

sandy loam to sandy clay loam on soft plinthic deep subsoil of the Avalon form; shallow effective depth, greyish sand to light loam on soft plinthic deep subsoil of the Longlands form; shallow effective depth, soft plinthic, sandy loam to sandy clay loam of the Westleigh form; duplex soil of the Estcourt form, para-duplex soil of the Sepane form; plus poorly drained, dark coloured, loam to clay of the Katspruit form in bottomland sites. Shallow, sandy loam topsoil on hard plinthite of the Dresden form, whereas a gravel pit, an eroded area, a farm dam and a pan had also been mapped. (See **FIGURE 1** for spatial distribution and **TABLES 1, 2 and 3** for properties.)

9.2 Land capability

In terms of the system prescribed by the Chamber of Mines (2007), the following are present (**TABLE 6**):

- Class I: Wetland of permanent status (map units D, P);
- Class I: Wetland of seasonal status (units Ka, Lo-We, Lo-We-Es);
- Class I: Wetland of temporary status (units Lo, We, Se, Dr);
- Class II: Arable land with moderate high arable potential (units Hu, Li1, Gc1, Cv, Av1, Av2) and moderate arable potential (units Li2, Gc2, Li-Gc);
- Class III: Grazing land (units Li3, Gc3);
- Class IV: Wilderness land (units GP and E).

9.3 Wetland identification and delineation

All three kinds of wetlands had been identified and described (**TABLES 6 and 7** and shown spatially in **FIGURE 2**), whereas an attempt was made to assess the present ecological status on the basis of soil and landform indicators (**TABLE 8**). In general, a moderately modified ecological status may be ascribed to the wetlands of the Brown Shaft 2 area.

9.4 Impact description and assessment

The following are regarded as selected potentially significant impacts (**TABLE 9**):

- Degradation of wetlands (definite impact; medium-low with mitigation and high without).
- Loss of prime agricultural land/topsoil (definite impact; medium significance with and high without mitigation).

9.5 Monitoring

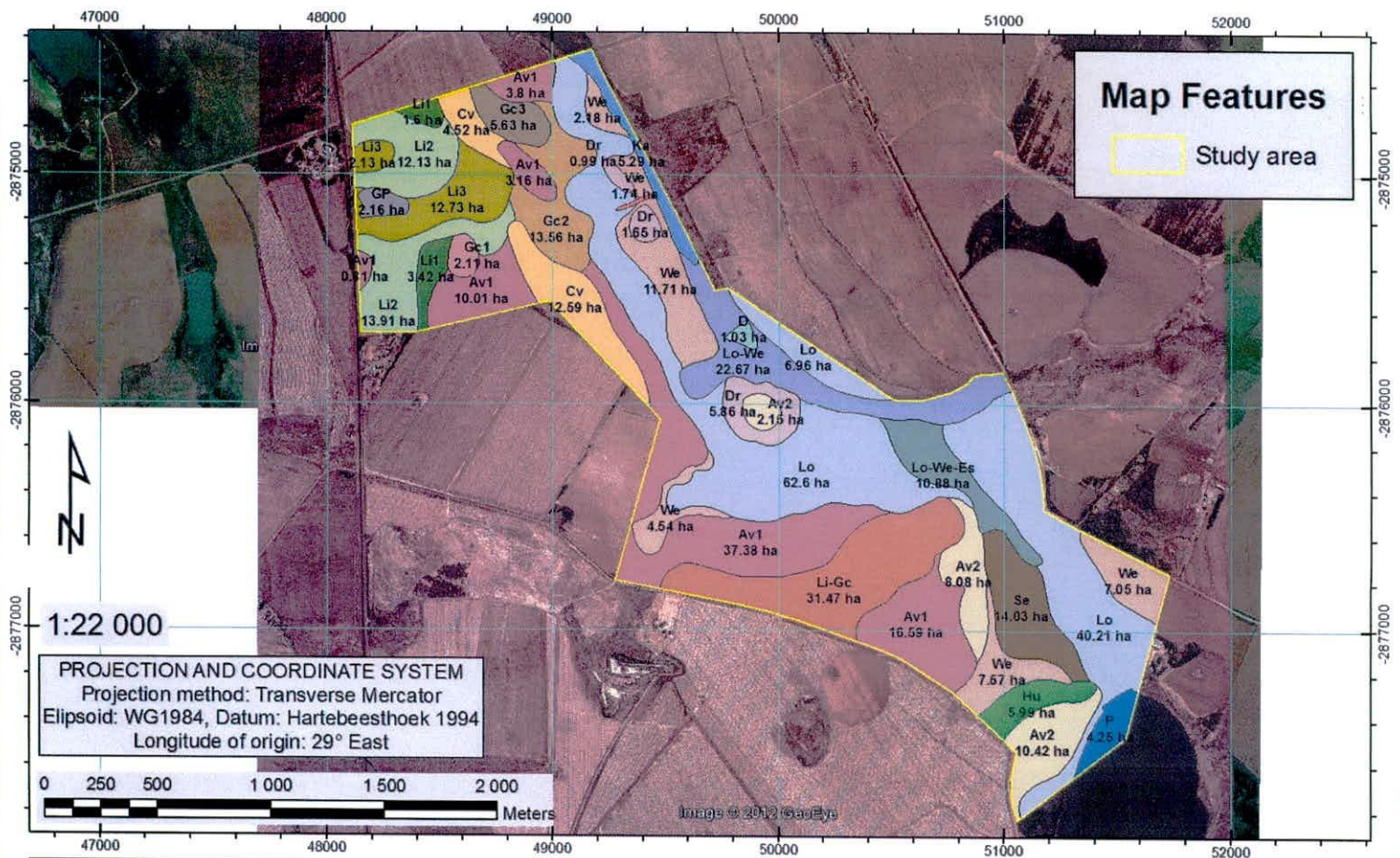
The following monitoring actions are recommended:

- Possible degradation of the wetlands
- Erosion of stockpiled materials and loading zones including haulage roads and other compacted areas
- Chemical pollution of mine seepage, soil and groundwater resources
- Evaluation of a free draining surface (due to compaction of soil surface materials) before topsoil is replaced during the rehabilitation process
- Replacing of topsoil evenly over the entire footprint during rehabilitation
- A post-mining soil assessment to evaluate and map the post-mining land capability which should also serve as required data for closure application.

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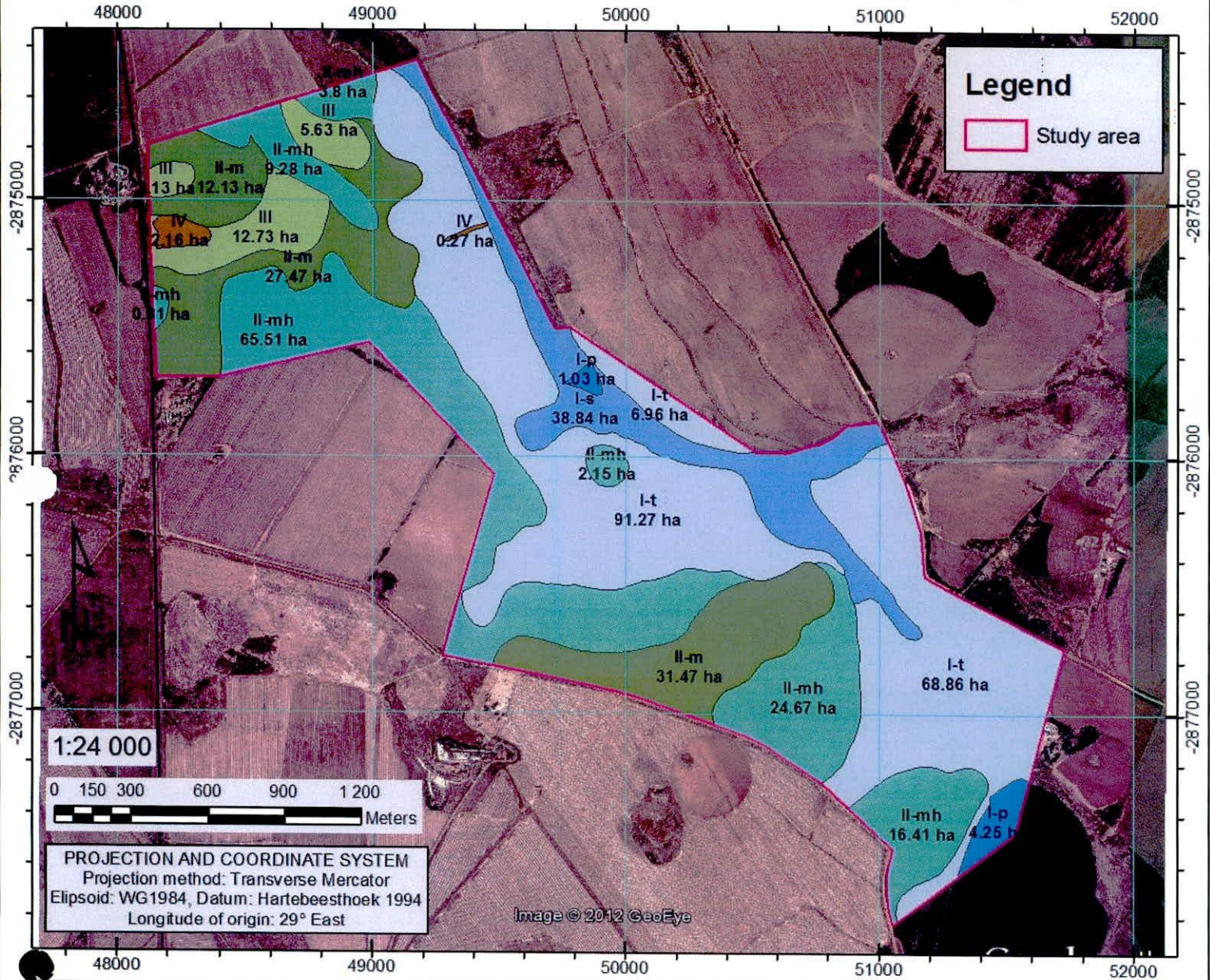
FIGURE 1: DETAILED SOIL-LANDFORM MAP OF PARTS OF PORTIONS 0, 1, 5, 7, 8, 10 AND 18 OF THE FARM WOLVENFONTEIN 471 JS, MIDDELBURG, MPUMALANGA



SOIL-LANDFORM LEGEND

MAP UNIT	LANDFORM COMPONENT	SOIL COMPONENT	AREA (ha)	AREA (%)
Hu	Gently to moderately sloping midslopes (3-6% slope)	Moderately deep to deep (80-120 cm), well-drained, dark red, apedal, sandy clay loam of the Hutton form, on weathered rock	5.99	1.40
Li1	Level to gently sloping crests or upper midslopes (1-2% slope)	Deep (100-140 cm), well-drained, red, apedal, sandy loam or sandy clay loam on hard plinthite of the Lichtenburg form	5.02	1.17
Li2	Level to gently sloping midslopes (2-5% slope)	Moderately deep (60-90 cm), well-drained, red, apedal, sandy loam or sandy clay loam on hard plinthite of the Lichtenburg form; many, hard Fe-Mn concretions in subsoil	26.04	6.09
Li3	Level to gently sloping crests or upper midslopes (1-2% slope)	Shallow (30-50 cm), well-drained, dark red, apedal, sandy loam or sandy clay loam on hard plinthite of the Lichtenburg form; few to many, hard Fe-Mn concretions	14.86	3.47
Gc1	Level to gently sloping crests (1-3% slope)	Deep (100-120 cm), well-drained, yellow-brown, apedal, sandy loam or sandy clay loam on hard plinthite of the Glencoe form	2.11	0.49
Gc2	Gently to moderately sloping midslopes (2-8% slope)	Moderately deep (50-100 cm), well-drained, yellow-brown, apedal, sandy loam or sandy clay loam on hard plinthite of the Glencoe form	13.56	3.17
Gc3	Gently to moderately sloping midslopes (4-8% slope)	Shallow (30-50 cm), well-drained, yellow-brown, apedal, sandy loam on hard plinthite of the Glencoe form; few to many, hard Fe-Mn concretions	5.63	1.32
Li-Gc	Gently sloping midslopes (2-5% slope)	Association of shallow to moderately deep (40-60 cm), well-drained, red or yellow-brown sandy loam or sandy clay loam on hard plinthite; few to many, hard Fe-Mn concretions	31.47	7.36
Cv	Gently to moderately sloping midslopes (2-6% slope)	Deep to very deep (100->150 cm), well-drained, yellow-brown, apedal, sandy loam to sandy clay loam of the Clovelly form on weathered sandstone	17.11	4.00
Av1	Gently to moderately sloping crests or midslopes (1-6% slope)	Moderately deep to deep (effective depth 80-130 cm), moderately well-drained, yellow-brown, apedal, sandy loam or sandy clay loam on soft plinthite deep subsoil of the Avalon form	71.75	16.78
Av2	Gently sloping footslopes (2-4 % slope)	Moderately deep (effective depth 60-90 cm), moderately well-drained, yellow-brown, mottled, apedal, sandy loam or sandy clay loam on soft plinthite deep subsoil of the Avalon form	20.65	4.83
We	Gently to moderately sloping footslopes and valley bottom (1-8% slope)	Shallow (effective depth 30-40 cm), poorly drained, grey brown, sandy loam or sandy clay loam topsoil on plinthic, sandy clay loam subsoil of the Westleigh form	34.79	8.14
Lo	Gently to moderately sloping footslopes (4-8% slope); uneven surface roughness in places in the form of erosion channels	Shallow (effective depth 30-40 cm), somewhat poorly drained, grey-brown or grey, loamy sand or sandy loam topsoil and E horizon, on grey, plinthic, sandy clay loam deep subsoil of the Longlands form	109.77	25.66
Lo-We	Level valley bottom (0-1% slope); uneven surface roughness in places in the form of erosion channels and overburden deposits	Association of poorly drained soils with shallow effective depth (10-40 cm): (i) grey, loamy sand or sandy loam topsoil and E horizon, over grey, plinthic, sandy clay loam deep subsoil of the Longlands form, and (ii) grey, sandy loam or sandy clay loam topsoil, on plinthic, sandy clay loam subsoil of the Westleigh form; water tables commonly present, associated with Katspruit form in places; sandy or loamy overburden in places	22.67	5.30
Lo-We-Es	Level valley bottom (0-1% slope); uneven surface roughness in places in the form of erosion channels and overburden deposits	Association of somewhat poorly to poorly drained soils with shallow effective depth (10-40 cm): (i) grey, loamy sand or sandy loam topsoil and E horizon, over grey, plinthic, sandy clay loam deep subsoil of the Longlands form; (ii) grey, sandy loam or sandy clay loam topsoil on plinthic, sandy clay loam subsoil of the Westleigh form; and (iii) loamy sand topsoil and E horizon, over grey-brown, strong prismatic, sandy clay subsoil of the Estcourt form	10.88	2.54
Se	Gently sloping footslopes (2-4 % slope)	Shallow (effective depth 20-30 cm), greyish brown, finely mottled, weak to moderate blocky, sandy clay loam over, greyish brown, mottled, strong angular blocky, sandy clay loam or sandy clay subsoil of the Sepane form	14.03	3.28
Ka	Level valley bottom (0-1% slope)	Deep soil materials: very poorly drained, dark grey, mottled, sandy loam or sandy clay loam topsoil on grey, gleyed sandy clay of the Katspruit form	5.29	1.24
Dr	Gently to moderately sloping midslopes and footslopes (4-8% slope)	Shallow (30-40 cm) somewhat poorly drained, dark grey, mottled, sandy loam on hard plinthite of the Dresden form; associated with similar soil of the Wasbank form	8.50	1.99
GP	Miscellaneous land class: Gravel pit		2.16	0.50
E	Miscellaneous land class: Erosion		0.27	0.06
D	Dam		1.03	0.24
P	Pan		4.25	0.99
TOTAL			427.83	100.0

FIGURE 2: CURRENT LAND CAPABILITY MAP OF PARTS OF PORTIONS 0, 1, 5, 7, 8, 10 AND 18 OF THE FARM WOLVENFONTEIN 471 JS, MIDDELBURG, MPUMALANGA



LEGEND: CURRENT LAND CAPABILITY

LAND CAPABILITY MAP UNITS	DESCRIPTION	MAP UNITS	AREA (ha)	% OF AREA
I-p	Class I – Wetland: permanent	D, P	5.28	1.23
I-s	Class I – Wetland: seasonal	Ka, Lo-We, Lo-We-Es	38.84	9.08
I-t	Class I – Wetland: temporary	Lo, We, Se, Dr	167.09	39.07
II-mh	Class II – Arable land: moderately high potential	Hu, Li1, Gc1, Cv, Av1, Av2	122.63	28.67
II-m	Class II – Arable land: moderate potential	Li2, Gc2, Li-Gc	71.07	16.62
III	Class III – Grazing land	Li3, Gc3	20.49	4.79
IV	Class IV – Wilderness land	GP, E	2.43	0.56
Total			427.83	100.0

Appendix 2

Vegetation Survey Report for the Proposed Access Brown Shaft II Project Area

BANK COLLIERY – ACCESS BROWN SHAFT II

**SHAFT AND INFRASTRUCTURE AREA
RAW WATER PIPELINE
USED WATER PIPELINE**

FLORA REPORT

MARCH 2013



Compiled by: J M Bate (Pr. Sci. Nat)
Geovicon Environmental (Pty) Ltd

SUMMARY

Flora

The proposed Bank Colliery, Access Brown Shaft II, proposed shaft and infrastructure area, raw water pipeline and used water pipeline are situated in the Grassland Biome of South Africa (Rutherford, 1988). Mucina and Rutherford (2006) classify these areas within the Eastern Highveld Grassland vegetation unit (Gm 12) of the Mesic Highveld Grassland Bioregion.

The 1:50 000 topocadastral maps, 2629AB, 2629BA, 2529CD and 2529DC indicate the proposed shaft and infrastructure area, the raw water pipeline area and the used water pipeline area as cultivated fields and grazing land. The proposed shaft and infrastructure area comprises mainly a cultivated weeping love grazing area. The proposed raw water pipeline comprises mainly grazing land on the western side of the R 35 and cultivated pasture on the eastern side of the R 35. The proposed used water pipeline comprises firstly a cultivated grazing area from the proposed shaft, then cultivated maize areas and grassland areas up to the defunct South Shaft from where it will follow the existing water pipeline servitude between existing maize fields.

Hundred and eighteen plant species were observed in total in the different areas of investigation. This is quite a large number for areas where intensive crop cultivation, livestock farming and mining activities are the main land uses. It thus seems that the vegetation biodiversity is high, but it must be taken into account that many of these species are exotic species due to the current land uses. Some declared weed and invader species were also observed. Of the 118 plant species, 31 are grass species and 5 are rush/sedge species while quite a number of forb species (not grass, tree, sedge or rush species) are established in the areas (82 in total).

According to the amended regulations in the Conservation of Agricultural Resources Act (no 43 of 1983), five declared weed and invader species were observed in the areas of investigation viz. Pampas grass (*Cortaderia selloana*), Scottish thistle (*Cirsium vulgare*), Large cocklebur (*Xanthium strumarium*), Thorn apple (*Datura stramonium*) and Mexican poppy (*Argemone ochroleuca*). These plants must be eradicated.

According to the National red list of South African Plants version 2012.1, one plant species encountered in the areas of investigation is listed as declining (*Hypoxis hemerocallidea* – African potato). This plant is still used by the local people. It occurs in large numbers in the area where the proposed raw water pipeline will be constructed.

Eleven medicinal plant species were observed in the areas of investigation viz. *Aster harveyanus* (Bloublommetjie), *Helichrysum nudifolium* (Everlastings), *Dicoma anomala* (Maagbitterwortel), *Vernonia oligocephala* (Bitterbossie), *Hypoxis hemerocallidea* (African potato), *Pelargonium luridum* (Wild malva), *Gomphocarpus fruticosus* (Milkweed), *Elephantorrhiza elephantine* (Elephant's root), *Centella asiatica* (Pennywort), *Typha capensis* (Bulrush) and *Physalis viscosa* (Sticky gooseberry). All these plant species are widespread.

The proposed raw water and used water pipelines will transect certain wetland areas associated with the Bankspruit and its tributaries. These wetland areas are in close proximity to existing agriculture (cultivation and grazing), pipeline servitude, road and mining activities.

Following rehabilitation of the proposed shaft and infrastructure area, the following grass species are recommended for re-vegetation: *Eragrostis curvula* (Ermelo variety) – Weeping love grass; *Chloris*

gayana - Rhodes grass; *Digitaria eriantha* - Common finger grass; *Eragrostis tef* - Tef; *Cynodon dactylon* - Couch grass.

Recommendations:

- After rehabilitation and re-vegetation of the shaft and infrastructure area, regular inspections must be conducted over the area to determine if vegetation cover is successful in order to combat erosion. If bare patches become visible, seeding of the areas must follow.
- Inspections must also include the establishment of any declared invader plant species. If they exist in the area an immediate eradication program must be implemented.

The closure objective for vegetation is to restore the area to grazing land and to eradicate all declared invader plant species.

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1 INTRODUCTION

Anglo Operations Ltd, Bankfontein Colliery intends to establish a second shaft and infrastructure area named Access Brown Shaft II, situated directly south of the defunct Brown Shaft I. This proposed shaft is situated on the remaining extent of portion 7 of the farm Wolvenfontein 471 JS in the Middelburg District. Underground mining will be conducted from this shaft area. The proposed shaft and infrastructure area is situated approximately 300 m east of the Middelburg – Bethal road (R 35), just south-east of the T-junction to Bank Colliery.

Associated with the proposed shaft and infrastructure area is a raw water pipeline that will stretch from the Bank Colliery pollution control dam to the proposed shaft area as well as a dirty water pipeline that will stretch from the proposed shaft area to the Bank Colliery, south shaft underground workings and a conveyer belt that will stretch from the proposed shaft area to the existing Brown Shaft 1 area.

Figure 1 indicates the regional setting for the Access Brown Shaft II area. The proposed shaft and infrastructure area is approximately 13 ha in size. The raw water pipeline area will be approximately 2.2 ha in size, the dirty water pipeline will be approximately 4.2 ha in size, while the conveyor belt will be approximately 0.6 ha in size.

2 PURPOSE AND METHODOLOGY

The purpose of the investigation was to determine the extent of the species biodiversity on the proposed shaft and infrastructure area as well as the pipeline areas and to identify rare and endangered species (if any), as well as declared alien and invader species.

The methodology included the studying of relevant maps and literature studies for the gathering of background information, identification of the actual species on site, identification of species with a possibility of occurrence, listing of red data and alien species and the demarcation of sensitive areas.

3 BACKGROUND INFORMATION

According to: Determining the conservation value of land in Mpumalanga - Mpumalanga Biobase Report; (Mpumalanga Parks Board, Emery *et al.*2002) the proposed Access Brown Shaft II area falls into the following categories:

Landscape: The broad landscape is dry undulating / flat highlands.

Land use/Land cover: Cultivation, Forest plantations, Mines and quarries, urban.

Transformation:

- Cultivated: 32.05 %
- Degraded: 1.17 %
- Forest Plantations: 1.31 %
- Mines & Quarries: 1.82 %
- Urban: 2.26 %
- Only 1.39 % protected

Communities:

Wetlands: Access Brown Shaft II is situated in an area with seepage importance.

Forests: Access Brown Shaft II is situated in an area with no forest importance.

Vegetation community according to Acocks (1988): Themeda veld (52).

Themeda veld:

It is endemic in Mpumalanga;

It is quite fragmented (FI = 146);

It is 39.07 % transformed;

Cultivation is the largest transformer – 37.01%;

Degradation = 0.07%;

Protected within Mpumalanga = 0%;

Untransformed land in Mpumalanga = 620 165 ha;

Need 101 800 ha of untransformed land to get to 10% protected area;

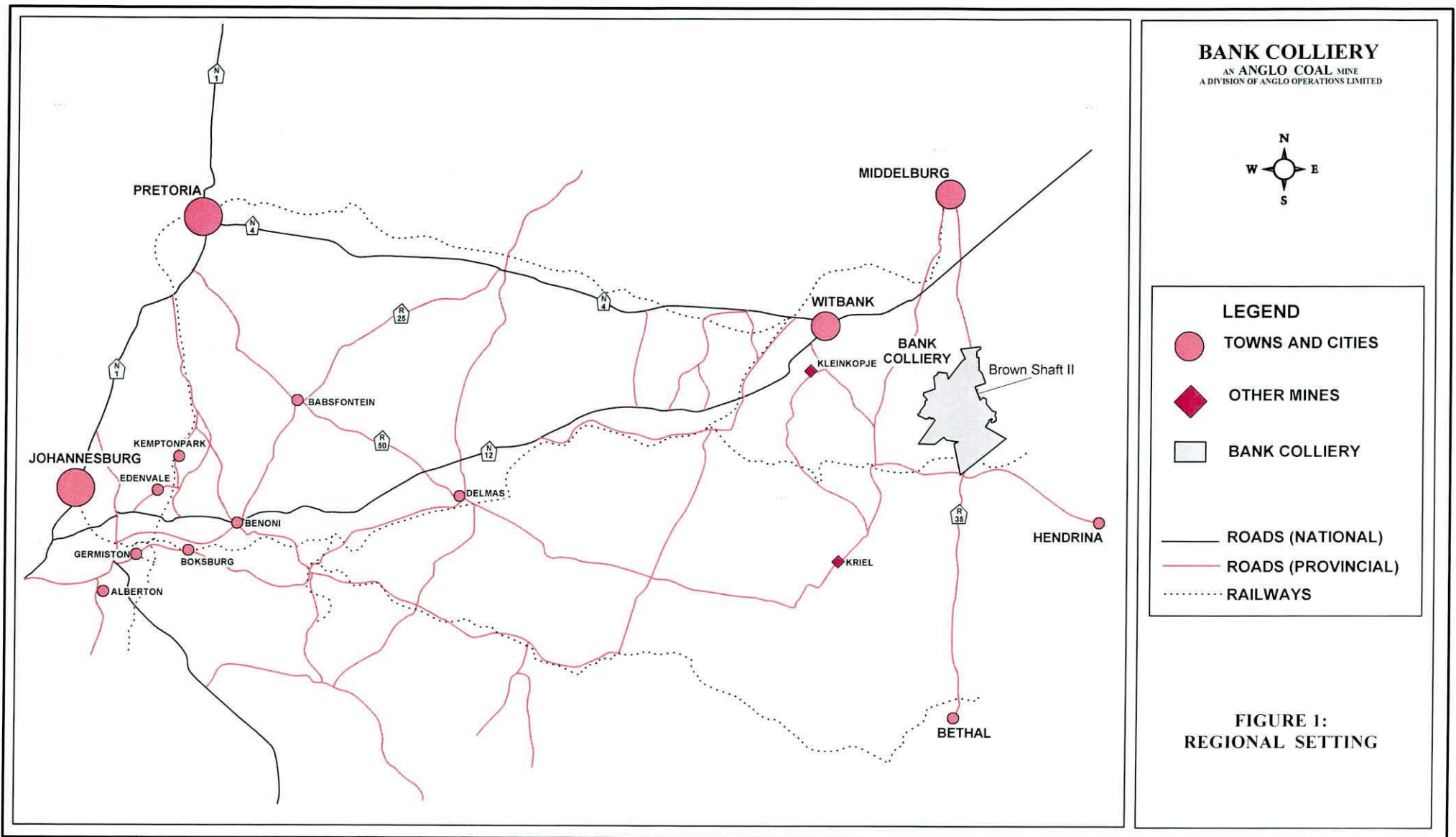
Importance value = 3.6 (Very important in Mpumalanga)

Phytochoria: Centres and regions of plant endemism: No importance.

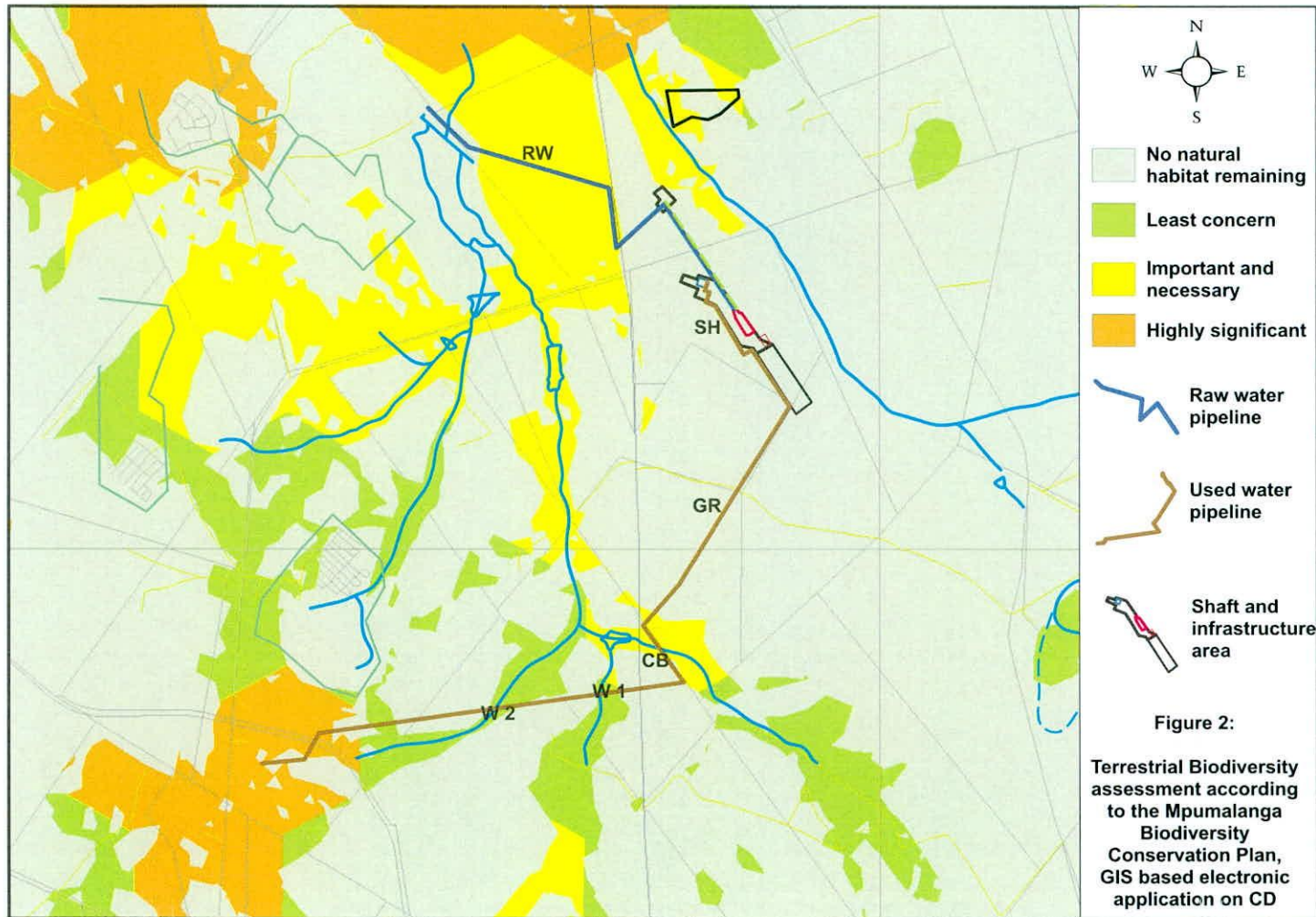
Cave ecosystems: Access Brown Shaft II does not fall in a cave area.

Conservation areas: Access Brown Shaft II does not fall in close proximity to a Nature Reserve

	Very high importance	High importance	Medium importance	Medium-Low importance	Low importance	No importance	No data available
Landscape importance			X				
Forest importance						X	
Vegetation Community importance		X					
Vegetation Community coverage importance				X			
Threatened plant importance						X	
Medicinal plant importance						X	
Mammal species importance					X		
Bird species importance				X			
Amphibian species importance					X		
Reptile species importance					X		
Fish species importance						X	
Invertebrate species importance							X
Intrinsic species value importance (Sites coverage)				X			Transformed land
Intrinsic biodiversity value importance (Community level)				X			Transformed land
Intrinsic biodiversity value importance (Species level)				X			Transformed land



According to the Mpumalanga Biodiversity Conservation Plan GIS-based electronic application on CD (Mpumalanga Tourism and Parks Agency (MTPA), 2007), the proposed shaft and infrastructure area, pipelines and conveyor belt areas are primarily situated in biodiversity areas of “Least concern” and “No natural habitat remaining” indicating that these areas are not important to the MTPA to achieve their conservation goals. The raw water pipeline transects an area on the western side of the R35 that is indicated as a biodiversity area of “Important and necessary” indicating that it may be important for the MTPA to achieve their conservation goals (Figure 2). The dirty water pipeline transects an area on the eastern side of the R35 that is indicated as a biodiversity area of “Important and necessary” indicating that it may be important for the MTPA to achieve their conservation goals (Figure 2).



4 CURRENT LAND USE

The proposed shaft and infrastructure area currently comprises cultivated pasture land. Dryland cultivation of weeping love grass for grazing is taking place over the said area. The 1:50 000 topocadastral map, 2529CC indicates the proposed shaft and infrastructure area as historic cultivated fields and forestation, probably maize monocrop cultivation and gum trees. Historic farm residences occur to the south-west of the proposed shaft and infrastructure area, adjacent to the Middelburg – Bethal road. Gravel farm roads transect and occur in the vicinity of the proposed shaft and infrastructure area. An Eskom power line transects the area to the north-east of the proposed shaft and infrastructure area. Dryland monocrop maize cultivation and grazing are currently also taking place in surrounding areas. The Bank Colliery infrastructure area is situated approximately 3 km to the north west of the proposed shaft and infrastructure area, west of the Middelburg-Bethal road. Historic underground mine workings (south) are also established in the vicinity of the proposed shaft and infrastructure area. Industrial activities are taking place approximately 1 km west of the area, directly west of the Middelburg - Bethal road in the form of a tyre retail business and a vehicle workshop.

The raw water pipeline and conveyor belt comprises mostly grazing land. The raw water pipeline will start at an area directly north-east of the Bankfontein dam wall. The dam area is utilised for recreational activities by employees of Bank Colliery and surrounding people. From the dam wall the pipeline will transect areas utilised as grazing land.

The dirty water pipeline comprises maize monocrop cultivation and grazing land. The dirty water pipeline will start at the proposed Brown Shaft II and transect cultivated fields and grazing land up to where it ends. From where the pipeline runs into the existing Bank Colliery conveyor belt that crosses the R35, it will follow the conveyor belt servitude up to the defunct South Shaft area and from there it will follow an existing servitude area for an underground water pipeline up to the South Shaft underground workings.

Figure 3 and 4 indicate the shaft and infrastructure area in relation to the land uses on the 1:50 000 topocadastral maps as well as on a Google Earth image.

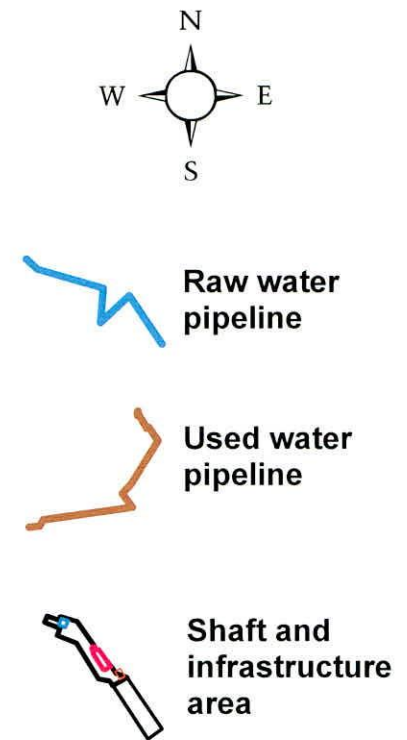
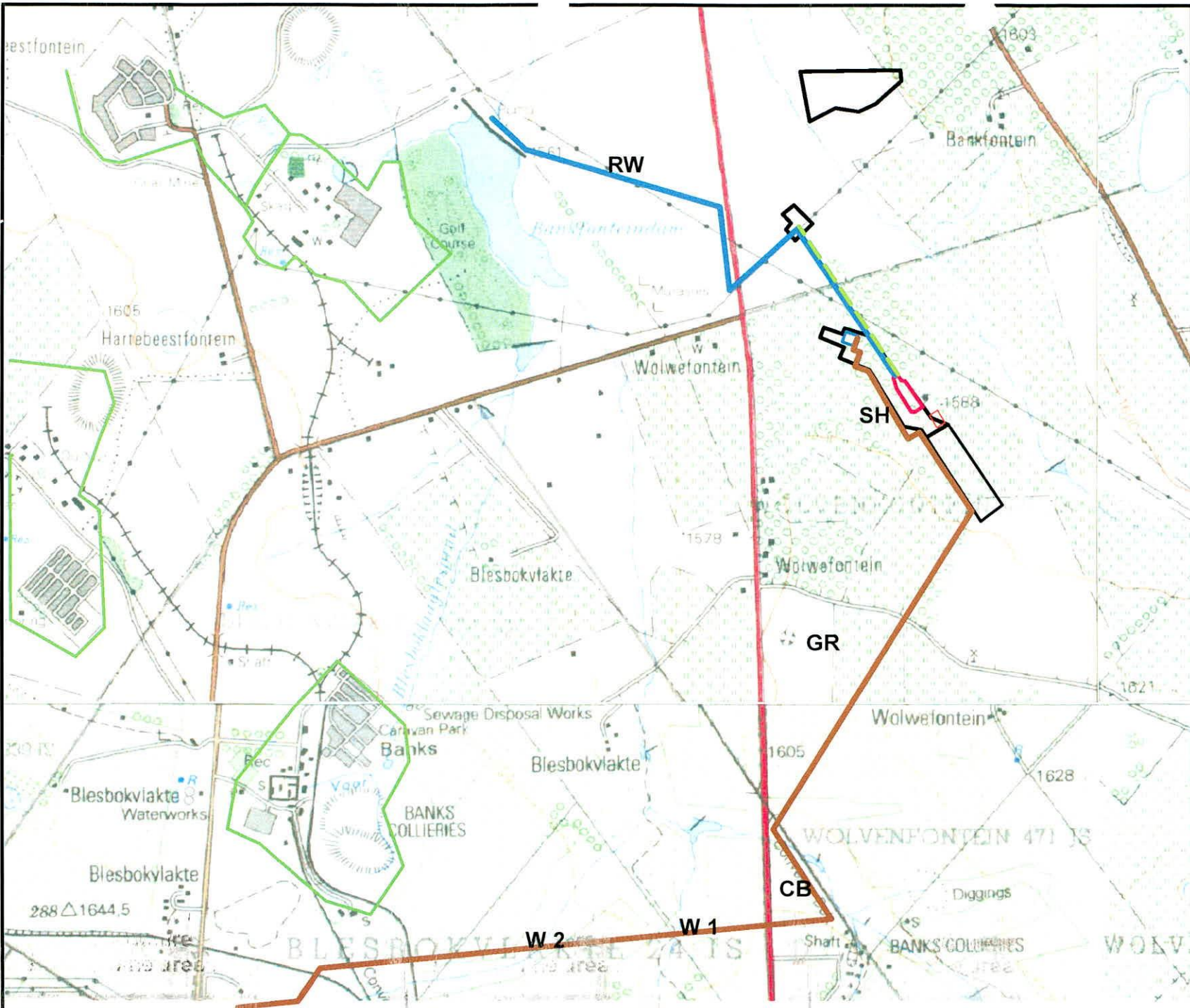
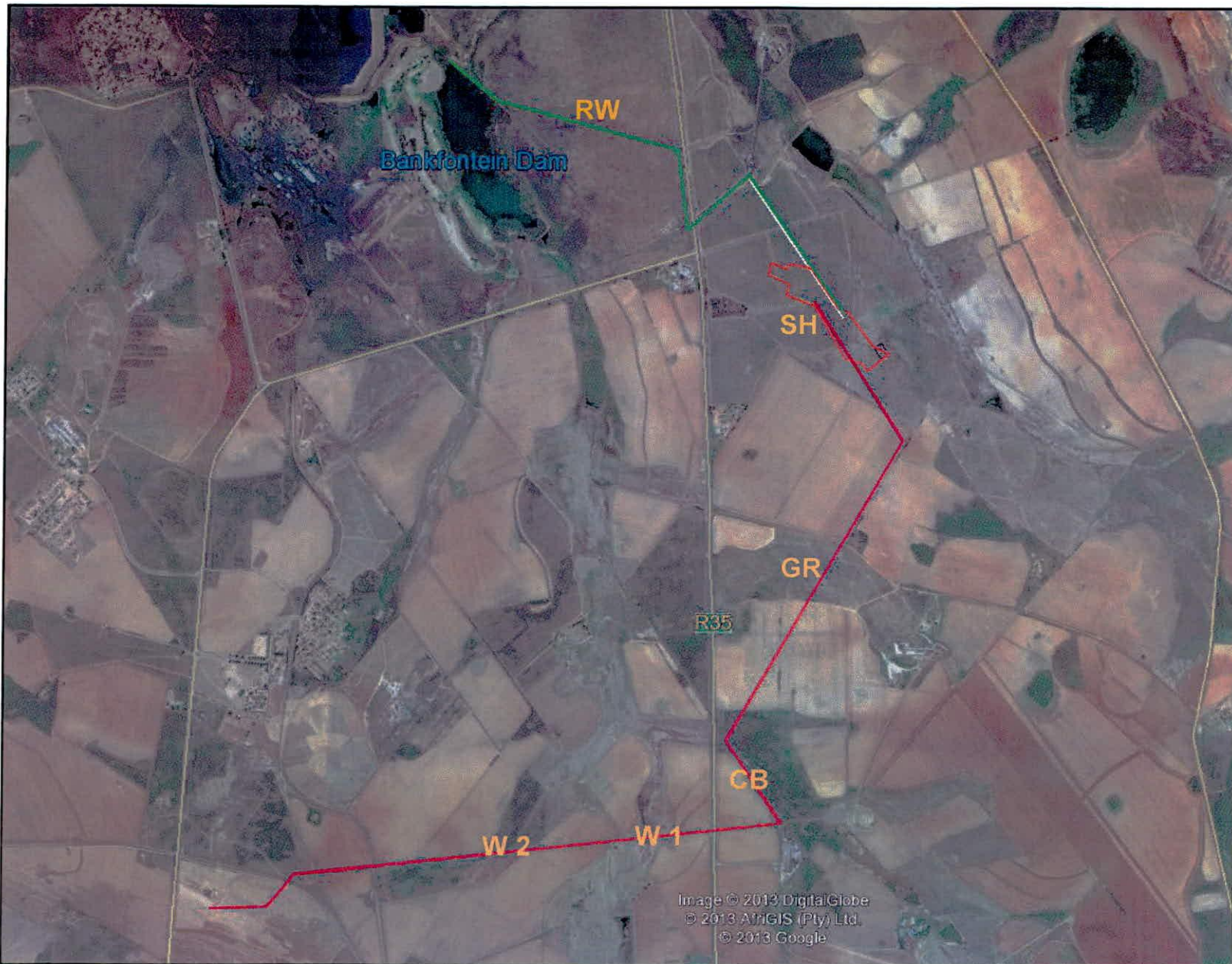




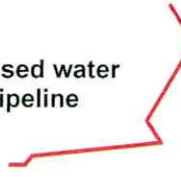
Figure 3:
 1 in 50 000
 Topocadastral map
 indicating
 land uses in the
 vicinity of the
 Access Brown Shaft II
 infrastructure
 and pipeline areas








Raw water pipeline



Used water pipeline



Shaft and infrastructure area

Figure 4:
 Google Earth image indicating land uses in the vicinity of the Access Brown Shaft II infrastructure and pipeline areas

5 VEGETATION (FLORA)

As a component of the EMP for the proposed shaft and infrastructure area, as well as the pipelines and conveyor belt, a vegetation survey was conducted during January 2013 over the proposed shaft and infrastructure area. The survey was conducted in order to obtain a species list for the survey area.

Rare and endangered species (if any) were then identified according to the National red list of South African Plants version 2012.1.

Declared invader weed species were identified according to the amended regulations in the Conservation of Agricultural Resources Act (no 43 of 1983).

Medicinal plant species were also listed.

5.1 BIOME AND VEGETATION UNIT DESCRIPTION

The area of investigation is situated in the Grassland Biome of South Africa (Rutherford, 1988). Mucina and Rutherford (2006) classify the survey site within the Eastern Highveld Grassland vegetation unit (Gm 12) of the Mesic Highveld Grassland Bioregion.

This vegetation unit is situated in the Mpumalanga and Gauteng Provinces on the plains between Belfast and the eastern side of Johannesburg in the west and extending southwards to Bethal, Ermelo and west of Piet Retief. The altitude varies from 1 520 to 1 780 mamsl but may also be as low as 1 300 mamsl in places.

The vegetation and landscape features consist of slightly too moderately undulating plains, including some low hills and pan depressions. The vegetation is short dense grassland dominated by the usual highveld grass composition (*Aristida*, *Digitaria*, *Eragrostis*, *Themeda*, *Tristachya* etc.) with small, scattered rocky outcrops with wiry, sour grasses and some woody species (*Acacia caffra*, *Celtis africana*, *Diospyros lycioides* subsp *lycioides*, *Parinari capensis*, *Protea caffra*, *Protea welwitschii* and *Rhus magalismontanum*).

The climate is strongly seasonal summer rainfall, with very dry winters. Figure 5 shows a climate diagram for the Eastern Highveld Grassland vegetation unit.

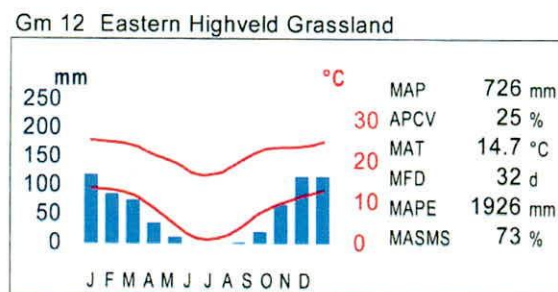


Figure 5: Climate diagram for the Eastern Highveld Grassland subdivision.

MAP – Mean Annual Precipitation

APCV – Annual Precipitation Coefficient of variation

MAT – Mean Annual Temperature

MFD – Mean Frost Days

MAPE – Mean Annual Potential Evaporation

MASMS – Mean Annual Soil Moisture Stress

Table 1: List of the dominant taxa in the Eastern Highveld Grassland vegetation unit

Graminoids (Grasses)	
<i>Aristida aequiglumis</i>	Three-awn
<i>Aristida congesta</i>	Tassel three-awn
<i>Aristida junciformis</i>	Gongoni three-awn
<i>Brachiaria serrata</i>	Velvet signal grass
<i>Cynodon dactylon</i>	Couch grass
<i>Digitaria monodactyla</i>	One finger grass
<i>Digitaria tricholaenoides</i>	Purple finger grass
<i>Elionurus muticus</i>	Wire grass
<i>Eragrostis chloromelas</i>	Narrow curly leaf
<i>Eragrostis curvula</i>	Weeping love grass
<i>Eragrostis plana</i>	Tough love grass
<i>Eragrostis racemosa</i>	Narrow heart love grass
<i>Eragrostis sclerantha</i>	Love grass
<i>Heteropogon contortus</i>	Spear grass
<i>Loudetia simplex</i>	Common russet grass
<i>Microchloa caffra</i>	Pincushion grass
<i>Monocymbium ceresiiforme</i>	Boat grass
<i>Setaria sphacelata</i>	Bristle grass
<i>Sporobolus africanus</i>	Ratstail dropseed
<i>Sporobolus pectinatus</i>	Dropseed
<i>Themeda triandra</i>	Red grass
<i>Trachypogon spicatus</i>	Giant spear grass
<i>Tristachya leucothrix</i>	Trident grass
<i>Tristachya rehmannii</i>	Trident grass
Herbs (Forbs, plants)	
<i>Berkheya setifera</i>	Rasperdissedoring
<i>Haplocarpa scaposa</i>	Tonteldoosbossie
<i>Justicia anagalloides</i>	--
<i>Pelargonium luridum</i>	--
<i>Acalypha angustata</i>	Copper leaf
<i>Chamaecrista mimosoides</i>	Fishbone cassia
<i>Dicoma anomala</i>	Maagbitterwortel
<i>Euryops gilfillanii</i>	--
<i>Euryops transvaalensis</i>	--
<i>Helichrysum aureonitens</i>	--
<i>Helichrysum caespititium</i>	Speelwonderboom
<i>Helichrysum calicomum</i>	--
<i>Helichrysum oreophilum</i>	--
<i>Helichrysum rugulosum</i>	--
<i>Ipomoea crassipes</i>	--
Geophytic herbs	
<i>Gladiolus crassifolius</i>	--
<i>Haemanthus humilis</i>	--
<i>Hypoxis rigidula</i>	Kaffertulp
<i>Ledebouria ovatifolia</i>	--
Succulent herbs	
<i>Aloe ecklonis</i>	Ecklone's aloe
Low shrubs	
<i>Anthospermum rigidum</i>	--0
<i>Stoebe plumose</i>	--

5.2 RESULTS

The topocadastral map indicates the proposed shaft and infrastructure area to be a cultivated area (Figure 3). Currently it is a cultivated pasture area. All natural vegetation was thus historically removed from the area. The topocadastral map indicates the area on the eastern side of the Bankfontein dam where the proposed raw water pipeline transects as a grazing area. Currently it is still a grazing area and it seems quite overgrazed. The topocadastral map indicates the areas where the proposed used water pipeline transects as cultivated areas and grazing land. Currently this proposed pipeline will be constructed on an existing conveyor belt area just north of the defunct South Shaft and from the shaft it will be constructed on an existing water pipeline servitude that transects cultivated areas. It also transects two wetland areas surrounded by cultivated fields. A vegetation species list was compiled for the proposed shaft and infrastructure area situated on historically disturbed land as well as on the proposed raw water and used water pipelines.

Species cover abundance was recorded according to the Braun-Blanquet cover abundance scale. Species cover can never be measured exactly. Results will differ between different observers and at different times of observation. The Braun-Blanquet method place visual estimates in 7 cover classes. Table 2 indicates the cover abundance classes. The percentage range within each class allows for the differences between observers. The different classes determine the dominance of a species in an area of investigation.

Table 2: Braun-Blanquet cover abundance classes

Value	Scale
r	<< 1 % cover
+	< 1 % cover
1	1 – 5 % cover
2	6 – 25 % cover
3	26 – 50 % cover
4	51 – 75 % cover
5	76 – 100 % cover

The commonly observed grass species (dominant species) within the proposed shaft and infrastructure area was *Eragrostis curvula* (Weeping love grass). The cover abundance for some additional grass species that got re-established after pasture establishment was lower than the cover abundance of the dominant species. These grass species were incorporated in the sub-ordinate plant species list. The area contained some herbaceous forb species (plant species that are not grass species), that also got re-established after pasture establishment. The commonly observed forb species was *Hypochaeris radicata* (Hairy wild lettuce). Vegetation species are all listed in Table 3.

The commonly observed grass species (dominant species) within the raw water pipeline area was *Hyparrhenia hirta* (Common thatching grass) while the commonly observed forb species was *Seriphium plumosum* (Bankrupt bush).

The commonly observed grass species (dominant species) within the grassland area of the proposed used water pipeline area were *Digitaria eriantha* (Common finger grass) and *Cynodon dactylon* (Couch grass) while the commonly observed forb species was *Amaranthus hybridus* (Pigweed).

The commonly observed grass species (dominant species) within the grassland area of the proposed used water pipeline area at the existing conveyor belt were *Cynodon dactylon* (Couch grass), *Hyparrhenia tamba* (Blue thatching grass), *Eragrostis chloromelas* (Curly leaf) and *Imperata cylindrical* (Cottonwool

grass while the commonly observed forb species were *Cosmos bipinnatus* (Cosmos) and *Verbena bonariensis* (Wild verbena).

The commonly observed grass species (dominant species) within the wetland areas of the proposed used water pipeline area was, in the eastern tributary wetland of the Bankspruit, *Leersia hexandra* (Rice grass) and the commonly observed forb species was *Cirsium vulgare* (Scottish thistle), while in the Bankspruit wetland area the commonly observed grass species was *Hyparrhenia tamba* (Blue thatching grass) and the commonly observed forb species was *Verbena bonariense* (Wild verbena).

Table 3: Vegetation list for all areas of investigation

W1 = Eastern tributary of the Bankspruit
SH = Shaft and infrastructure area

W2 = Bankspruit
RW = Raw water pipeline

CB = Conveyor belt

Scientific name	Plant family	Common name	Areas of investigation					
			W1	W2	CB	GR	SH	RW
<i>Leersia hexandra</i>	Poaceae	Rice grass	X		X			
<i>Hyparrhenia tamba</i>	Poaceae	Blue thatching grass	X	X	X			
<i>Cynodon dactylon</i>	Poaceae	Couch grass	X	X	X	X	X	X
<i>Paspalum dilatatum</i>	Poaceae	Dallis grass	X	X	X			
<i>Sporobolus africanus</i>	Poaceae	Ratstail dropseed	X	X				
<i>Urochloa panicoides</i>	Poaceae	Garden urochloa	X			X		
<i>Setaria pallide-fusca</i>	Poaceae	Garden bristle grass	X	X	X			
<i>Pennisetum clandestinum</i>	Poaceae	Kikuyu	X		X	X		
<i>Panicum maximum</i>	Poaceae	Guinea grass	X	X	X			
<i>Eragrostis chloromelas</i>	Poaceae	Narrow curly leaf	X		X	X		
<i>Andropogon appendiculatus</i>	Poaceae	Vlei bluestem	X					
<i>Imperata cylindrica</i>	Poaceae	Cottonwool grass	X	X	X			
<i>Aristida canescens</i>	Poaceae	Pale three-awn	X					X
<i>Eragrostis gumiflua</i>	Poaceae	Gum grass	X	X				
<i>Miscanthus junceus</i>	Poaceae	Wireleaf daba grass	X	X	X			
<i>Hyparrhenia hirta</i>	Poaceae	Common thatching grass		X		X		
<i>Andropogon eucomis</i>	Poaceae	Snowflake grass		X				
<i>Cortaderia selloana</i>	Poaceae	Pampas grass		X		X		
<i>Eragrostis curvula</i>	Poaceae	Weeping love grass		X			X	X
<i>Eragrostis racemosa</i>	Poaceae	Narrow heart love grass		X				
<i>Eragrostis trichophora</i>	Poaceae	Hairy love grass		X	X			
<i>Digitaria eriantha</i>	Poaceae	Common finger grass				X		
<i>Urochloa mosambicensis</i>	Poaceae	Bushveld signal grass				X		
<i>Tristachya leucothrix</i>	Poaceae	Hairy trident grass				X		X

<i>Heteropogon contortus</i>	Poaceae	Spear grass						X
<i>Ctenium concinnum</i>	Poaceae	Sickle grass						X
<i>Melinis repens</i>	Poaceae	Natal red top						X
<i>Digitaria tricholaenoides</i>	Poaceae	Purple finger grass						X
<i>Panicum natalense</i>	Poaceae	Natal panicum						X
<i>Aristida congesta</i>	Poaceae	Tassel three-awn						X
<i>Aristida stipitata</i>	Poaceae	Long-awned grass						X
<i>Gomphrena celosoides</i>	Amaranthaceae	Bachelor's button	X					
<i>Amaranthus hybridus</i>	Amaranthaceae	Pigweed	X		X	X		
<i>Verbena bonariensis</i>	Verbenaceae	Wild verbena	X	X	X	X		
<i>Cirsium vulgare</i>	Asteraceae	Scottish Thistle	X	X	X			
<i>Tegetes minuta</i>	Asteraceae	Khaki weed	X		X			
<i>Sonchus wilmsii</i>	Asteraceae	Milk thistle	X		X			
<i>Helichrysum aureonitens</i>	Asteraceae		X	X				
<i>Cosmos bipinnata</i>	Asteraceae	Cosmos	X	X	X	X		
<i>Helichrysum rugulosum</i>	Asteraceae		X		X			X
<i>Schkuria pinnata</i>	Asteraceae	Dwarf marigold	X		X			
<i>Conyza bonariensis</i>	Asteraceae	Flax-leaf fleabane	X		X			
<i>Senecio gregatus</i>	Asteraceae		X					
<i>Senecio inornatus</i>	Asteraceae		X		X			
<i>Senecio consanguineus</i>	Asteraceae	Starvation senecio	X					
<i>Berkheya radula</i>	Asteraceae	Boesmansrietjie		X				
<i>Vernonia poskeana</i>	Asteraceae			X				X
<i>Senecio inaequidens</i>	Asteraceae	Canary weed		X	X			
<i>Haplocarpa scaposa</i>	Asteraceae	Tonteldoosbossie		X				
<i>Bidens bipinnata</i>	Asteraceae	Blackjack		X				
<i>Tolpis capensis</i>	Asteraceae			X				
<i>Senecio erubescens</i>	Asteraceae			X	X			
<i>Helichrysum melanacme</i>	Asteraceae			X				
<i>Senecio affinis</i>	Asteraceae				X			

<i>Helichrysum cooperi</i>	Asteraceae	Yellow everlasting			X			
<i>Aster harveyanus</i>	Asteraceae	Bloublommetjie			X			
<i>Xanthium strumarium</i>	Asteraceae	Large cocklebur			X			
<i>Haplocarpa lyrata</i>	Asteraceae				X			
<i>Arctotis arctotooides</i>	Asteraceae				X			
<i>Berkheya setifera</i>	Asteraceae	Rasperdisseldoring			X			
<i>Tripteris aghillana</i>	Asteraceae					X		
<i>Hypochaeris radicata</i>	Asteraceae	Hairy wild lettuce				X	X	
<i>Conyza podocephala</i>	Asteraceae						X	
<i>Senecio isatideus</i>	Asteraceae	Dan's cabbage						X
<i>Helichrysum dasymallum</i>	Asteraceae							X
<i>Geigeria burkei</i>	Asteraceae	Vermeerbos						X
<i>Helichrysum nudifolium</i>	Asteraceae	Hottentot's tea			X			X
<i>Dicoma anomala</i>	Asteraceae	Maagbitterwortel						X
<i>Nidorella anomala</i>	Asteraceae				X			X
<i>Helichrysum coriaceum</i>	Asteraceae	Vaalteebossie			X			X
<i>Vernonia oligocephala</i>	Asteraceae	Bitterbossie			X			X
<i>Felicia muricata</i>	Asteraceae							X
<i>Chamaecrista comosa</i>	Caesalpiniaceae		X	X	X			
<i>Vigna vexillata</i>	Fabaceae			X				
<i>Elephantorrhiza elephantorina</i>	Fabaceae	Elephant'sroot						X
<i>Rhynchosia monophylla</i>	Fabaceae							X
<i>Indigofera oxytropis</i>	Fabaceae							X
<i>Eriosema salignum</i>	Fabaceae							X
<i>Ledebouria cooperii</i>	Liliaceae		X					
<i>Albuca Sp</i>	Liliaceae				X			
<i>Gladiolus spp</i>	Liliaceae							X
<i>Kniphofia ensifolia</i>	Asphodelaceae				X			
<i>Ciclospermum leptophyllum</i>	Apiaceae	Wild celery	X	X				
<i>Centella asiatica</i>	Apiaceae	Pennywort		X				

<i>Hibiscus trionum</i>	Malvaceae	Bladderweed	X					
<i>Juncus effusus</i>	Juncaceae	Rush	X					
<i>Juncus punctorius</i>	Juncaceae	Rush	X					
<i>Cyperus congestus</i>	Cyperaceae	Sedge	X					
<i>Bulbostylis burchellii</i>	Cyperaceae	Sedge				X		X
<i>Scirpus burkei</i>	Cyperaceae	Sedge				X		X
<i>Oenothera rosea</i>	Onagraceae	Pink evening primrose	X			X		
<i>Epilobium hirsutum</i>	Onagraceae					X		
<i>Oenothera tetraptera</i>	Onagraceae	White evening primrose				X		
<i>Typha capensis</i>	Typhaceae	Bulrush	X			X		
<i>Commelina africana</i>	Commelinaceae	Wandering jew	X	X				
<i>Solanum nigrum</i>	Solanaceae	Nightshade	X			X		
<i>Datura stramonium</i>	Solanaceae	Thorn apple	X			X		
<i>Physalis viscosa</i>	Solanaceae	Sticky gooseberry				X		
<i>Diospyros austro-africana</i>	Ebenaceae	Jakkalsbos	X					X
<i>Euclea crispa</i>	Ebenaceae	Guarri						X
<i>Persicaria lapathifolia</i>	Polygonaceae	Spotted knotweed	X	X		X		
<i>Lobelia flacida</i>	Lobeliaceae					X		
<i>Hypoxis hemerocallidea</i>	Hypoxidaceae	Gifbol				X		
<i>Hypoxis rigidula</i>	Hypoxidaceae	Kaffertulp				X		
<i>Argemone ochroleuca</i>	Papaveraceae	Mexican poppy				X		
<i>Chenopodium album</i>	Chenopodiaceae	White goosefoot				X	X	X
<i>Wahlenbergia caledonica</i>	Campanulaceae					X		
<i>Lepidium africanum</i>	Brassicaceae	Pepperweed				X		
<i>Euphorbia striata</i>	Euphorbiaceae	Melkgras				X		
<i>Acalypha angustata</i>	Euphorbiaceae	Copper leaf				X		X
<i>Hermannia depressa</i>	Sterculiaceae	Rooi-opslag				X		
<i>Hermannia transvaalensis</i>	Sterculiaceae					X		
<i>Pelargonium luridum</i>	Geraniaceae					X		
<i>Asclepias aurea</i>	Apocynaceae					X		X

<i>Gomphocarpus fruticosus</i>	Apocynaceae	Milkweed				X		
<i>Walafrida densiflora</i>	Selaginaceae							X
<i>Hebenstretia comosa</i>	Selaginaceae	Katstert						X
<i>Pygmaeothamnus zeyheri</i>	Rubiaceae	Sand apple						X

Table 4: Species list indicating ecological information on plant species encountered in the areas of investigation

Scientific name	Plant Family	Common name	Occurrence	Threatened status	Declared weed status	Medicinal	Perenniality	Grazing value	Grazing status	Plant succession
Dominant species										
<i>Leersia hexandra</i>	Poaceae	Rice grass	Wet places				Creeping	High		
<i>Hyparrhenia tamba</i>	Poaceae	Blue thatching grass	Disturbed places, damp places				Perennial tufted	Low	Inc. 1	Climax
<i>Cynodon dactylon</i>	Poaceae	Couch grass	Disturbed places, often in damp places				Creeping	High	Inc. 2	Pioneer
<i>Eragrostis chloromelas</i>	Poaceae	Narrow curly leaf	Grassland, stony areas				Perennial tufted	Average	Inc. 2	Subclimax
<i>Digitaria eriantha</i>	Poaceae	Common finger grass	Sandy areas, damp places				Perennial tufted	High	Dec.	Climax
<i>Eragrostis curvula</i>	Poaceae	Weeping love grass	Disturbed places/Cultivated				Perennial tufted	High	Inc. 2	Climax/Subclimax
Sub-ordinate species										
<i>Paspalum dilatatum</i>	Poaceae	Dallis grass	Moist places, weed in cultivated lands		Exotic		Weak perennial tufted	High	--	--
<i>Sporobolus africanus</i>	Poaceae	Ratstail dropseed	Disturbed places, trampled veld, damp places				Perennial tufted	Low	Inc. 3	Subclimax
<i>Urochloa panicoides</i>	Poaceae	Garden urochloa	Disturbed places				Annual tufted	Low	Inc. 2	Pioneer
<i>Setaria pallidifusca</i>	Poaceae	Garden bristle grass	Disturbed places, damp places				Annual tufted	Average	Inc. 2	Pioneer
<i>Pennisetum clandestinum</i>	Poaceae	Kikuyu	Disturbed places, damp soil		Exotic		Creeping	High		
<i>Panicum maximum</i>	Poaceae	Guinea grass	Damp soil				Perennial tufted	High	Dec.	Climax/Subclimax
<i>Andropogon appendiculatis</i>	Poaceae	Vlei bluestem	Wet places				Perennial tufted	High	Dec	Climax
<i>Imperata cylindrica</i>	Poaceae	Cottonwool grass	Damp soil				Creeping	Low	Inc. 1	
<i>Aristida canescens</i>	Poaceae	Pale three-awn	Disturbed and eroded places				Perennial tufted	Low	Inc. 2	Subclimax

<i>Eragrostis gumiflua</i>	Poaceae	Gumgrass	Grassland, disturbed places, damp places				Perennial tufted	Low	Inc. 2	Climax/Subclimax
<i>Miscanthus junceus</i>	Poaceae	Wireleaf daba grass	Wet places				Perennial tufted	Low	Inc. 1	Climax
<i>Hyparrhenia hirta</i>	Poaceae	Common thatching grass	Open grassland, old cultivated lands				Perennial tufted	Average	Inc. 1	Climax/Subclimax
<i>Adropogon eucomus</i>	Poaceae	Snowflake grass	Wet places, disturbed places				Perennial tufted	Low	Inc. 2	Subclimax
<i>Cortaderia selloana</i>	Poaceae	Pampas grass			Cat 1					
<i>Eragrostis racemosa</i>	Poaceae	Narrow heart love grass	Disturbed places, damp soil				Perennial tufted	Average	Inc. 2	Subclimax
<i>Eragrostis trichophora</i>	Poaceae	Hairy love grass	Disturbed places where rainwater collects				Annual tufted	Average	Inc. 2	Subclimax
<i>Urochloa mosambicensis</i>	Poaceae	Bushveld signal grass	Disturbed places, overgrazed areas, trapped veld				Annual tufted	High	Inc. 2	Subclimax/Pioneer
<i>Tristachya leucothrix</i>	Poaceae	Hairy trident grass	Grassland, stony areas, moist areas				Perennial tufted	Average	Inc. 1	Climax
<i>Heteropogon contortus</i>	Poaceae	Spear grass	Disturbed places				Perennial tufted	Average	Inc. 2	Subclimax
<i>Ctenium concinnum</i>	Poaceae	Sickle grass	Grassland, damp soil				Perennial tufted	Low	Inc. 1	Climax
<i>Melinis repens</i>	Poaceae	Natal red top	Disturbed places				Annual tufted	Low	Inc. 2	Subclimax/Pioneer
<i>Digitaria tricholaenoides</i>	Poaceae	Purple finger grass	Grassland				Perennial tufted	High	Dec.	Climax
<i>Panicum natalense</i>	Poaceae	Natal panicum	Grassland				Perennial tufted	Low	Dec.	Climax
<i>Aristida congesta</i>	Poaceae	Tassel three-awn	Disturbed places, bare patches, overgrazed veld				Annual tufted	Low	Inc. 2	Pioneer
<i>Aristida stipitata</i>	Poaceae	Long-awned grass	Disturbed places, overgrazed veld				Weak perennial tufted	Low	Inc. 2	Subclimax/Pioneer

<i>Gomphrena celosoides</i>	Amaranthaceae	Bachelor's button	Common weed of disturbed places		Exotic					
<i>Amaranthus hybridus</i>	Amaranthaceae	Pigweed	Common weed of disturbed places		Exotic					
<i>Verbena bonariensis</i>	Verbenaceae	Wild verbena	Weed of disturbed places		Exotic					
<i>Cirsium vulgare</i>	Asteraceae	Scottish thistle	Weed of disturbed places		Cat 1					
<i>Tagetes minuta</i>	Asteraceae	Khaki weed	Weed of disturbed places		Exotic					
<i>Sonchus wilmsii</i>	Asteraceae	Milk thistle	Disturbed grassland							
<i>Helichrysum aureonitens</i>	Asteraceae	--	Grassland							
<i>Cosmos bipinnata</i>	Asteraceae	Cosmos	Grassland, weed of disturbed places		Exotic					
<i>Helichrysum rugulosum</i>	Asteraceae	--	Grassland							
<i>Schkuhria pinnata</i>	Asteraceae	Dwarf marigold	Weed of disturbed places							
<i>Conyza bonariensis</i>	Asteraceae	Flax-leaf fleabane	Weed of disturbed places		Exotic					
<i>Senecio gregatus</i>	Asteraceae	--	Wet places							
<i>Senecio inornatus</i>	Asteraceae	--	Grassland, moist places							
<i>Senecio consanguineus</i>	Asteraceae	Starvation senecio	Grassland, weed of cultivated land							
<i>Berkheya radula</i>	Asteraceae	Boesmansrietjie	Moist grassland, vleis							
<i>Senecio inaquidens</i>	Asteraceae	Canary weed	Grassland, trampled and disturbed areas							
<i>Haplocharpa scaposa</i>	Asteraceae	Tonteldoosbossie	Grassland, moist places							
<i>Bidens bipinnata</i>	Asteraceae	Blackjack	Weed of disturbed places		Exotic					
<i>Tolpis capensis</i>	Asteraceae	--	Grassland, disturbed places							

<i>Senecio erubescens</i>	Asteraceae	--	Grassland, moist places							
<i>Helichrysum melanacme</i>	Asteraceae	--	Grassland							
<i>Senecio affinis</i>	Asteraceae	--	Grassland							
<i>Helichrysum cooperi</i>	Asteraceae	Yellow everlasting	Grassland							
<i>Aster harveyanus</i>	Asteraceae	Bloublommetjie	Grassland			Roots				
<i>Xanthium strumarium</i>	Asteraceae	Large cocklebur	Weed of disturbed places		Cat 1					
<i>Haplocarpa lyrata</i>	Asteraceae	--	Grassland, moist places							
<i>Arctotis arctotoides</i>	Asteraceae	--	Grassland, vleis							
<i>Berkheya setifera</i>	Asteraceae	Rasperdisseldoring	Grassland							
<i>Tripteris aghillana</i>	Asteraceae	--	Grassland							
<i>Hypochaeris radicata</i>	Asteraceae	Hairy wild lettuce	Disturbed places							
<i>Conyza podocephala</i>	Asteraceae	--	Disturbed grassland							
<i>Senecio isatideus</i>	Asteraceae	Dan's cabbage	Moist grassland							
<i>Helichrysum dasymallum</i>	Asteraceae	--	Grassland							
<i>Geigeria burkei</i>	Asteraceae	Vermeerbos	Grassland							
<i>Helichrysum nudifolium</i>	Asteraceae	Hottentot's tea	Grassland			Leaves, twigs				
<i>Dicoma anomala</i>	Asteraceae	Maagbitterwortel	Grassland			Leaves, twigs				
<i>Nidorella anomala</i>	Asteraceae	--	Grassland							
<i>Helichrysum coriaceum</i>	Asteraceae	Vaalteebossie	Grassland							
<i>Vernonia oligocephala</i>	Asteraceae	Bitterbossie	Grassland			Leaves, twigs				
<i>Felicia muricata</i>	Asteraceae	--	Grassland, overgrazed places							
<i>Chamaecrista comosa</i>	Caesalpiaceae	--	Grassland							

<i>Vigna vexillata</i>	Fabaceae	--	Grassland						
<i>Elephantorrhiza elephantina</i>	Fabaceae	Elephant's root	Grassland			Underground rhizomes			
<i>Rhynchosia monophylla</i>	Fabaceae	--	Grassland						
<i>Indigofera oxytropis</i>	Fabaceae	--	Grassland						
<i>Eriosema salignum</i>	Fabaceae	--	Grassland						
<i>Ledebouria cooperi</i>	Liliaceae	--	Grassland						
<i>Albuca spp.</i>	Liliaceae	--	Grassland						
<i>Gladiolus spp.</i>	Liliaceae	Gladiolus	Grassland						
<i>Kniphofia ensifolia</i>	Asphodeliaceae	Poker	Moist places						
<i>Ciclospermum leptophyllum</i>	Apiaceae	Wild celery	Disturbed, damp places		Exotic				
<i>Centella asiatica</i>	Apiaceae	Pennywort	Moist places			Dried aboveground parts			
<i>Hibiscus trionum</i>	Malvaceae	Bladderweed	Weed of disturbed places		Exotic				
<i>Juncus effusus</i>	Juncaceae	Rush	Grassland						
<i>Juncus punctorius</i>	Juncaceae	Rush	Moist areas						
<i>Cyperus congestus</i>	Cyperaceae	Sedge	Wet places						
<i>Bulbostylis burchellii</i>	Cyperaceae	Sedge	Grassland						
<i>Scirpus burkei</i>	Cyperaceae	Sedge	Grassland						
<i>Oenothera rosea</i>	Onagraceae	Rose evening primrose	Moist disturbed places		Exotic				
<i>Epilobium hirsutum</i>	Onagraceae	--	Moist grassland						
<i>Oenothera tetraptera</i>	Onagraceae	White evening primrose	Weed of disturbed places		Exotic				
<i>Typha capensis</i>	Typhaceae	Bulrush	Wet places			Thick fleshy rhizomes			
<i>Commelina Africana</i>	Commelinaceae	Wandering jew	Grassland						
<i>Solanum nigrum</i>	Solanaceae	Nightshade	Disturbed places						

<i>Datura stramonium</i>	Solanaceae	Thorn apple	Weed of disturbed places		Cat 1	Leaves, green fruit				
<i>Physalis viscosa</i>	Solanaceae	Sticky gooseberry	Weed of disturbed grassland		Exotic					
<i>Diospyros austro-africana</i>	Ebenaceae	Jakkalsbos	Grassland							
<i>Euclea crispa</i>	Ebenaceae	Guarri	Bush clumps							
<i>Persicaria lapathifolia</i>	Polygonaceae	Spotted knotweed	Weed of moist places		Exotic					
<i>Lobelia flacida</i>	Lobeliaceae	--	Grassland, moist places							
<i>Hypoxis hemerocallidea</i>	Hypoxidaceae	African potato	Grassland			Tuberous rootstock				
<i>Hypoxis rigidula</i>	Hypoxidaceae	--	Grassland							
<i>Argemone ochroleuca</i>	Papaveraceae	Mexican poppy	Weed of disturbed and overgrazed places		Cat 1					
<i>Chenopodium album</i>	Chenopodiaceae	White goosefoot	Weed of disturbed places		Exotic					
<i>Wahlenbergia caledonica</i>	Campanulaceae	--	Grassland, seasonal moist places							
<i>Lepidium africanum</i>	Brassicaceae	Pepperweed	Weed of disturbed places		Exotic					
<i>Euphorbia striata</i>	Euphorbiaceae	Melkgras	Grassland, seasonal moist areas							
<i>Acalypha angustata</i>	Euphorbiaceae	Copper leaf	Grassland							
<i>Hermannia depressa</i>	Sterculiaceae	Rooi opslag	Grassland, trampled areas							
<i>Hermannia transvaalensis</i>	Sterculiaceae	--	Grassland							
<i>Pelargonium luridum</i>	Geraniaceae	Wild malva	Grassland			Fleshy rootstock				
<i>Asclepias aurea</i>	Apocynaceae	--	Grassland							
<i>Gomphocarpus fruticosus</i>	Apocynaceae	Milkweed	Grassland, cultivated fields			Leaves, roots				

<i>Walafrida densiflora</i>	Selaginaceae	--	Grassland							
<i>Hebenstretia comosa</i>	Selaginaceae	Katstert	Grassland							
<i>Pygmothamnus zeyheri</i>	Rubiaceae	Sand apple	Grassland							

5.3 GLOSSARY

Pioneer = Pioneer species are hardy, annual plants that can grow in very unfavourable conditions, and are normally the first plants to colonise bare soil.

Subclimax = Subclimax species infiltrate after pioneer species and give more protection to the soil so that more moisture becomes available.

Climax = Climax species are strong perennial plants that are adapted to normal, optimal growth conditions, and will grow in an area as long as these conditions prevail.

Inc. 1 = Increaser 1 - Grasses that are abundant in underutilised veldt. These grasses are usually unpalatable, robust climax species that can grow without any defoliation.

Inc. 2 = Increaser 2 - Grasses that are abundant in overgrazed veldt. These grasses increase due to the disturbing effect of overgrazing and include mostly pioneer and subclimax species.

Inc. 3 = Increaser 3 - Grasses that are commonly found in overgrazed veldt. These are usually unpalatable, dense climax grasses.

Dec = Grasses that are abundant in good veldt, but that decrease in number when the veldt is overgrazed or undergrazed.

Cat. 1 = Category 1 declared weeds and invader plants. These plants shall not occur on any land or on any inland water surface. Such plants shall be eradicated (Regulation 15 and 16 of the Conservation of Agricultural Resources Act – Act 43 of 1983).

Cat. 2 = Category 2 declared weeds and invader plants. These plants may only occur or may be established on areas demarcated for that purpose *viz.* plantations. The spreading of seed or any other propagating material must be reduced. If category 2 invader plants occur on any land or water surface outside the demarcated areas, they will be eradicated. (Regulation 15 and 16 of the Conservation of Agricultural Resources Act – Act 43 of 1983).

Cat. 3 = Category 3 declared weeds and invader plants. These plants shall not occur on any land or inland water surface other than in a biological control reserve. However, plants already in existence at the time of commencement of these regulations (March 2001) may continue to exist, provided they are not within 30 m of the 1 : 50 year floodline of a river, stream, lake or other type of inland water body.

5.4 PHOTOGRAPHIC RECORD



Figure 6: Cultivated pasture area of the proposed shaft and infrastructure area



Figure 7: Grazing area towards the Bankfontein dam where the proposed raw water pipeline will transect



Figure 8: Grazing area towards the Middelburg – Bethal road where the proposed raw water pipeline will transect



Figure 9: Grassland area where the proposed used water pipeline will transect from the shaft area



Figure 10: Grassland area where the proposed used water pipeline will transect within the area of the existing conveyor belt (soybean field on right, defunct south shaft on top)



Figure 11: First Moist grassland area where the proposed used water pipeline will transect from the shaft area to the old underground workings. The white poles indicate the existing water pipeline.



Figure 12: Second moist grassland area where the proposed used water pipeline will transect from the shaft area to the old underground workings. The white poles indicate the existing water pipeline.

5.5 DISCUSSION

The proposed shaft and infrastructure area comprises mainly a cultivated grazing area. The proposed raw water pipeline comprises mainly grazing land on the western side of the R 35 and cultivated pasture on the eastern side of the R 35. The proposed used water pipeline comprises firstly a cultivated grazing area from the proposed shaft, then cultivated maize areas and grassland areas up to the defunct South Shaft from where it will follow the existing water pipeline servitude between existing maize fields. Hundred and eighteen plant species were observed in total in the different areas of investigation. This is quite a large number for areas where intensive crop cultivation, livestock farming and mining activities are the main land uses. It thus seems that the vegetation biodiversity is high, but it must be taken into account that many of these species are exotic species. Some declared weed and invader species were also observed. Of the 118 plant species, 31 are grass species and 5 are rush/sedge species while quite a number of forb species (not grass, tree, sedge or rush species) are established in the areas (82 in total).

Disturbance

The R 35 tar road is one of the major disturbances in the area. Disturbances in the proposed shaft and infrastructure area comprise mostly of historic crop cultivation and current cultivated pastures. The proposed raw water pipeline area comprises disturbances in the form of the Bankfontein dam, an existing powerline, livestock grazing and part of the defunct Brown Shaft I infrastructure area. Overgrazing is rife in the grassland area west of the R 35 tar road. The proposed used water pipeline area comprises disturbances in the form of crop cultivation areas, grazing areas, an existing conveyor belt and a servitude area where an existing underground water pipeline is buried.



Figure 13: The cultivated pasture at the proposed shaft and infrastructure area is also utilised for the making of hay

Veldt condition

The veldt condition in the proposed shaft and infrastructure area seems good since it is a cultivated pasture. The veldt condition in the area where the proposed raw water pipeline is going to transect is in a somewhat poor condition due to overgrazing. The grassland area where the used water pipeline will be transecting is also in a good condition since it seems that common finger grass was also historically cultivated in this area. This area is surrounded by maize fields. The veldt condition in the existing water pipeline servitude area does not seem to be in a good condition since a number of declared weed and invader species is established in this area between the maize fields.

Rare or endangered species

According to the National red list of South African Plants version 2012.1, one plant species encountered is listed as declining viz. *Hypoxis hemerocallidea* (African potato).

Declared invader species

Five declared invader species were observed in the areas of investigation.

Pampas grass	<i>Cortaderia selloana</i> (Category 1 declared invader)
Scottish thistle	<i>Cirsium vulgare</i> (Category 1 declared invader)
Large cocklebur	<i>Xanthium strumarium</i> (Category 1 declared invader)
Thorn apple	<i>Datura stramonium</i> (Category 1 declared invader)
Mexican poppy	<i>Argemone ochroleuca</i> (Category 1 declared invader)

Medicinal species

Eleven medicinal plant species were observed in the areas of investigation.

***Aster harveyanus* (Bloublommetjie)** – It is used as a traditional headache remedy.

***Helichrysum nudifolium* (Everlastings)** – It is used to treat coughs, colds, fever, infections, headache and menstrual pain. Also used for wound dressings.

***Dicoma anomala* (Maagbitterwortel)** – It is widely used to treat an upset stomach and numerous other ailments. The roots are ground and snuffed as a treatment for colds.

***Vernonia oligocephala* (Bitterbossie)** – Infusions are taken as stomach bitters to treat abdominal pain and colic. Other ailments treated include rheumatism, dysentery and diabetes. The roots have been used to treat ulcerative colitis.

***Hypoxis hemerocallidea* (African potato)** – Infusions of the corm are used as emetics to treat dizziness, bladder disorders and insanity. Decoctions have been given to weak children as a tonic and the juice can be applied to burns.

***Gomphocarpus fruticosus* (Milkweed)** – It is mainly used as a snuff for headache, but also to treat tuberculosis and as an emetic to strengthen the body.

***Elephantorrhiza elephantina* (Elephant's root)** – A traditional remedy for diarrhoea

***Centella asiatica* (Pennywort)** – Used to treat leprosy, cancer and wounds.

***Typha capensis* (Bulrush)** – Used for venereal diseases.

***Physalis viscosa* (Sticky gooseberry)**

Pelargonium luridum - Used to treat diarrhoea and dysentery.

All these plant species are widespread.

Wetland conditions

The proposed shaft and infrastructure area is situated on the western side of a wetland area associated with a tributary of the Spookspruit. According to the Mpumalanga Biodiversity Conservation Plan GIS-based electronic application on CD (Mpumalanga Tourism and Parks Agency (MTPA), 2007), the proposed shaft and infrastructure area is situated in a biodiversity area of "No natural habitat remaining" indicating that this area is not important to the MTPA to achieve their conservation goals. The proposed shaft and infrastructure area will not be constructed within this wetland area. Several farm dams were constructed in this tributary resulting in the occurrence of standing water only during heavy rainfall events. Water is not flowing in this tributary. No definite channel was observed. Where ploughing can take place, cultivated maize areas occur in close proximity to this wetland area. An Eskom power line is also constructed through this wetland area in the vicinity of the proposed shaft and infrastructure area.



Figure 14: Wetland area associated with the tributary of the Spookspruit

The proposed raw water pipeline will cross the Spookspruit immediately on the northern side of the damwall of the Bankfontein dam. This area is in close proximity to the mining activities of Bank Colliery. The dam is utilised for recreational activities.

The proposed used water pipeline, where it will be constructed in the existing conveyor belt area of the defunct South Shaft, is in close proximity of the wetland area of the far eastern tributary of the Spookspruit. Since the pipeline will be constructed within the existing conveyor belt area, no additional wetland areas will be utilised. Soybean cultivation is also taking place in this area.



Figure 15: Wetland area north of the Bankfontein dam

From the defunct South Shaft, the proposed used water pipeline will cross the eastern tributary of the Bankspruit and the Bankspruit itself. In this area the pipeline will be constructed within an existing water pipeline servitude between maize fields.

No water is flowing in the Eastern tributary of the Bankspruit. A deep erosion gully is present on the southern side of the servitude in this wetland area. It is currently dry.



Figure 16: Wetland area at the eastern tributary of the Bankspruit indicating the erosion gully

No channel exists in the area where the proposed used water pipeline will cross the Bankspruit within the existing pipeline servitude. No water is flowing in this area and it is surrounded by maize fields.



Figure 17: Wetland area at the Bankspruit

5.6 RE-VEGETATION

Since all vegetation will be removed at the proposed shaft and infrastructure area, the area will need to be re-vegetated following rehabilitation. The post mining land use goal will be grazing. Grass species suitable for this purpose are listed in table 5.

Table 5: Grass species for re-vegetation include the following:

Scientific name	Common name	Rate
<i>Eragrostis curvula</i> (Ermelo variety)	Weeping love grass	10 kg/ha
<i>Chloris gayana</i>	Rhodes grass	8 kg/ha
<i>Digitaria eriantha</i>	Common finger grass	15 kg/ha
<i>Eragrostis tef</i>	Tef	3 kg/ha
<i>Cynodon dactylon</i>	Couch grass	3 kg/ha

5.7 RECOMMENDATIONS

- After rehabilitation and re-vegetation of the shaft and infrastructure area, regular inspections must be conducted over the area to determine if vegetation cover is successful in order to combat erosion. If bare patches become visible, seeding of the areas must follow.
- Inspections must also include the establishment of any declared invader plant species. If they exist in the area an immediate eradication program must be implemented.

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Appendix 3

Mammal List for the Proposed Access Brown Shaft II Project Area

Reg.No: 2007 / 149565 / 23

VAT No: 4580 2410 34

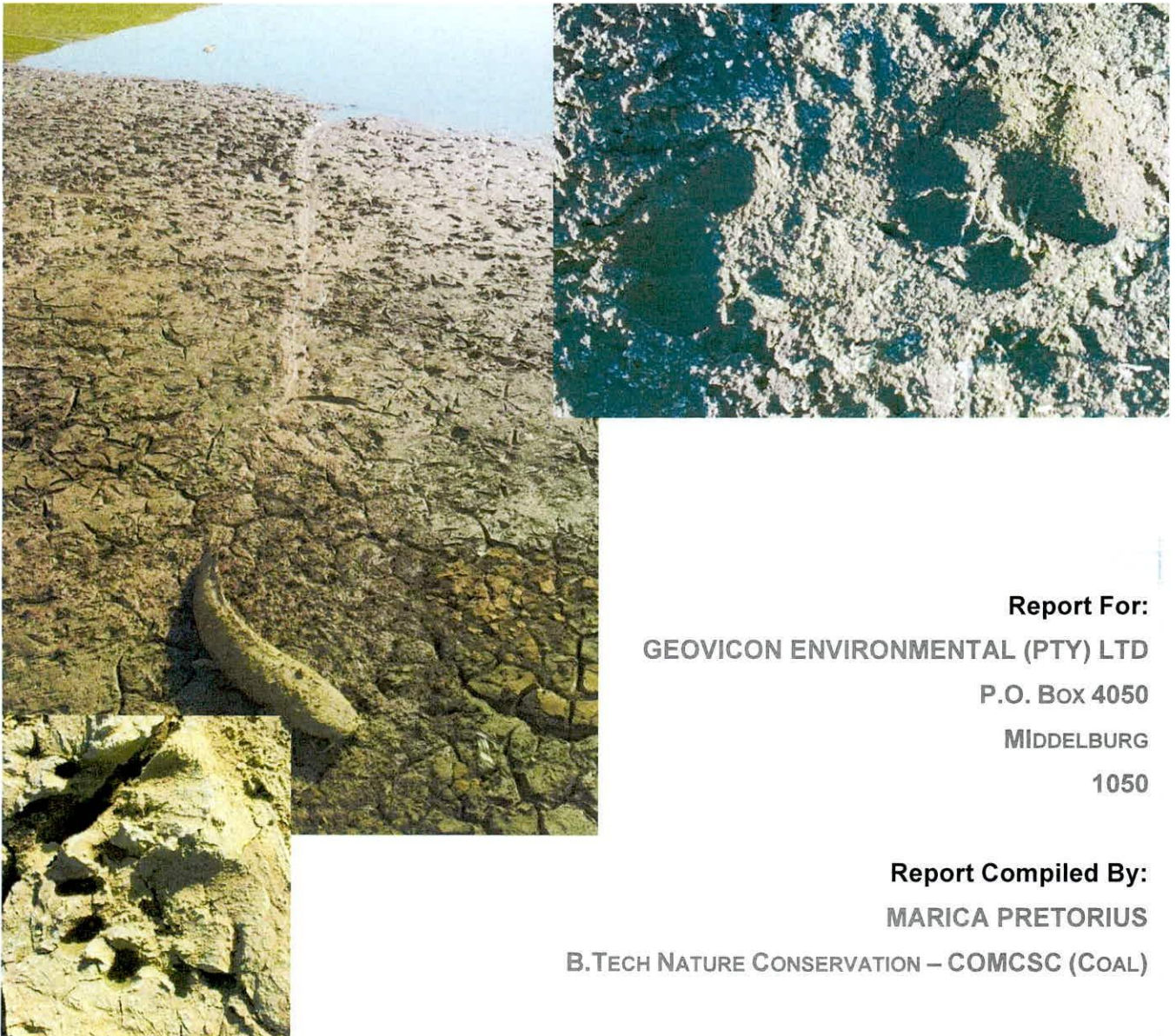
PO Box 2615
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Mammal List – Wolvenfontein/Goedehoop



Report For:
GEOVICON ENVIRONMENTAL (PTY) LTD
P.O. Box 4050
MIDDELBURG
1050

Report Compiled By:
MARICA PRETORIUS
B.TECH NATURE CONSERVATION – COMCSC (COAL)



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1. INTRODUCTION

Big C Rock Engineering CC was requested by Geovicon Environmental (PTY) LTD to assist in the compiling of a mammal list on part of the Farm Wolvenfontein 471 JS. The area of concern is illustrated in Figure 1 below demarcated by a red boundary.

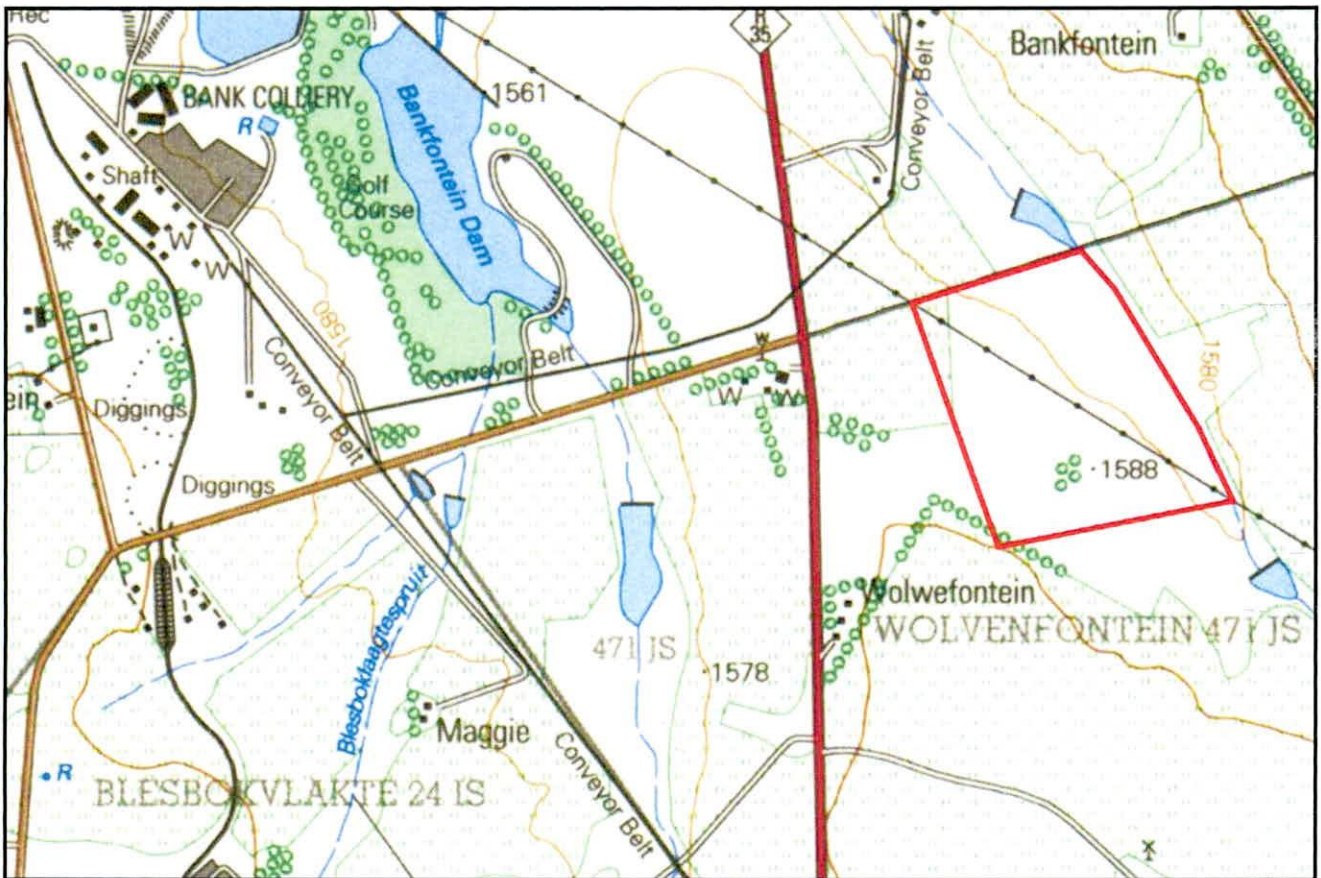


Figure 1: Illustration of the area of concern located on the farm Wolvenfontein 471 JS

2. BACKGROUND

The study will form part of the Environmental Management Plan Report (EMPR) for the area. The purpose of the study is to identify the entire current fauna (mammals, insects and reptilian) active on the property.

The field survey was conducted on the 2nd and 3rd of July 2012 by Morne Pretorius (B.Tech Nature Conservation) and Paul Viljoen (BsC (Hons) Environmental Management). The area of concern is proposed for a decline mine shaft and is currently being used for cultivation. Upon investigation it was found that the area has been burnt recently – see Picture 1.



Picture 1: Illustration of the study area

3. METHODOLOGY

Prior to investigation of the area a study was conducted on historic occurrence of mammals which is attached to this report as an addendum. Line transects per foot was conducted in the study area order to identify species through either behavioral (nesting, footprints, etc.) or actual sightings.

4. FINDINGS

4.1. MAMMALS



The following mammals (or signs thereof) were detected on the study area with their respective conservation status:

Species Name	Common Name	Conservation Status	
		IUCN	NEMBA
<i>Canis mesomelas</i>	Black backed Jackal	Least Concern	Not Listed
<i>Civettictis civetta</i>	African Civet	Least Concern	Not Listed
<i>Cynictis penicillata</i>	Yellow Mongoose	Least Concern	Not Listed
<i>Felis lybica</i>	African Wild Cat	Least Concern	Not Listed
<i>Genetta genetta</i>	Small Spotted Genet.	Least Concern	Not Listed
<i>Lutra lutra (Picture 2)</i>	Spotted Necked Otter	Near Threatened	Protected Species
<i>Otomys irroratus</i>	Vlei Rat	Least Concern	Not Listed
<i>Tatera brantsii</i>	Highveld Gerbil	Least Concern	Not Listed



Picture 2: Footprint of the Spotted Necked Otter (*Lutra lutra*)

4.2. AVIFAUNA

The following bird species were observed on the study area:

Species Name	Common Name
<i>Anas sparsa</i>	African Black Duck
<i>Ardea melanocephala</i>	Black Headed Heron
<i>Boystrichia hagedash</i>	Hadedda Ibis
<i>Bubulcus ibis</i>	Cattle Egret
<i>Cisiticola fulvicapilla</i>	Neddicky
<i>Cisticola tinniens</i>	Levaillant's Cisticola
<i>Euplectes orix</i>	Red Bishop
<i>Fulica cristata</i>	Red – Knobbed Coot
<i>Himantopus himantopus</i>	Black – Winged Stilt
<i>Platalea alba</i>	African Spoonbill
<i>Ploceus capensis</i>	Cape Weaver
<i>Streptopelia capicola</i>	Cape Turtle Dove
<i>Streptopelia senegalensis</i>	Laughing Dove
<i>Threskiornis aethiopicus</i>	Sacred Ibis
<i>Vanellus armatus</i>	Blacksmith Lapwing
<i>Vanellus coronatus</i>	Crowned Lapwing

4.3. INVERTEBRATES

The following invertebrates were observed on the study area:

Species Name	Common Name
<i>Apis mellifera</i>	Honey Bee
<i>Olorunia ocellata</i>	Common Grass Funnel Web Spider
<i>Onitis alexis</i>	Bronze Dung Beetle
<i>Trinervitermes spp.</i>	Snouted Harvester Termite

5. CONCLUSION

An important observation during the study is that of the Spotted Necked Otter (*Lutra lutra*) which has a near threatened/protected species conservation status.



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ADDENDUM

A: Avifauna occurrence in the study area (According to the South African Bird Atlas Project,
Pentad Nr. 2550_2925)

	Common Name	Scientific Name	Sightings	Reporting Rate
1	Acacia Pied Barbet (Bonthoutkapper)	<i>Tricholaema leucomelas</i>	2	6.9%
2	African Black Duck (Swarteend)	<i>Anas sparsa</i>	3	10.3%
3	African Darter (Slanghalsvoel)	<i>Anhinga rufa</i>	18	62.1%
4	African Green-Pigeon (Papegaaiduif)	<i>Treron calvus</i>	1	3.4%
5	African Hoopoe (Hoephoep)	<i>Upupa africana</i>	3	10.3%
6	African Jacana (Grootlangtoon)	<i>Actophilornis africanus</i>	3	10.3%
7	African Marsh-Harrier (Afrikaanse Vleivalk)	<i>Circus ranivorus</i>	1	3.4%
8	African Openbill (Oopbekooievaar)	<i>Anastomus lamelligerus</i>	1	3.4%
9	African Palm-Swift (Palmwindswael)	<i>Cypsiurus parvus</i>	12	41.4%
10	African Pipit (Gewone Koester)	<i>Anthus cinnamomeus</i>	18	62.1%
11	African Sacred Ibis (Skoorsteenveer)	<i>Threskiornis aethiopicus</i>	4	13.8%
12	African Snipe (Afrikaanse Snip)	<i>Gallinago nigripennis</i>	12	41.4%
13	African Spoonbill (Lepelaar)	<i>Platalea alba</i>	4	13.8%
14	African Stonechat (Gewone Bontrokkie)	<i>Saxicola torquatus</i>	10	34.5%
15	African Wattled Lapwing (Lelkiewiet)	<i>Vanellus senegallus</i>	10	34.5%
16	Amethyst Sunbird (Swartsuikerbekkie)	<i>Chalcomitra amethystina</i>	3	10.3%
17	Amur Falcon (Oostelike Rooipootvalk)	<i>Falco amurensis</i>	5	17.2%
18	Anteater Chat (Swartpiek)	<i>Myrmecocichla formicivora</i>	7	24.1%
19	Arrow-marked Babbler (Pylvekkatlagter)	<i>Turdoides jardineii</i>	2	6.9%
20	Banded Martin (Gebande Oewerswael)	<i>Riparia cincta</i>	2	6.9%
21	Barn Swallow (Europese Swael)	<i>Hirundo rustica</i>	19	65.5%
22	Black Crake (Swartriethaan)	<i>Amaurornis flavirostris</i>	4	13.8%
23	Black-backed Puffback (Sneeubal)	<i>Dryoscopus cubla</i>	1	3.4%
24	Black-chested Prinia (Swartbandlangstertjie)	<i>Prinia flavicans</i>	1	3.4%
25	Black-collared Barbet (Rooikophoutkapper)	<i>Lybius torquatus</i>	4	13.8%
26	Black-headed Heron (Swartkopreier)	<i>Ardea melanocephala</i>	17	58.6%
27	Black-headed Oriole (Swartkopwielewaal)	<i>Oriolus larvatus</i>	1	3.4%

28	Black-shouldered Kite (Blouvalk)	<i>Elanus caeruleus</i>	18	62.1%
29	Black-throated Canary (Bergkanarie)	<i>Crithagra atrogularis</i>	5	17.2%
30	Black-winged Stilt (Rooipootelsie)	<i>Himantopus himantopus</i>	2	6.9%
31	Blacksmith Lapwing (Bontkiewiet)	<i>Vanellus armatus</i>	28	96.6%
32	Blue Waxbill (Gewone Blousysie)	<i>Uraeginthus angolensis</i>	2	6.9%
33	Brown-throated Martin (Afrikaanse Oewerswael)	<i>Riparia paludicola</i>	12	41.4%
34	Cape Bunting (Rooivlerkstreepkoppie)	<i>Emberiza capensis</i>	1	3.4%
35	Cape Glossy Starling (Kleinglansspreeu)	<i>Lamprotornis nitens</i>	14	48.3%
36	Cape Longclaw (Oranjekeelkalkoentjie)	<i>Macronyx capensis</i>	11	37.9%
37	Cape Robin-Chat (Gewone Janfrederik)	<i>Cossypha caffra</i>	6	20.7%
38	Cape Shoveler (Kaapse Slopeend)	<i>Anas smithii</i>	3	10.3%
39	Cape Sparrow (Gewone Mossie)	<i>Passer melanurus</i>	28	96.6%
40	Cape Turtle-Dove (Gewone Tortelduif)	<i>Streptopelia capicola</i>	25	86.2%
41	Cape Wagtail (Gewone Kwikkie)	<i>Motacilla capensis</i>	24	82.8%
42	Cape Weaver (Kaapse Wewer)	<i>Ploceus capensis</i>	8	27.6%
43	Cape White-eye (Kaapse Glasogie)	<i>Zosterops virens</i>	4	13.8%
44	Cattle Egret (Veereier)	<i>Bubulcus ibis</i>	26	89.7%
45	Chinspot Batis (Witliesbosbontrokkie)	<i>Batis molitor</i>	1	3.4%
46	Cinnamon-breasted Bunting (Klipstreepkoppie)	<i>Emberiza tahapisi</i>	1	3.4%
47	Comb Duck (Knobbeleend)	<i>Sarkidiornis melanotos</i>	3	10.3%
48	Common Fiscal (Fiskaallaksman)	<i>Lanius collaris</i>	29	100.0%
49	Common Moorhen (Grootwaterhoender)	<i>Gallinula chloropus</i>	26	89.7%
50	Common Myna (Indiese Spreeu)	<i>Acridotheres tristis</i>	29	100.0%
51	Common Ostrich (Volstruis)	<i>Struthio camelus</i>	22	75.9%
52	Common Peacock (Makpou)	<i>Pavo cristatus</i>	2	6.9%
53	Common Sandpiper (Gewone Ruiters)	<i>Actitis hypoleucos</i>	11	37.9%
54	Common Waxbill (Rooibeksysie)	<i>Estrilda astrild</i>	6	20.7%
55	Crested Barbet (Kuifkophoutkapper)	<i>Trachyphonus vaillantii</i>	7	24.1%
56	Crowned Lapwing (Kroonkiewiet)	<i>Vanellus coronatus</i>	23	79.3%
57	Dark-capped Bulbul (Swartoogtiptol)	<i>Pycnonotus tricolor</i>	11	37.9%
58	Diderick Cuckoo (Diederikkie)	<i>Chrysococcyx caprius</i>	8	27.6%
59	Egyptian Goose (Kolgans)	<i>Alopochen aegyptiacus</i>	24	82.8%
60	European Bee-eater (Europese Byvreter)	<i>Merops apiaster</i>	1	3.4%
61	Familiar Chat (Gewone Spekvreter)	<i>Cercomela familiaris</i>	1	3.4%
62	Fan-tailed Widowbird (Kortstertflap)	<i>Euplectes axillaris</i>	5	17.2%



63	Fiscal Flycatcher (Fiskaalvlievanger)	<i>Sigelus silens</i>	1	3.4%
64	Fork-tailed Drongo (Mikstertbyvanger)	<i>Dicrurus adsimilis</i>	2	6.9%
65	Fulvous Duck (Fluiteend)	<i>Dendrocygna bicolor</i>	1	3.4%
66	Giant Kingfisher (Reusevisvanger)	<i>Megaceryle maximus</i>	6	20.7%
67	Glossy Ibis (Glansibis)	<i>Plegadis falcinellus</i>	3	10.3%
68	Great Crested Grebe (Kuifkopdobbertjie)	<i>Podiceps cristatus</i>	1	3.4%
69	Great Egret (Grootwitreier)	<i>Egretta alba</i>	2	6.9%
70	Greater Striped Swallow (Grootstreepswael)	<i>Hirundo cucullata</i>	16	55.2%
71	Green Wood-Hoopoe (Rooibekkekelaar)	<i>Phoeniculus purpureus</i>	2	6.9%
72	Grey Heron (Bloureier)	<i>Ardea cinerea</i>	14	48.3%
73	Grey-headed Gull (Gryskopmeeu)	<i>Larus cirrocephalus</i>	6	20.7%
74	Groundscraper Thrush (Gevlekte Lyster)	<i>Psophocichla litsipsirupa</i>	2	6.9%
75	Hadeda Ibis (Hadeda)	<i>Bostrychia hagedash</i>	27	93.1%
76	Hamerkop Hamerkop (Hamerkop)	<i>Scopus umbretta</i>	12	41.4%
77	Helmeted Guineafowl (Gewone Tarentaal)	<i>Numida meleagris</i>	27	93.1%
78	House Sparrow (Huis mossie)	<i>Passer domesticus</i>	25	86.2%
79	Jackal Buzzard (Rooiborsjakkalsvoel)	<i>Buteo rufofuscus</i>	1	3.4%
80	Karoo Thrush (Geelbeklyster)	<i>Turdus smithi</i>	2	6.9%
81	Laughing Dove (Rooiborsduifie)	<i>Streptopelia senegalensis</i>	29	100.0%
82	Lazy Cisticola (Luitinktinkie)	<i>Cisticola aberrans</i>	1	3.4%
83	Lesser Striped Swallow (Kleinstreepswael)	<i>Hirundo abyssinica</i>	3	10.3%
84	Levaillant's Cisticola (Vleitinktinkie)	<i>Cisticola tinniens</i>	6	20.7%
85	Little Egret (Kleinwitreier)	<i>Egretta garzetta</i>	7	24.1%
86	Little Grebe (Kleindobbertjie)	<i>Tachybaptus ruficollis</i>	9	31.0%
87	Little Stint (Kleinstrandloper)	<i>Calidris minuta</i>	1	3.4%
88	Little Swift (Kleinwindswael)	<i>Apus affinis</i>	10	34.5%
89	Long-billed Crombec (Bosveldstompstert)	<i>Sylvietta rufescens</i>	1	3.4%
90	Long-billed Pipit (Nicholsonse Koester)	<i>Anthus similis</i>	1	3.4%
91	Long-tailed Widowbird (Langstertflap)	<i>Euplectes progne</i>	26	89.7%
92	Maccoa Duck (Bloubekeend)	<i>Oxyura maccoa</i>	1	3.4%
93	Mallard Duck (Groenkopeend)	<i>Anas platyrhynchos</i>	12	41.4%
94	Mountain Wheatear (Bergwagter)	<i>Oenanthe monticola</i>	1	3.4%
95	Namaqua Dove (Namakwaduifie)	<i>Oena capensis</i>	1	3.4%
96	Natal Spurfowl (Natalse Fisant)	<i>Pternistis natalensis</i>	2	6.9%



97	Neddicky Neddicky (Neddikkie)	<i>Cisticola fulvicapilla</i>	3	10.3%
98	Olive Thrush (Olyflyster)	<i>Turdus olivaceus</i>	3	10.3%
99	Orange-breasted Waxbill (Rooiassie)	<i>Amandava subflava</i>	1	3.4%
100	Pied Crow (Witborskraai)	<i>Corvus albus</i>	1	3.4%
101	Pied Kingfisher (Bontvisvanger)	<i>Ceryle rudis</i>	13	44.8%
102	Pied Starling (Witgatspreeu)	<i>Spreo bicolor</i>	4	13.8%
103	Pin-tailed Whydah (Koningrooibekkie)	<i>Vidua macroura</i>	16	55.2%
104	Plain-backed Pipit (Donkerkoester)	<i>Anthus leucophrys</i>	1	3.4%
105	Purple Heron (Rooiereier)	<i>Ardea purpurea</i>	12	41.4%
106	Red-billed Quelea (Rooibekkelelea)	<i>Quelea quelea</i>	22	75.9%
107	Red-billed Teal (Rooibekeend)	<i>Anas erythrorhyncha</i>	10	34.5%
108	Red-chested Cuckoo (Piet-my-vrou)	<i>Cuculus solitarius</i>	2	6.9%
109	Red-collared Widowbird (Rooikeelflap)	<i>Euplectes ardens</i>	1	3.4%
110	Red-eyed Dove (Grootringduif)	<i>Streptopelia semitorquata</i>	16	55.2%
111	Red-faced Mousebird (Rooiwangmuisvoel)	<i>Urocolius indicus</i>	1	3.4%
112	Red-headed Finch (Rooikopvink)	<i>Amadina erythrocephala</i>	1	3.4%
113	Red-knobbed Coot (Bleshoender)	<i>Fulica cristata</i>	26	89.7%
114	Red-throated Wryneck (Draaihals)	<i>Jynx ruficollis</i>	8	27.6%
115	Red-winged Starling (Rooivlerkspreeu)	<i>Onychognathus morio</i>	2	6.9%
116	Reed Cormorant (Rietduiker)	<i>Phalacrocorax africanus</i>	25	86.2%
117	Rock Dove (Tuinduif)	<i>Columba livia</i>	13	44.8%
118	Rufous-naped Lark (Rooineklewerik)	<i>Mirafra africana</i>	12	41.4%
119	Sabota Lark (Sabotalewerik)	<i>Calendulauda sabota</i>	1	3.4%
120	Southern Bald Ibis (Kalkoenibis)	<i>Geronticus calvus</i>	1	3.4%
121	Southern Boubou (Suidelike Waterfiskaal)	<i>Laniarius ferrugineus</i>	1	3.4%
122	Southern Grey-headed Sparrow (Gryskopmossie)	<i>Passer diffusus</i>	11	37.9%
123	Southern Masked-Weaver (Swartkeelgeelvink)	<i>Ploceus velatus</i>	28	96.6%
124	Southern Pochard (Bruineend)	<i>Netta erythrophthalma</i>	9	31.0%
125	Southern Red Bishop (Rooivink)	<i>Euplectes orix</i>	20	69.0%
126	Speckled Mousebird (Gevlekte Muisvoel)	<i>Colius striatus</i>	7	24.1%
127	Speckled Pigeon (Kransduif)	<i>Columba guinea</i>	26	89.7%
128	Spotted Flycatcher (Europese Vlieievanger)	<i>Muscicapa striata</i>	3	10.3%
129	Spotted Thick-knee (Gewone Dikkop)	<i>Burhinus capensis</i>	5	17.2%
130	Spur-winged Goose (Wildemakou)	<i>Plectropterus gambensis</i>	18	62.1%

131	Steppe Buzzard (Bruinjakkalsvoel)	<i>Buteo vulpinus</i>	5	17.2%
132	Streaky-headed Seedeater (Streepkopkanarie)	<i>Crithagra gularis</i>	1	3.4%
133	Swainson's Spurfowl (Bosveldfisant)	<i>Pternistis swainsonii</i>	5	17.2%
134	Tawny-flanked Prinia (Bruinsylangstertjie)	<i>Prinia subflava</i>	3	10.3%
135	Thick-billed Weaver (Dikbekwewer)	<i>Amblyospiza albifrons</i>	1	3.4%
136	Three-banded Plover (Driebandstrandkiewiet)	<i>Charadrius tricollaris</i>	13	44.8%
137	Village Weaver (Bontrugwewer)	<i>Ploceus cucullatus</i>	4	13.8%
138	Whiskered Tern (Witbaardsterretjie)	<i>Chlidonias hybrida</i>	11	37.9%
139	White-backed Duck (Witrugeend)	<i>Thalassornis leuconotus</i>	2	6.9%
140	White-breasted Cormorant (Witborsduiker)	<i>Phalacrocorax carbo</i>	3	10.3%
141	White-browed Sparrow-Weaver (Koringvoel)	<i>Plocepasser mahali</i>	7	24.1%
142	White-faced Duck (Nonnetjie-eend)	<i>Dendrocygna viduata</i>	2	6.9%
143	White-fronted Bee-eater (Rooikeelbyvreter)	<i>Merops bullockoides</i>	2	6.9%
144	White-rumped Swift (Witkruiswindswael)	<i>Apus caffer</i>	8	27.6%
145	White-throated Swallow (Witkeelswael)	<i>Hirundo albigularis</i>	10	34.5%
146	White-winged Tern (Witvlerksterretjie)	<i>Chlidonias leucopterus</i>	6	20.7%
147	White-winged Widowbird (Witvlerkflap)	<i>Euplectes albonotatus</i>	2	6.9%
148	Willow Warbler (Hofsanger)	<i>Phylloscopus trochilus</i>	1	3.4%
149	Wood Sandpiper (Bosruiter)	<i>Tringa glareola</i>	1	3.4%
150	Woodland Kingfisher (Bosveldvisvanger)	<i>Halcyon senegalensis</i>	2	6.9%
151	Yellow Bishop (Kaapse Flap)	<i>Euplectes capensis</i>	1	3.4%
152	Yellow-billed Duck (Geelbekeend)	<i>Anas undulata</i>	27	93.1%
153	Yellow-billed Egret (Geelbekwitreier)	<i>Egretta intermedia</i>	1	3.4%
154	Yellow-billed Kite (Geelbekwou)	<i>Milvus aegyptius</i>	1	3.4%
155	Yellow-crowned Bishop (Goudgeelvink)	<i>Euplectes afer</i>	11	37.9%
156	Yellow-fronted Canary (Geeloogkanarie)	<i>Crithagra mozambicus</i>	2	6.9%
157	Yellow-fronted Tinkerbird (Geelblestinker)	<i>Pogoniulus chrysoconus</i>	1	3.4%
158	Zitting Cisticola (Landerykloppie)	<i>Cisticola juncidis</i>	9	31.0%

B: Historic Mammal occurrence for the Study Area

Scientific Name	Common Name
<i>Aethomys chrysophilus</i>	Red Veld Rat
<i>Aethomys ineptus</i>	Tete Veld Rat
<i>Aethomys silindensis</i>	Silinda Rat
<i>Amblysomus septentrionalis</i>	Highveld Golden Mole
<i>Aonyx capensis</i>	Cape Clawless Otter
<i>Attilax paludinosus</i>	Water (Marsh) Mongoose
<i>Canis mesomelas</i>	Black-backed Jackal
<i>Caracal caracal</i>	Caracal
<i>Chrysopalax villosus</i>	Rough-haired Golden Mole
<i>Connochaetes gnou</i>	Black Wildebeest
<i>Cryptomys hottentotus</i>	Common (African) Mole-rat
<i>Cynictis penicillata</i>	Yellow Mongoose
<i>Dendromus melanotis</i>	Grey Climbing Mouse
<i>Dendromus mystacalis</i>	Chestnut Climbing Mouse
<i>Felis nigripes</i>	Small Spotted Cat
<i>Felis lybica</i>	African Wild Cat
<i>Genetta genetta</i>	Small-spotted Genet
<i>Graphiurus kelleni</i>	Lesser Savanna Dormouse
<i>Graphiurus murinus</i>	Woodland Dormouse
<i>Hystrix africaeaustralis</i>	Cape Porcupine
<i>Ichneumia albicauda</i>	White-tailed Mongoose
<i>Ictonyx striatus</i>	Striped Polecat
<i>Leptailurus serval</i>	Serval
<i>Lepus saxatillis</i>	Scrub Hare
<i>Lutra maculicollis</i>	Spotted-necked Otter
<i>Mastomys coucha</i>	Southern Multimammate Mouse

<i>Mastomys natalensis</i>	Natal Multimammate Mouse
<i>Mellivora capensis</i>	Honey Badger (Ratel)
<i>Miniopterus schreibersii</i>	Schrieber's Long-fingered Bat
<i>Mungos mungo</i>	Banded Mongoose
<i>Mus minutoides</i>	Pygmy Mouse
<i>Mus musculus</i>	House Mouse
<i>Neoromicia capensis</i>	Cape Serotine Bat
<i>Nycteris thebiaca</i>	Egyptian Slit-faced Bat
<i>Orycteropus afer</i>	Aardvark
<i>Otomys angoniensis</i>	Angoni Vlei Rat
<i>Otomys irroratus</i>	Vlei Rat
<i>Papio cynocephalus ursinus</i>	Savanna Baboon
<i>Pipistrellus hesperidus</i>	African Pipistrelle
<i>Poecilogale albinucha</i>	African Striped Weasel
<i>Pronolagus rupestris</i>	Smith's Red Rock Rabbit
<i>Raphicerus campestris</i>	Steenbok
<i>Rattus rattus</i>	House Rat
<i>Rhabdomys pumilio</i>	Four-striped Grass Mouse
<i>Rhinolophus blasii</i>	Peak-saddle Horseshoe Bat
<i>Rhinolophus clivosus</i>	Geoffrey's Horseshoe Bat
<i>Rhinolophus darlingi</i>	Darling's Horseshoe Bat
<i>Sylvicapra grimmia</i>	Common Duiker
<i>Tadarida aegyptiaca</i>	Egyptian Free-tailed Bat
<i>Tatera brantsii</i>	Highveld Gerbil
<i>Thallomys paedulus</i>	Acacia Rat



C: Historic Arthropod occurrence for the study area.

Super class	Class	Order	Family	Genus	Species	Common Name
Myriapodia	Insecta	Blattodea	Blaberidae	<i>Gyna</i>	<i>caffrorum</i>	Tree cockroach
			Blattidae	<i>Deropeltis</i>	<i>Erythrocephala</i>	
		Isoptera	Termitidae	<i>Trinervitermes</i>	<i>spp</i>	Snouted Harvester Termite
			Hodotermitidae	<i>Hodotermes</i>	<i>mossambicus</i>	Nothern Harvester Termite
		Mantodea	Hymenopodidae	<i>Harpagomantis</i>	<i>tricolor</i>	Flower Mantid
			Mantidae	<i>Sphodromantis</i>	<i>gastrica</i>	Common Green Mantid
			Pyrgomorphidae	<i>Phymateus</i>	<i>morbillosus</i>	Common Milkweed Locust
			Acrididae	<i>Acrida</i>	<i>acuminata</i>	Common Stick Grasshopper
				<i>Acanthacris</i>	<i>ruficornis</i>	Garden Locust
		Hemiptera	Pyrrhocoridae	<i>Dysdercus</i>	<i>nigrofasciatus</i>	Cotton Stainer
		Coleoptera	Carabidae	<i>Thermophilum</i>	<i>homoplatum</i>	Two Spotted Ground Beetle
				<i>Caminara</i>	<i>spp</i>	Starred Ground Beetle
			Scarabidae	<i>Onitis</i>	<i>alexis</i>	Bronze dung beetle
			Tenebrionidae	<i>Gonocephalum</i>	<i>simplex</i>	Dusty Maize Beetle
		Diptera	Calliphoridae	<i>Chrysomya</i>	<i>chloropyga</i>	Copper-tailed



						blowfly
				<i>Chrysomya</i>	<i>albiceps</i>	Banded blowfly
	Lepidoptera	Geometridae		<i>Rhodometra</i>	<i>sacraria</i>	Vestal
	Hymenoptera	Apidae		<i>Apis</i>	<i>Mellifera</i>	Honey Bee
		Formicidae		<i>Messor</i>	<i>capensis</i>	Harvester Ant
				<i>Camponotus</i>	<i>maculatus</i>	Spotted Sugar Ant
				<i>Anoplolepis</i>	<i>custodiens</i>	Pugnacious ant
	Scorpiones	Buthidae				
	Araneae	Arachnidae				Millipede



D: Historic Reptile Species of the study area

Scientific Name	Common Name
<i>Acontias gracilicauda</i>	Thin-tailed Legless Skink
<i>Agama aculeata</i>	Ground Agama
<i>Aparallactus capensis</i>	Cape Centipede Eater
<i>Atractaspis bibronii</i>	Southern or Bibron's Burrowing Asp
<i>Bitis arietans</i>	Puff Adder
<i>Chamaeleo dilepis</i>	Flap-neck Chamaeleon
<i>Charmaesaura aenea</i>	Transvaal Grass Lizard
<i>Crotaphopeltis hotamboeia</i>	Herald or Red-lipped Snake
<i>Dasypeltis scabra</i>	Common or Rhombic Egg Eater
<i>Duberria lutrix</i>	Common Slug Eater
<i>Elapsoidea sunevalli</i>	Sundevall's Garter Snake
<i>Gerrhosaurus flavigularis</i>	Yellow-throated Plated Lizard
<i>Homoroselaps lacteus</i>	Spotted Harlequin Snake
<i>Ichnotropis squamulosa</i>	Common Rough-scaled Lizard
<i>Lamprophis aurora</i>	Aurora House Snake
<i>Lamprophis fuliginosus</i>	Brown House Snake
<i>Leptotyphlops scutifrons</i>	Peter's Thread Snake
<i>Lycodonomorphus rufulus</i>	Common Brown Water Snake
<i>Lycophidion capense</i>	Cape Wolf Snake
<i>Lygodactylus capensis</i>	Cape Dwarf Gecko
<i>Mabuya capensis</i>	Cape Skink
<i>Mabuya striata</i>	Striped Skink
<i>Mabuya varia</i>	Variable Skink
<i>Naja mossambica</i>	Mozambique Spitting Cobra
<i>Nucras taeniolata</i>	Ornate Sandveld Lizard
<i>Pachydactylus capensis</i>	Cape Gecko
<i>Panaspis wahlbergii</i>	Walberg's Snake-eyed Skink
<i>Pedioplanis lineocellata</i>	Spotted Sand Lizard
<i>Philothamnus hoplogaster</i>	Green Water Snake
<i>Philothamnus natalensis</i>	Natal Green Snake
<i>Philothamnus semivariegatus</i>	Spotted Bush Snake
<i>Psammophis crucifer</i>	Cross-marked or Montane Grass Snake
<i>Psammophylax rhombeatus</i>	Spotted or Rhombic Skaapsteker
<i>Pseudoaspis cana</i>	<i>cana</i> Mole Snake
<i>Typhlops bibronii</i>	Bibron's Blind Snake
<i>Varanus exanthematicus</i>	Rock or White-throated Monitor
<i>Varanus niloticus</i>	Nile or Water Monitor

Appendix 4

Surface water Study for The proposed Access Brown Shaft II Project Area

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REPORT ON

BROWN SHAFT SPECIALIST SURFACE WATER STUDY

Report No :0073-Rep-001 Rev0

Submitted to:

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Middleburg
1050

DISTRIBUTION:

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October 2012

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REVISION TRACKING

Rev 0: Original document.

1 INTRODUCTION

Geovicon (Pty) Ltd commissioned iLanda Water Services CC to conduct a surface water specialist study for Goedehoop North's proposed Brown Shaft Mining operations. This report details the results of the study, as well as recommendations coming from the work done.

2 REGIONAL SETTING

Goedehoop North Colliery is located in the Mpumalanga Province of South Africa. The colliery is located approximately 27 km south east of Emalathleni and approximately 146 km east of Johannesburg, in the upper reaches of the Olifants River catchment. The colliery is located in the upper reaches of the Loskop and Flag Boshielo Dam catchments.

The Loskop and Flag Boshielo dams are located downstream of Witbank Dam, on the Olifants River, and are an important source of domestic, irrigation and industrial water to their surrounding areas. The Olifants River is an international river, flowing through the Kruger National Park and into Mozambique. With the Olifants River flowing through the Kruger National Park, provision for meeting ecological requirements is one of the controlling factors for managing water resources throughout the Olifants River catchment. Significant quantities of water are transferred into the catchment, mainly for power station cooling water.

3 LOCAL SETTING

The site is located in quaternary catchment B11H. It is located next to the R35, approximately 12 km North of Komati village and the Komati power station.

The natural vegetation in the study area is predominantly grassland. Extensive irrigated and dry-land agricultural activities are prevalent. Various forms of livestock farming also exist in the catchment. A few small towns and smaller urban settlements exist in the study area.

Three streams flow through the study area. All three streams flow in a generally northerly direction. The most eastern stream is a tributary of the Spookspruit and is referred to as such in this study. The most western stream is the Blesboklaagtespruit. The central stream merges with the Blesboklaagtespruit in the Bankfontein Dam. For the purposes of this study it is referred to as a tributary of the Blesboklaagtespruit. The outflow of the Bankfontein Dam becomes the Spookspruit.

4 HYDROLOGICAL INVESTIGATION

4.1 Catchment Delineation

The catchments of all three streams that traverse the study area were delineated using the Surveyor General's 5m contour data. These catchment boundaries are shown in Figure 1.

The tributary of the Spookspruit catchment measures 20.1 km² where it exits the study area. The Blesboklaagtespruit catchment measures 7.3 km² where it passes under the proposed conveyor. The tributary of the Blesboklaagtespruit catchment measures 25.3 km² where it passes under the proposed conveyor.

4.2 Catchment Characterisation

The proposed mining activities are located in quaternary catchment B11H, in the Olifants Water Management Area.

The catchments are typical Mpumalanga Highveld catchments. Vegetation is predominantly Highveld grasslands and dry land maize lands. Limited lands appear to be under irrigation. There are numerous small dams located on the rivers within the study areas. There is little development in Spookspruit tributary and Blesboklaagtespruit tributary catchments, with a few farmsteads scattered throughout the catchment. The villages of Bank and Schoongesicht are located in the Blesboklaagtespruit catchment. All catchments can be considered as rural.

4.3 Colliery layout

The proposed mining activities consist of the following key areas:

- An underground mining section to the west of the tributary of the Spookspruit
- A new conveyor constructed between Goedehoop North Colliery and the proposed underground workings.
- Although no pollution control dam has currently been specified, it is likely that a pollution control dam will be located at the adit or shaft serving the underground workings.

The layout of these facilities is shown in Figure 2.

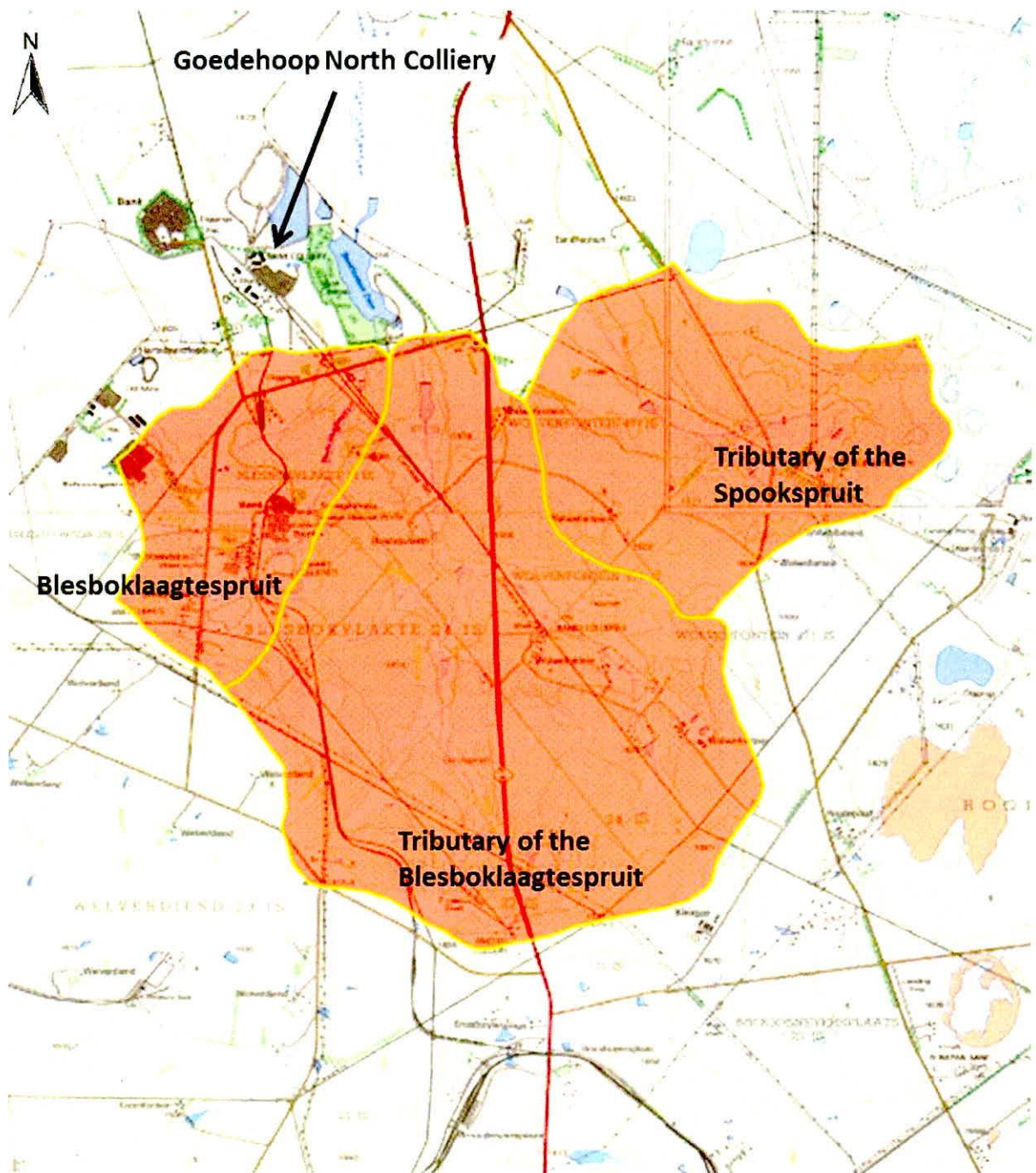


Figure 1: Catchment delineation

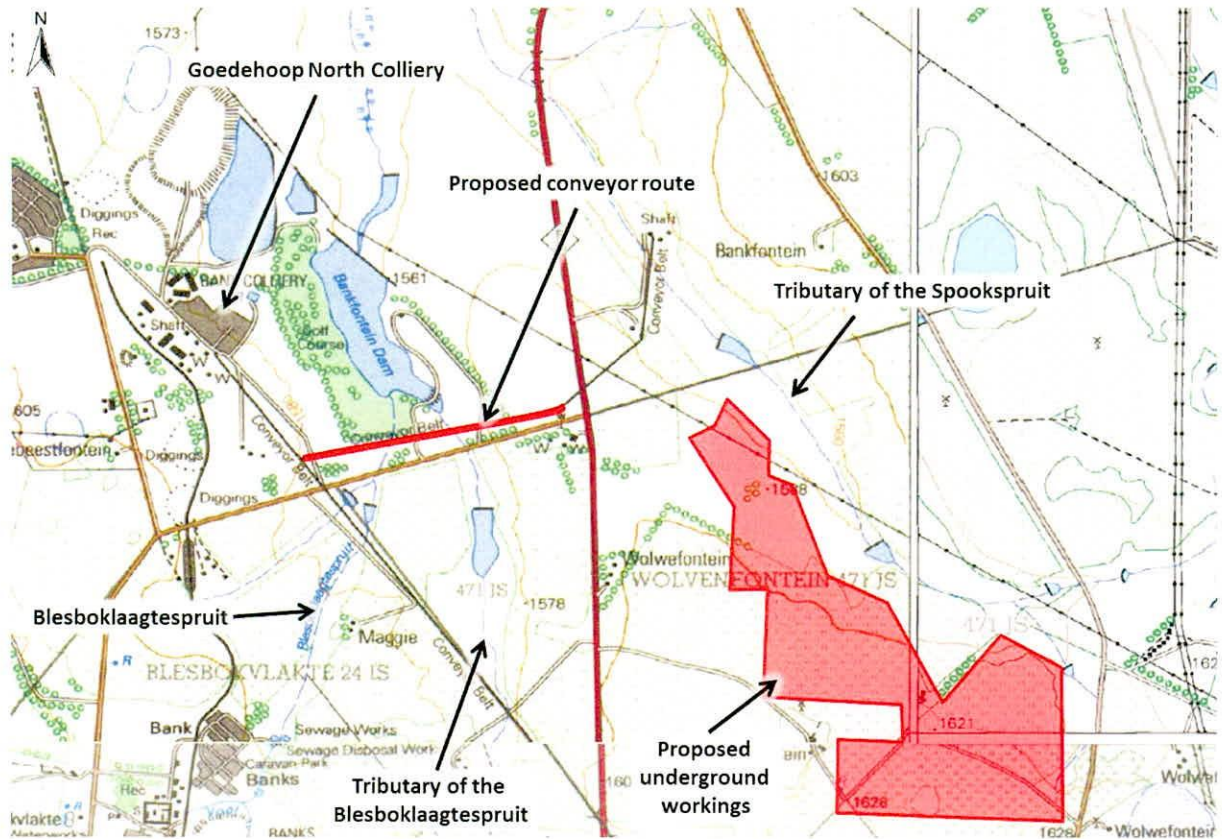


Figure 2: Proposed mine layout

4.4 Climate and Mean Annual Precipitation Analysis

The mean annual precipitation of the site is 687 mm. The mean annual evaporation of the site is 1 522 mm (S-Pan). The monthly average rainfall, rainfall days, and evaporation rates are presented in Table 1. The Mpumalanga Highveld has distinct wet and dry seasons. 91% of the Colliery's mean annual rainfall falls between October and April inclusively. 68% of the area's mean annual evaporation occurs in this period (Midgley et al., 1990).

Table 1: Mean monthly rainfall, rain days and evaporation data for the site

Month	Ave Rainfall (mm)	Ave rain days	Ave Evaporation (mm S-Pan)
October	67.8	7.0	164.1
November	112.6	10.4	154.8
December	110.6	10.3	170.5
January	116.5	10.4	167.4
February	96.3	7.8	139.6
March	74.8	7.1	137.7
April	42.8	4.5	105.9
May	16.3	2.1	89.2
June	7.6	1.2	72.4
July	6.6	0.9	79.3
August	6.9	1.0	105.0
September	24.2	2.8	136.1
Mean Annual	687*		1522

* Note: The sum of the mean monthly rainfall depths does not necessarily equal the mean annual precipitation.

4.4.1 Sources of rainfall data

Daily rainfall data was sourced from the CCWR (Computing Centre for Water Research, Natal University) rainfall database (gauge number 0478546 – van Dyksdrift), as well as data from the South African Weather Service (SAWS) for the same gauge. The gauge is located approximately 20 km south west of the site. The CCWR data contains daily records and patched records up to May 2000. These were patched by the CCWR. The patching prior to 1929 appears suspect and this data was discarded. The SAWS data beyond January 2006 contained significant gaps. There was a poor correlation between the shorter Goedehoop record and the van Dyksdrift record, so the van Dyksdrift data beyond January 2006 was discarded. The final data set is a complete record between 1/1/1929 and 30/1/2006, or over 77 years. The data is considered representative of the site and is good quality.

Gauge number 0478726 (Goedehoop Colliery) is located on site but has less than 25 years of useable data (CCWR and SAWS data combined). The gauge was therefore considered inappropriate to use for long-term statistical analysis.

4.4.2 Sources of evaporation data

The mean annual evaporation was sourced from the average evaporation for quaternary catchment B11H, documented in the Water Resources of South Africa, 2005 Study (Middleton and Bailey, 2009). Its monthly distribution was sourced from the Water Resources of South Africa Study data set, zone 4A (Midgley et al., 1990). The data is considered representative of the site.

4.5 Temperature and Wind Analysis

No weather stations are located in close proximity to the proposed colliery. The closest weather stations are located in Witbank and Springs. Temperature data from the Witbank weather station (Station number 0515320 8) was analysed and a summary of the data is presented in Table 2. The temperature data spanned 2001 to 2010.

Table 2: Mean monthly temperature data for 0515320 (Witbank)

Month	Average daily minimum temperature (°C)	Average daily maximum temperature (°C)
January	15.3	26.1
February	14.9	26.3
March	13.3	25.0
April	10.7	23.2
May	7.1	20.8
June	4.8	18.3
July	4.1	18.5
August	6.6	21.3
September	9.3	24.9
October	12.3	26.0
November	13.5	25.2
December	14.7	26.1

Wind data from the Witbank weather station (Station number 05153208) was analysed and a summary of average wind speeds and directions is presented in Figure 3. The monthly breakdown of average wind speeds and directions is presented in Figure 4.

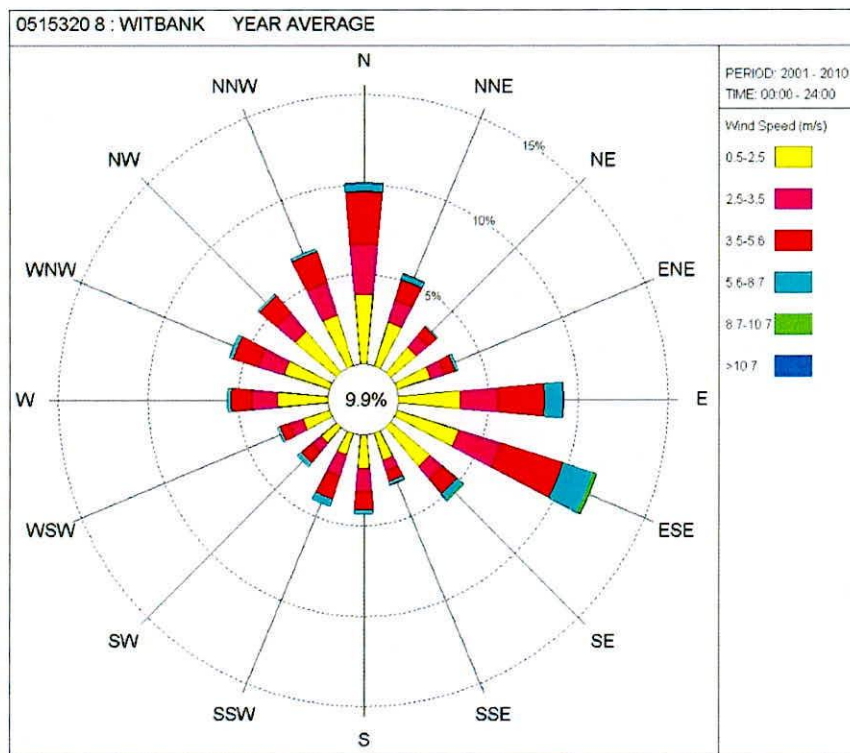
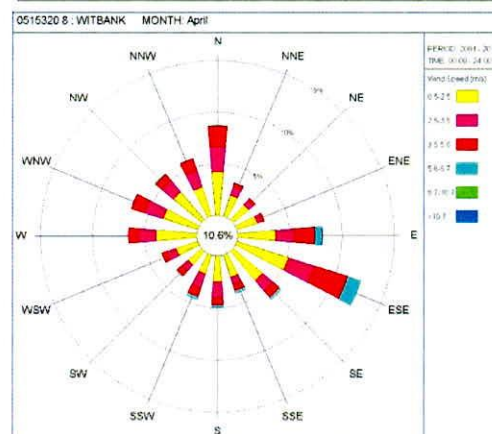
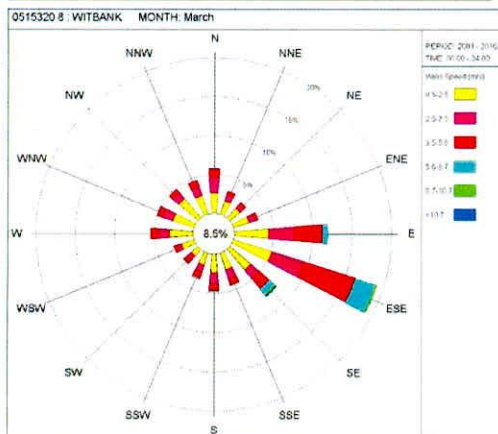
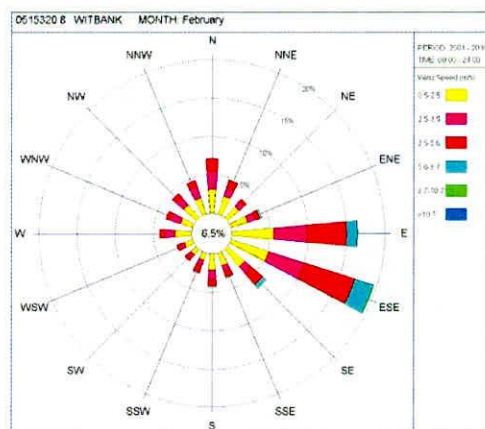
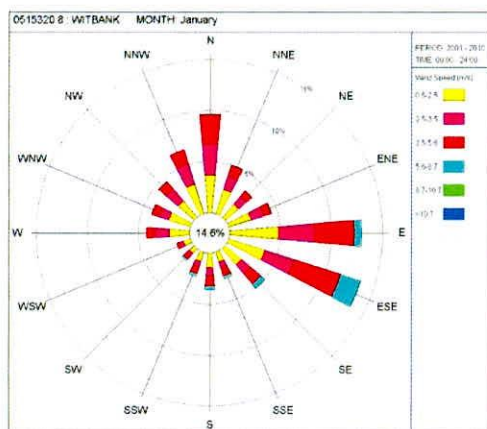


Figure 3: Average wind rose data (throughout the year)



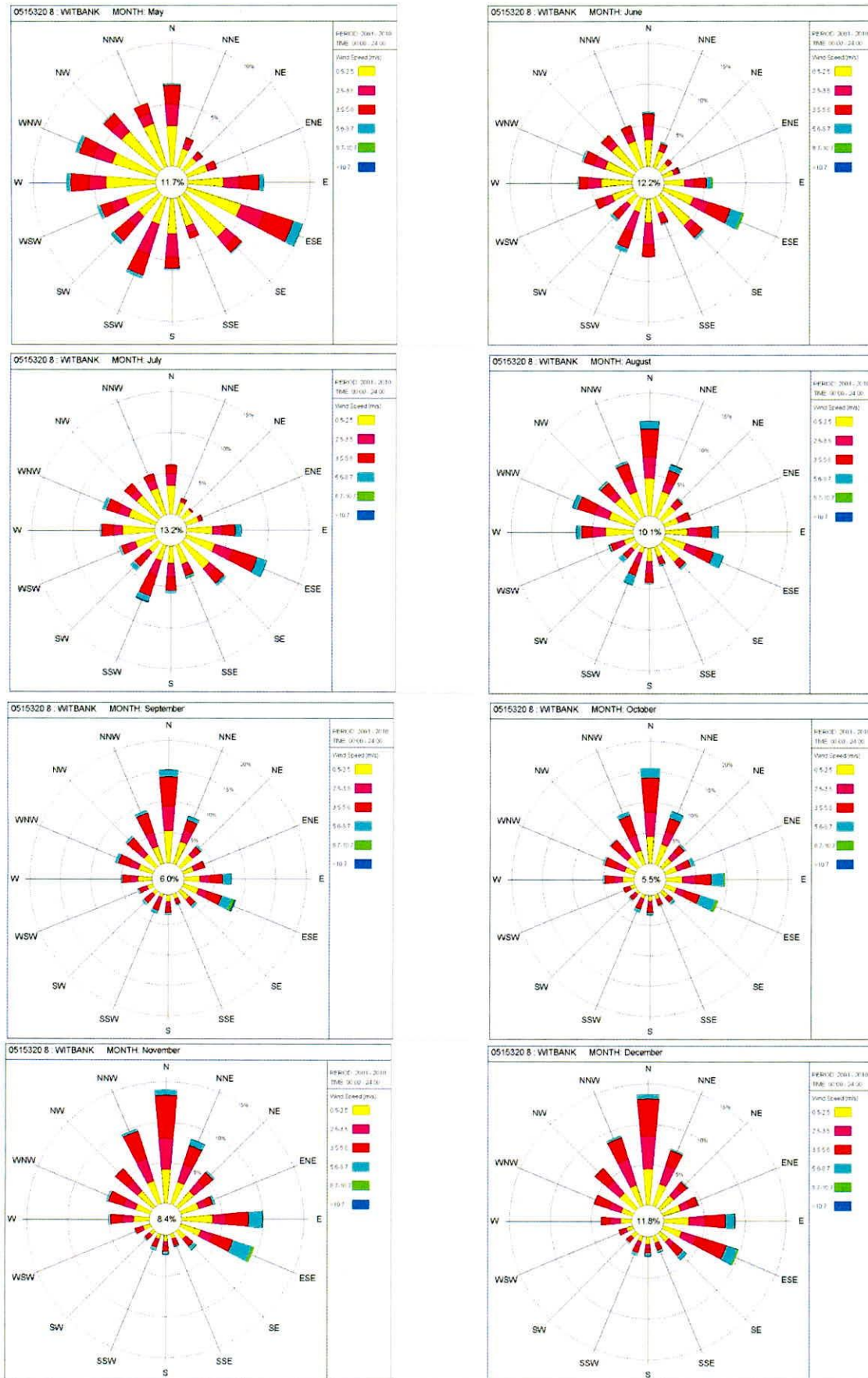


Figure 4: Monthly wind rose data

4.6 Mean Annual Runoff Analysis

The mean annual runoff for the tributary of the Spookspruit is 0.56 Mm³ where it exits the study area (catchment shown in Figure 1). The mean annual runoff for the tributary of the Blesboklaagtespruit is 1.17 Mm³ where it exits the study area (catchments shown in Figure 1). The mean annual runoff for the Blesboklaagtespruit is 0.34 Mm³ at the point where it exits the study area (catchments shown in Figure 1).

The mean annual runoff for the quaternary catchment B11H is 11.38 Mm³ (Middleton and Bailey, 2009). The catchment characteristics of the rivers and streams mentioned above are similar to those of the quaternary catchment so the mean annual runoff was scaled from the quaternary catchment runoff, based on relative catchment size.

4.7 Normal Dry Weather Flows

The normal dry weather flows are based on the average monthly flows documented in the Water Resources of South Africa, 2005 Study (Middleton and Bailey, 2009) for quaternary catchment B11H. The flows were scaled based on relative catchment size. The dry weather flows for the three streams that flow through the study area are presented in Table 3. The dry weather flows have been highlighted in bold text.

Table 3: Normal dry weather flows (highlighted in bold text)

Month	Blesboklaagtespruit (m ³ /month)	Tributary of the Blesboklaagtespruit (m ³ /month)	Tributary of the Spookspruit (m ³ /month)
October	15,117	52,785	25,170
November	34,447	120,280	57,353
December	47,883	167,193	79,723
January	53,135	185,534	88,469
February	58,489	204,227	97,382
March	49,027	171,188	81,628
April	30,741	107,338	51,182
May	15,880	55,448	26,440
June	9,965	34,795	16,591
July	7,839	27,373	13,052
August	6,401	22,349	10,657
September	6,085	21,247	10,131