosion can be ensured with several methods.

It is recommended that a low berm be installed at the edge of the mining excavation and adjacent to the main channel of the watercourse or Vaal River. This will prevent sediments washed from the bank or catchment to enter the watercourse. This berm should be vegetated to ensure that it does not itself form a source of sediment and remains stable for a short period to allow the watercourse bank to stabilise and vegetation to establish and form part of the natural environment and is self-sustaining. The height of the berm is not recommended to exceed 1 meter and should decrease in height in accordance with the size of the watercourse. It is anticipated that through annual flooding of the watercourses the berm will be decreased in size as a result of water flow. This will cause the berm to be removed by flooding after a period. This will allow the bank to gain a more natural topography. The berm is therefore envisioned to be temporary and to be decreased by flooding after a period of time. The function of the berm will therefore be to initially prevent sedimentation from the banks to enter the watercourse until the banks are stabilised.

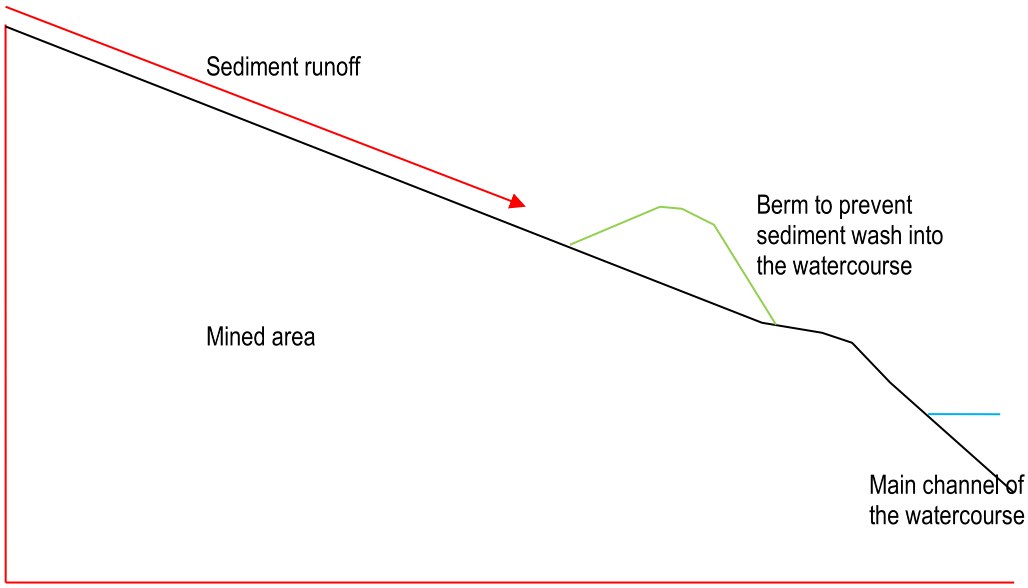


Figure 15: Illustration of the recommended berm to be erected at the border of the mined area and adjacent to the affected watercourse.

In order to decrease runoff velocity and therefore the erosional force of runoff it is recommended that the bank be contoured during rehabilitation. This rehabilitation measure is mostly applicable to the banks of the Vaal River and perhaps some of the larger watercourses in the interior of the study area. This will act as barriers to runoff which will decrease the runoff velocity. The position of the contours should be determined by a qualified surveyor. The height of the contours should not be such that they alter the topography of the bank and act as total barriers to runoff. The aim of the contours should be to retard runoff velocity.

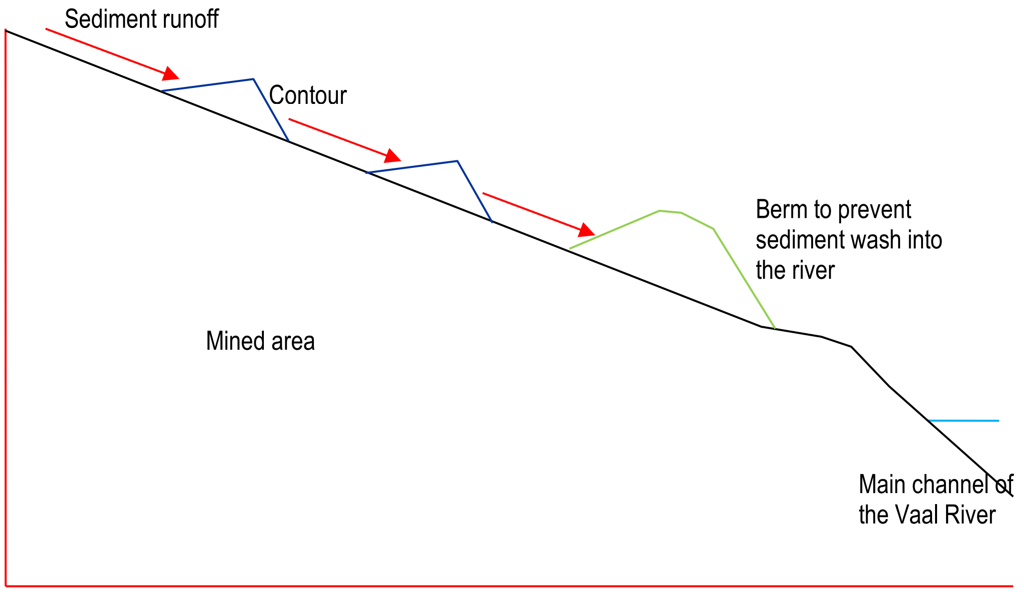


Figure 16: Illustration of the recommended contours to be installed along the bank of the Vaal River where mining has taken place.

In order to further stabilise the soil surface, it is recommended that suitable geotextiles be utilised. This measure will be costlier and is more specifically recommended where mining takes place along the banks of the Vaal River and where erosion is problematic. This can be achieved by applying a geotextile netting. It is recommended that a biodegradable type netting be utilised which will biodegrade and will allow the river bank to attain a close to natural condition. Net openings should be 1 cm x 1 cm to allow vegetation to grow through the netting. The netting should be staked at approximately 1 m^2 intervals and be secured to prevent removal of it by flooding. Biodegradable netting for soil stabilising is commercially available and should not be difficult to obtain. This netting will further stabilise the soil surface and prevent erosion. The use of gabions is not recommended as this will prevent the re-instatement of natural geomorphology of watercourses. Where this is desired it should be implemented but removed once soils have stabilised.

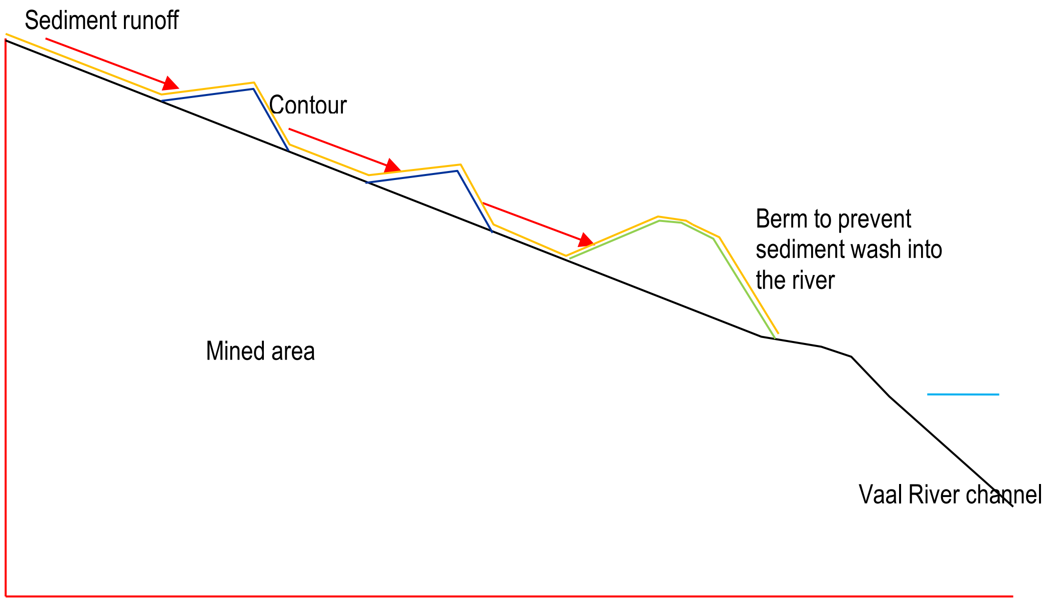


Figure 17: Illustration of the recommended geotextile netting to be implemented on the soil surface.

Where seasonal or ephemeral watercourses in the interior of the study area is affected additional erosion measures should also be implemented. A berm should be erected perpendicular to the direction of flow and across the main channel of the watercourse. This will retard water flow following mining and will stem gully erosion within the main channel. Many of the watercourses in the study area also contain a bed covered by round stream rocks (Figure 18). These also aid in retardation of flow and would decrease erosion. As a result, where erosion is problematic rocks can be placed in the main channel to aid with erosion prevention.


Figure 18: View of one of the watercourses in the study area with a bed dominated by round stream rocks. Such a bed will aid in decreasing erosion.

If all of the above recommended rehabilitation measures are implemented it is considered likely that erosion will be decreased to a large extent. However, areas where erosion may become problematic is likely to occur despite these erosion measures. It is therefore recommended that continuous monitoring of erosion be done. It is further recommended that erosion monitoring and remedial action be continued for a period after mining has ceased. Rehabilitation may seem adequate once mining has ceased but often deteriorates after the site has been vacated. It is therefore recommended that monthly erosion monitoring and remediation be continued for one year after mining has ceased.

Remedial action where erosion has occurred should include importing topsoil to place in eroded areas. Coarse rock or similar material should also be inserted in eroded areas to stem erosion from advancing further. Topsoil should then be replaced and compacted to some degree. Where berms and contours have been damaged and where it is clear that this damage will promote erosion they should be repaired. It is however envisaged that after a period has elapsed these berms and contours will be removed by flooding. At this time the soil should be sufficiently stabilised and vegetation adequately established to prevent erosion.

4.2.2 Riparian vegetation establishment

The prevention of erosion and stabilising of the soil surface forms a suitable surface for re-vegetation of the watercourses but can in itself not ensure an adequate and self-sustaining environment. The establishment of a riparian vegetation layer is therefore of paramount importance.

Several techniques should be implemented to ensure the watercourse banks are adequately re-vegetated.

Mulching is a technique whereby the soil surface is covered by an organic layer. The function of such a mulch layer is manifold. Firstly, this layer serves to stabilise and protect the underlying soil layer. The mulch also ensures more soil moisture is retained and for longer periods forming a suitable environment of the germination and establishment of vegetation. Furthermore, the decaying mulch layer contributes to the nutrients within the soil and improves the soil qualities. It is recommended that the topsoil layer be mulched with plant material. When clearing the site prior to mining the vegetation material should be retained to be used as mulch during rehabilitation. It is not of concern if large tree trunks and large pieces of plant material is used as mulch as they will also act as flow barriers and reduce erosion along the bank. This will also speed up the rehabilitation to an almost natural condition. Alternatively, the material can also be chipped to produce a smaller grain mulch.

In order to ensure vegetation establishment is successful a range of manual establishing methods will have to be applied.

Seeding of rehabilitated areas is a sound basis for the establishment of a riparian vegetation layer. Hydro seeding mixes is commonly available but as the site in question consist of riparian vegetation these mixes are unlikely to successfully establish in an area which experiences periodic flooding. It is therefore recommended to source seeds of riparian species already present at these sites. Harvesting of seeds from the surrounding areas is anticipated to have mixed results as time of seeding varies and amount of seed harvested will be low. It is therefore considered an option to source commercially available seed.

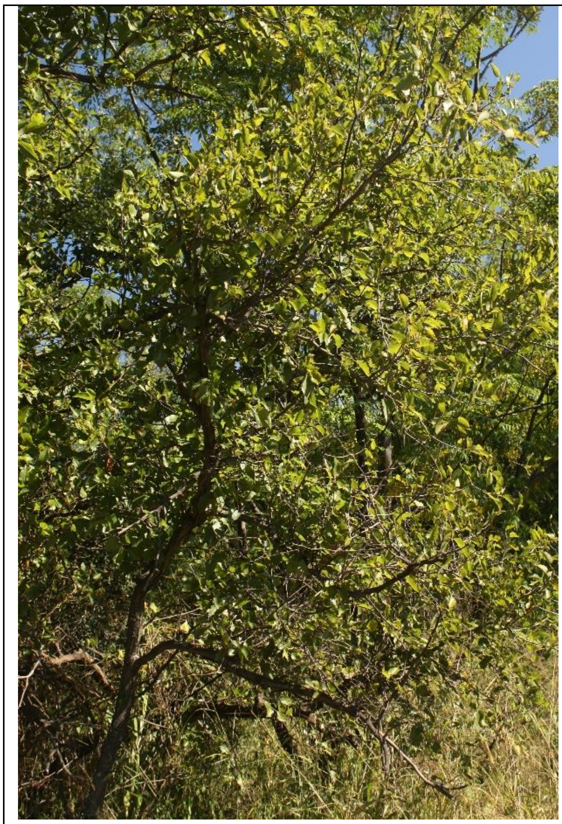
Grass species which are readily available and which are considered likely to establish include *Cynodon dactylon, Chloris virgata, S. verticillata* and *Panicum coloratum*. Of these *C. dactylon* is a pioneer species often occurring along watercourses and impoundments and is abundant in the study area along watercourses. It is highly likely to establish on the post mining rehabilitated surfaces. *C. virgata* is also a pioneer grass adapted to disturbed environments although it is better suited to terrestrial environments it is included in order to establish in areas of the site where the soil moisture is not high enough to sustain the other grass species. The species is also abundant in the study area, especially along the smaller, ephemeral watercourses as well as floodplains. *S. verticillata* and *P. coloratum* is adapted to shaded areas and is normally found underneath trees along the banks of the Vaal River as well as the larger watercourses. These species are included to be utilised underneath trees and shrubs as well as in conjunction with tree saplings.

	
Cynodon dactylon - Kweekgras, Couch Grass	*Chloris virgata* - Witpluim-chloris, Feather top

	
Panicum coloratum - Buffelsgras, Guinea Grass	*Setaria verticillata* - Klitsgras, Bur Bristle Grass

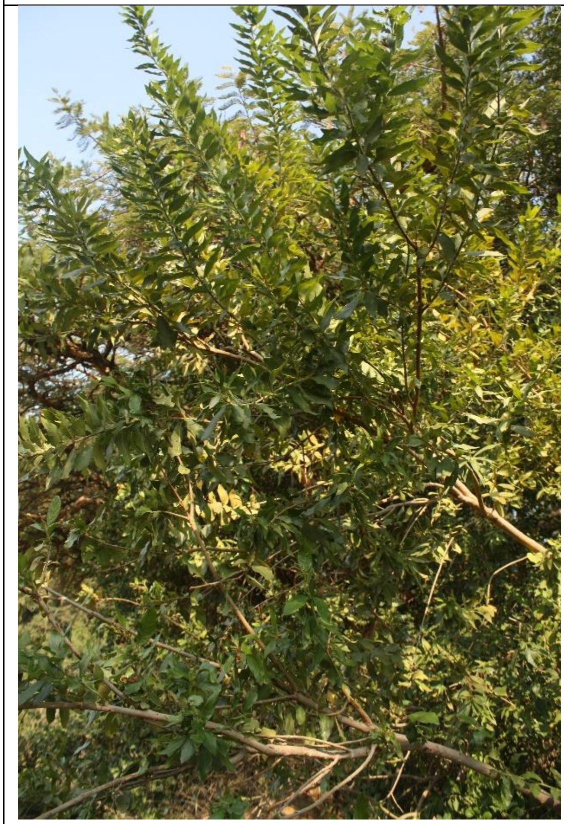
Figure 19: Grasses recommended to be seeded along watercourses affected by mining.

The vegetation structure along the banks of the watercourses contain a distinctive tree/shrub layer along the banks and also along the upper zone of the Vaal River bank (Refer to Section 3). Trees and shrubs are important binders of soil. It is recommended that tree and shrub saplings also be planted in the rehabilitated areas. The trees on these sites are all easily grown from seed and it is recommended that seeds be harvested on the site and used to replant rehabilitated areas. Seeds should be germinated in black plastic nursery bags which are commercially available and should be stored outside the mining area in a designated nursery area. Following rehabilitation the saplings can then be planted on the banks of watercourses. After planting they should receive a thorough drenching with water. Tree and shrubs species occurring along the banks and which can be utilised in rehabilitation include *Ziziphus mucronata, Diospyros lycioides, Combretum erythrophyllum, Vachellia karroo* and *Searsia lancea*.

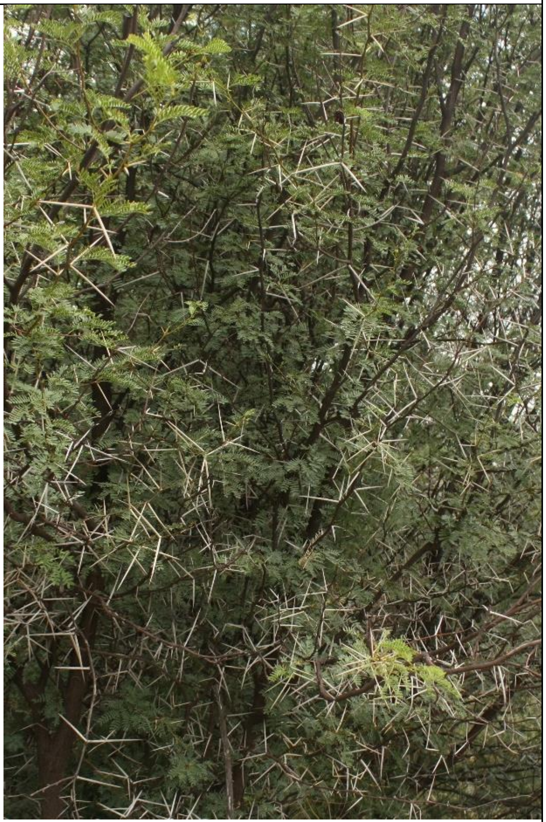


Ziziphus mucronata - Blinblaar Wag-'n-Bietjie, Buffalo Thorn

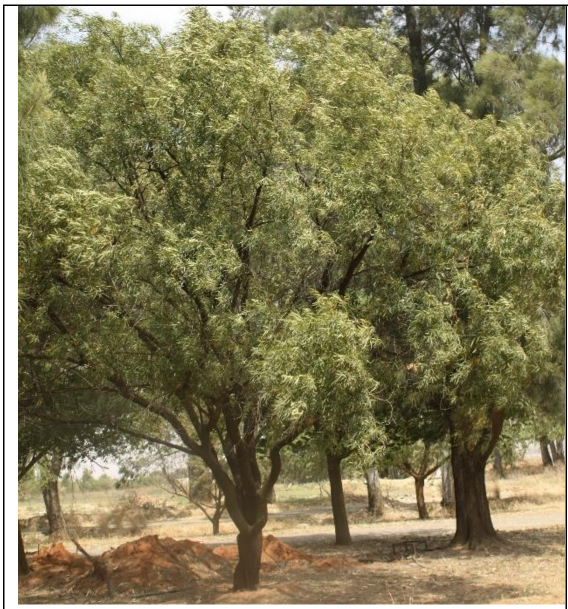
Diospyros lycioides - Bloubos, Bluebush



Combretum erythrophyllum - Vaderlandswilg, River Bushwillow



Vachellia karroo - Soetdoring, Sweetthorn



Searsia lancea - Karee

Figure 20: Trees to be established in the riparian layer along the banks of watercourses.

The use of exotic species to seed the rehabilitated areas should be refrained from. These also include Kikuyu (*Pennisetum clandestinum*) which is often planted in disturbed areas but which are exotic and a widespread weed invading natural areas.

Several sedge and riparian grass species are not commercially available and would be difficult to seed in the rehabilitated areas. These species are however mostly confined to the marginal zone of the Vaal River and wetland areas identified in the interior of the study area. The technique of sodding can be used to easily establish large plants along the Vaal River bank as well as where wetland areas were affected by mining. The illustration below illustrates this technique. The sods should be removed from immediately upstream or downstream areas and should be immediately taken to the rehabilitated areas and re-planted. Care should be taken to plant the sods in the same area as where they were removed from in terms of slope and distance from the water's edge, i.e. if the sod was taken at the water's edge it should also be planted at the water's edge at the rehabilitated site. Species which can be planted in this manner and which occurs in the area include *Phragmites australis, Hemarthria altissima, Cyperus longus, C. marginatus, Juncus exsertus* and *Paspalum distichum*.

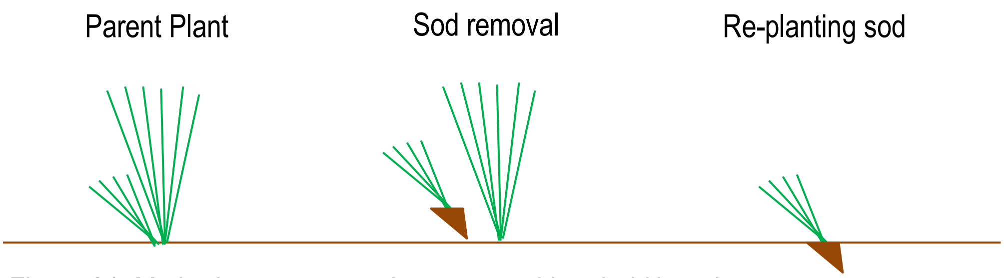


Figure 21: Method to remove and re-plant sod in rehabilitated areas.

All planting and seeding of vegetation on the rehabilitated sites should preferably be done at the start of the rainy season (October) in order to encourage germination and rapid vegetation establishment.

After rehabilitation these areas will be highly susceptible to grazing and trampling by game. Due to the extent of the mining area and the portions which will require rehabilitation it will be costly to fence these areas. However, where monitoring indicates that planted tree saplings or sods are unable to establish small wire cages or similar structures should be erected around them until they successfully establish. Fencing of smaller areas such as the steep banks occurring along the Vaal River should also be considered.

4.3 Weed eradication

Weed eradication should play a crucial part of the rehabilitation process. Weeds may play an initial role in soil stabilisation but should be removed prior to flowering.

As was observed during the survey of the study area it contains relatively few exotic species, especially the terrestrial interior which is almost devoid of exotics. As a result proposed mining operations will create conditions highly susceptible to the establishment of exotic weeds and invaders. It is therefore recommended that weed control be judiciously and continually practised. Monitoring of weed establishment should form a prominent part of management of the mining area. Where category 1 and 2 weeds occur, they require removal by the property owner according to the Conservation of Agricultural Resources Act, No. 43 of 1983 and National Environmental Management: Biodiversity Act, No. 10 of 2004.

A few exotic weeds were observed in the study area, especially along watercourses and include: *Ambrosia artemisiifolia, Sphaeralcea bonariensis, Salsola kali, Verbena officinalis, Xanthium spinosum, Bidens pinata, Oenothera rosea, Datura ferox, D. stramonium, Tagetes minuta, Achyranthes aspera* and *Argemone ochroleuca*.

Other exotic weeds and invaders known to occur in the area and which is likely to establish in mined areas include: *Solanum nigrum, Chenopodium carinatum, Schkuhria pinata, Sesbania bispinosa, Prosopis glandulosa* and *Emex australis*

It is recommended that mechanical methods instead of herbicide is used to control weeds on the rehabilitated sites and especially adjacent to watercourses. Herbicide control is not a specific control which will also affect indigenous seedlings.

Methods to mechanically remove weeds should include hand pulling, cutting and hacking. Where the weeds contain flowers and seeds they should be removed from the site. If no flowers or seeds are present they can be left on the site as mulch.

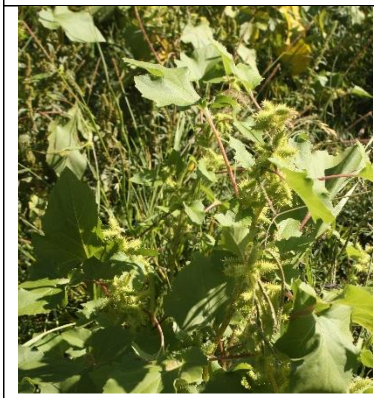
Establishment of an indigenous vegetation layer will also aid in out competing weeds on the rehabilitated sites.

It is recommended that initial weed eradication take place monthly for the first three months and once every three months thereafter for two years following mining activities.


Flaveria bidentis


Ambrosia artemisiifolia


Xanthium spinosum


Xanthium strumarium


Bidens pinnata


Tagetes minuta


Sphaeralcea bonariensis

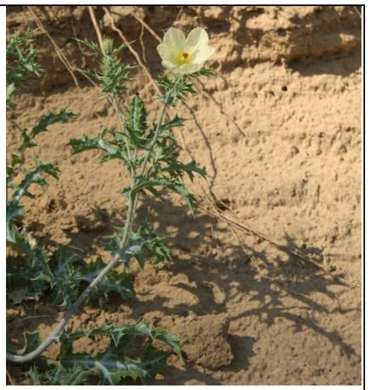

Salsola kali


Verbena bonariensis


Oenothera rosea


Sesbania bispinosa


Datura ferox

		
Datura stramonium	*Achyranthes aspera*	*Argemone ochroleuca*

4.4 Recommended monitoring

Comprehensive rehabilitation will be in vain unless coupled with a comprehensive monitoring plan. The following monitoring aspects pertaining to the rehabilitation phase should be included in the monitoring of the mining operations:

Biomonitoring should be implemented and should be undertaken during the operational as well as the rehabilitation phases. It is recommended that the health of the Vaal River system be monitored every six months in the autumn and spring of each year. Biomonitoring should take place using the SASS5 and IHI indices.

Monitoring of erosion measures as stipulated in the rehabilitation plan should be undertaken and remedial action taken where it is identified. Long term monitoring should also be implemented with the aid of fixed point photography. One or several points prone to erosion can be marked to be used as a fixed point. Consecutive photographs during monthly monitoring from these fixed points can then be used to compile a trend of erosion in rehabilitated areas.

The monitoring of vegetation establishment where rehabilitation has been done is crucial. Monitoring should include the application of vegetation rehabilitation techniques as well as the succession of vegetation establishment. The application of initial vegetation establishment including seeding and sodding should be monitored. Thereafter the success of establishment should be monitored. The use of fixed point photography as discussed previously can also be utilised to monitor vegetation establishment. This will illustrate an increase in percentage vegetation cover, height and species composition over time. This type of monitoring should be undertaken by a qualified ecologist or botanist which is knowledgeable of plant succession, species composition and plant species.

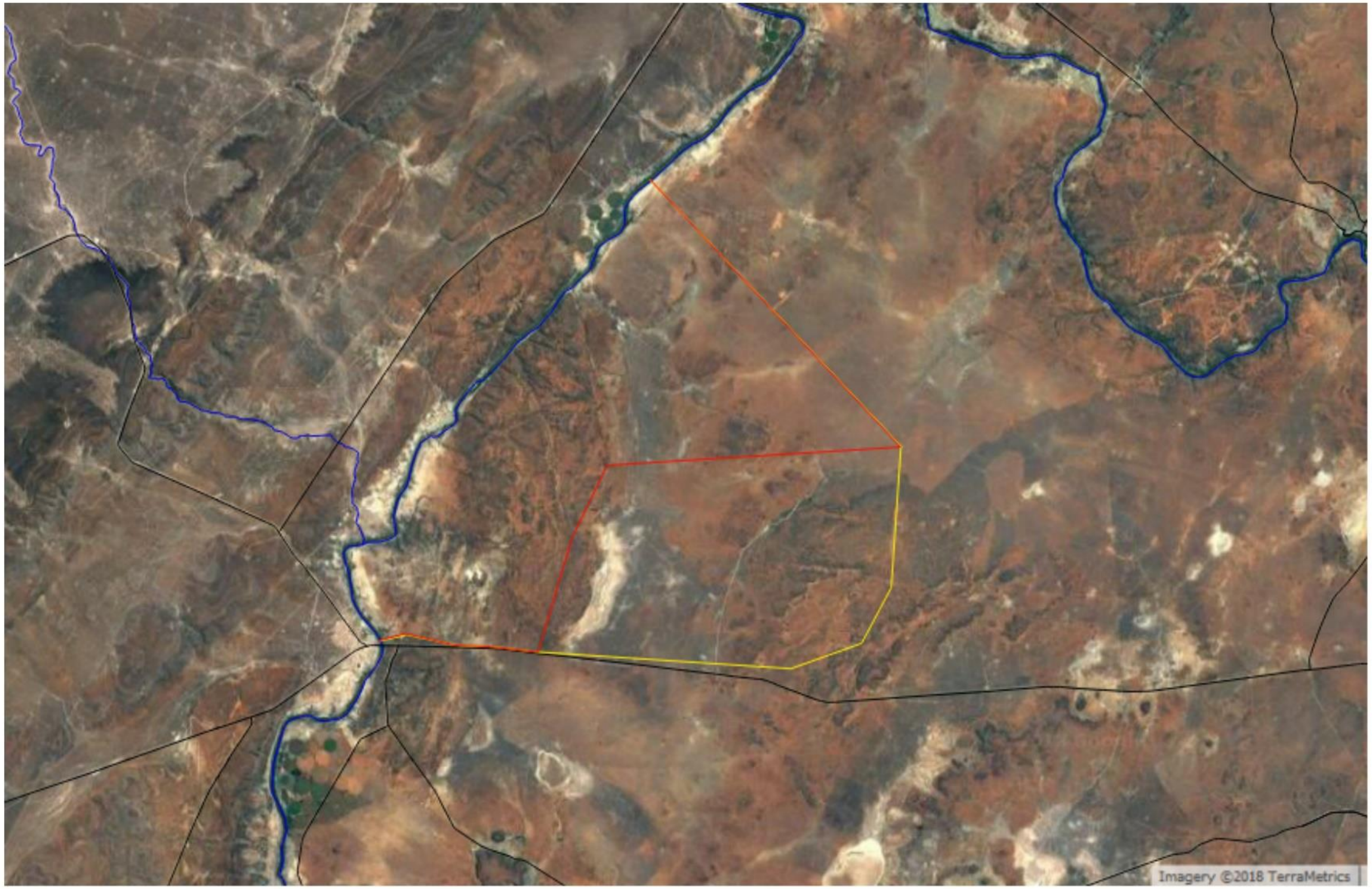
In order to monitor rehabilitation succession of natural vegetation it is recommended that a series of sample plots be penned of approximately 20 x 20 m. These plots should be spread over the rehabilitated area and should include watercourses and terrestrial habitats. The plots should not be fenced so that they are subjected to the same impacts as the surrounding area. Sample plot monitoring should include aspects such as percentage vegetation cover, height and species composition. Monitoring of the sample plots should be undertaken on a six monthly basis by a suitably qualified ecologist. The monitoring of the plots will also indicate any changes to the vegetation and ecosystem health as results from the sample plots will be comparable to previous monitoring results. Monitoring of sample plots should be done every six months during December and March in order to obtain comparable results.

During operation and rehabilitation the site and affected watercourses will be highly susceptible to the establishment of weeds and alien invader species. This is a result of the disturbance of the soil surface which eliminates competition and allows the establishment of weeds which are adapted to disturbed environments. Watercourses and wetlands are exceptionally susceptible to the establishment of weeds due to the disturbance regime caused by flooding and therefore the monitoring of weed establishment along watercourses and wetlands should be a priority.

Establishment of weeds on the site should be monitored by a suitably qualified person on the site such as an Environmental Control Officer. Weed establishment and eradication should be monitored monthly for the first three months where vegetation rehabilitation is being done. Weed establishment and eradication should also be monitored every six months for the entire site and watercourses in conjunction with sample plot monitoring every six months. Monitoring should also include the success rate of eradication techniques on specific weeds and should recommend alternative methods to successfully eradicate specific weeds where necessary.

Annexure A: Maps

Locality of the alluvial diamond mining operations at Rooipoort on the farms Zandplaats 102/5, Vogelstruis Pan 101/0, Vogelstruis Pan 98/0, Bergplaats 100/0 and Klipfontein 99/0 near Schmidtsdrif, Northern Cape Province.



Map 1: Locality map for the proposed Rooipoort mining operations near Schmidstdrif, Northern Cape Province. The application area and the mining area has both been indicated. Note also that the Vaal River forms the western border of the mining area.

Preparred for:
Rooipoort Developments (Pty) Ltd
P.O. Box 110471
Hadison Park
8306

Legend:

- Mining Area (Study Area)
- Application area
- Road network
- Vaal River

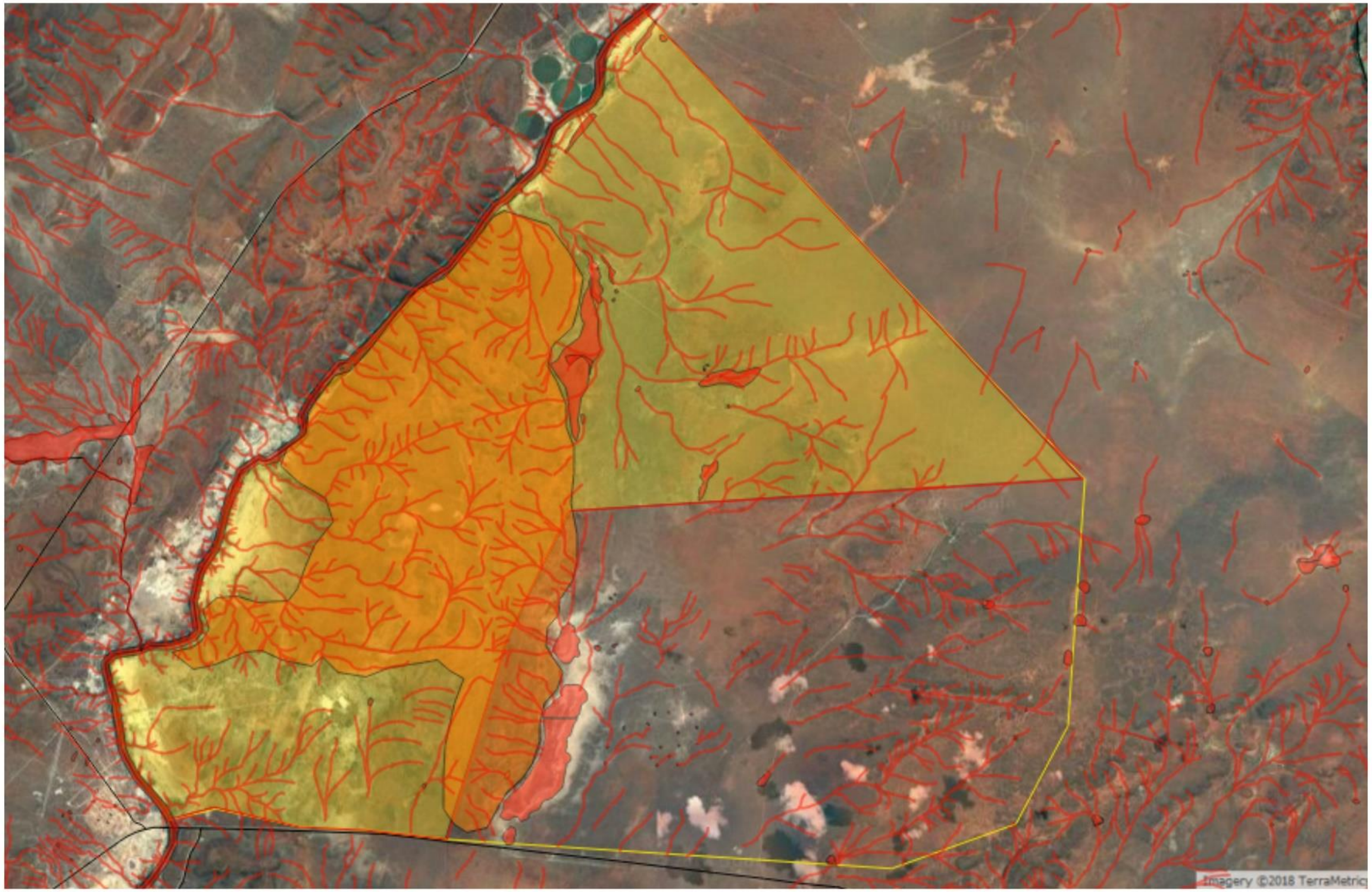
Map Information

S 28.656145º
E 24.123029º

Spheroid: WGS 84
Scale: 1:200 000
Quantum GIS

DPR Ecologists
Contact Darius van Rensburg at:
darius@dprecologists.co.za
P.O. Box 12726, Brandhof, 9324
Tel: 083 410 0770

Sensitivity map of the alluvial diamond mining operations at Rooipoort on the farms Zandplaats 102/5, Vogelstruis Pan 101/0, Vogelstruis Pan 98/0, Bergplaats 100/0 and Klipfontein 99/0 near Schmidtsdrif, Northern Cape Province.



Preparred for:
Rooipoort Developments (Pty) Ltd
P.O. Box 110471
Hadison Park
8306

Legend:

- Mining Area (Study Area)
- Application area
- Road network
- Vaal River
- Very High Sensitivity
- High Sensitivity
- Moderate Sensitivity
- Low Sensitivity

Map Information

S 28.656145º
E 24.123029º

Spheroid: WGS 84
Scale: 1:100 000
Quantum GIS

DPR Ecologists
Contact Darius van Rensburg at:
darius@dprecologists.co.za
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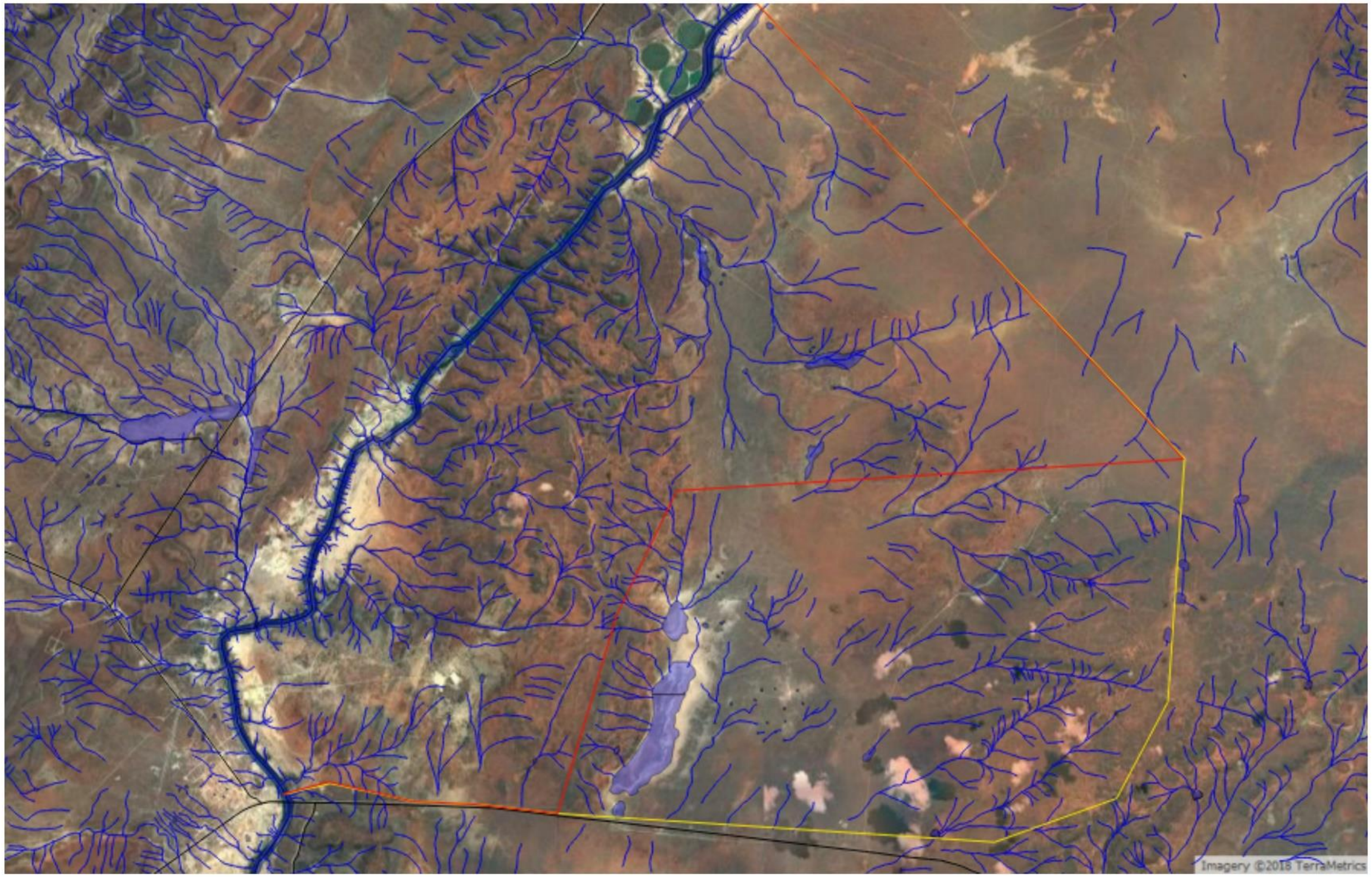
Tel: 083 410 0770

Map 2: Sensitivity map for the proposed Rooipoort mining operations near Schmidstdrif, Northern Cape Province. The vegetation types in the study area is indicated as well as watercourses and wetlands. Areas of very high sensitivity include all watercourses and wetland areas as well as the low quartzite ridge. Areas of high sensitivity consist of the central and south eastern rocky, mountainous portion of the study area. The plains in the south western portion and northern and eastern portions are considered to be of moderate sensitivity.

Wetlands and surface water map of the alluvial diamond mining operations at Rooipoort on the farms Zandplaats 102/5, Vogelstruis Pan 101/0, Vogelstruis Pan 98/0, Bergplaats 100/0 and Klipfontein 99/0 near Schmidtsdrif, Northern Cape Province.



Map 3: Wetlands and surface water map for the proposed Rooipoort mining operations near Schmidstdrif, Northern Cape Province. All watercourses and wetlands in the study area is indicated and survey locations corresponding to Table 6 is also indicated.

Preparred for:
Rooipoort Developments (Pty) Ltd
P.O. Box 110471
Hadison Park
8306

Legend:

- Mining Area (Study Area)
- Application area
- Road network
- Watercourses
- Wetland areas

Map Information

S 28.656145º
E 24.123029º

Spheroid: WGS 84
Scale: 1:100 000
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