## 4.2 The Biophysical Environment

Baseline PRECIS data for 2629CD grid square was collected to determine the expected species list for this region according to SANBI (Appendix B). The vegetation type in which proposed site falls is Soweto Highveld Grassland (Mucina and Rutherford, 2006).

Synonyms of Soweto highveld grassland are VT52 *Themeda* veld (Turf Highveld) 56% and (Acocks 1953).LR 35 Moist Clay Highveld Grassland (51%) (Low & Rebelo 1996)

### *Distribution*

This vegetation type predominantly occurs in Mpumalanga and Gauteng (and to a very small extent also in neighbouring Free State and North-west) Provinces. It is in a broad band roughly delimited by the N1 road between Ermelo and Johannesburg in the north, Perdekop in the southeast and the Vaal River (border with the Free State) in the south. It extends further westwards along the southern edge of the Johannesburg Dome (including part of Soweto) as far as the vicinity of Randfontein. In southern Gauteng it includes the surrounds of Vanderbijlpark and Vereeniging as well as Sasolburg in the northern Free State. The altitude for this vegetation type is between 1420 and 1760m (Mucina and Rutherford, 2006).

### *Vegetation and Landscape Features*

The landscape features include gently to moderately undulating landscape on the Highveld plateau supporting short to medium-high, dense, tufted grassland dominated almost entirely by *Themeda triandra* and accompanied by a variety of other grasses such as *Elionurus muticus, Eragrostis racemosa, Heteropogon contortus* and *Tristachya leucothrix.* In places not disturbed, only scattered small wetlands, narrow stream alluvia, pans and occasional ridges or rocky outcrops interrupt the continuous grassland cover (Mucina and Rutherford, 2006).

### *Geology and Soils*

Shale, sandstone or mudstone of the Madzaringwe Formation (Karoo Supergroup) or the intrusive Karoo Suite dolerites feature prominently in the area. In the south, the Volksrust Formation (Karoo Supergroup) is found and in the west, the rocks of the older Transvaal, Ventersdorp and Witwatersrand Supergroups are most significant. Soils are deep, reddish on flat plains and are typically Ea, Ba and BB land types (Mucina and Rutherford, 2006).

### *Climate*

This is a summer-rainfall region (MAP 662mm) and has a cool-temperature climate with thermic continentality (high extremes between maximum summer and minimum winter temperatures), frequent occurrence of frost and large thermic diurnal differences especially in autumn and spring (Mucina and Rutherford, 2006).

### *Important Taxa*

The important taxa for this vegetation type include:

Graminoids: *Andropogon appendiculatus* (d), *Brachiaria serrata* (d), *Cymbopogon pospischilii* (d), *Cynodon dactylon* (d), *Elionurus muticus* (d), *Eragrostis capensis* (d), *E. chloromelas* (d), *E. curvula* (d), *E. plana* (d), *E. planiculmis* (d), *E. racemosa* (d), *Heteropogon contortus* (d), *Hyparrhenia hirta* (d), *Setaria nigrirostris* (d), *S. sphacelata* (d), *Themeda triandra* (d), *Tristachya leucothrix* (d), *Andropogon schirensis, Aristida adscensionis, A. biartita, A. congesta, A. junciformis* subsp. *galpinii, Cymbopogon caesius, Digitaria diagonalis, Diheteropogon amplectens, Eragrostis micrantha, E.superba, Harpochloa falx, Microchloa caffra, Paspalum dilatatum,*

Herbs: *Hermannia depressa* (d), *Acalypha angustata, Berkheya setifera, Dicoma anomala, Euryops gilfillanii, Geigeria aspera* var. *aspera, Graderia subintegra, Haplocarpha scaposa, Helichrysum miconiifolium, H. nudifolium* var. *nudifolium, H. rugulosum, Hibiscus pusillus, Justicia anagalloides, Lippia scaberrima, Rynchosia effusa, Schistostephium crataegifolium, Selago densiflora, Senecio coronatus, Vernonia oligocephala, Wahlenbergia undulata.*

Geophytic Herbs: *Haemanthus humilis* subsp. *hirsutus, H. montanus.*

Herbaceous Climber: *Rynchosia totta.*

Low Shrubs: *Anthospermum hispidulum, A. rigidum* subsp. *pumilum, Berkheya annectens, Felicia muricata, Ziziphus zeyheriana* (Mucina and Rutherford, 2006).

### *Conservation*

This vegetation type is classified as Endangered and has a Conservation Target of 24%. Only a handful of patches are statutorily conserved (Waldrift, Krugersdorp, Leeuwkuil, Suikerbosrand, Rolfe's Pan Nature Reserves) or privately conserved (Johanna Jacobs, Tweefontein, Gert Jacobs, Nikolaas and Avalon Nature Reserves, Heidelberg Natural Heritage Site). Almost half of the area is already transformed by cultivation, urban sprawl, mining and building of road infrastructure. Some areas have been flooded by dams, (Grootdraai, Leeukuil, Trichardtsfontein, Vaal, Willem Brummer). Erosion is generally very low (93%) (Mucina and Rutherford, 2006).

# 5.0 BASELINE RESULTS

## 5.1 Fauna

### 5.1.1 Mammals

Mammals were identified through visual identification of the species, prints or faeces. Species identified during the survey can be seen in Table 3. Red Data mammals were also taken into account, but no Red Data species were encountered. Large amounts of scat were found on the site. From the scat samples mammals were identified, however there was scat that could not be positively identified as a specific species.

**Table 3: Mammals species identified during the survey**

| Species Name | Common Name |
|---|---|
| *Canis mesomelas* | Black-backed jackal |
| *Cynictis penicillata* | Yellow mongoose |
| *Hystrix africaeaustralis* | Porcupine |

### 5.1.2 Avifauna

During the survey all birds species encountered or bird calls identified were listed (Table 4). Red Data species were also taken into account for this region, but no Red Data species were found. Due to the fact that the survey was conducted during the dry season and the impacted nature of the grassland, Avifauna diversity was low.

**Table 4: Bird species identified during the field survey**

| Scientific Name | Common Name |
|---|---|
| Acrocephalus scoenobaenus | European sedge warbler |
| Ardea cinerea | Grey heron |
| Bostrychia hagedash | Hadeda |
| *Cercomela familiaris* | Familiar chat |
| *Estrilda astrild* | Common waxbill |
| *Euplexis orix* | Southern red bishop |
| *Fulica cristata* | Redknobbed coot |
| *Gallinula chloropus* | Common moorhen |

| Scientific Name | Common Name |
|---|---|
| *Mirafra sabota* | Sabota lark |
| *Myrmecocichla formicivora* | Anteating Chat |
| *Numida meleagris* | Guinefowl |
| *Passer diffusus* | Southern Greyheaded Sparrow |
| *Passer melanurus* | Cape Sparrow |
| *Ploceus velatus* | Southern masked weaver |
| *Streptopelia senegalensis* | Palm dove |
| *Turdus olivaceus* | Olive thrush |
| *Upupa africana* | African hoopoe |

### 5.1.3 Herpetofauna

During the field survey, no reptiles or amphibians were observed. Reasons for not finding any species can be attributed to the time of the year the survey was conducted (July 2010) which falls within the dry season when reptiles are not as active and the amount of time spent in the field (two days). It is likely that reptiles such as snakes and lizards do occur on site. Red Data species possibly occurring within the study area include *Homoroselaps lacteus* (Spotted harlequin snake). The probability of occurrence of this species is seen as moderate due to the fact that the habitat type of this species includes grasslands.

### 5.1.4 Arthropoda

Arthropods identified during the site survey can be seen in Table 5. Unfortunately at this time no Red Data butterflies list exist for Mpumalanga and therefore the probability of occurrence for Red Data species could not be determined.

**Table 5: Arthropods found during the site survey**

| Family | Species |
|---|---|
| Acrididae | *Acrida acuminata* |
| Alydidae | *Mirperus faculus* |
| Bombyliidae | *Exoprosopa* |
| Bradyporidae | *Hetrodes pupus* |
| Calliphoridae | *Chrysomya chloropyga* |
| Gryllidae | *Gryllus bimaculatus* |
| Hymenopodidae | *Harpagomantis tricolor* |
| Libiduridae | *Labidura riparia* |
| Melirydae | *Melyris* |
| Nemopteridae | *Nemia costalis* |
| Pamphagidae | *Hoplolopha* |
| Pyrgomorphidae | *Phymateus morbillosus* |
| Pyrrhocoridae | *Scantius fosteri* |
| Reduviidae | *Etrichodia crux* |
| Tabanidae | *Tabanus taeniatus* |
| Tettigonidae | *Phaneroptera* |

## 5.2 Flora

A large percentage of exotic species were found and most areas were highly impacted already by grazing or anthropogenic impacts. Due to the fact that the survey took place during the dry season, species level identification was impaired and species that might occur on site could have been overlooked, due to lack of foliage that's only visible during the dry season. Based on physiognomy, moisture regime, rockiness, slope and soil properties, two vegetation communities were recognised. These vegetation communities included *Themeda* secondary grassland and Artificial wetland communities.

### Themeda secondary grassland

This vegetation community covers the majority of the study area. Although no geological studies were done as part of the ecological study, the substrate of this vegetation community is characterised by dark clay. The disturbed grassland or other disturbed areas such as road reserves or fallow fields, not cultivated for some years, are usually dominated by the species *Hyparrhenia*. *Themeda triandra* is, however, the dominant species for this vegetation unit.

Other species present are a result of historical disturbances such as over-grazing, sand mining and crop cultivation. This vegetation unit is low in species richness, with only a few species able to establish or survive in the shade of the dense sward of tall grass. The most prominent species include the following grasses: *Themeda, Eragrostis, Heteropogon, Aristida, Digitaria, Tristachya* and *Elionurus*. Invasive species occurring in this area include: *Cirsium vulgare; Bidens pilosa; Conyza albida; Schkuhhria pinnata; Tagetes minuta; Asclepias fruticosa; Datura stramonium;* and *Solanum sisymbrifolium*.

**Table 6: Species found for the Themeda secondary grass community**

| Family | Species |
|---|---|
| ASTERACEAE | *Cirsium vulgare |
| ASTERACEAE | *Bidens pilosa |
| ASTERACEAE | *Tagetes minuta |
| ASTERACEAE | *Schkuhria pinnata |
| MALVACEAE | Hermannia depressa |
| POACEAE | Aristida bipartita |
| POACEAE | Aristida congesta |
| POACEAE | Cynodon dactylon |
| POACEAE | Elionurus muticus |
| POACEAE | Eragrostis chloromelas |
| POACEAE | Eragrostis curvula |
| POACEAE | Eragrostis plana |
| POACEAE | Heteropogon contortus |
| POACEAE | Setaria sphacelata |
| POACEAE | Themeda triandra |
| POACEAE | Hyparrhenia hirta |
| SOLANACEAE | *Datura stramonium |
| SOLANACEAE | *Solanum sisymbriifolium |
| VERBENACEAE | *Verbena bonariensis |
| VERBENACEAE | *Verbena brasiliensis |

### Artificial Wetland region

There are a few isolated artificial wetlands within the study area which are associated with hydrophilic species. Artificial wetlands are any type of wetland constructed by man, or formed due to anthropogenic disturbances of natural areas. In this case these wetlands formed due to excavations filling up with rain and infiltration from the groundwater table. This area is, however, heavily disturbed and dominated by exotic species which forms dense stands in the area. Very little natural vegetation occurs in this area; the few indigenous species are pioneer grasses and some annual species. Species include *Pragmites australis, Cyperus fastigiatus, Aristida bipartita, Hyparrhenia hirta, Datura stramonium,Datura ferox, Cirsium vulgare, Solanum sisymbriifolium, Verbena bonariensis* and *Xanthium strumarium.*

**Table 7: Species identified in the artificial wetland community**

| Family | Species |
|---|---|
| ASTERACEAE | **Cirsium vulgare* |
| ASTERACEAE | **Bidens pilosa* |
| ASTERACEAE | **Tagetes minuta* |
| ASTERACEAE | **Xanthium strumarium* |
| CYPERACEAE | *Cyperus fastigiatus* |
| POACEAE | *Aristida bipartita* |
| POACEAE | *Phragmites australis* |
| POACEAE | *Hyparrhenia hirta* |
| POACEAE | *Andropogon eucomus* |
| SOLANACEAE | **Datura stramonium* |
| SOLANACEAE | **Datura ferox* |
| SOLANACEAE | **Solanum sisymbriifolium* |
| VERBENACEAE | **Verbena bonariensis* |

Exotic species indicated by *

The vegetation types can be considered as being of moderate ecological status as some of the patterns and processes in these areas have been diminished or eliminated by anthropogenic/industrial impacts. Although impacts on the vegetation are envisaged to be insignificant on a local scale, due to the complex nature of ecological systems further extensive impacts in these areas could cause rapid and perhaps irreversible degradation of these areas.

### Red Data species

Red Data vegetation retrieved from SANBI for grid square 2629CD was taken into account during the assessment. Only one Red Data species is indicated to potentially occur within the project area, namely *Cineraria austrotransvaalensis*. This species has a Near Threatened status, but was not found on site during the site visit. Protected species of Mpumalanga was also considered, none of which were found on site. However, due to the fact that the survey was conducted during the dry season the potential of protected species occurring on site cannot be eliminated.

## 5.3 Sensitive Habitat Assessment

According to the MBCP (Mpumalanga Biodiversity Conservation Plan) this area falls within the "Least Concern" and "No Natural Habitat Remaining" areas. The definitions of these statuses are as follows:

**Least Concern**: These areas have biodiversity value in the form of natural vegetation cover. Although they are not currently required in order to meet biodiversity targets, they do contribute significantly to functioning ecosystems including ecological connectivity. A greater variety of development choices exists in these areas.

However they are still subject to National EIA legislation, where at least a scoping report is required for all listed activities.

**No natural habitat remaining**: This area covers the rest of the Mpumalanga Province in which natural vegetation has been lost. It includes all land transformed by urban/industrial development and cultivation. Biodiversity is irreversibly changed, reduced to levels that are virtually dysfunctional. These landscapes have only residual or negative effects on the functioning of natural ecosystems (SANBI, 2007).

There are no areas on site that are of conservation value. It does however border next to irreplaceable sites as identified by MBCP and for this reason no activities extending the project site should be implemented and management of the site area should be efficient enough to prevent escape of pollutants into neighbouring properties. In terms of protected areas, the closest nature reserve is Bloukop which is approximately 25km from the site and for this reason will not be impacted by the development (Figure 2).

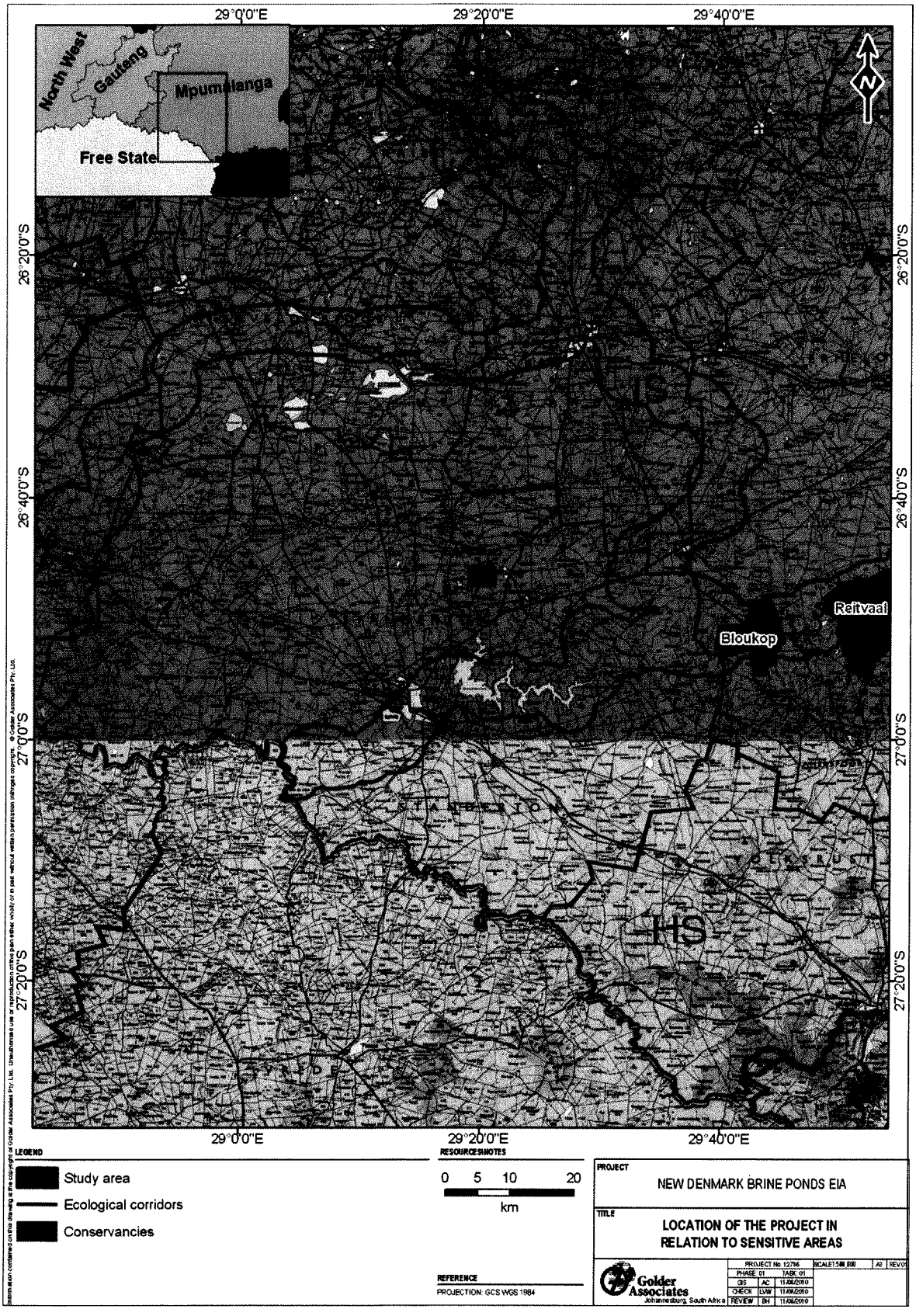


*Figure 2: The location of the project in relation to protected areas*

# 6.0 ECOLOGICAL IMPACT ASSESSMENT

A summary of the potential impacts are presented in Table 8. Including:

- Loss or alteration to plant communities
- Increased run-off and change in drainage patterns
- Loss and changes in ecosystem functions
- Change in soil nutrient status
- Destruction of Faunal and Floral habitat
- Reduction in biodiversity on-site
- Habitat degradation through windblown dust
- Loss of medicinal and other plants used by the local community
- Contamination through pollution, leachate, runoff, flooding discharge
- Removal of current alien species

**Table 8: Ecological impact assessment**

| | Before mitigation | | | | | | | After mitigation | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Description of impact** | **Magnitude** | **Duration** | **Scale** | **Probability** | **Score** | **Significance rating** | **Mitigation measures** | **Magnitude** | **Duration** | **Scale** | **Probability** | **Score** | **Significance rating** |
| **Construction-related impacts** | | | | | | | | | | | | | |
| Loss or alteration to plant communities | 6 | 4 | 1 | 4 | 44 | M | Due to the removal of vegetation species, plant communities will be adjusted. Removal of alien species is suggested, but indigenous species should be re-established during and after construction, maintain and manage the area. | 4 | 3 | 1 | 3 | 24 | L |
| Increased run-off and change in drainage patterns | 4 | 4 | 2 | 3 | 30 | M | Removal of vegetation will result in open areas that increase Re-run-off and drainage pattern changes. Establishment of indigenous plant species/communities will mitigate this. | 4 | 2 | 2 | 3 | 24 | L |
| Loss and changes in ecosystem functions | 8 | 4 | 2 | 4 | 56 | M | Avoid removal of key-stone species and prevent reduction of the current biodiversity that may result in loss or change of ecosystems. | 6 | 4 | 1 | 3 | 33 | M |
| Change in soil nutrient status | 6 | 4 | 1 | 4 | 44 | M | Avoid change in soil due to construction material and leachate/escape of waste into the environment. Properly dispose of construction material and manage waste systems. Maintain fertile soil for vegetation growth | 4 | 3 | 1 | 3 | 24 | L |
| Loss of medicinal and other plants used by the local community | 6 | 5 | 1 | 4 | 48 | M | Re-establish plants of cultural importance after construction phase and maintain and manage area, this does not include exotics or invasives. | 4 | 3 | 1 | 3 | 24 | L |
| Destruction of Faunal and Floral habitat | 8 | 5 | 1 | 4 | 56 | M | Avoid dens, burrows, nests where possible and re-establish vegetation as habitat cover. | 6 | 5 | 1 | 3 | 36 | M |

| | Before mitigation | | | | | | | After mitigation | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Description of impact** | **Magnitude** | **Duration** | **Scale** | **Probability** | **Score** | **Significance rating** | **Mitigation measures** | **Magnitude** | **Duration** | **Scale** | **Probability** | **Score** | **Significance rating** |
| Habitat degradation through windblown dust | 6 | 4 | 1 | 4 | 44 | M | Establish indigenous vegetation to cover soil that has been exposed by removal of vegetation, maintain and manage environment | 4 | 4 | 1 | 3 | 27 | L |
| Contamination through pollution, leachate, runoff, flooding discharge | 10 | 4 | 2 | 3 | 48 | M | Take management measures and risk assessments to avoid accidental spillage, leachate or pollution | 8 | 3 | 2 | 2 | 26 | L |
| Reduction in biodiversity on-site | 8 | 5 | 1 | 4 | 56 | M | Re-establish indigenous species, this will also ensure faunal habitat where possible, also relocation of faunal species when necessary and where habitat degradation cannot be prevented. Minimize disturbances where possible. | 6 | 4 | 1 | 4 | 44 | M |
| Removal of current alien species | 10 | 4 | 1 | 5 | 75 | | Positive impact that will remove all alien and invasive vegetation, no mitigation measures needed. | 10 | 4 | 1 | 5 | 75 | |
| **Operational-related impacts** | | | | | | | | | | | | | |
| Loss and changes in ecosystem functions | 8 | 4 | 2 | 4 | 56 | M | Avoid removal of key-stone species and prevent reduction of the current biodiversity that may result in loss or change of ecosystems. | 6 | 4 | 1 | 3 | 33 | M |
| Change in soil nutrient status | 6 | 4 | 1 | 4 | 44 | M | Avoid change in soil due to construction material and leachate/escape of waste into the environment. Properly dispose of construction material and manage waste systems. Maintain fertile soil for vegetation growth | 4 | 3 | 1 | 3 | 24 | L |
| Destruction of areas and Faunal and Floral habitat | 8 | 5 | 1 | 4 | 56 | M | Avoid dens, burrows, nests where possible and re-establish vegetation as habitat cover. | 6 | 5 | 1 | 3 | 36 | M |

| Description of impact | Before mitigation | | | | | | Mitigation measures | After mitigation | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Magnitude | Duration | Scale | Probability | Score | Significance rating | | Magnitude | Duration | Scale | Probability | Score | Significance rating |
| Habitat degradation through windblown dust | 6 | 4 | 1 | 4 | 44 | M | Establish indigenous vegetation to cover soil that has been exposed by removal of vegetation, maintain and manage environment | 4 | 4 | 1 | 3 | 27 | L |
| Contamination through pollution, leachate, runoff, flooding discharge | 10 | 4 | 2 | 3 | 48 | M | Take management measures and risk assessments to avoid accidental spillage, leachate or pollution | 8 | 3 | 2 | 2 | 26 | L |
| Reduction in biodiversity on-site | 8 | 5 | 1 | 4 | 56 | M | Re-establish indigenous species, this will also ensure faunal habitat where possible, also relocation of faunal species when necessary and where habitat degradation cannot be prevented. Minimize disturbances where possible. | 6 | 4 | 1 | 4 | 44 | M |
| Removal of current alien species | 10 | 4 | 1 | 5 | 75 | | Positive impact that will remove all alien and invasive vegetation, no mitigation measures needed. | 10 | 4 | 1 | 5 | 75 | |
| **Planned closure-related impacts** | | | | | | | | | | | | | |
| Loss or alteration to plant communities | 6 | 4 | 1 | 4 | 44 | M | Due to the encroachment of exotic/invasives, plant communities will be adjusted. Removal of alien species is suggested, but indigenous species should be maintained and managed in the area. | 4 | 3 | 1 | 3 | 24 | L |
| Changes in ecosystem functions | 6 | 4 | 2 | 4 | 48 | M | Avoid removal of key-stone species and any further reduction of the current biodiversity. | 6 | 4 | 1 | 3 | 33 | M |

| Description of impact | Before mitigation | | | | | | Mitigation measures | After mitigation | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Magnitude | Duration | Scale | Probability | Score | Significance rating | | Magnitude | Duration | Scale | Probability | Score | Significance rating |
| **Unplanned closure-related impacts** | | | | | | | | | | | | | |
| Habitat degradation | 8 | 4 | 2 | 4 | 56 | M | This will be due to the encroachment of exotics, escape of pollutant into the environment and general lack of management in the area. Continual management and monitoring of closure plans need to be followed to prevent degradation. | 6 | 4 | 2 | 3 | 36 | M |
| Contamination through pollution, leachate, runoff, flooding discharge | 10 | 4 | 1 | 5 | 75 | | Take management measures as part of closure plans and risk assessments to avoid accidental spillage, leachate or pollution | 8 | 3 | 2 | 2 | 26 | |

# 7.0 MITIGATION AND MONITORING

The proposed pipeline route and sites for the development of the evaporation ponds predominantly are situated in areas that have already been impacted by industrial activities or previous agricultural activities, therefore large quantities of exotic species were found. Furthermore, the impacts identified for the site range between moderate and low significance due to the current ecological integrity of the site and no Red Data species were found. The proposed project could include a rehabilitation process to improve the general veld conditions. The following will need to be implemented:

- All exotic and invasive species should be removed.
- Thereafter, indigenous and currently occurring species should be planted and maintained. Species include grasses such as *Eragrostis* species.
- The maintenance and management of the pipeline and ponds to prevent leakage and contamination of the environment.

By restoring the biophysical environment, the habitat may be improved, which can, in turn, be adequate for ecological restoration if sources are sufficient for colonization of species. An ecosystem has characteristics that need to materialise in order for it to regain integrity.

- It needs to undergo natural development, where bare soil slowly releases nutrients through weathering; nutrients are in turn released to plants, which colonize the area.
- The initial vegetation releases more nutrients which allow the colonization of more species.
- The exotic species will have to be reduced, removed and managed (Cairns, 1995).
- Treatment of soil may be required to restore fertility and ensure healthy plant growth. The soil should allow all the natural nutrient cycles and therefore it will need "plant food" to provide the carbons, nitrogen and other important plant elements for growth. This should also be associated with the type of soil, organic material will assist in improving the drainage of the soil (Harris, 2000). However care must be taken to prevent the spread of pollutants and dangerous components.

Rehabilitation of the project area can be conducted by vegetation or landscaping specialists. Small mammals were found on site and the rectification of the site by establishing indigenous species will provide habitat for fauna and will reduce the significance of most of the impacts identified. Monitoring of the site can be conducted by continually removing exotic species that might encroach. Disturbance to the environment should be reduced as far as possible and should be limited to the project site, as irreplaceable areas are identified adjacent to the project site by MBCP.

In all instances contamination of the environment is crucial and must be prevented by implementing managements and maintenance measures, including monthly inspection of the pipeline.

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# APPENDIX A

## PROTECTED SPECIES OF MPUMALANGA

**Schedule 12: Specially Protected Plants**
*(Section 69(1)(b))*

In this schedule "seedling" means a plant of which the diameter of the trunk or bulb, either above or below the ground, does not exceed 150mm.

| Common Name | Scientific Name | Protection covers |
|---|---|---|
| Dolomiticus cycad | *Encephalartos dolomiticus* | Species, excluding seedlings |
| Dyer cycad | *E. dyerianus* | Species, excluding seedlings |
| Middelburg cycad | *E. middelburgensis* | Species, excluding seedlings |
| Eugene marias cycad | *E. Eugene maraissii* | Species, excluding seedlings |
| Heenen cycad | *E. heenanii* | Species, excluding seedlings |
| Inopinus cycad | *E. inopinus* | Species, excluding seedlings |
| Laevifolius cycad | *E. laevifolius* | Species, excluding seedlings |
| Lanatus cycad | *E. lanatus* | Species, excluding seedlings |
| Lebombo cycad | *E. lebomboensis* | Species, excluding seedlings |
| Ngoyanus cycad | *E. ngoyanus* | Species, excluding seedlings |
| Paucidentatus cycad | *E. paucidentatus* | Species, excluding seedlings |
| Modjadje cycad | *E. transvenosus* | Species, excluding seedlings |
| Villosus cycad | *E. villosus* | Species, excluding seedlings |
| Cupidus cycad | *E. cupidus* | Species |
| Humilis cycad | *E. humilus* | Species |
| Cycads in native habitat | All *Encephalartos* | Whole genus |

**Schedule 11: Protected Plants**
*(Section 69 (1)(a))*

*In this schedule:*
*a) the plants referred to shall not include plants which have been improved by selection or cross-breeding;*
*b) "seedling" means a plant of which the diameter of the trunk or bulb, either above or below the ground, does not exceed 150mm.*

| Common Name | Scientific Name | Grouping |
|---|---|---|
| Tree fern | *Cyathea capensis* | Species |
| | *Cyathea dregei* | Species |
| | | |
| Cycads occurring in SouthAfrica and seedlings ofcycad sp. in schedule 12. | | |
| | | |
| Zamiaceae occurring in South Africa & Encephalartos seedling in schedule 12. Whole family | | |
| | | |
| Yellow wood | *Podicarpus* | Whole genus |
| Arum lilies | *Zantedeschia* | Whole genus |

| Common Name | Scientific Name | Grouping |
|---|---|---|
| Volstruiskos | *Schizobasis intricata* | Species |
| Knolklimop | *Bowiea volubis* | Species |
| Red hot pokers | *Kniphofia* | Whole genus |
| All aloe sp. excluding: | all sp. Not in Mpumalanga *Aloe* | Whole genus |
| Haworthias | *Haworthia* | Whole genus |
| Agapanthus | *Agapanthus* | Whole genus |
| Squill | *Scilla* | Whole genus |
| Pineapple flower | *Eucomis* | Whole genus |
| Dracaena | *Draceena* | Whole genus |
| Paint brush | *Haemanthus* | Whole genus |
| | *Scadoxis* | Whole genus |
| Cape poison bulb | *Boophane disticha* | Species |
| Clivia | *Clivia* | Whole genus |
| Brunsvigia | *Brunsvigia* | Whole genus |
| Crinum | *Crinum* | Whole genus |
| Ground lily | *Ammocharis coranica* | Species |
| Fire lily | *Cyrtanthus* | Whole genus |
| Elephant's foot | *Dioscorea* | Whole genus |
| River lily | *Hesperantha coccinea* | Species |
| Gladioli | *Gladiolus* | Whole genus |
| Watsonia | *Watsonia* | Whole genus |
| Wild ginger | *Siphonochilus aethiopicus* | Species |
| Orchids | Orchidaceae | Whole family |
| Proteas | Proteaceae | Whole family |
| Black stinkwood | *Octea* | Whole genus |
| Kiaat | *Pterocarpus angolensis* | Species |
| Tamboti | *Spirostachys Africana* | Species |
| Euphorbia bernardii | *Euphorbia bernardii* | Species |
| Euphorbia grandialata | *Euphorbia grandialata* | Species |
| Common bersamia | *Bersamia tysoniana* | Species |
| Red ivory | *Berchemia zeyheri* | Species |
| Pepperbark tree | *Warbergia salutaris* | Species |
| Adenia | *Adenia* | Whole genus |
| Bastard onion weed | *Cassipourea gerrardii* | Species |
| Assegai tree | *Curtisia dentate* | Species |
| Olive trees | *Olea* | Whole genus |
| Impala lilies | *Adenium* | Whole genus |
| Kudu lily | *Pachypodium saundersii* | Species |

| Common Name | Scientific Name | Grouping |
|---|---|---|
| Brachystelma | *Brachystelma* | Whole genus |
| Ceropegia | *Ceropegia* | Whole genus |
| Hueniopsis | *Hueniopsis* | Whole genus |
| Huernia | *Huernia* | Whole genus |
| Duvalia | *Duvalia* | Whole genus |
| Stapeliads | *Stapelia* | Whole genus |
| Orbeanthus | *Orbeanthus* | Whole genus |
| Orbeas | *Orbeas* | Whole genus |

# APPENDIX B

## PRECIS DATA FOR GRID SQUARE 2629CD

| Family | Species | Status | SA Endemic |
|---|---|---|---|
| ACANTHACEAE | Blepharis subvolubilis | LC | No |
| ACANTHACEAE | Chaetacanthus burchellii | LC | No |
| ACANTHACEAE | Crabbea acaulis | LC | No |
| ACANTHACEAE | Crabbea hirsuta | LC | No |
| ACANTHACEAE | Thunbergia atriplicifolia | LC | No |
| AMARANTHACEAE | *Achyranthes aspera | | No |
| AMARANTHACEAE | *Alternanthera pungens | | No |
| AMARANTHACEAE | *Amaranthus hybridus | | No |
| AMARANTHACEAE | Amaranthus thunbergii | LC | No |
| AMARANTHACEAE | *Gomphrena celosioides | | No |
| AMARYLLIDACEAE | Haemanthus humilis subsp. hirsutus | LC | No |
| AMARYLLIDACEAE | Haemanthus montanus | LC | No |
| AMARYLLIDACEAE | Nerine laticoma | LC | No |
| ANACARDIACEAE | Searsia dentata | LC | No |
| ANACARDIACEAE | Searsia discolor | LC | No |
| ANACARDIACEAE | Searsia gerrardii | LC | No |
| ANACARDIACEAE | Searsia rigida | LC | Yes |
| ANTHERICACEAE | Chlorophytum fasciculatum | LC | No |
| APIACEAE | *Berula thunbergii | | No |
| APIACEAE | Centella asiatica | LC | No |
| APIACEAE | Conium chaerophylloides | LC | No |
| APOCYNACEAE | Asclepias gibba | LC | No |
| APOCYNACEAE | Asclepias gibba var. media | LC | No |
| APOCYNACEAE | Asclepias stellifera | LC | No |
| APOCYNACEAE | Aspidoglossum interruptum | LC | No |
| APOCYNACEAE | *Gomphocarpus fruticosus | | No |
| APOCYNACEAE | Pachycarpus schinzianus | LC | No |
| APOCYNACEAE | Schizoglossum periglossoides | LC | Yes |
| APOCYNACEAE | Xysmalobium undulatum | LC | No |
| APONOGETONACEAE | Aponogeton junceus | LC | No |
| ASPARAGACEAE | Asparagus cooperi | LC | No |
| ASPHODELACEAE | Bulbine capitata | LC | No |
| ASPLENIACEAE | Asplenium cordatum | LC | No |
| ASTERACEAE | Arctotis arctotoides | LC | No |
| ASTERACEAE | Aster harveyanus | LC | No |
| ASTERACEAE | Berkheya onopordifolia | LC | No |
| ASTERACEAE | Berkheya pinnatifida subsp. ingrata | LC | Yes |
| ASTERACEAE | Berkheya radula | LC | No |

| Family | Species | Status | SA Endemic |
|---|---|---|---|
| ASTERACEAE | *Bidens pilosa | | No |
| ASTERACEAE | Cineraria austrotransvaalensis | NT | Yes |
| ASTERACEAE | Cineraria lyratiformis | LC | No |
| ASTERACEAE | *Conyza bonariensis | | No |
| ASTERACEAE | *Conyza canadensis | | No |
| ASTERACEAE | Conyza podocephala | LC | No |
| ASTERACEAE | Denekia capensis | LC | No |
| ASTERACEAE | Dicoma anomala subsp. gerrardii | LC | No |
| ASTERACEAE | Geigeria aspera var. aspera | LC | No |
| ASTERACEAE | Haplocarpha lyrata | LC | Yes |
| ASTERACEAE | Haplocarpha nervosa | LC | No |
| ASTERACEAE | Helichrysum chionosphaerum | LC | No |
| ASTERACEAE | Helichrysum nudifolium | LC | No |
| ASTERACEAE | Helichrysum psilolepis | LC | No |
| ASTERACEAE | Helichrysum rugulosum | LC | No |
| ASTERACEAE | Lactuca inermis | LC | No |
| ASTERACEAE | Nidorella anomala | LC | No |
| ASTERACEAE | Nidorella hottentotica | LC | No |
| ASTERACEAE | Nidorella resedifolia | LC | No |
| ASTERACEAE | Othonna natalensis | LC | No |
| ASTERACEAE | *Platycarphella parvifolia | | Yes |
| ASTERACEAE | *Pseudognaphalium luteo-album | | No |
| ASTERACEAE | Pseudognaphalium oligandrum | LC | No |
| ASTERACEAE | Pulicaria scabra | LC | No |
| ASTERACEAE | *Schkuhria pinnata | | No |
| ASTERACEAE | Senecio affinis | LC | No |
| ASTERACEAE | Senecio burchellii | LC | Yes |
| ASTERACEAE | Senecio hieracioides | LC | No |
| ASTERACEAE | Senecio inornatus | LC | No |
| ASTERACEAE | Senecio laevigatus | LC | Yes |
| ASTERACEAE | Senecio othonniflorus | LC | No |
| ASTERACEAE | Senecio venosus | LC | No |
| ASTERACEAE | *Sonchus asper | | No |
| ASTERACEAE | Sonchus nanus | LC | No |
| ASTERACEAE | *Tagetes minuta | | No |
| ASTERACEAE | Tolpis capensis | LC | No |
| ASTERACEAE | Tripteris aghillana | LC | No |
| ASTERACEAE | Ursinia nana subsp. leptophylla | LC | No |

| Family | Species | Status | SA Endemic |
|---|---|---|---|
| ASTERACEAE | *Zinnia peruviana | | No |
| BORAGINACEAE | Anchusa capensis | LC | No |
| BORAGINACEAE | Cynoglossum hispidum | LC | No |
| BORAGINACEAE | Cynoglossum lanceolatum | LC | No |
| BORAGINACEAE | Lithospermum cinereum | LC | No |
| BRASSICACEAE | Lepidium transvaalense | LC | No |
| BRASSICACEAE | *Nasturtium officinale | | No |
| BRASSICACEAE | Rorippa fluviatilis | LC | No |
| BRASSICACEAE | *Sinapis arvensis | | No |
| BRASSICACEAE | Sisymbrium capense | LC | No |
| BRASSICACEAE | Sisymbrium turczaninowii | LC | No |
| BUDDLEJACEAE | Gomphostigma virgatum | LC | No |
| CAMPANULACEAE | Wahlenbergia undulata | LC | No |
| CAPPARACEAE | Cleome monophylla | LC | No |
| CARYOPHYLLACEAE | Dianthus basuticus | LC | No |
| CARYOPHYLLACEAE | *Dianthus mooiensis var. dentatus | | Yes |
| CARYOPHYLLACEAE | Herniaria erckertii | LC | No |
| CARYOPHYLLACEAE | Pollichia campestris | LC | No |
| CARYOPHYLLACEAE | Silene undulata | LC | No |
| CARYOPHYLLACEAE | *Vaccaria hispanica | | No |
| CHENOPODIACEAE | *Chenopodium ambrosioides | | No |
| CHENOPODIACEAE | *Chenopodium hircinum | | No |
| CHENOPODIACEAE | *Chenopodium multifidum | | No |
| CHENOPODIACEAE | *Chenopodium phillipsianum | | No |
| CHENOPODIACEAE | *Chenopodium schraderianum | | No |
| COMMELINACEAE | Commelina africana | LC | No |
| COMMELINACEAE | Cyanotis speciosa | LC | No |
| CONVOLVULACEAE | Convolvulus sagittatus | LC | No |
| CONVOLVULACEAE | Ipomoea crassipes | LC | No |
| CRASSULACEAE | Crassula alba | LC | No |
| CRASSULACEAE | *Crassula setulosa | | No |
| CUCURBITACEAE | Cucumis myriocarpus | LC | No |
| CYPERACEAE | Bulbostylis humilis | LC | No |
| CYPERACEAE | Cyperus congestus | LC | No |
| CYPERACEAE | Cyperus longus var. tenuiflorus | LC | No |
| DIPSACACEAE | Cephalaria pungens | LC | No |
| DIPSACACEAE | Cephalaria zeyheriana | LC | No |
| DIPSACACEAE | Scabiosa columbaria | LC | No |

| Family | Species | Status | SA Endemic |
|---|---|---|---|
| EBENACEAE | Diospyros austro-africana var. microphylla | LC | No |
| EUPHORBIACEAE | Clutia natalensis | LC | No |
| EUPHORBIACEAE | Euphorbia inaequilatera | LC | No |
| EUPHORBIACEAE | Euphorbia striata | LC | No |
| FABACEAE | Eriosema nutans | LC | No |
| FABACEAE | Erythrina zeyheri | LC | No |
| FABACEAE | Indigofera evansiana | LC | No |
| FABACEAE | Indigofera obscura | LC | Yes |
| FABACEAE | Lessertia affinis | LC | Yes |
| FABACEAE | Lessertia thodei | LC | No |
| FABACEAE | Lotononis adpressa | LC | No |
| FABACEAE | Lotononis listii | LC | No |
| FABACEAE | Lotononis mucronata | LC | No |
| FABACEAE | *Medicago laciniata | | No |
| FABACEAE | Melolobium candicans | LC | No |
| FABACEAE | Rhynchosia adenodes | LC | No |
| FABACEAE | Rhynchosia totta | LC | No |
| FABACEAE | Tephrosia capensis | LC | No |
| FABACEAE | Tephrosia multijuga | LC | No |
| FABACEAE | Trifolium africanum | LC | No |
| FABACEAE | Trifolium burchellianum | LC | No |
| FABACEAE | *Trifolium pratense | | No |
| FABACEAE | Vigna vexillata | LC | No |
| GENTIANACEAE | Chironia palustris | LC | No |
| GENTIANACEAE | Sebaea repens | LC | No |
| GERANIACEAE | Pelargonium luridum | LC | No |
| GESNERIACEAE | Streptocarpus pentherianus | LC | No |
| HYACINTHACEAE | *Albuca baurii | | No |
| HYACINTHACEAE | Dipcadi viride | LC | No |
| HYACINTHACEAE | Drimia elata | DDT | No |
| HYACINTHACEAE | Drimia multisetosa | LC | No |
| HYACINTHACEAE | *Eucomis autumnalis subsp. clavata | | No |
| HYACINTHACEAE | Ledebouria ovatifolia | LC | No |
| HYACINTHACEAE | Ornithogalum flexuosum | LC | No |
| HYDROCHARITACEAE | Lagarosiphon major | LC | No |
| HYPOXIDACEAE | Empodium elongatum | LC | No |
| HYPOXIDACEAE | Hypoxis acuminata | LC | No |

| Family | Species | Status | SA Endemic |
|---|---|---|---|
| HYPOXIDACEAE | Hypoxis argentea | LC | No |
| HYPOXIDACEAE | Hypoxis multiceps | LC | No |
| HYPOXIDACEAE | Hypoxis rigidula | LC | No |
| IRIDACEAE | Babiana bainesii | LC | No |
| IRIDACEAE | Gladiolus dalenii | LC | No |
| IRIDACEAE | Gladiolus elliotii | LC | No |
| IRIDACEAE | Gladiolus longicollis subsp. platypetalus | LC | No |
| IRIDACEAE | Moraea simulans | LC | No |
| JUNCACEAE | Juncus exsertus | LC | No |
| LAMIACEAE | Aeollanthus buchnerianus | LC | No |
| LAMIACEAE | Ajuga ophrydis | LC | No |
| LAMIACEAE | Mentha longifolia subsp. polyadena | LC | No |
| LAMIACEAE | Salvia repens | LC | No |
| LAMIACEAE | Salvia repens var. transvaalensis | LC | No |
| LAMIACEAE | Salvia runcinata | LC | No |
| LAMIACEAE | Stachys hyssopoides | LC | No |
| LOBELIACEAE | Monopsis decipiens | LC | No |
| LYTHRACEAE | Nesaea sagittifolia | LC | No |
| LYTHRACEAE | Nesaea schinzii | LC | No |
| MALVACEAE | Hermannia cordata | LC | Yes |
| MALVACEAE | Hermannia oblongifolia | LC | Yes |
| MALVACEAE | Hibiscus microcarpus | LC | No |
| MALVACEAE | *Hibiscus trionum | | No |
| MOLLUGINACEAE | Limeum viscosum var. glomeratum | LC | No |
| MOLLUGINACEAE | Psammotropha myriantha | LC | No |
| ONAGRACEAE | *Oenothera jamesii | | No |
| ORCHIDACEAE | Eulophia ovalis | LC | No |
| OROBANCHACEAE | Cycnium tubulosum | LC | No |
| OROBANCHACEAE | Striga bilabiata | LC | No |
| OROBANCHACEAE | Striga elegans | LC | No |
| OXALIDACEAE | *Oxalis corniculata | | No |
| OXALIDACEAE | Oxalis obliquifolia | LC | No |
| PAPAVERACEAE | Papaver aculeatum | LC | No |
| PHYTOLACCACEAE | Phytolacca heptandra | LC | No |
| PLANTAGINACEAE | Plantago lanceolata | LC | No |
| POACEAE | Alloteropsis semialata | LC | No |
| POACEAE | Andropogon appendiculatus | LC | No |
| POACEAE | Aristida junciformis | LC | No |

| Family | Species | Status | SA Endemic |
|---|---|---|---|
| POACEAE | Catalepis gracilis | LC | No |
| POACEAE | Cynodon dactylon | LC | No |
| POACEAE | Eragrostis capensis | LC | No |
| POACEAE | Eragrostis chloromelas | LC | No |
| POACEAE | Eragrostis cilianensis | LC | No |
| POACEAE | Eragrostis plana | LC | No |
| POACEAE | Eragrostis planiculmis | LC | No |
| POACEAE | Eragrostis racemosa | LC | No |
| POACEAE | Heteropogon contortus | LC | No |
| POACEAE | Imperata cylindrica | LC | No |
| POACEAE | Panicum volutans | LC | Yes |
| POACEAE | *Phalaris canariensis | | No |
| POACEAE | Setaria incrassata | LC | No |
| POACEAE | *Setaria italica | | No |
| POACEAE | Setaria nigrirostris | LC | No |
| POACEAE | Setaria sphacelata | LC | No |
| POACEAE | Stipagrostis zeyheri subsp. sericans | LC | No |
| POACEAE | Themeda triandra | LC | No |
| POACEAE | Trachypogon spicatus | LC | No |
| POLYGALACEAE | Polygala gracilenta | LC | No |
| POLYGONACEAE | *Fallopia convolvulus | | No |
| POLYGONACEAE | *Persicaria amphibia | | No |
| POLYGONACEAE | Persicaria attenuata subsp. africana | LC | No |
| POLYGONACEAE | Persicaria hystricula | LC | No |
| POLYGONACEAE | *Persicaria lapathifolia | | No |
| POLYGONACEAE | *Polygonum aviculare | | No |
| POLYGONACEAE | *Rumex acetosella subsp. angiocarpus | | No |
| POLYGONACEAE | *Rumex crispus | | No |
| POLYGONACEAE | Rumex lanceolatus | LC | No |
| PORTULACACEAE | *Portulaca oleracea | | No |
| RANUNCULACEAE | *Ranunculus multifidus | | No |
| RHAMNACEAE | Ziziphus mucronata | LC | No |
| ROSACEAE | Agrimonia procera | LC | No |
| RUBIACEAE | Anthospermum rigidum | LC | No |
| RUBIACEAE | Galium capense | LC | No |
| SANTALACEAE | Thesium lesliei | LC | Yes |
| SCROPHULARIACEAE | Diclis reptans | LC | No |
| SCROPHULARIACEAE | Diclis rotundifolia | LC | No |

| Family | Species | Status | SA Endemic |
|---|---|---|---|
| SCROPHULARIACEAE | Hebenstretia rehmannii | LC | Yes |
| SCROPHULARIACEAE | Jamesbrittenia montana | LC | No |
| SCROPHULARIACEAE | Jamesbrittenia stricta | LC | No |
| SCROPHULARIACEAE | Manulea paniculata | LC | No |
| SCROPHULARIACEAE | Manulea rhodantha subsp. aurantiaca | LC | Yes |
| SCROPHULARIACEAE | Mimulus gracilis | LC | No |
| SCROPHULARIACEAE | Selago cucullata | LC | No |
| SCROPHULARIACEAE | Selago densiflora | LC | No |
| SCROPHULARIACEAE | Veronica anagallis-aquatica | LC | No |
| SINOPTERIDACEAE | Cheilanthes hirta | LC | No |
| SINOPTERIDACEAE | Pellaea calomelanos | LC | No |
| SOLANACEAE | *Datura stramonium | | No |
| SOLANACEAE | *Physalis angulata | | No |
| SOLANACEAE | *Physalis viscosa | | No |
| SOLANACEAE | Solanum capense | LC | Yes |
| SOLANACEAE | Solanum lichtensteinii | LC | No |
| SOLANACEAE | Solanum panduriforme | LC | No |
| SOLANACEAE | Solanum retroflexum | LC | No |
| SOLANACEAE | Withania somnifera | LC | No |
| THYMELAEACEAE | Gnidia burchellii | LC | No |
| THYMELAEACEAE | Gnidia capitata | LC | No |
| THYMELAEACEAE | Gnidia gymnostachya | LC | No |
| TYPHACEAE | Typha capensis | LC | No |
| VERBENACEAE | Lantana rugosa | LC | No |
| VERBENACEAE | *Verbena brasiliensis | | No |
| VERRUCARIACEAE | *Endocarpon pusillum | | No |
| ZYGOPHYLLACEAE | Tribulus terrestris | LC | No |

*Exotic/Invasive species

# APPENDIX C
## DOCUMENT LIMITATIONS

# DOCUMENT LIMITATIONS

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Golder Associates

# APPENDIX G

## AQUATIC ECOLOGY AND WETLAND ASSESSMENT

December 2010
Report No. 12786-10092-9

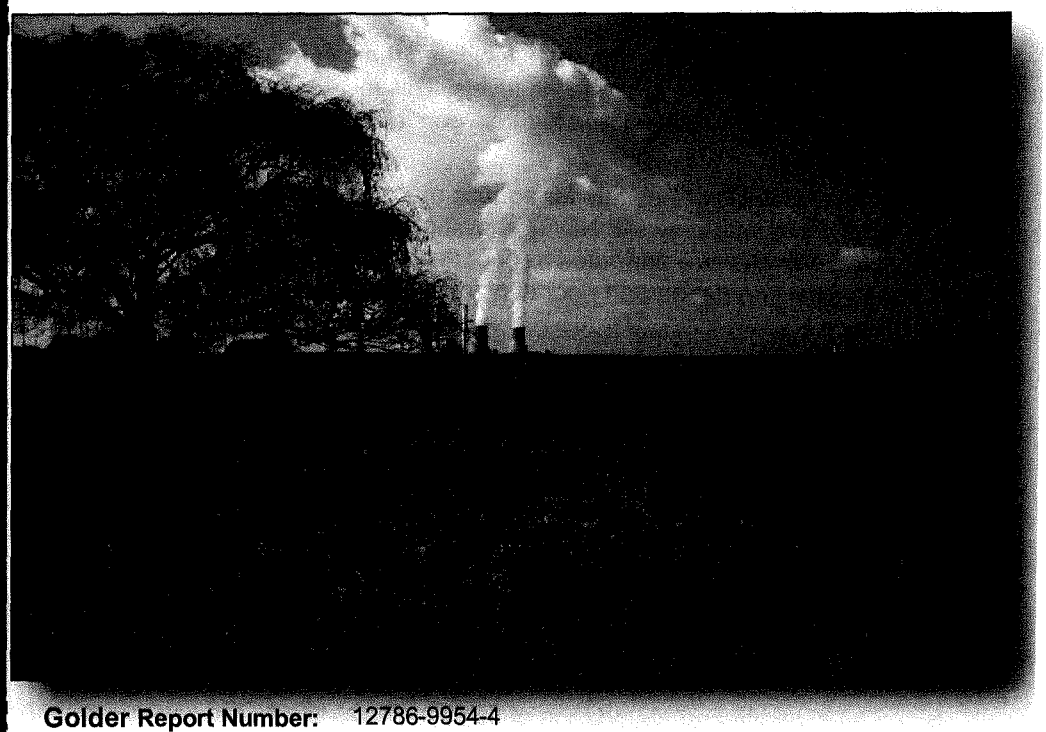
Golder Associates

November 2010

CELEBRATING 50 YEARS in 2010

ANGLO AMERICAN

# Aquatic Ecology and Wetland Assessment for the New Denmark Colliery Evaporation Pond



Golder Report Number: 12786-9954-4

world capabilities locally

Golder Associates

# Executive Summary

Golder Associates Africa (Golder) was approach by New Denmark Colliery to conduct a specialist aquatic and wetland baseline and impact assessment for input into the Environmental Impact Assessment (EIA) associated with the proposed construction of two evaporation ponds and a pipeline near to the Tutuka Power Station, Standerton, Mpumalanga.

This document presents the specialist baseline results, obtained during the August 2010 survey, and details the specialist Environmental Impact Report of aquatic and wetland ecosystems and lists the potential impacts and mitigation measures associated with the proposed project.

The objectives of the aquatic and wetland assessment included the following:

- A baseline characterisation of the aquatic and wetland habitats associated with the proposed project area;
- An assessment of the current status of the aquatic and wetland habitats and their importance;
- Evaluation of the extent of site-related impacts in terms of selected ecological indicators; and
- Identification of potential problems, direct and cumulative impacts associated with the project and recommendation of suitable mitigation measures.

The results obtained are based on a single survey conducted in August 2010, with supporting data collected in April 2010 included.

The following conclusions were reached based on the results of the baseline assessment of the aquatic and wetland ecosystems:

- *In situ* water quality parameters indicated that pH from site NDC5 to NDC7 increased rapidly and to above recommended guideline levels. This increase has been attributed to the eutrophication within the system. The saturation and high oxygen levels recorded at site NDC7 may be limiting to aquatic biota if persistent;
- The availability of habitats for aquatic macroinvertebrates was found to be generally poor within the study area with only site NDC7 showing varied biotopes and scoring a fair / adequate state. The poor IHAS scores were attributed to poor flow conditions (and variability), eroded channel banks, uniform marginal vegetation and poor substrate variety;
- The aquatic macroinvertebrates diversity at all sites showed to be similar with ASPT scores varying slightly. Site NDC5 showed the lowest ASPT score, indicating that the cattle may well be having an effect on the aquatic ecosystem. Site NDC7 which showed the most favourable habitat for aquatic macroinvertebrates showed the same number of taxa as site NDC6, indicating that the unusual in situ water quality variables observed may be impacting on the aquatic biota;
- Aquatic macroinvertebrate data indicated that biotic integrity ranged from moderately modified to largely natural. Site NDC5, which scored as fair (moderately modified), displayed poor habitat availability and was further impacted by cattle watering;
- Of the 11 expected fish species, a total of six species were recorded at the sites. The fish species at the sites were dominated by *Barbus anoplus* (Chubbyhead Barb) and *Pseudocrenilabrus philander* (Southern Mouthbrooder), both widespread and tolerant species;
- The diversity and abundance of fish species at site NDC6 was lower than in the main stream of the Leeuspruit. Due to flow and habitat this was expected;
- Ichthyofaunal diversity increased in a downstream direction from site NDC5 to NDC7, as did abundance;
- *Clarias gariepinus* was only recorded at site NDC5, however skeletal remains at site NDC6 suggest it is widespread during the high flow season.

The following conclusions were reached based on the impact assessment of the proposed evaporation ponds and associated pipelines on the aquatic and wetland ecosystems:

- There will be of wetland habitat at one of the artificial wetlands. The artificial wetland has, however, little to no ecosystem function;
- All of the identified impacts associated with the proposed project were rated as low to moderate before mitigation and, if mitigated, would result in low impacts;
  - Surface runoff carrying sediment away from the construction site and into the surrounding environment was identified as a moderate impact prior to mitigation;
  - Increased TDS levels as a result of seepage or spillage was identified as a moderate impact and the highest concern to the aquatic ecosystems prior to mitigation;
- No impacts associated with the project were rated as highly significant;
- Most of the impacts were related to the construction phase of the project, with operational phase maintenance and risk impacts, been identified; and
- All of the mitigation measures developed and proposed are feasible and should be implemented in order to mitigate the impacts.

Based on the conclusions of the impact assessment, the following recommendations are made:

- Implementation of a long-term monitoring program of the surrounding ecosystems. This will increase the understanding of the surrounding ecosystems and help identify possible impacts which may arise. Parameters to be monitored include:
  - *In situ* water quality;
    - Sediments during construction;
  - Wetland and riparian systems;
  - Aquatic Biomonitoring
    - Ichthyofauna;
    - Aquatic Macroinvertebrates;
    - Diatoms
  - Seepage and overflow from the proposed evaporation ponds.

## Implications for proposed New Denmark Colliery evaporation ponds

The significance of the impacts of the proposed construction and operation of the two evaporation ponds and associated pipeline on the aquatic and wetland ecosystems are expected to be moderate to low, and, if mitigated effectively, will result in an overall low impact.

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# 1.0 INTRODUCTION

New Denmark Colliery is proposing to construct and operate two evaporation ponds and a pipeline associated with Eskom's Tutuka power station. The site is located approximately 22 km north east of Standerton in the Mpumalanga Province. The project area falls within the Highveld Ecoregion (11) and the Upper Vaal Water Management Area (WMA 8). The sites are located in Quaternary Drainage region: C11K, and encompass the lower foothills longitudinal zones of the Leeuspruit and associated tributaries, which flow into the Vaal River.

Golder was contracted by New Denmark Colliery to conduct a specialist aquatic and wetland characterisation and impact assessment for input into the Environmental Impact Assessment (EIA) associated with the proposed construction and operation of the evaporation ponds.

This document presents the specialist baseline results obtained during the August 2010 survey and describes the possible impacts and mitigation measures associated with the proposed evaporation ponds.

The document limitations are presented in APPENDIX A.

## 1.1 Definitions

In order to effectively evaluate and asses the aquatic and wetland ecosystem, one must first define and understand the relevant components of the system. The aquatic and wetland ecosystems considered in this assessment include the watercourses, riparian habitats and wetlands. According to DWAF (2005) these components can be defined as follows:

### 1.1.1 Watercourses

A "watercourse" is defined as:

- A river or spring;
- A natural channel in which water flows regularly or intermittently;
- A wetland, lake or dam into which, or from which, water flows; and
- Any collection of water which the Minister may, by notice in the Gazette, declare to be a watercourse, and a reference to a watercourse includes, where relevant, its bed and banks; "[(Water Act 36 of 1998 (DWAF 2005)].

### 1.1.2 Riparian habitat

The riparian habitat includes the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterized by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent land areas (DWAF, 2005).

### 1.1.3 Wetland Ecosystems

A wetland is defined by the National Water Act as: "land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil." (DWAF 2005).

# 2.0 PROJECT DESCRIPTION

New Denmark Colliery (NDC) provides coal to Eskom's Tutuka Power Station for daily operations. The excess mine water that accumulates in the underground mine workings as a result of coal mining activities, must be pumped to the surface and treated. Treatment of the mine water takes place at a reverse osmosis plant at Tutuka Power Station.

The treated water is split into two streams, namely a clean stream and a reject stream. The reject is a concentrated salt solution. Currently, a reverse osmosis (RO) reject stream of approximately 3 Mℓ (megaliters) per day is produced. Some of the reject is used on the ash dump at the power station for dust suppression, some is evaporated in the boilers, and the remainder of about 1 Mℓ/day is returned to NDC for disposal. This returned reject is stored in a mined out void (cavern) referred to as the "321 compartment" at NDC.

In November 2009, NDC received a Directive from the Department of Water Affairs instructing the mine to implement an alternative management option for the RO reject, by October 2011.

In response to the Directive, Eskom is proposing to construct and operate an RO reject concentrator plant at Tutuka Power Station. The purpose of this plant will be to reduce the volume of RO reject produced from 3 Mℓ/day to 1 Mℓ/day. The Eskom proposal to construct the additional concentrator plant forms part of a separate EIA, being conducted by Aurecon.

The concentrated RO reject produced by Eskom's concentrator plant will be sent to NDC's brine pond proposed in this EIA. The implementation of the proposed concentrator plant and brine pond project is a collective effort by Eskom and Anglo American to meet the requirements of the Directive issued by the DWA.

## 2.1 Location

The study area is located approximately 22 km north east of the town of Standerton, near Eskom's Tutuka Power Station, and falls between the R38 and R39 roads, in the Mpumalanga Province (Figure 1). The project area falls within the Highveld Ecoregion (11) and the Upper Vaal Water Management Area (WMA 8). The sites are located in Quaternary Drainage region: C11K, and encompass the lower foothills longitudinal zones of the Leeuspruit and associated tributaries, which flow into the Vaal River (Kleynhans, Louw and Moolman 2007). GPS coordinates and descriptions of sampling sites are provided in Table 1.

**Table 1: GPS coordinates and descriptions of aquatic sampling sites**

| Site | | Description | GPS coordinates | |
|---|---|---|---|---|
| | | | Latitude | Longitude |
| Sampled sites | NDC4 | Northern tributary, draining westward into the Leeuspruit. | -26.77774 | 29.30749 |
| | NDC6 | Drainage line, draining westward from the power station towards the Leeuspruit | -26.75881 | 29.31138 |
| | NDC5 | Leeuspruit upstream of confluences with tributaries draining the project area | -26.75847 | 29.27755 |
| | NDC7 | Leeuspruit downstream of confluences with tributaries draining the project area | -26.80733 | 29.28825 |
| | NDC8 | Artificial wetlands located near the proposed evaporation ponds | -26.77730 | 29.33160 |

| Site | | Description | GPS coordinates | |
|---|---|---|---|---|
| | | | Latitude | Longitude |
| Previously sampled sites | TuA04 | Southern tributary of the Leeuspruit located to the southwest of the power station, downstream of a bridge on the road | -26.80323 | 29.32003 |
| | TuA05 | Northern tributary of the Leeuspruit located to the southwest of the power station, upstream of a bridge on the road | -26.80079 | 29.32126 |
| | TuA06 | Downstream site on the tributary of the Leeuspruit, downstream of the confluences of the tributaries from TuA04 and TuA05 | -26.80252 | 29.31869 |

Datum WGS 84, Geographic Coordinate System, represented in decimal degrees.

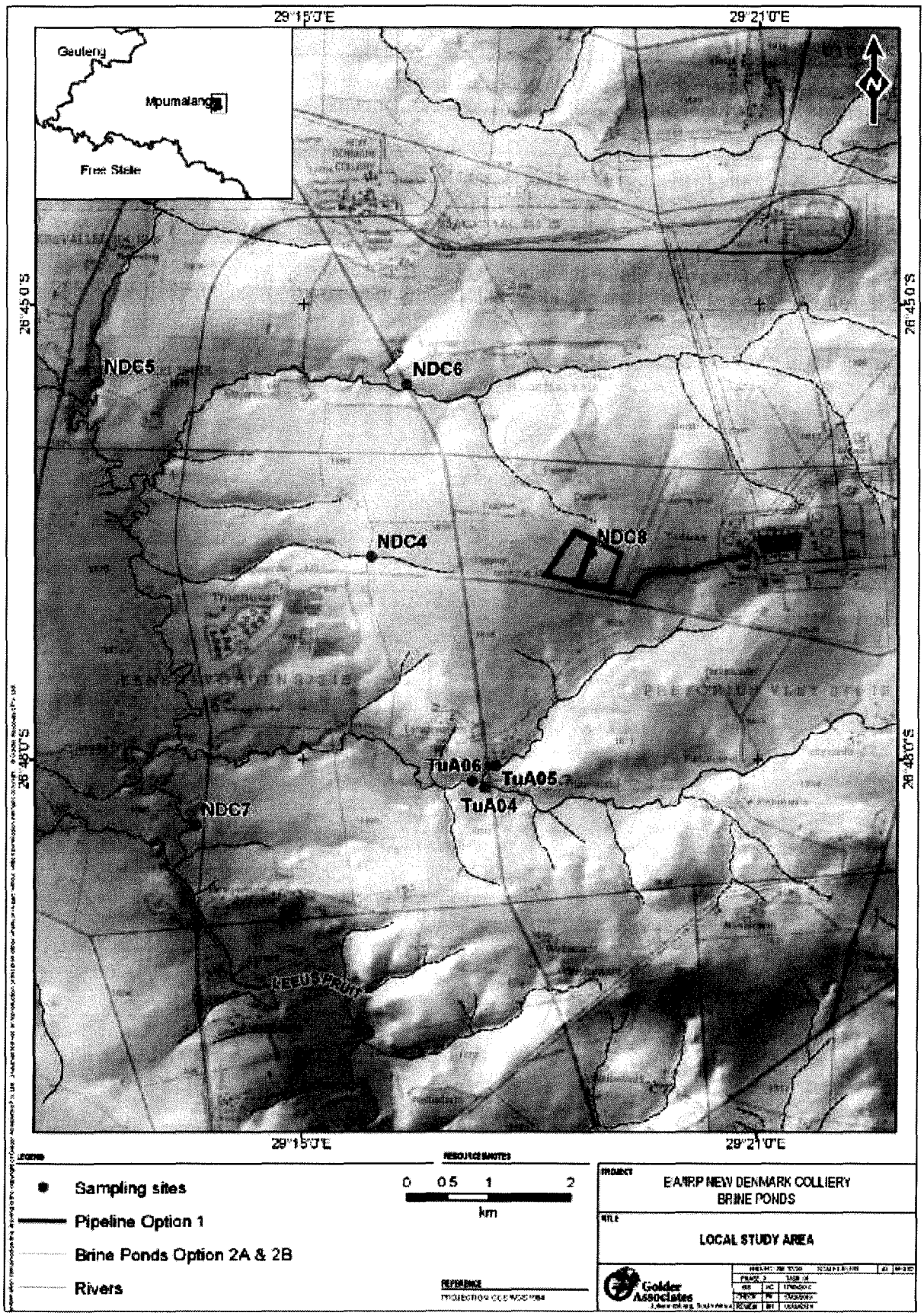



*Figure 1: Project locality and sampling sites*

# 3.0 TERMS OF REFERENCE

## 3.1 Aquatic assessment

The objectives of the aquatic assessment include the following:

- Characterisation of the biotic integrity of the aquatic ecosystems in the project area;
- Identification of listed biota based on the latest IUCN rankings, or other pertinent conservation ranking bodies;
- Identification of sensitive or unique habitats which could suffer irreplaceable loss;
- Evaluation of the extent of site-related impacts in terms of selected ecological indicators; and
- Identification of potential problems, direct and cumulative impacts associated with the project and recommendation of suitable mitigations.

## 3.2 Wetland assessment

The objectives of the wetland assessment include the following:

- Delineation of wetlands associated with the proposed infrastructure upgrade;
- Classification of the wetlands;
- Characterisation of the fauna and flora of the wetlands;
- Assessment of the Present Ecological Status (PES) of the wetlands;
- Assessment of the Ecological Importance and Sensitivity (EIS) of the wetlands;
- Assessment of the ecosystem services supplied by the wetlands;
- Evaluation of the extent of possible effects in terms of selected ecological indicators; and
- Identification of potential problems and recommendation of suitable mitigation measures.

# 4.0 STUDY APPROACH AND METHODS

## 4.1 Aquatic assessment

In order to enable a characterization of the aquatic environments, certain ecological indicators were selected to represent general ecological components involved in the aquatic environment. These included the following:

### Stressor Indicators

- *In situ* water parameters: pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Dissolved Oxygen (DO) and temperature (°C).

### Habitat Indicators

- General habitat assessment including: site photographs, general descriptions and habitat characteristics; and
- Aquatic macroinvertebrate habitat availability based on the Invertebrate Habitat Assessment System (IHAS, v*ersion 2*);

### Response Indicators

- Aquatic macroinvertebrates based on the South African Scoring System: *Version 5* (SASS5); and

- Ichthyofauna based on the Fish Assemblage Integrity Index (FAII).

### 4.1.1 *In situ* water quality parameters

During the field survey the following water quality parameters were determined on site using lightweight compact field instruments:

- pH (EUTECH pH Meter);
- Dissolved Oxygen (DO) (EUTECH DO 300 Meter);
- Electrical Conductivity (EC) (EUTECH ECTester-11 Dual Range Meter); and
- Temperature (°C) (EUTECH DO 300 Meter).

These parameters have a direct influence on aquatic life forms and although these measurements only provide a "snapshot" of water quality they provide valuable insight into the *in situ* characteristics of a specific sample site at the time of the survey.

### 4.1.2 Habitat assessment

Habitat assessment can be defined as the evaluation of the structure of the surrounding physical habitat that influences the quality of the water resource and the condition of the resident aquatic community (Babour, Gerritsen and White 1996). Habitat quality and availability plays a critical role in the occurrence of aquatic biota. For this reason habitat evaluation is conducted simultaneously with biological evaluations in order to facilitate the interpretation of results.

#### *4.1.2.1 General aquatic habitat descriptions*

Photographs of the sites are taken and a general description of the sampling sites is made, including the following:

- The surrounding land uses;
- The amount of human activity at or near the site;
- The catchment influences;
- The access to sites; and
- The presence of other aquatic-dependant biota observed at the sites.

Habitat characteristics are recorded such as the clarity of the water and the presence of recent disturbances.

#### *4.1.2.2 Invertebrate Habitat Assessment System (IHAS, Version 2)*

Aquatic macroinvertebrate habitat can be defined as any combination of velocity, depth, substrate (bedrock, cobbles, vegetation, sand, gravel, mud), physicochemical characteristics (such as chemical composition, turbidity, oxygen concentration, temperature) and biological features (food source and predators) that will provide the organism with its requirements for each specific life stage at a particular time and locality (Thirion 2007). These habitats can be grouped into specific invertebrate biotopes such as Stones-In-Current (SIC), Stones-Out-Of-Current (SOC), aquatic vegetation and macrophytes (in or out of current), fringing or marginal vegetation (in or out of current) and Gravel, Sand and Mud (GSM).

The Invertebrate Habitat Assessment System (IHAS, *version 2*) was developed specifically for use with the South African Scoring System, *Version 5* (SASS5) index in South Africa (McMillan 1998). The IHAS evaluates the availability of these biotopes at each site and expresses the availability and suitability as a percentage, where 100 % represents "ideal" habitat availability. It is presently thought that a total score of over 65% represents good habitat conditions, and over 55% indicates adequate habitat conditions, while scores below 55 % represent poor habitat availability (MacMillan 2002).

### 4.1.3 Aquatic macroinvertebrates

The monitoring of benthic macroinvertebrates forms an integral part of the monitoring of the integrity of an aquatic ecosystem as they are relatively sedentary and enable the detection of localized disturbances. Their relatively long life histories (±1 year) allow for the integration of pollution effects over time. Field sampling is easy and since the communities are heterogeneous and several phyla are usually represented, response to environmental impacts is normally detectable in terms of the community as a whole (Hellawell 1977).

The SASS5 methodology (Dickens and Graham 2001) is currently utilised in South Africa and is the only accredited methodology for aquatic macroinvertebrate sampling. SASS provides an indication of more than mere water quality, but rather a general indication of the present state of the invertebrate community (Thirion 2007). Sampling of aquatic macroinvertebrates was done using a standard sized SASS net, whereby aquatic macroinvertebrates are physically dislodged from aquatic vegetation, collected from the water column, removed from the substrate and caught in the fine mesh of the net. Thereafter, these organisms are placed into a white identification tray and identified to family level (Thirion, Mocke and Woest 1995, Davies and Day 1998, Dickens and Graham 2001, Gerber and Gabriel 2002).

#### *4.1.3.1 Biotic integrity based on SASS results*

The endpoint of any biological or ecosystem assessment is a value expressed either in the form of measurements (data collected) or in a more meaningful format by summarising these measurements into one or several index values (Cyrus, et al. 2000). The endpoints used for this study were, total SASS score and Average Score per Taxa (ASPT). All sites were scored on these indices and evaluated in terms of biotic integrity.

SASS Data Interpretation Guidelines (Dallas 2007) were used to evaluate the SASS5 data collected during the survey. Biological bands for SASS5 scores and ASPT values for each site were evaluated according to the Level 1 Ecoregions for the Highveld Ecoregion, in which the study area is situated (Dallas 2007). These bands for the lower longitudinal zones of rivers within the Highveld Ecoregion are shown in Figure 2. As indicated by (Kleynhans, Louw and Moolman 2007), the study area tributaries fall within the Lower foothill longitudinal zone before entering the Vaal River.

SASS scores are plotted against the ASPT values and give an indication as to the integrity of the aquatic macroinvertebrate integrity at a site. Plotted results are then divided into bands that represent different Ecological Categories associated with the Highveld Ecoregion - lower zones.

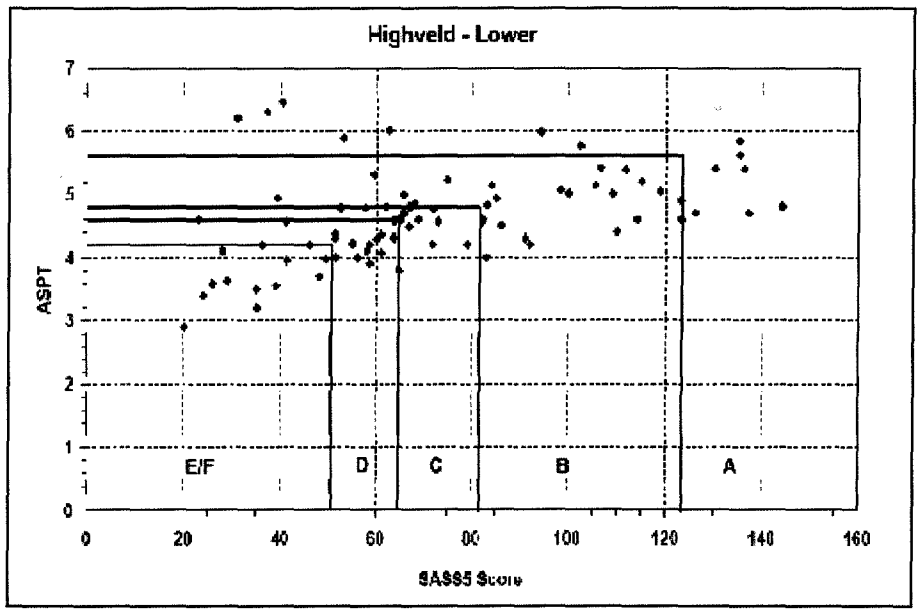



*Figure 2: Biological bands associated with the Highveld Ecoregion for lower longitudinal zone rivers (Dallas 2007)*

A description of the general Ecological Categories (ECs) used for the interpretation of the biological bands is shown in Table 2.

**Table 2: Ecological categories for the interpretation of SASS data (Dallas 2007, Kleynhans 1999)**

| Ecological Category (EC) | EC Name | Description |
|---|---|---|
| A | Natural | Unmodified natural; community structures and functions comparable to the best situation to be expected. Optimum community structure for stream size and habitat quality. |
| B | Good | Largely natural with few modifications; A small change in community structure may have taken place but ecosystem functions are essentially unchanged |
| C | Fair | Moderately modified; community structure and function less than the reference condition. Community composition lower than expected due to loss of some sensitive forms. Basic ecosystem functions are still predominantly unchanged. |
| D | Poor | Largely modified; fewer families present than expected, due to loss of most intolerant forms. An extensive loss of basic ecosystem function has occurred. |
| | Seriously modified | Seriously modified; few aquatic families present, due to loss of most intolerant forms. |
| | Critically modified | Critically or extremely modified; An extensive loss of basic ecosystem function has occurred. |

### 4.1.4 Ichthyofauna (Fish)

Whereas invertebrate communities are good indicators of localised conditions in a river over the short-term, fish, being relatively long-lived and mobile:

- Are good indicators of long-term influences;
- Are good indicators of general habitat conditions;
- Integrate effects of lower trophic levels; and
- Are consumed by humans (Uys, Goetch and O'Keeffe 1996).

The dominant fish habitat types present within the aquatic ecosystems of the sites required the use of electrofishing. These habitats included shallow pools, runs and riffle areas.

Electrofishing is the use of electricity to catch fish. The electricity is generated by a system whereby a high voltage potential is applied between two electrodes that are placed in the water (USGS 2004). The responses of fish to electricity are determined largely by the type of electrical current and its wave form. These responses include avoidance, electrotaxis (forced swimming), electrotetanus (muscle contraction), and electronarcosis (muscle relaxation or stunning) (USGS 2004).

Electrofishing was conducted by means of a Smith-Root LR24 electrofisher. This device also incorporates the highest Health and Safety standards for both the operator and the fish, thus allowing for scientifically accurate, safe, ethical and environmentally friendly fish surveys. Electrofishing is regarded as the most effective single method for sampling fish communities in wadeable streams (Plafkin 1989). Capture results are recorded as number of fish caught per time unit [fish per minute or Catch per Unit Effort (CPUE)]. The standard time set per habitat type or biotope is 15 minutes.

All fish were identified in the field and released unharmed at the point of capture. Fish species were identified using the guide Freshwater Fishes of Southern Africa (Skelton 2001).

#### 4.1.4.1 *Expected Fish Assemblage*

Based on a desktop review of available literature an expected species list was compiled for the New Denmark Colliery sites utilising Kleynhans *et al.*, (2007) and Skelton, (2001). A total of 10 expected indigenous fish species within four families are expected to occur in the study area (Table 3). One exotic fish species; *Cyprinus carpio* (Carp) was also expected to occur.

**Table 3: Expected fish assemblage list for the study area.**

| Species | Common Name | Habitat preference | IUCN Status |
|---|---|---|---|
| **Family Austroglanididae** | | | |
| *Austroglanis sclateri* | Rock catfish | Flowing rocky rivers with rapids | Least Concern |
| **Family Cichlidae** | | | |
| *Tilapia sparrmanii* | Banded Tilapia | Tolerant of a wide range of habitats but prefers quiet or standing waters with submerged or emergent vegetation | Unlisted |
| *Pseudocrenilabrus philander* | Southern Mouthbrooder | Wide variety of habitats from flowing waters to lakes, usually favours vegetated zones | Unlisted |
| **Family Clariidae** | | | |
| *Clarias gariepinus* | Sharptooth Catfish | Occurs in a wide variety of habitats but favours floodplains, large sluggish rivers, lakes and dams | Unlisted |
| **Family Cyprinidae** | | | |
| *Barbus anoplus* | Chubbyhead Barb | Wide variety of habitats | Least Concern |
| *Barbus neefi* | Sidespot barb | Wide variety of habitats | Unlisted |
| *Barbus paludinosus* | Straightfin Barb | Slow flowing and vegetated habitats | Unlisted |
| *Cyprinus carpio* | Carp | Slow moving rivers with soft substrates. Thrives in dams and turbid waters | Data Deficient |
| *Labeo capensis* | Orange River Mudfish | Slow flowing and vegetated habitats | Least Concern |
| *Labeo umbratus* | Moggel | Slow moving rivers with soft substrates. Thrives in dams and turbid waters | Least Concern |
| *Labeobarbus aeneus* | Vaal-Orange Smallmouth Yellowfish | Large, clear-flowing rivers with sandy or rocky substrates | Least Concern |

Exotics represented in Red

This expected species list for the study area was adjusted for each of the sampling sites, based on the specific habitats recorded at the sites.

#### 4.1.4.2 *Expected IUCN Red List species*

In order to assess the IUCN status of fish species occurring in the sample area, the 2010 IUCN Red List of Threatened Species (IUCN 2010) was consulted. Based on the 2010 IUCN list, it was shown that of the 11 expected fish species expected to occur in the study area:

- Five are currently unlisted (IUCN 2010);
- Five are currently listed as Least Concern (LC) (Table 3) (IUCN 2010). A species in this category is widespread and abundant and is not considered to be an IUCN red data species at this time (IUCN 2010); and
- One species (*Cyprinus carpio*) is currently listed as Data Deficient (DD) (Table 3). A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution are lacking (IUCN 2010). This species is exotic in South Africa, introduced in the 1700's (Skelton 2001). The deficiency in data for Carp (*C.carpio*) is of no concern as the species is exotic in South Africa. In South Africa *C.carpio* is regarded as a pest by conservation authorities due to its destructive feeding habits (Skelton 2001). Should this species occur in the study area, its presence may currently impact the tributaries by increasing the turbidity.

#### 4.1.4.3 *Fish Health Assessment*

For the purpose of this study the fish health assessment was based on an external examination of the skin and fins, eyes, gills, opercula and the presence of ectoparasites. This approach ensured the minimization of stress due to handling and allowed the fish to be released unharmed.

#### 4.1.4.4 *Biotic integrity based on the Fish Assemblage Integrity Index (FAII)*

The FAII is not considered suitable for the assessment of streams with naturally low species diversity (Kleynhans 1999). Fish species data and abundances were therefore compared for each site and trends identified.

## 4.2 Wetland Characterisation

In conducting the wetland characterisation the following approach was undertaken:

- The area was examined on topographical maps and satellite imagery and wetland units identified. These are typically a grouping of wetland components that form a system. The grouping is usually along the lines of the localised sub-catchments;
- Based on the identified wetland units sites were then selected for field survey;
- During the field survey the following activities were conducted:
  - Wetland delineation;
  - Wetland classification;
  - Wetland characterisation;
  - Ecological Importance and Sensitivity (EIS) assessment;
  - Present Ecological Status (PES) determination (Wetland IHI); and
  - Ecosystems services assessment.

### 4.2.1 Wetland delineation

The field procedure for the wetland delineation was conducted according to the Guidelines for delineating the boundaries of a wetland set out by the Department of Water Affairs and Forestry (DWAF 2005). Due to the transitional nature of wetland boundaries, these are often not clearly apparent and the delineations should

therefore be regarded as a human construct. The delineations are based on scientifically defensible criteria and are aimed at providing a tool to facilitate the decision making process regarding the assessment of the significance of impacts that may be associated with the proposed developments.

The wetlands were delineated by considering the following wetland indicators (DWAF 2005):

- Terrain unit indicator helps identifying those parts of the landscape where wetlands are most likely to occur. Wetlands occupy characteristic positions in the landscape and can occur on the following terrain units: crest, midslope, footslope, and valley bottom.
- Soil wetness indicator identifies the morphological signatures developed in the soil profile as a result of prolonged and frequent saturation.
- The vegetation indicator identifies hydrophytic vegetation associated with frequently saturated soils.

The following procedure was followed during the delineation of the wetland boundaries and zones:

- Desktop delineations were undertaken using satellite imagery of the study sites;
- Areas for verification were identified; and
- Areas were then assessed in the field with boundaries being recorded using a GPS.

According to the wetland definition used in the South African National Water Act, vegetation is the primary indicator, which must be present under normal circumstances. However, in practise the soil wetness indicator tends to be the most important, and the other three indicators are used in the confirmatory role (DWAF 2005).

**Table 4: Criteria for distinguishing different soil saturation zones and hydric vegetation within a wetland (Kotze, Breen and Klug 1994)**

| **SOIL** | **DEGREE OF WETNESS** | | |
|---|---|---|---|
| | **Temporary** | **Seasonal** | **Permanent/Semi-permanent** |
| Soil depth 0-20cm | Matrix brown to greyish brown (chroma 0-3, usually 1 or 2). Few/no mottles. Nonsulphudic. | Matrix brownish grey to grey (chroma 0-2). Many mottles. Sometimes sulphidic. | Matrix grey (chroma 0-1). Few/no mottles. Often sulphidic. |
| Soil depth 20-40cm | Matrix greyish brown (chroma 0-2, usually 1). Few/many mottles. | Matrix brownish grey to grey (chroma 0-1). Many mottles. | Matrix grey (chroma 0-1). No/few mottles. |
| **VEGETATION** | | | |
| If herbaceous: | Predominantly grass species; mixture of species, which occur extensively in non-wetland areas, and hydrophytic plant species, which are restricted largely to wetland areas. | Hydrophytic sedge and grass species which are restricted to wetland areas, usually <1m tall. | Dominated by: (1) emergent plants, including reeds (*Phragmites* sp.), sedges and bulrushes (*Typha* sp.), usually >1m tall (marsh); or (2) floating or submerged aquatic plants. |

In effect the wetlands boundaries are a construct of those delineating them based on certain scientifically defensible criteria.

### 4.2.2 Wetland classification

SANBI's "Further development of a proposed National Classification System for South Africa" was used to classify the wetlands within the study area (SANBI 2009). The wetlands were classified up to level four where applicable, which includes the system, regional setting, landscape unit and hydrogeomorphic unit.

**Table 5: Wetland classification level 1-4 (SANBI 2009)**

| Level 1: System | Level 2: Regional setting | Level 3: Landscape unit | Level 4: Hydrogeomorphic (HGM) unit | | | |
|---|---|---|---|---|---|---|
| Connectivity to open ocean | Ecoregion | Landscape setting | HGM type | Longitudinal zonation / landform | Drainage - outflow | Drainage - inflow |
| | | | A | B | C | D |
| INLAND | DWAF Level 1 Ecoregions | SLOPE | Channel (river) | Mountain headwater stream | Not applicable | Not applicable |
| | | | | Mountain stream | Not applicable | Not applicable |
| | | | | Transitional river | Not applicable | Not applicable |
| | | | | Rejuvenated bedrock fall | Not applicable | Not applicable |
| | | | Hillslope seep | Not applicable | With channel inflow | Not applicable |
| | | | | | Without channel inflow | Not applicable |
| | | | Depression | Not applicable | Exorheic | With channel inflow |
| | | | | | | Without channel inflow |
| | | | | | Endorheic | With channel inflow |
| | | | | | | Without channel inflow |
| | | | | | dammed | With channel inflow |
| | | | | | | Without channel inflow |
| | | VALLEY FLOOR | Channel (river) | Mountain stream | Not applicable | Not applicable |
| | | | | Transitional river | Not applicable | Not applicable |
| | | | | Rejuvenated bedrock fall | Not applicable | Not applicable |
| | | | | Upper foothill river | Not applicable | Not applicable |
| | | | | Lower foothill river | Not applicable | Not applicable |
| | | | | Lowland river | Not applicable | Not applicable |
| | | | | Rejuvenated foothill river | Not applicable | Not applicable |
| | | | | Upland floodplain river | Not applicable | Not applicable |
| | | | Channeled valley-bottom wetland | Valley-bottom depression | Not applicable | Not applicable |
| | | | | Valley-bottom flat | Not applicable | Not applicable |
| | | | Unchanneled valley-bottom wetland | Valley-bottom depression | Not applicable | Not applicable |
| | | | | Valley-bottom flat | Not applicable | Not applicable |
| | | | Floodplain wetland | Floodplain depression | Not applicable | Not applicable |
| | | | | Floodplain flat | Not applicable | Not applicable |
| | | | Depression | Not applicable | Exorheic | With channel inflow |
| | | | | | | Without channel inflow |
| | | | | | Endorheic | With channel inflow |
| | | | | | | Without channel inflow |
| | | | | | dammed | With channel inflow |
| | | | | | | Without channel inflow |
| | | | Valleyhead seep | Not applicable | Not applicable | Not applicable |
| | | PLAIN | Channel (river) | Lowland river | Not applicable | Not applicable |
| | | | | Upland floodplain river | Not applicable | Not applicable |
| | | | Floodplain wetland | Floodplain depression | Not applicable | Not applicable |
| | | | | Floodplain flat | Not applicable | Not applicable |
| | | | Unchanneled valley-bottom wetland | Valley-bottom depression | Not applicable | Not applicable |
| | | | | Valley-bottom flat | Not applicable | Not applicable |
| | | | Depression | Not applicable | Exorheic | With channel inflow |
| | | | | | | Without channel inflow |
| | | | | | Endorheic | With channel inflow |
| | | | | | | Without channel inflow |
| | | | Flat | Not applicable | Not applicable | Not applicable |
| | | BENCH (Hilltop/saddle/shelf) | Depression | Not applicable | Exorheic | With channel inflow |
| | | | | | | Without channel inflow |
| | | | | | Endorheic | With channel inflow |
| | | | | | | Without channel inflow |
| | | | Flat | Not applicable | Not applicable | Not applicable |

### 4.2.3 Characterisation of fauna and flora

The sampling sites were traversed on foot and all species of plants and animals seen or deduced as being present were recorded. Background literature surveys were also conducted to assess what species have previously been recorded in the area as well as their conservation status.

### 4.2.4 Ecological Importance and Sensitivity (EIS)

The ecological importance and sensitivity assessment was conducted according to the guidelines provided by DWAF (1999c). Here DWAF defines "ecological importance" of a water resource as an expression of its importance to the maintenance of ecological diversity and function on local and wider scales. "Ecological sensitivity", according to DWAF (1999c), refers to the system's ability to resist disturbance and its capability to recover from disturbance once it has occurred. In the method outlined by DWAF a series of determinants for EIS are assessed on a scale of 0 to 4, where 0 indicates no importance and 4 indicates very high importance (Table 6). The median of the determinants is used to determine the EIS (Table 7).

**Table 6: Score sheet for the determination of ecological importance and sensitivity (1999c)**

| Determinant | Score | Confidence |
|---|---|---|
| **Primary determinants** | | |
| Rare and endangered species | | |
| Species/taxon richness | | |
| Diversity of Habitat types or features | | |
| Migration route/breeding and feeding site for wetland species | | |
| Sensitivity to changes in the natural hydrological regime | | |
| Sensitivity to water quality changes | | |
| Flood storage, energy dissipation and particulate/element removal | | |
| **Modifying determinants** | | |
| Protected status | | |
| Ecological integrity | | |

Score guideline: 4 = Very High; 3 = High; 2 = Moderate; 1 = Marginal/Low; 0 = None. Confidence rating: 4 = Very High Confidence; 3 = High Confidence; 2 = Moderate Confidence; 1 = Marginal/Low Confidence.

**Table 7: Ecological Importance and Sensitivity (EIS) categories and the interpretation of median scores for biotic and habitat determinants (DWAF 1999c)**

| Range of Median | EIS Category | Category Description | Recommended Ecological Management Class |
|---|---|---|---|
| **>3 and <=4** | **Very High** | Wetlands that are considered ecologically important and sensitive on a national or even international level. The biodiversity of these wetlands is usually very sensitive to flow and habitat modifications. They play a major role in moderating the quantity and quality of water of major rivers. | |
| **>2 and <=3** | **High** | Wetlands that are considered to be ecologically important and sensitive. The biodiversity of these wetlands is usually very sensitive to flow and habitat modifications. They play a role in moderating the quantity and quality of water in major rivers. | **B** |

| Range of Median | EIS Category | Category Description | Recommended Ecological Management Class |
|---|---|---|---|
| >1 and <=2 | Moderate | Wetlands that are to be considered ecologically important and sensitive on a provincial or local scale. The biodiversity of these floodplains is not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water of major rivers. | C |
| >0 and <=1 | Low/ Marginal | Wetlands that are not ecologically important and sensitive at any scale. The biodiversity of these wetlands is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water of major rivers. | |

### 4.2.5 Present Ecological Status

#### *4.2.5.1 (Wetland IHI)*

The Wetland Index of Habitat Integrity (Wetland-IHI) (DWAF 2007) was designed for the rapid assessment of floodplain and channelled valley bottom wetlands. The purpose of this assessment is to determine the habitat integrity of the wetlands found on site. From this rating the Present Ecological Status (PES) of wetlands can be derived in the form of Ecological Category (EC).

Prior to field assessment a set of 1:50 000 topographical maps of the area, recent aerial photographs and land-cover were obtained. From this data sites for verification during the field assessment were identified.

Site information was recorded according to the following components:

#### Wetland type classification

The wetland types were classified according to Wetland-IHI. The reference state was determined by considering what the site would have looked like prior to any impacts occurring.

#### Vegetation alteration assessment

The extent of the surrounding land use activities and rating of the impacts thereof on the wetland were recorded. The land use activities that were assessed included the following:

- Mining or excavation;
- Infilling or backfilling;
- Vegetation clearing, loss, or alteration; and
- Presence of invasive plant species.

#### Hydrological assessment

At the catchment scale the following criteria were evaluated:

- Changes in flood peaks and frequencies;
- Changes in base flows;
- Changes in seasonality; and

- Changes in occurrence or duration of zero flow periods.

The within wetland factors that were evaluated were:

- Connectivity – altered channel size or competency;
- Increased water retention on the floodplain; and
- Decreased water retention on the floodplain.

Reference state patterns were also recorded by considering the site without any impacts.

### Geomorphic assessment

At the catchment scale the following criteria were evaluated:

- Changes in sediment budget; and
- Sediment transport capacity.

The within wetland factors that were evaluated were:

- Erosional processes; and
- Depositional processes.

### Present Ecological Status (PES) assessment

The field data was transferred to the Wetland-IHI spreadsheet from where the PES obtained and the final Ecological Category (EC) calculated. The percentages and descriptions of the EC are provided in Table 8 below.

**Table 8: Ecological categories (Kleynhans, Louw and Moolman 2007)**

| Ecological Category | % | Description of Ecological Category |
|---|---|---|
| | 90-100 | Unmodified/Natural |
| B | 80-89 | Largely natural with few modification. A small change in natural habitat and biota may have taken place, but the ecosystem function is essentially unchanged. |
| C | 60-79 | Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged. |
| D | 40-59 | Largely modified. A large loss of natural habitat, biota and basic ecosystem functions have occurred. |
| | 20-39 | Seriously modified. The loss of natural habitat, biota and basic ecosystem functions are extensive. |
| | 0-19 | Critically modified. Modifications have reached a critical level and the lotic system has been modified completely with an almost complete loss of natural habitat and biota. The basic ecosystem functions have been destroyed and the changes are irreversible. |

### *4.2.5.2 Present Ecological Status (PES) Method*

The Present Ecological Status (PES) Method (DWAF, 2005) was used to establish the integrity of the wetlands in the study area that were not part of systems forming channelled valley bottoms or floodplain wetlands and is based on the modified Habitat Integrity approach developed by Kleynhans (DWAF 1999a).

Table 9 provides the criteria for assessing the habitat integrity of wetlands along with Table 10 describing the allocation of scores to attributes and the rating of confidence levels associated with each score. These criteria were selected based on the assumption that anthropogenic modification of the criteria and attributes listed under each selected criterion can generally be regarded as the primary drivers in the ecological integrity of a wetland.

**Table 9: Habitat integrity assessment criteria for wetland ecosystems (DWAF 1999a)**

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

**Table 10: The allocation of scores to attributes and the rating of confidence levels associated with each score (DWAF 1999a)**

| **Scoring Guidelines per Attribute:** | |
|---|---|
| Natural/Unmodified | 5 |
| Largely Natural | 4 |
| Moderately Modified | 3 |
| Largely Modified | 2 |
| Seriously Modified | 1 |
| Critically Modified | 0 |
| **Relative Confidence of Scores:** | |
| Very High Confidence | 4 |
| High Confidence | 3 |
| Moderate Confidence | 2 |
| Marginal/Low Confidence | 1 |

Once the wetland units have been assessed the Present Ecological Status Class (PESC) is then assigned (Table 11) based on the mean score determined for Table 9.

This approach is based on the assumption that extensive degradation of any of the wetland attributes may determine the PESC (DWAF, 2005).

**Table 11: Guidelines for the determination of the Present Ecological Status Class (PESC) of a wetland (DWAF 1999a)**

| **Class Boundary** | **Class** | **Class Description** |
|---|---|---|
| **Within generally acceptable range** | | |
| | Very High | Unmodified or approximated natural condition. |
| >3 and <=4 | High | Largely natural with few modifications, but with some loss of natural habitats. |
| >2 and <=3 | Moderate | Moderately modified, but with some loss of natural habitats. |
| 2 | Low | Largely modified. A large loss of natural habitats and basic ecosystem functions has occurred. |
| **Outside generally acceptable range** | | |
| >0 and <2 | Very Low | Seriously modified. The losses of natural habitats and basic ecosystem functions are extensive. |
| 0 | Non Existent | Critically modified. Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat. |

### 4.2.6 Ecosystem services supplied by wetlands (Wet-EcoServices)

The assessment of the ecosystem services supplied by the identified wetland units was conducted according to the guidelines as described by (Kotze, et al. 2005). A Level 2 assessment was undertaken which examines and rates Natural and Human services.

### Natural Services

The following natural services were assessed:

- Flood attenuation;
- Stream flow regulation;
- Sediment trapping;
- Phosphate trapping;
- Nitrate removal;
- Toxicant removal;
- Erosion control;
- Carbon storage; and
- Maintenance of biodiversity.

### Human Services

The following human services were assessed:

- Water supply for human use;
- Natural resources;
- Cultivated foods;
- Cultural significance;
- Tourism and recreation; and
- Education and research.

## 4.3 Impact assessment

### 4.3.1 Assessment of potential impacts

In order to assess the impacts of the proposed development on the aquatic and wetland ecosystems the following components were included:

- The impact of the proposed development on the surrounding ecosystem;
- Recommend mitigation measures to deal with significant impacts;
- Evaluation of the impact significance; and
- Identification of aspects which may require further study.

#### *4.3.1.1 Development of Mitigation Measures*

The quantitative accuracy and precision of impact predictions is particularly important for prescribing mitigation measures (DEAT 2002). This is especially important for those impacts, pollutants or resources that require the setting of a site-specific discharge limit or need to be within legislated standards (DEAT 2002). A common approach to describing mitigation measures for critical impacts is to specify a range of targets with predetermined acceptable range and an associated monitoring and evaluation plan (DEAT 2002). To ensure successful implementation, mitigation measures should be unambiguous statements of actions and

requirements that are practical to execute (DEAT 2002). The following methods summarize the different approaches to prescribing and designing mitigation measures.

- **Avoidance:** Mitigation by not carrying out the proposed action on the specific site, but rather on a more suitable site.
- **Minimization:** Mitigation by scaling down the magnitude of a development, reorienting the layout of the project or employing technology to limit the undesirable environmental impact.
- **Rectification:** Mitigation through the rehabilitation of environments affected by the action.
- **Reduction:** Mitigation by taking maintenance steps during the course of the action.
- **Compensation:** Mitigation through the creation, enhancement or acquisition of similar environments to those affected by the action.

#### *4.3.1.2 Environmental Impact Significance Assessment*

The impacts of the proposed development are assessed in terms of impact significance and recommended mitigation measures.

The determination of significant impacts relates to the degree of change in the environmental resource measured against some standard or threshold (DEAT 2002). This requires a definition of the magnitude, prevalence, duration, frequency and likelihood of potential change (DEAT 2002). The following criteria have been proposed by the Department of Environmental Affairs and Tourism for the description of the magnitude and significance of impacts (DEAT 2002).

The consequence of impacts can be derived by considering the following criteria:

- Extent or spatial scale of the impact;
- Intensity or severity of the impact;
- Duration of the impact;
- Potential for Mitigation;
- Acceptability;
- Degree of certainty/Probability;
- Status of the impact; and
- Legal Requirements.

Describing the potential impact in terms of the above criteria provides a consistent and systematic basis for the comparison and application of judgments (DEAT 2002).

The significance of the impact is calculated as:

**Significance of Impact = Consequence (magnitude + duration + spatial scale) x Probability**

Magnitude relates to how severe the impact is. Duration relates to how long the impact may be prevalent for and the spatial scale relates to the physical area that would be affected by the impact. Having ranked the severity, duration and spatial scale using the criteria outlined in Table 12, the overall consequence of impact can be determined by adding the individual scores assigned in the severity, duration and spatial scale. Overall probability of the impacts must then be determined. Probability refers to how likely it is that the impact may occur.

**Table 12: Consequence and probability ranking**

| Magnitude/Severity (M) | Duration (D) | Spatial Scale (SS) | Probability (P) |
|---|---|---|---|
| 10 - Very high/don't know | 5 - Permanent | 5 - International | 5 - Definite/don't know |
| 8 - High | 4 - Long-term (impact ceases after operational life) | 4 - National | 4 - Highly probable |
| 6 - Moderate | 3 - Medium-term (5-15 years) | 3 - Regional | 3 - Medium probability |
| 4 - Low | 2 - Short-term (0-5 years) | 2 - Local | 2 - Low probability |
| 2 - Minor | 1 - Immediate | 1- Site only | 1 - Improbable |
| | | 0 - None | 0 - None |

The maximum value, which can be obtained, is 150 significance points (SP). Environmental effects are rated as either of High, Moderate, Low or No Impact significance on the following basis (Table 13):

**Table 13: Impact significance rating**

| | | |
|---|---|---|
| **SP >75** | Indicates **high** environmental significance | An impact which could influence the decision about whether or not to proceed with the project regardless of any possible mitigation. |
| ***SP 30 – 75*** | *Indicates **moderate** environmental significance* | *An impact or benefit which is sufficiently important to require management and which could have an influence on the decision unless it is mitigated* |
| ***SP <30*** | *Indicates **low** environmental significance* | *Impacts with little real effect and which should not have an influence on or require modification of the proposed alignment.* |

Any development in a natural system will impact on the environment, usually with adverse effects. From a technical, conceptual or philosophical perspective the focus of impact assessment ultimately narrows down to a judgment on whether the predicted impacts are significant or not (DEAT 2002). Alterations of the natural variation of flow by river regulation through decreasing or increasing the flows can only have a profound influence upon almost every aspect of river ecological functioning (Davies and Day 1998). A change in water quality variables which include physical (turbidity, suspensoids, temperature) and chemical (TDS, pH, conductivity, nutrients, toxins, dissolved oxygen) attributes will either have a beneficial or detrimental effect on aquatic organisms (Davies and Day 1998).

Current South African legislation, as indicated at the outset of this report, requires that the necessary aquatic and wetland ecosystem impact assessment be conducted and mitigation measures assessed so as to reduce or prevent the degradation of aquatic habitats and biotic populations due to alterations in the river / wetlands that may impact on migration and ecosystem functioning.

# 5.0 LIMITATIONS AND ASSUMPTIONS

- GPS points taken in the field are within an accuracy of 10 m;
- Delineations and related spatial data generated by Golder for this report will be supplied in GIS (shapefile) format only upon request and will be for use in conceptual planning purposes only and not detailed design. If the client requires that data be accurate to the level of detailed design this will be negotiated and budgeted for separately.
- Historical data relating to aquatic and wetland ecosystems has been incorporated to increase the understanding of the localised aquatic ecosystems;

- The results of this report have been generated from a single survey which took place in August, before the onset of spring.

# 6.0 LEGAL REQUIRMENTS, STANDARDS AND GUIDELINES

## 6.1 Compliance with Legislation

It is the goal of the specialist impact assessment to ensure the project compliance with the following current South African legislation:

- The National Water Act, 1998 (Act No. 36 of 1998)
- The National Environmental Management Act (Act 107 of 1998)
- The National Environmental Management Biodiversity Act (Act 10 of 2004)

  The National Environmental Management Biodiversity Act (NEMBA, Act 10 of 2004), in terms of Regulation 57 (1) restricts the activity involving a specimen of a listed or protected species. This includes an activity:

  a) Which is of a nature that may negatively impact on the survival of a listed, threatened or protected species.

- Mpumalanga Nature Conservation Act (Act 10 of 1998)

  Section 69 (1) (a) and Section 69(1) (b) specifically stipulate plant species protected within the Mpumalanga province. All of these species should be submitted to the Mpumalanga Tourism and Parks Agency as stated in the Mpumalanga Tourism and Parks Agency requirements for biodiversity assessments.

  Thus, in terms of the above-mentioned current South African legislations, any in-stream activity within a watercourse, which could theoretically impede, increase or reduce river flow, modify habitats or alter the supporting function of the aquatic or wetland ecosystem, is listed as a water use, and would require a license. If the structure or activity is of a nature that may negatively impact on the survival of a listed, threatened or protected species, the granting of the water license should be conditional on providing mitigations to ensure the survival of the species. A baseline assessment as well as an impact assessment of the proposed area is thus required, prior to the approval of the proposed project.

- Ramsar convention on wetlands

  South Africa became a signatory of the Ramsar Convention on the 21 December 1975 and at the moment has 20 wetland sites that are recognised by the Convention as a wetland of international importance covering a surface area of 553,178ha (Ramsar 2008). The project area does not fall within a listed Ramsar site.

# 7.0 BASELINE INVESTIGATION

The results presented below are based on a single survey conducted by Golder in August 2010. Data from additional sampling sites within the project area, which were collected in April 2010 by Golder (12685-9845-1), have been included to increase the insight into the aquatic and wetland ecosystems associated with the project area.

## 7.1 Aquatic results

### 7.1.1 *In situ* water quality parameters

*In situ* water quality measurements were recorded during both field surveys using portable field instruments. This information assists in the interpretation of biological results because of the direct influence water quality has on aquatic life forms. These *in situ* readings only describe the water quality parameters at the time of the survey and are considered to be important variables when assessing and interpreting the site specific conditions and biological assemblages during field sampling. Results of the August 2010 survey are presented below in Table 14 with additional data collected in April 2010.

**Table 14: *In situ* water quality values recorded during the April and August 2010 surveys.**

| Site | August 2010 | | | | | |
|---|---|---|---|---|---|---|
| | pH | DO (mg/l) | DO (%) | EC (µS/cm) | TDS (mg/l) | Temperature (°C) |
| NDC5 | 8.7 | 9.9 | 170 | 340 | 220 | 19.3 |
| NDC6 | 7.2 | 7.1 | 82 | 530 | 345 | 12.3 |
| NDC7 | 10.0 | 13.7 | 180 | 480 | 310 | 16.6 |
| | **April 2010** | | | | | |
| TuA04 | 8.7 | 5.2 | - | 1060 | 689 | 18.5 |
| TuA05 | 8.7 | 9.5 | - | 1370 | 890 | 17.3 |
| TuA06 | 8.5 | 0.06 | - | 1160 | 754 | 19.8 |

DO Dissolved Oxygen
EC Electrical Conductivity
TDS Total Dissolved Salts

#### *7.1.1.1 pH*

The pH value is a measure of the hydrogen ion activity in a water sample (DWAF 1996). The pH of natural waters is determined by both geological and atmospheric influences, as well as by biological activities. Most fresh waters are usually relatively well buffered and more or less neutral, with a pH range from 6 to 8, and most are slightly alkaline due to the presence of bicarbonates of the alkali and alkaline earth metals (DWAF 1996). The pH target for fish health is presented as ranging between 6.5 and 9.0, as most species will tolerate and reproduce successfully within this range (Alabaster and Lloyd 1980). The pH values should not be allowed to vary from the range of the background pH values for a specific site and time of day, by > 0.5 of a pH unit, or by > 5 % (DWAF 1996).

The *in situ* pH values recorded during the August 2010 survey were generally alkaline and ranged from 7.2 to 10.0 (Table 14). Elevated pH values were measured at sites in the Leeuspruit with site NDC7 exceeding the target range and showing a large increase from the upstream site (NDC5). The source of the increase in pH is unknown but if it persists it may have a limiting factor to the aquatic biota. Further investigations would be required to determine the source point of origin of the high pH observed but this may be linked to the farming in the area. These activities commonly use limes and fertilizers, resulting in the rivers becoming eutrophic (high level of primary production). Eutrophication results in high levels of photosynthesis, a process during which plants take up $CO_2$, which results in an increase in pH (Dallas and Day, 2005).

### 7.1.1.2 Dissolved Oxygen (DO)

The maintenance of adequate dissolved oxygen (DO) is critical for the survival and functioning of aquatic ecosystems because it is required for the respiration of all aerobic organisms. Therefore, DO concentration provides a useful measure of the health of an ecosystem (DWAF 1996). The median guideline for DO for the protection of aquatic biota is > 5.0 mg/l (Kempster, Hattingh and Van Vliet 1980).

*In situ* DO concentrations ranged from 7.1 mg/l at site NDC6 to 13.7 mg/l at site NDC7 (Table 14) and was consistently above the DO guideline. The DO concentration at site NDC7 was elevated compared to the other samples reaching 13.7 mg/l and a saturation of 177%.

Percent saturation is the amount of oxygen ($O_2$) in a litre of water relative to the total amount of oxygen that the water can hold at that temperature. DO levels fluctuate seasonally and diurnally over a 24-hour period and vary with water temperature and altitude (DWAF 1996). The South African Water Quality Guidelines (DWAF 1996), state that the target water quality range (TWQR) for DO to protect aquatic biota through most life stages is 80% - 120% of saturation, and that below 40% would be lethal. From this it can be concluded that DO saturation at sites NDC5 and NDC7 exceeded the TWQR. Although not comparable, it was noted that results obtained in April 2010 were low with site TuA6 being practically devoid of dissolved oxygen.

### 7.1.1.3 Electrical Conductivity (EC) and Total Dissolved Solids (TDS)

Electrical conductivity (EC) is a measure of the ability of water to conduct an electrical current (DWAF 1996). This ability is a result of the presence in water of ions such as carbonate, bicarbonate, chloride, sulphate, nitrate, sodium, potassium, calcium and magnesium, all of which carry an electrical charge (DWAF 1996). Many organic compounds dissolved in water do not dissociate into ions (ionise), and consequently they do not affect the EC (DWAF 1996). According to (Davies and Day 1998), freshwater organisms usually occur at EC values below 3000 $^{\mu}$S/cm. Because EC can be measured in the field it is routinely used as an estimate of the TDS concentration. For the purposes of this report and for comparison purposes, the following general relationship is commonly used as an approximation for TDS concentrations from EC for South African inland waters (DWAF 1996):

**TDS (mg/l) = EC ($^{m}$S/m at 25 °C) x 6.5**

Natural waters contain varying quantities of TDS as a consequence of the dissolution of minerals in rocks, soils and decomposing plant material, the TDS concentrations of natural waters are therefore dependent at least in part on the characteristics of the geological formations which the water has been in contact with. The TDS concentrations also depend on physical processes such as evaporation and rainfall (DWAF 1996). According to the South African Water Quality Guidelines for aquatic ecosystems TDS concentrations should not be changed by > 15 % from the normal cycles of the water body under unimpacted conditions at any time of the year; and the amplitude and frequency of natural cycles in TDS concentrations should not be changed (DWAF 1996). In freshwater the TDS concentrations are generally in the range of (DWAF 1996):

- Low in rainwater (less than 1 mg/l);
- Low in water in contact with granite, siliceous sand and well-leached soils (less than 30 mg/l);
- Greater than 65 mg/l in water in contact with Precambrian shield areas;
- In the range of 200 - 1 100 mg/l in water in contact with Palaeozoic and Mesozoic sedimentary rock formations (most inland rivers within the interior of South Africa); and
- High as a result of evapo-concentration (usually greater than 1 100 mg/ml).

The TDS concentrations range of 200 - 1 100 mg/l was therefore used as a general guideline values for TDS for the purposes of this assessment.

*In situ* EC values ranges from 340 $^{\mu}$S/cm at site NDC5 to 530 $^{\mu}$S/cm at site NDC6 (Table 14). All values were within guideline values, however the percentage change in TDS concentrations in a downstream direction between the sites located in the Leeuspruit was >15%. TDS concentrations increased from 221 mg/l at site NDC5 to 312 mg/l at site NDC7, with a slightly higher concentration (345 mg/l) being recorded at site NDC6. This represents an increase of more than 15% and may therefore have a limiting effect on aquatic biota. It

was noted that the Wolwespruit (April 2010), shows higher TDS values, however being collected at a different time of the year cannot be compared to the August 2010 results.

#### *7.1.1.4 Temperature*

Temperature plays an important role in water by affecting the rates of chemical reactions and therefore also the metabolic rates of organisms. Temperature is therefore one of the major factors controlling the distribution of aquatic organisms (DWAF 1996). Natural variations in water temperature occur in response to seasonal and diurnal cycles and organisms use these changes as cues for activities such as migration, emergence and spawning (DWAF 1996). Artificially-induced changes in water temperature can impact on individual organisms and on entire aquatic communities (DWAF 1996). Temperature affects the rate of development, reproductive periods and emergence time of organisms (Davies and Day 1998). The temperatures of inland waters in South Africa generally range from 5 - 30 °C (DWAF 1996).

During the August 2010 survey *in situ* temperatures ranged from 12.3°C at site NDC6 to 19.3°C at site NDC5 (Table 14). These temperatures were considered to be normal for these freshwater aquatic systems at that time of the year and would not have a limiting effect on aquatic biota.

### 7.1.2 Habitat Assessment

The quality of the instream and riparian habitat influences the structure and function of the aquatic community in a stream; therefore evaluation of habitat availability is critical to any assessment of aquatic biota. General habitat descriptions were compiled and photographs taken of each of the aquatic sampling sites. Habitat availability for aquatic macroinvertebrates was assessed by means of the Invertebrate Habitat Assessment System (IHAS).

#### *7.1.2.1 General habitat of the sites*

Photographs of the sampling sites are provided in APPENDIX B. General habitat observations were made at each of the sites and are presented in Table 15.

**Table 15: General habitat characteristics observed at the aquatic sites during the August 2010 survey**

| Site | General habitat characteristics |
|---|---|
| NDC5 | Moderate channel with low water bridge over rocky area providing habitat. Lots of cattle at site causing disturbance |
| NDC6 | Small channel with cut banks, muddy substrate with limited rock around road bridge |
| NDC7 | Small rocky channel with moderate flow into a pool area. Variety of habitat and substrate types |

Site NDC4 was dry at the time of the August 2010 survey so no habitat assessment could be conducted at the site. Habitat at site NDC6 was uniform with a lack of stones-in-current biotope or in-stream vegetation. Habitat at sites NDC5 and NDC7 was variable with changes in flow and substrate type present. At site NDC5 the area near to the bridge was largely dominated by bedrock.

#### *7.1.2.2 Invertebrate Habitat Assessment System (IHAS, Version 2)*

Habitat availability for aquatic macroinvertebrates was measured based on the IHAS index. Only the aquatic sites with surface water were included in this assessment (NDC4 excluded). The results are provided in Table 16.

**Table 16: IHAS scores recorded during the April and August 2010 surveys**

| Date | Site | IHAS Score | Description |
|---|---|---|---|
| August 2010 | NDC5 | [redacted] | Poor / Inadequate |
| | NDC6 | | Poor / Inadequate |
| | NDC7 | | Fair / Adequate |

| Date | Site | IHAS Score | Description |
|---|---|---|---|
| April 2010 | TuA04 | [redacted] | Poor / Inadequate |
| | TuA05 | | Poor / Inadequate |
| | TuA06 | | Poor / Inadequate |

Based on the IHAS scores habitat availability was poor at all the sites with the exception of NDC7 where there was a moderate degree of flow and a variety of stones sizes. At the remainder of the sites flow levels were low, channel banks eroded and cover in terms of marginal vegetation and substrate limited. The integrity of the habitat at site NDC5 was further compromised by the presence of cattle, which were drinking and walking through the river.

### 7.1.3 Aquatic macroinvertebrates

Aquatic macroinvertebrate communities were assessed in the field using the standard SASS5 methodology. The results of this assessment are presented in this section. The list of aquatic macroinvertebrate taxa collected during the surveys is presented in APPENDIX C.

The results of the August 2010 and April 2010 SASS assessments are shown in Table 17.

**Table 17: SASS results of the August 2010 and April 2010 surveys**

| Site | | SASS Score | No. of Taxa | ASPT |
|---|---|---|---|---|
| **August 2010** | **NDC5** | 76 | 16 | 4.75 |
| | **NDC6** | 75 | 15 | 5.00 |
| | **NDC7** | 77 | 15 | 5.13 |
| **April 2010** | **TuA04** | 86 | 19 | 4.53 |
| | **TuA05** | 91 | 19 | 4.79 |
| | **TuA06** | 72 | 17 | 4.24 |

ASPT - Average Score per Taxa

During the August 2010 survey SASS5 scores and number of taxa at the 3 sites were very similar with ASPT increasing in a downstream direction. Even though site NDC5 showed the highest number to taxa, it displayed the lowest ASPT value (Figure 4 and Figure 5). This is thought to be due to the large number of cattle utilizing the site as a drinking point as well as the substrate being dominated by bedrock, thus limiting the habitat for aquatic macroinvertebrates.

SASS results obtained during the April 2010 were very similar to those recorded in August 2010. The differences observed between the two surveys may be linked to expected seasonal changes (Figure 3, Figure 4 and Figure 5).

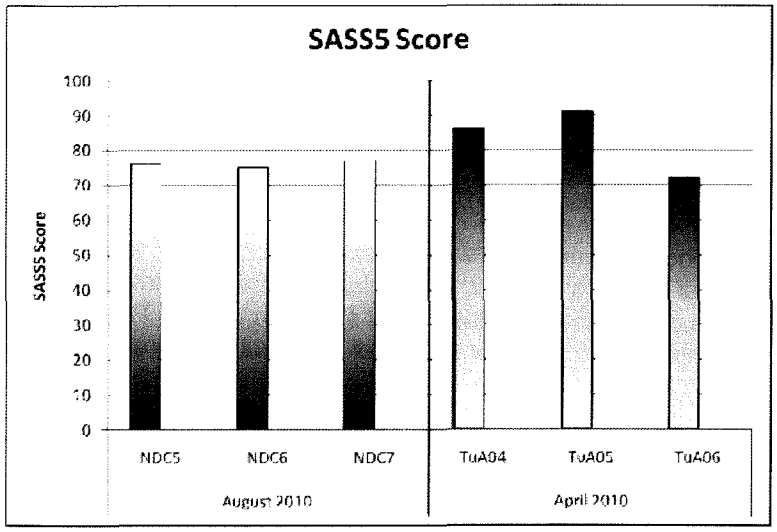



*Figure 3: Comparative SASS5 scores at the aquatic ecosystem sites*

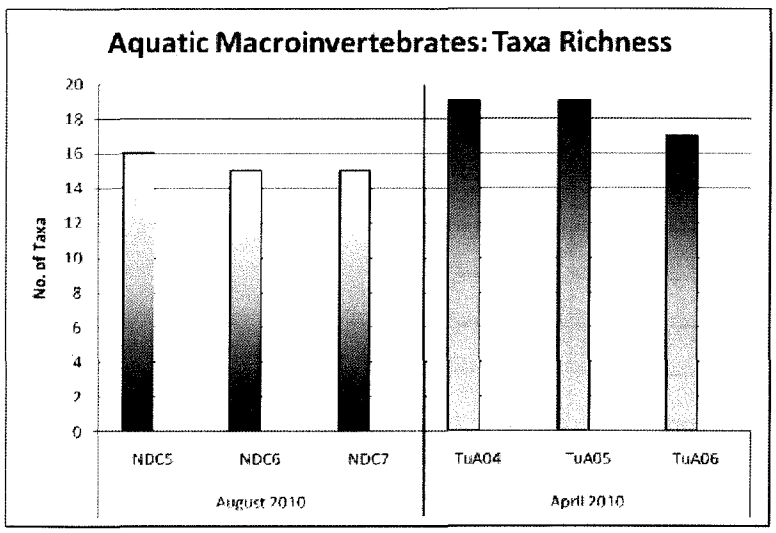



*Figure 4: Comparative number of aquatic macroinvertebrate taxa at the aquatic ecosystem sites*

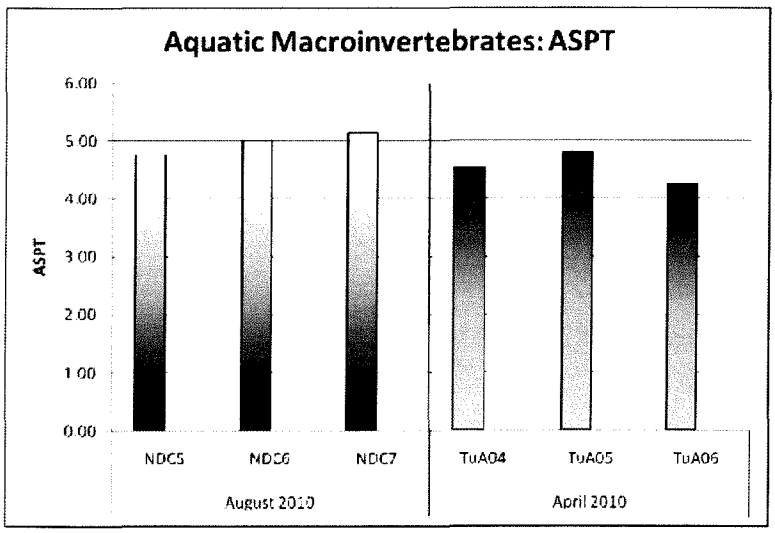



*Figure 5: Comparative Average Score per Taxa (ASPT) values at the aquatic ecosystem sites*

#### 7.1.3.1 *Biotic integrity based on SASS results*

The SASS5 and ASPT results were used to evaluate the biotic integrity of the sites using the SASS5 Data Interpretation Guidelines (Dallas 2007). SASS5 scores were plotted against the ASPT values and evaluated according to the biological bands associated with the Highveld Ecoregion - lower zones. The Ecological Categories used for the interpretation of the SASS5 data are provided in Table 2. Based on this the biotic integrity of the sites is shown in Table 18.

**Table 18: Biotic integrity of the aquatic ecosystem sites, based on SASS5 and ASPT scores**

| Site | | Ecological Category (EC) |
|---|---|---|
| August 2010 | NDC5 | C |
| | NDC6 | B |
| | NDC7 | B |
| April 2010 | TuA04 | B |
| | TuA05 | B |
| | TuA06 | C |

C - Fair; B - Good

Based on the SASS5 results obtained during the August 2010 survey, biotic integrity of the three sites ranged from fair to good (Table 18). Biotic integrity at site NDC5 was moderately modified (Ecological Category C), indicating that the community structure is less than the reference. Community composition at site NDC5 is lower than expected due to loss of some sensitive forms..While ecosystem functions at the site are predominantly unchanged the absence of more sensitive taxa is indicative of impacts such as cattle watering at the site. Biotic integrity at sites NDC6 and NDC7 was rated as largely natural (Ecological Category B) with little modification.

During the April 2010 survey, biotic integrity at sites TuA04 and TuA05 was rated as largely natural (Ecological Category B) (Table 18). Biotic integrity at site TuA06 was rated as fair (Ecological Category C) . This was attributed to the site been impacted by cattle and limited habitat availability.

### 7.1.4 Ichthyofauna (Fish)

#### 7.1.4.1 *Observed fish data*

The results of the August 2010 and April 2010 surveys are presented in Table 19. Of the 11 expected fish species (Table 3), a total of six species were recorded at the sites (Table 19).

**Table 19: Observed fish species at the aquatic ecosystem sites during the August 2010 and April 2010 surveys**

| Species | Common Name | August 2010 | | | April 2010 | | |
|---|---|---|---|---|---|---|---|
| | | NDC5 | NDC6 | NDC7 | TuA04 | TuA05 | TuA06 |
| ***Family Cichlidae*** | | | | | | | |
| *Pseudocrenilabrus philander* | Southern Mouthbrooder | 23 | 1 | 5 | 9 | 7 | |
| ***Family Clariidae*** | | | | | | | |
| *Clarias gariepinus* | Sharptooth Catfish | 1 | | | | | |
| ***Family Cyprinidae*** | | | | | | | |
| *Barbus anoplus* | Chubbyhead Barb | 19 | 33 | 25 | 1 | 1 | 6 |
| *Barbus paludinosus* | Straightfin Barb | | | 1 | | 1 | 22 |
| *Labeo umbratus* | Moggel | 2 | | 15 | | | 3 |

| Species | Common Name | August 2010 | | | April 2010 | | |
|---|---|---|---|---|---|---|---|
| | | NDC5 | NDC6 | NDC7 | TuA04 | TuA05 | TuA06 |
| *Labeobarbus aeneus* | Vaal-orange Smallmouth Yellowfish | | | 1 | | | 2 |
| **Total number of species** | | **4** | **2** | **5** | **2** | **3** | **4** |
| **Total number of individuals** | | **45** | **34** | **47** | **10** | **9** | **33** |

The fish assemblage was dominated by *Barbus anoplus* (Chubbyhead Barb) and *Pseudocrenilabrus philander* (Southern Mouthbrooder). *B. anoplus* (Chubbyhead Barb) has a wide distribution from the Highveld tributaries of the Limpopo to the highlands of KwaZulu-Natal, Transkei and the middle- and upper Orange River basins including the Karoo. It prefers cool waters and occurs in a wide range of habitats (Skelton 2001). This is a widespread and hardy species that prefers quiet well vegetated waters in lakes, swamps and marshes or marginal areas of larger rivers and slow-flowing streams (Skelton 2001). *P. philander* (Southern mouthbrooder) is regarded as a tolerant species that is widespread and common throughout Southern Africa (Skelton 2001). The fish results were plotted graphically so as to compare the results from the different sites. Fish species richness is shown in Figure 6. The highest fish species richness was measured at site NDC7. The lowest species richness was recorded at site NDC6, this was expected as it is a smaller tributary and habitat was less varied.

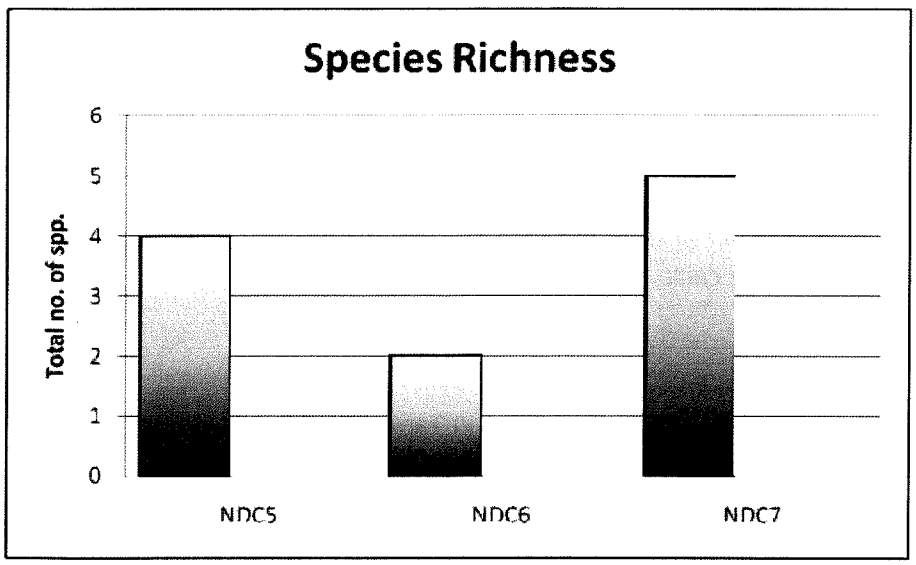



*Figure 6: Observed fish species richness from the August 2010 survey*

When looking at the community structure in association with species abundance, the following can be noted from the August 2010 results (Figure 7):

- Site NDC6 had low species diversity and the assemblage was dominated by B. *anoplus* (Figure 7). Habitat availability and the lack of flow are contributing factors to this result. Skeletal remains of *C. gariepinus* were observed at site, indicating that during periods of higher flow, they would be present;
- The species richness and abundance increased in a downstream direction from site NDC5 to NDC7 (Figure 7). Habitat availability at site NDC7 was adequate with a variety of flow and depth classes present over abundant substrate cover. Despite adequate habitat availability only five of the 11 expected fish species were recorded at the NDC7. This may be as a result of the low flow levels and surrounding land use practices.

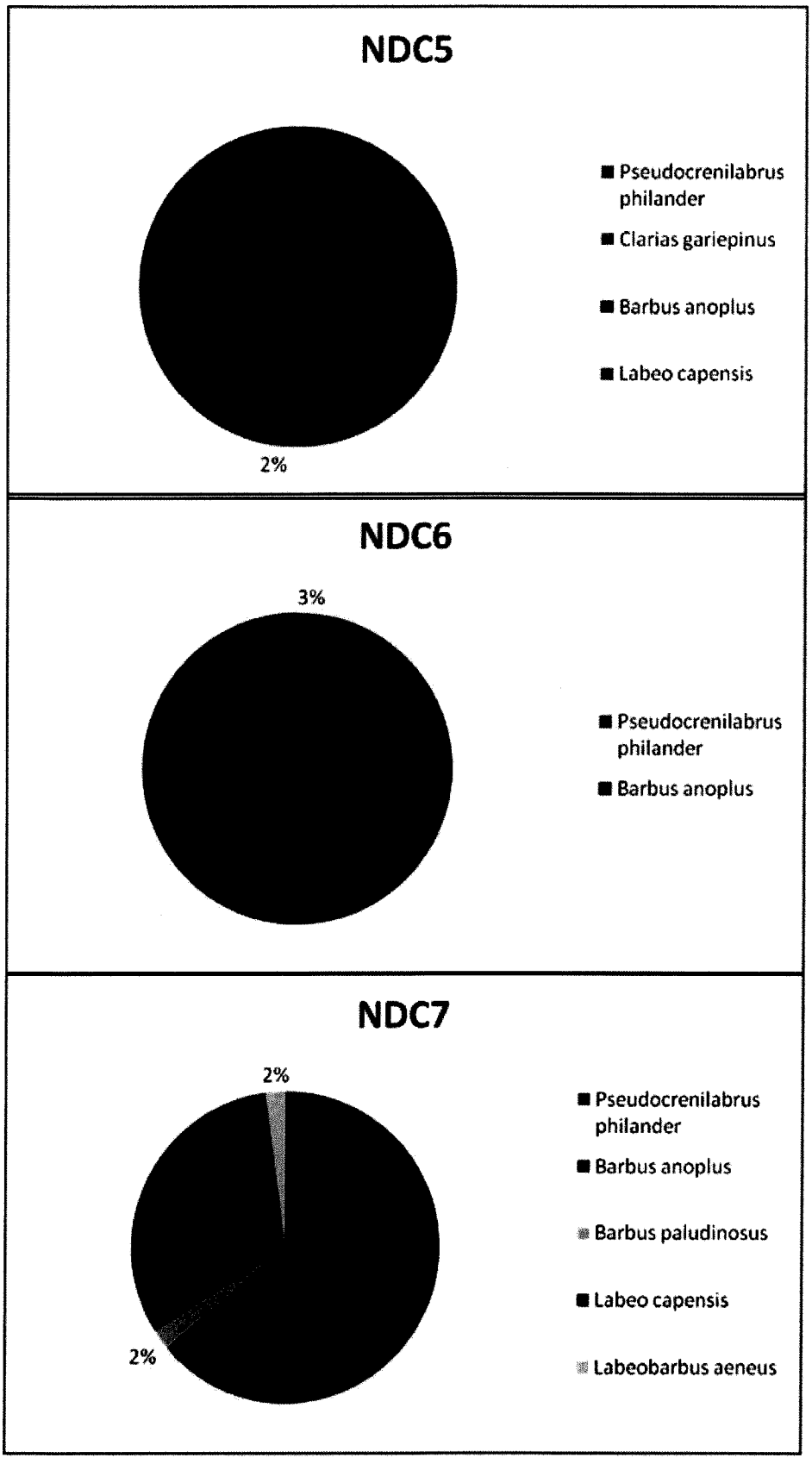



*Figure 7: Percentage contribution of different fish species to the fish communities at the different sites*

#### 7.1.4.2 *Presence of observed IUCN Red List species*

Based on the 2010 IUCN Red List, it was shown that of the six observed fish species (Table 19):

- Three species are currently unlisted (IUCN 2010); and
- Three species are currently listed as Least Concern (LC) (IUCN 2010). A species in this category is widespread and abundant and is not considered to be an IUCN Red Data species at this time (IUCN 2010).

#### 7.1.4.3 *Fish health assessment*

After thorough external examination, it was noted that fish captured at site NDC7 exhibited signs of external parasites, in particular *B. anoplus*. This may be due to the increased physiological stress on the species due to the impaired water quality.

## 7.2 Wetland Results

Eight wetland units were identified in association with the proposed project (Figure *8*). For each of these wetland units the wetlands were delineated, classified and assessed. Figure *8* shows an overview of the wetlands delineated in the study area and Table 20 shows the types of wetlands and their respective surface areas. Survey and assessment results for each of these wetland units will be presented in the sections below. For each of the wetland units a description of the following will be provided:

- The wetland types;
- The fauna and flora recorded on site;
- Notes on existing impacts; and
- Assessment of the PES, EIS, and Ecosystem Services for each of the wetland units.

A summary map of the wetland unit will be presented. This map is intended to present as much information about the wetland unit as possible. Thus at a glance, the reader should be able to look at the map and see the following:

- The boundary of the wetlands;
- The type of wetlands within the wetland unit; and
- The PES, EIS, Natural Services, and Human Services ratings.

**Table 20: Classification of the wetlands occurring within the study area and their respective surface areas**

| Short name | Total for the study area (ha) | Classification | | | | |
|---|---|---|---|---|---|---|
| | | Level 3 | Level 4 | | | |
| | | Landscape setting | Hydrogeomorphic type | Zonation/ Landform | Drainage - Outflow | Drainage - Inflow |
| Hillslope seep (without channeled outflow) | 18.8 | Slope | Hillslope seep | N/A | Without channeled outflow | N/A |
| Channeled valley bottom | 203.9 | Valley floor | Channeled valley-bottom wetland | Valley-bottom depression | N/A | N/A |
| | | | | Valley-bottom flat | N/A | N/A |
| Unchanneled valley bottom | 201.1 | | Unchanneled valley bottom wetland | Valley-bottom depression | N/A | N/A |
| | | | | Valley-bottom flat | N/A | N/A |
| Floodplain | 946.0 | | Floodplain wetland | Floodplain depression | N/A | N/A |
| | | | | Floodplain flat | N/A | N/A |
| Valleyhead seep | 16.0 | | Valleyhead seep | N/A | N/A | N/A |
| Dam | 45.6 | | Depression | N/A | Dammed | With Channeled inflow |

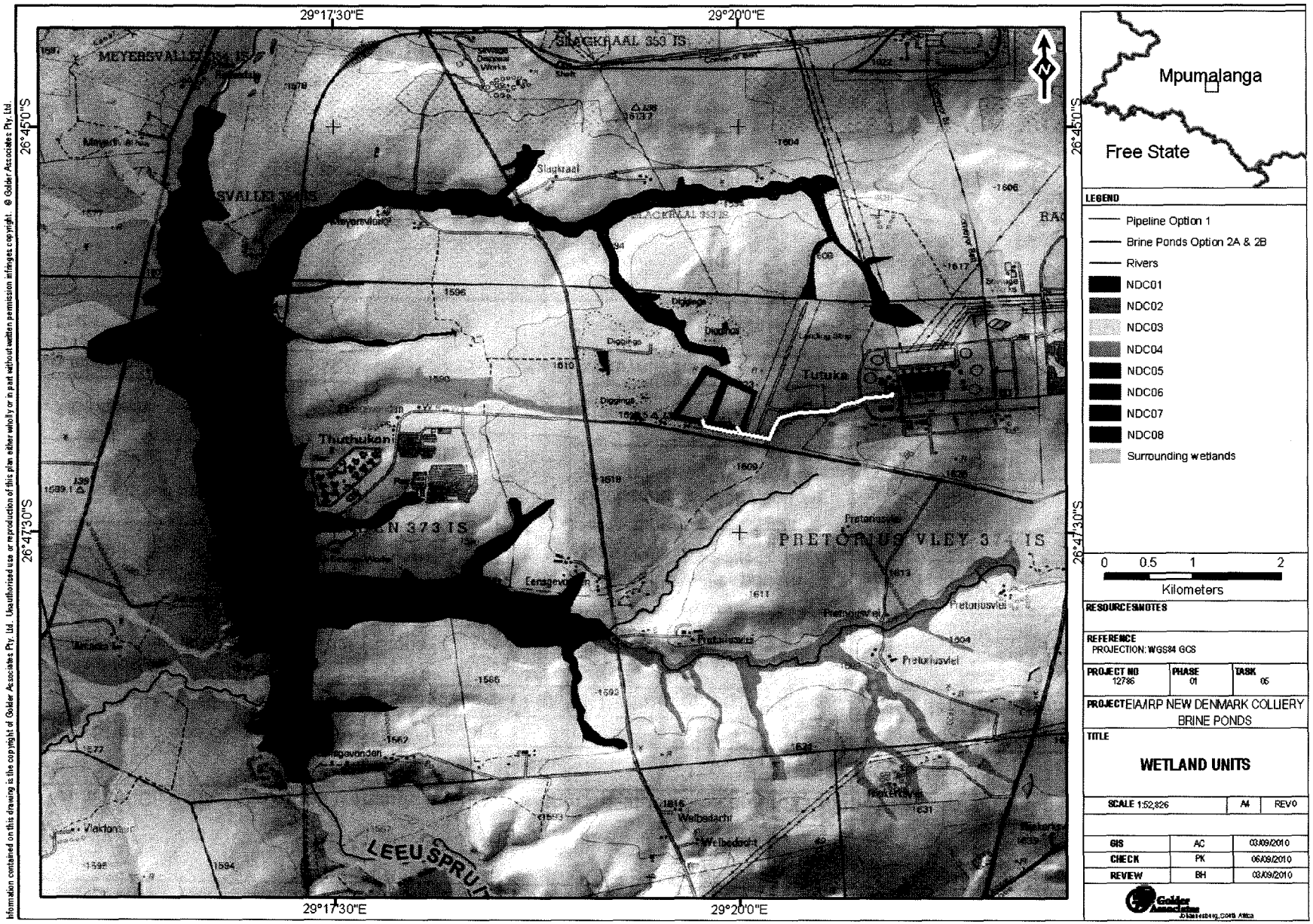





*Figure 8: Wetland units associated with the project area*

### 7.2.1 Wetland Unit NDC01

Wetland unit NDC01 consists of five wetland types, a broad flood plain (Figure 9) which is fed by two non-channelled valley bottoms and some hillslope seepage (Figure 10). The flood plain flows into the Leeuspruit. The wetland unit is situated approximately 2.5 km away from the proposed development and is 192 ha in size.

The wetland is moderately grazed and consequently the vegetation is uniform with generalist species such as *Themeda triandra, Hyparrhenia hirta*, and *Cynodon dactylon* dominating. Other grass species recorded include *Eragrostis curvula* and *Sporobolus africanus*. Wetland indicator species such as *Schoenoplectus brachyceras*, *Mariscus congestus*, *Phragmites australis*, and *Typha capensis* were recorded in the more permanent zones.

Bird life in the area was moderate with birds such as *Bubulcus ibis* (Cattle egret), *Ploceus velatus* (Southern masked weaver), and *Anas undulata* (Yellow-billed duck) recorded. Habitat for ground-nesting birds such as *Asio capensis* (Marsh owl), *Tyto capensis* (Grass owl), *Eupodotis afra* (Southern Black Korhaan) or *Eupodotis senegalensis* (White-bellied Korhaan) was poor due to over grazing in most of the flood plain areas.

Existing impacts on the wetlands in this unit are largely due to agricultural activities (cropping and grazing) with some impoundments (dams and roads). Severe bank erosion was noted in the flood plain.

The site was assessed to have a PES class of A/B and Moderate EIS. The wetland unit provides High Natural services and Low Human services.

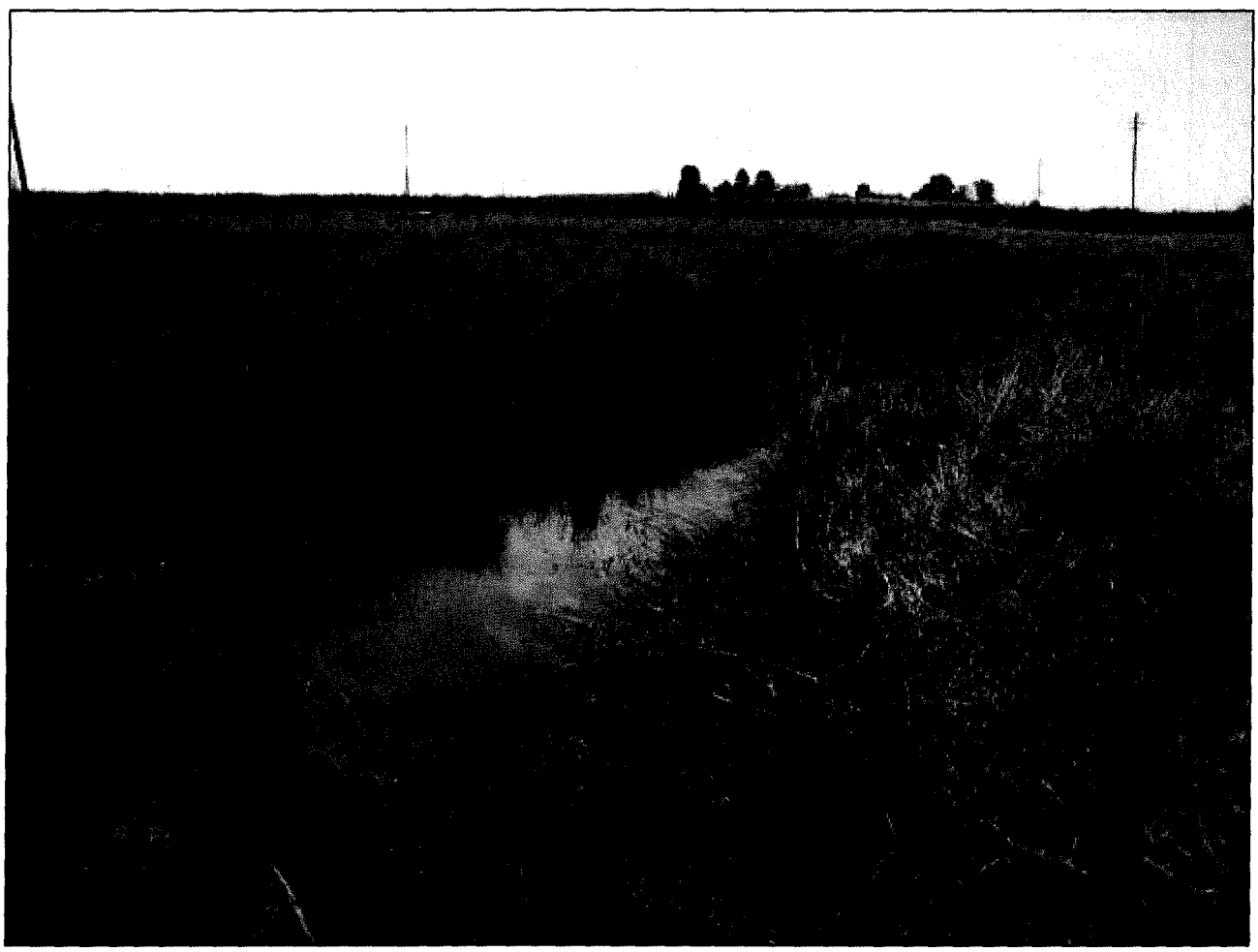


*Figure 9: Photograph of the floodplain within wetland unit NDC01*

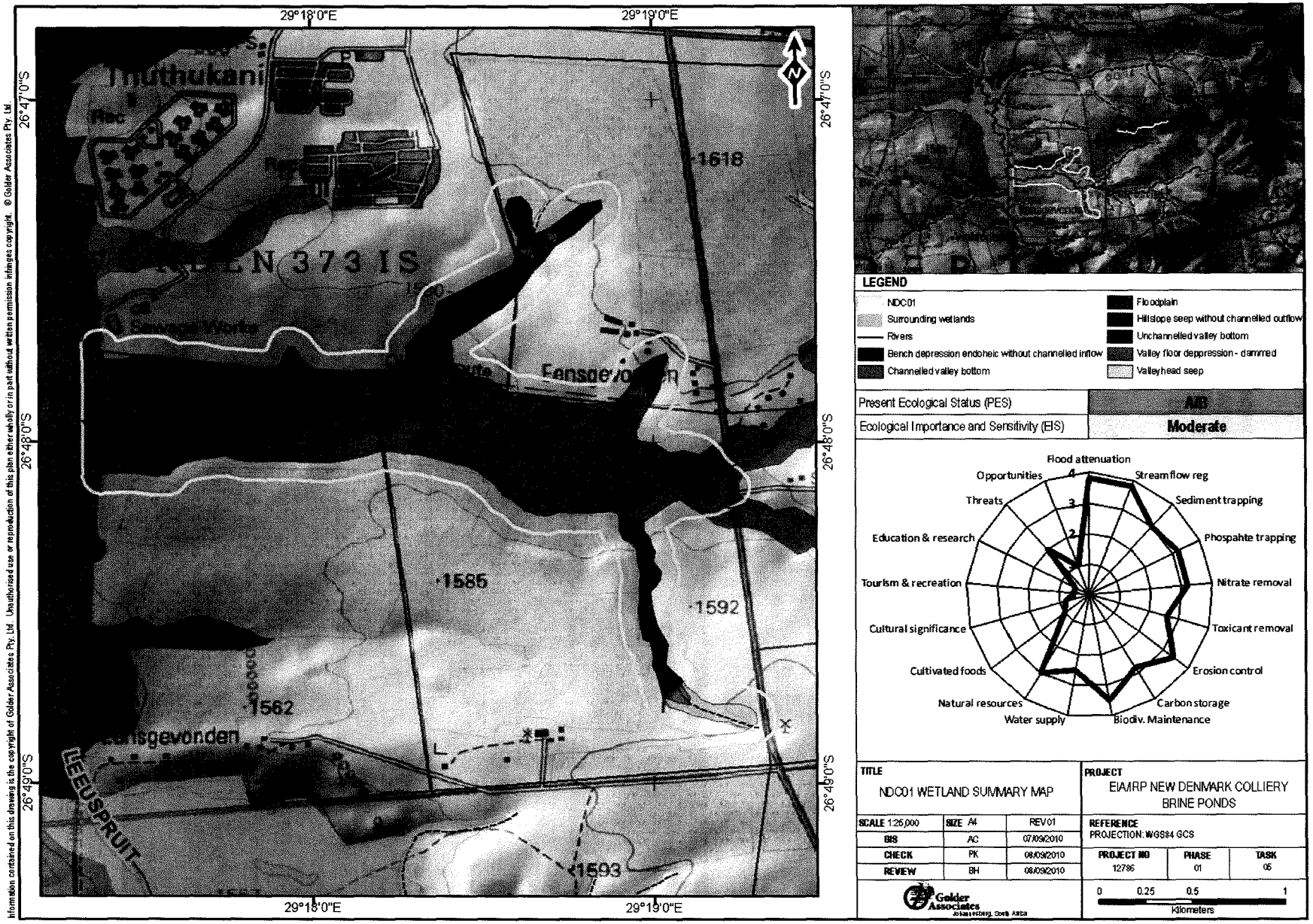



*Figure 10: Wetland unit NDC01 summary map*

### 7.2.2 Wetland Unit NDC02

Wetland unit NDC02 consists of five wetland types, a narrow flood plain which is fed by smaller channelled and non-channelled valley bottoms with seven dams noted in this wetland unit (Figure 12). The flood plain flows into the Leeuspruit. The wetland unit is situated approximately 2 km away from the proposed development and is 162 ha in size.

The wetland vegetation is somewhat uniform with generalist species such as *Themeda triandra* and *Hyparrhenia hirta* dominating (Figure 11). Other grass species recorded include *Sporobolus africanus*, and *Eragrostis curvula*. Wetland indicator species such as *Schoenoplectus brachyceras*, *Mariscus congestus*, and *Phragmites australis* were recorded in the more permanent zones.

Bird life in the area was moderate with birds such as *Bubulcus ibis* (Cattle egret), *Ardea melanocephala* (Black-headed heron), and *Alopochen aegyptiacus* (Egyptian goose) recorded. Habitat for ground-nesting birds such as *Asio capensis* (Marsh owl), *Tyto capensis* (Grass owl), *Eupodotis afra* (Southern Black Korhaan) or *Eupodotis senegalensis* (White-bellied Korhaan) was poor due to over grazing in most of the flood plain areas.

Existing impacts on the wetlands in this unit are largely due to agricultural activities (cropping and grazing) with impoundments (dams and roads) occurring throughout the wetland unit. Bank erosion was noted to the western end of the floodplain wetland.

The site was assessed to have a PES class of B and moderate EIS. The wetland unit provides moderate to high natural services and low human services.

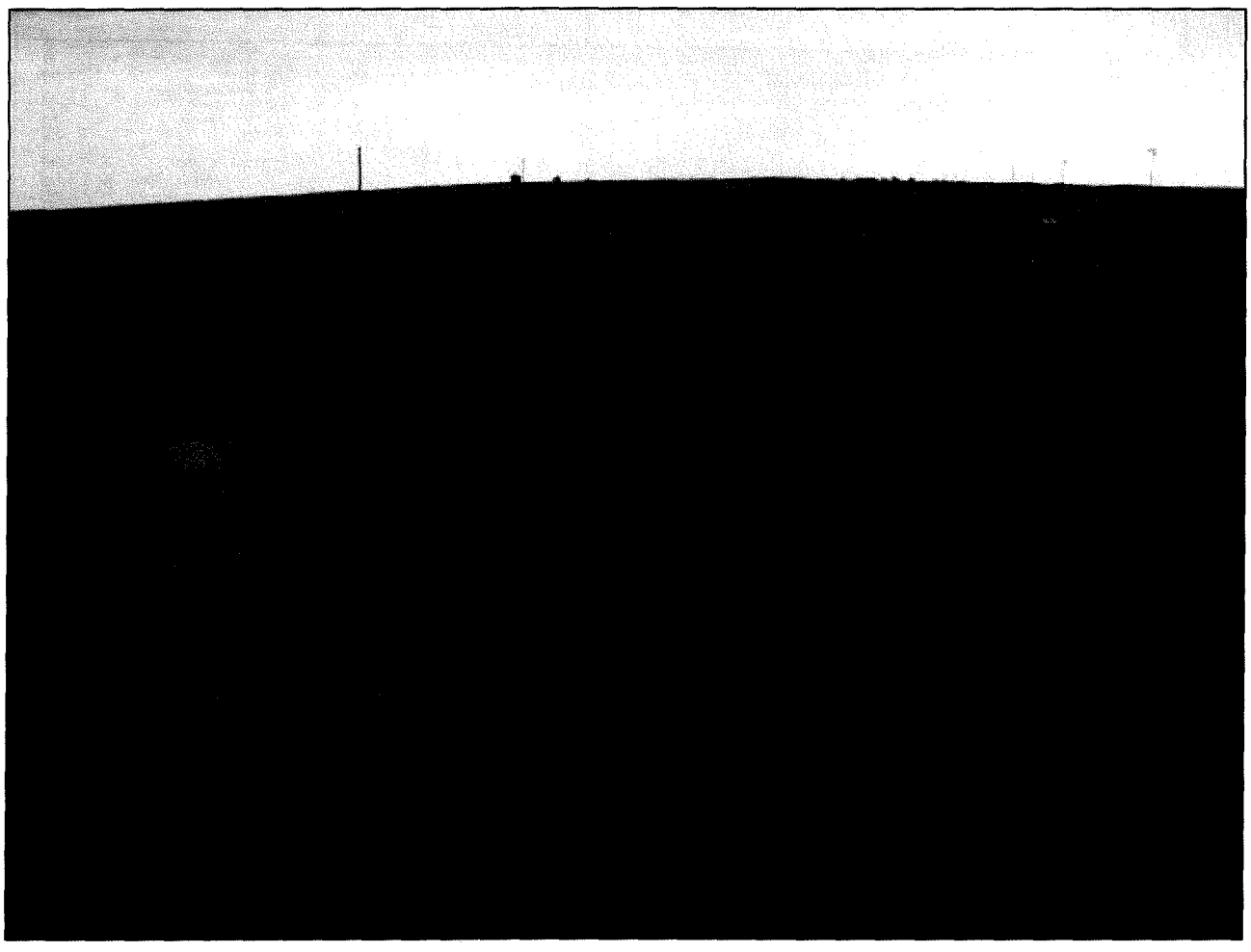


*Figure 11: Photograph of the floodplain within wetland unit NDC02*

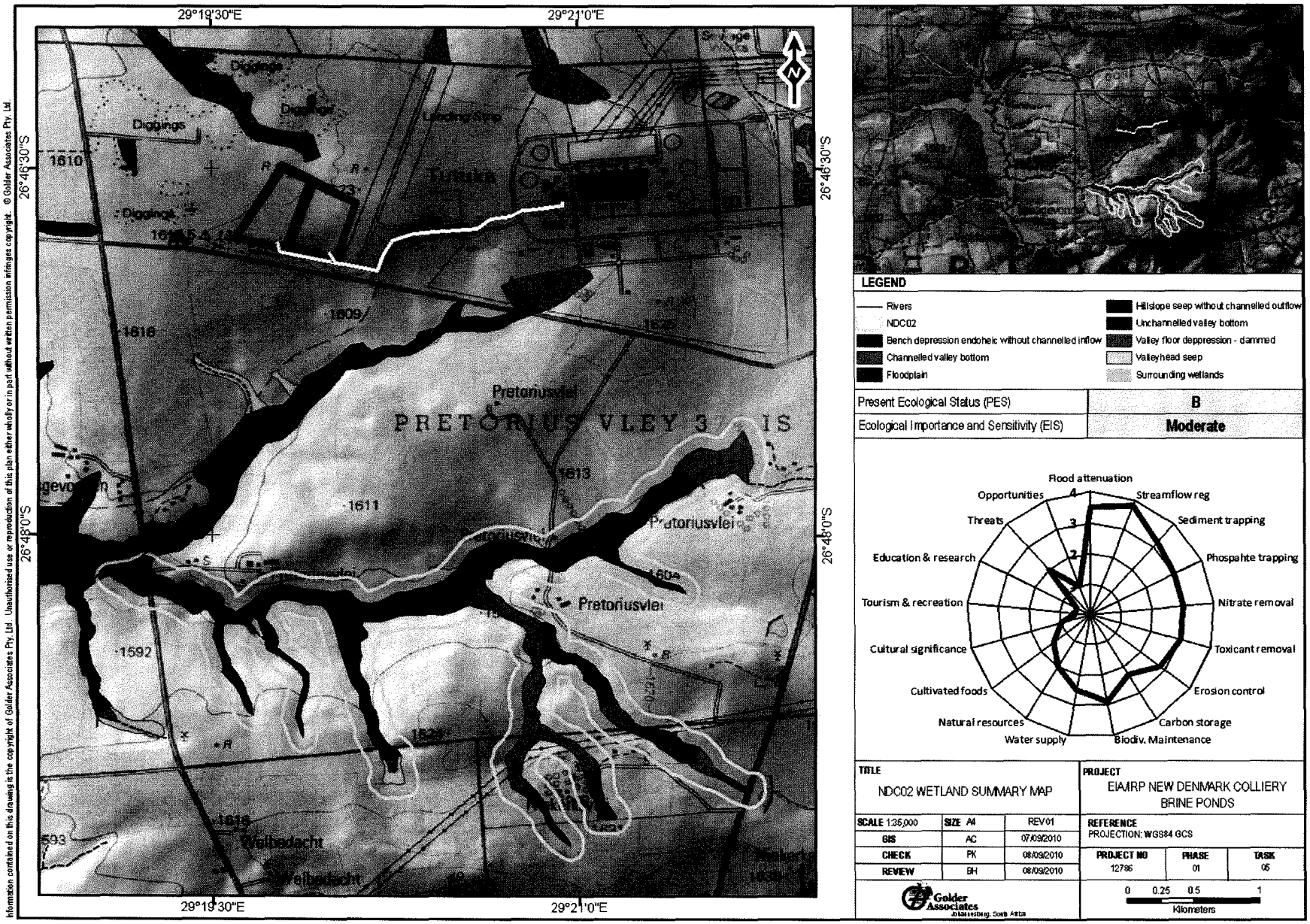





*Figure 12: Wetland unit NDC02 summary map*

### 7.2.3 Wetland Unit NDC03

Wetland unit NDC03 consists of four wetland types, a narrow flood plain which is fed by a non-channelled valley bottom which is situated downstream of a dam on the power station property (Figure 14). Some hillslope seepage is present to the north of the main channel. The flood plain flows into the Leeuspruit. The wetland unit is situated approximately 600 m away from the proposed development and is 78 ha in size.

The wetland vegetation is similar to that of NDC02 in its uniformity with generalist species such as *Themeda triandra* and *Hyparrhenia hirta* dominating. Other grass species recorded included *Sporobolus africanus*, *Eragrostis rigidor*, and *Leersia hexandria*. Wetland indicator species such as *Schoenoplectus brachyceras*, *Mariscus congestus*, *Phragmites australis*, *Cyperus longus* and *C. dives* were recorded in the more permanent zones.

Bird life in the area was moderate with birds such as *Bubulcus ibis* (Cattle egret), *Ardea melanocephala* (Black-headed heron), and *Alopochen aegyptiacus* (Egyptian goose) recorded. Habitat for ground-nesting birds such as *Asio capensis* (Marsh owl), *Tyto capensis* (Grass owl), *Eupodotis afra* (Southern Black Korhaan) or *Eupodotis senegalensis* (White-bellied Korhaan) was poor due to over grazing in most of the flood plain areas.

Existing impacts on the wetlands in this unit are largely due to agricultural activities (cropping and grazing) (Figure 13) with some impoundments (dams and roads). Bank erosion was noted to the western end of the flood plain wetland. On the northern bank of the flood plain is a rural homestead which makes use of the wetland. The site was assessed to have a PES class of B and moderate EIS. The wetland unit provides moderate to high natural services and moderate human services.

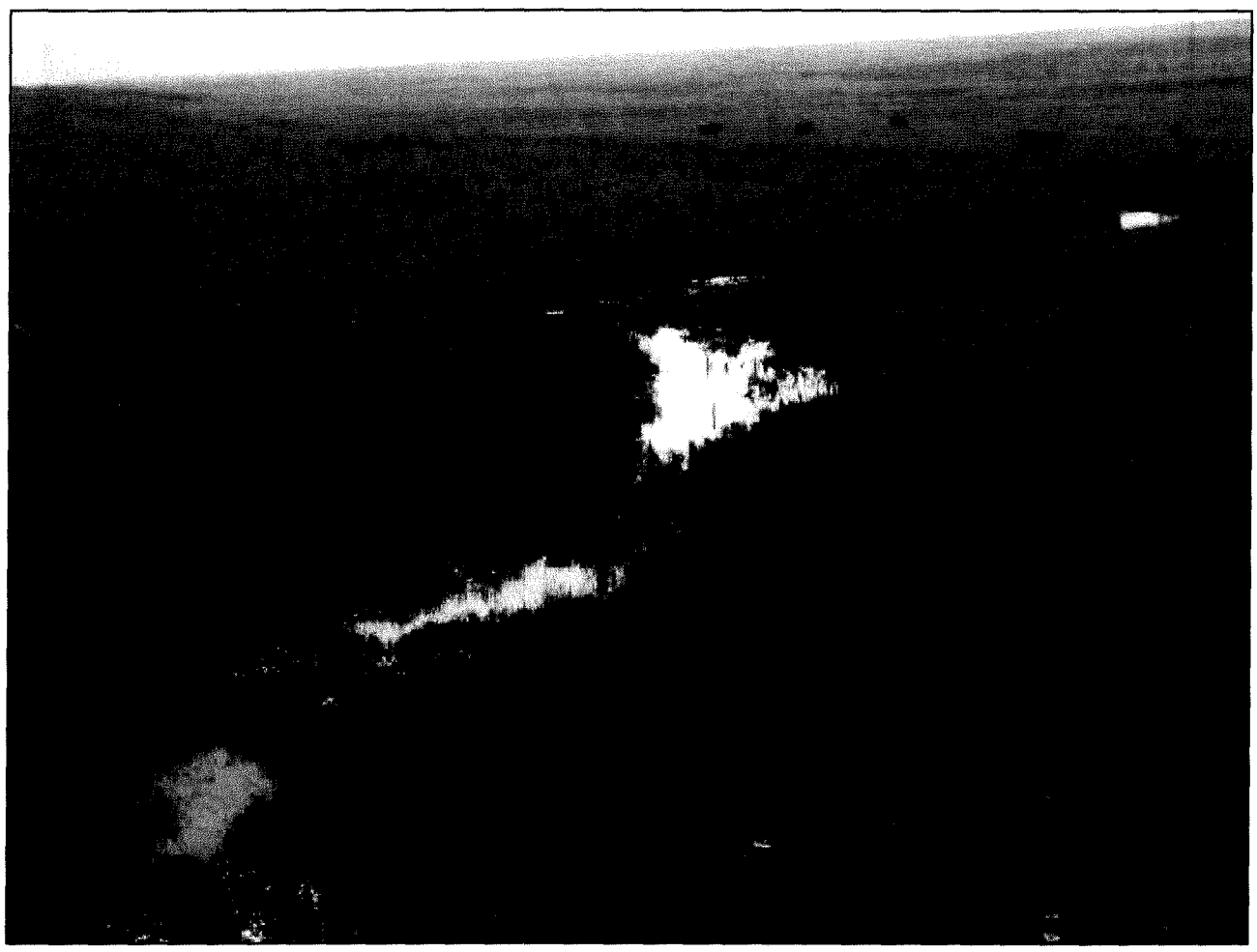


*Figure 13: Photograph of the channelled valley bottom within wetland unit NDC03*

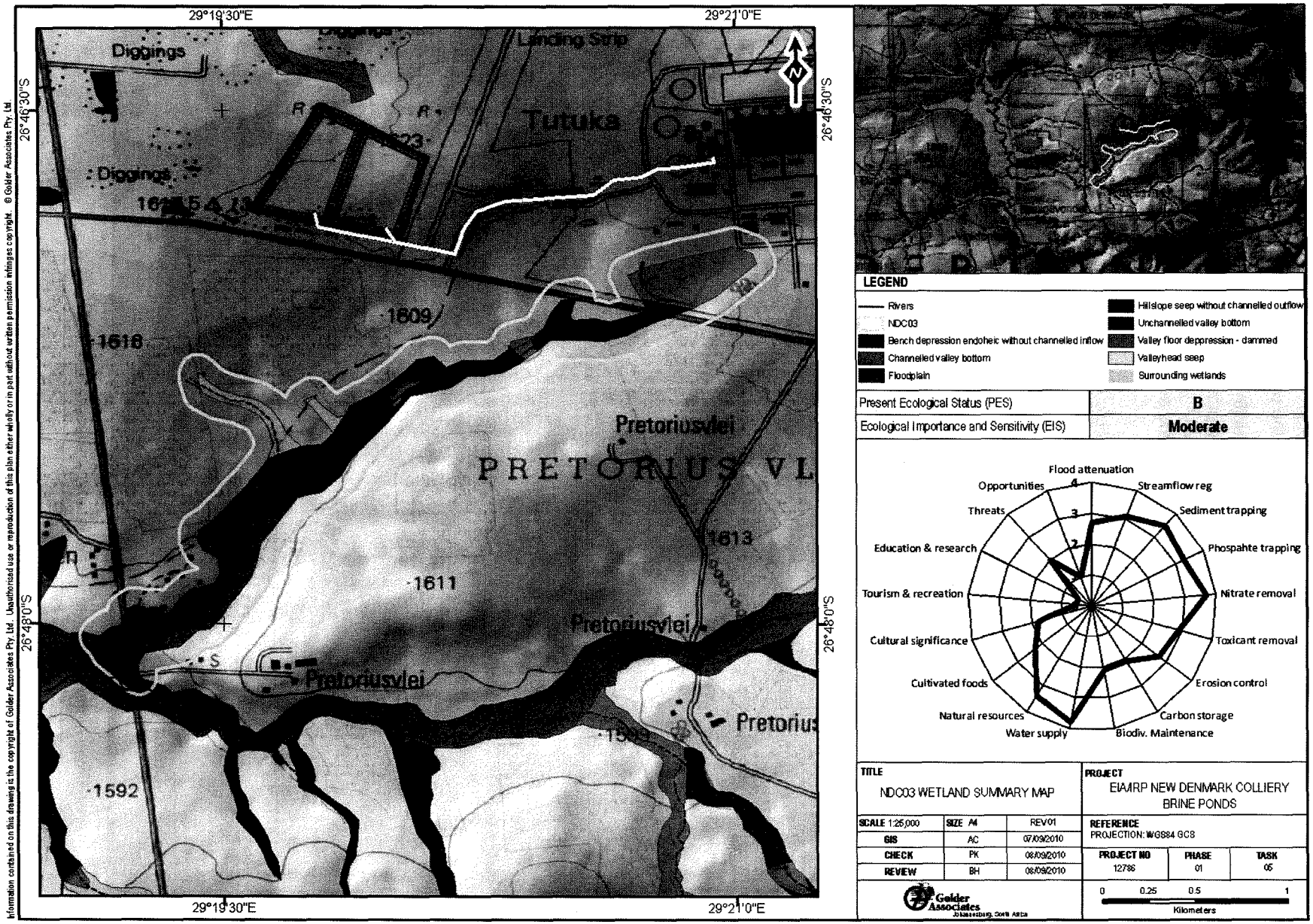





*Figure 14: Wetland unit NDC03 summary map*

### 7.2.4 Wetland Unit NDC04

Wetland unit NDC04 consists of an unchanneled valley bottom with a small dam (Figure 16). The wetland unit feeds into the floodplain of the Leeuspruit. The wetland unit is situated approximately 900 m away from the proposed development and is 77 ha in size.

The wetland is dominated by hardy generalist grass species such as *Hyparrhenia hirta*, *Themeda triandra*, *Eragrostis tef*, and *Panicum maximum*. The hardy wetland indicator species *Phragmites australis* and *Typha capensis* are present in the centre of the permanent zone. Weedy species such as *Circium vulgare* (Scottish thistle) were noted along the edge of the temporary zone.

Considering the general lack of habitat diversity at the site, the bird life was reasonable. Bird species observed at the site included *Ardea melanocephala* (Black-headed heron), *Asio capensis* (Marsh owl), *Elanus caeruleus* (Blackshouldered Kite), *Vanellus coronatus* and *V. armatus* (Crowned plover and Blacksmith plover), *Macronyx croceus* (Yellowthroated longclaw), *Saxicola torquata* (Common stonechat), and *Euplectes progne* (Longtailed widow). No reptiles, mammals, or amphibians were observed during the survey.

Existing impacts on the wetlands in this unit are largely due to agricultural activities (cropping and grazing) (Figure 13). The area at the head of the valley has been ploughed and maize (*Zia maize*) planted. Harvesting of hay was noted on the northern side of the wetland unit.

The site was assessed to have a PES class of B and moderate EIS. The wetland unit provides moderate natural services and low human services.

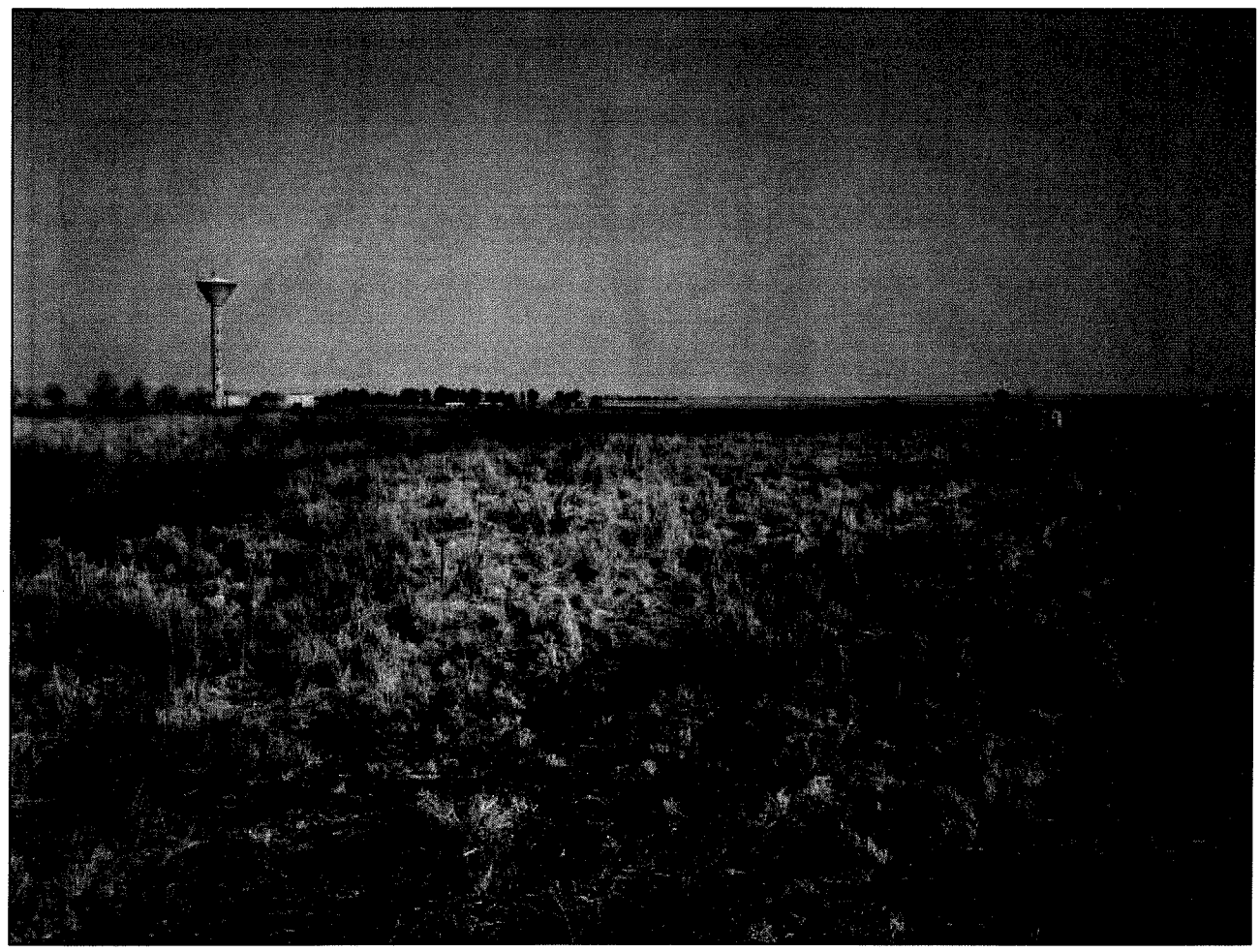


*Figure 15: Photograph of the unchanneled valley bottom within wetland unit NDC04*

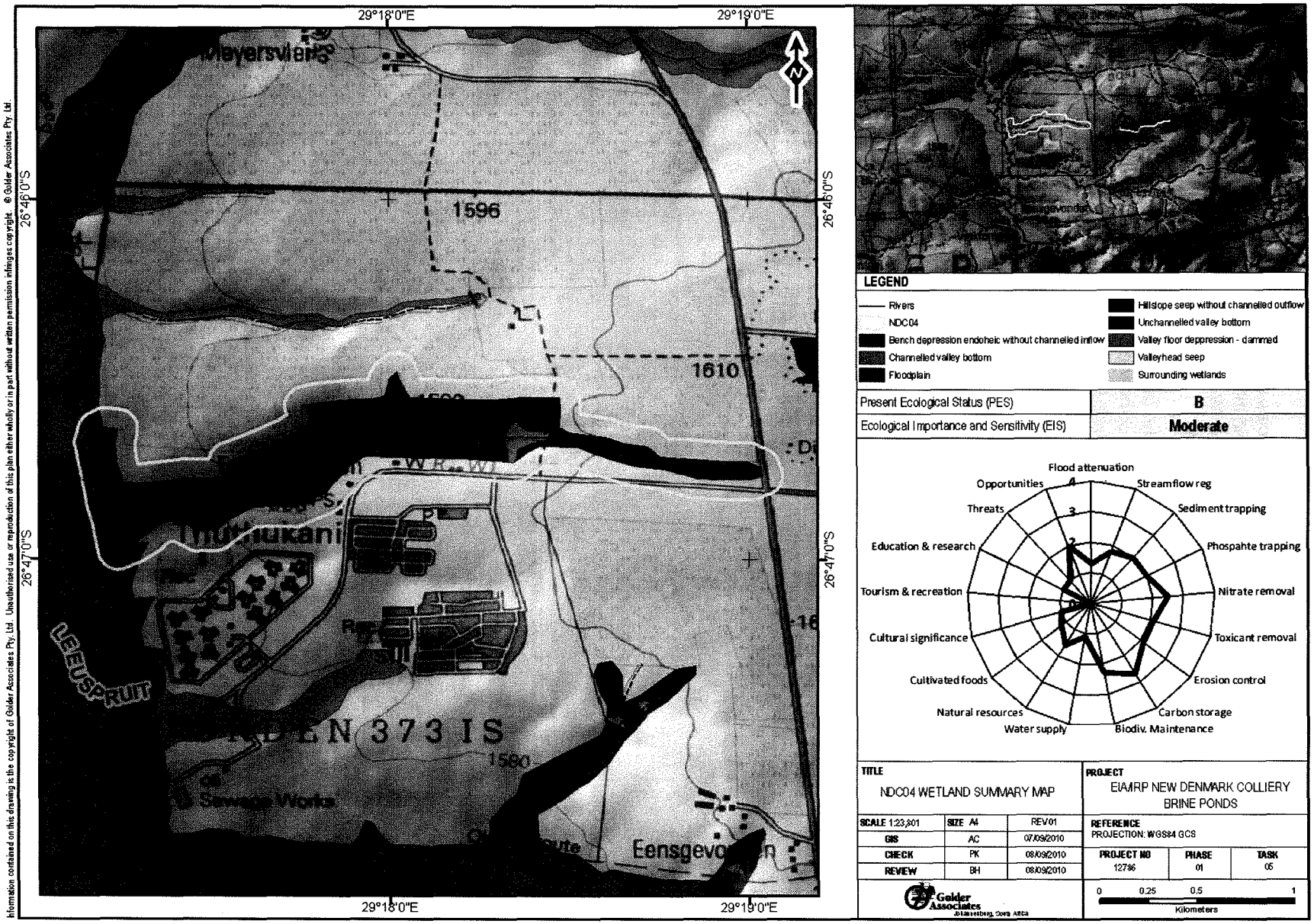





*Figure 16: Wetland unit NDC04 summary map*

### 7.2.5 Wetland Unit NDC05

Wetland unit NDC05 consists of a broad floodplain forming part of the Leeuspruit (Figure 19). Within the floodplain were floodplain depressions, alluding to previous courses of the main channel. The wetland unit is situated approximately 4 km away from the proposed development and is 140 ha in size.

The wetland vegetation was relatively diverse with a number of grass species recorded despite the diminished grass sward due to the time of year. Although *Hyparrhenia hirta* and *Themeda trindra* were noted as the more dominant species, other species such as *Aristida congesta subsp. Congesta* and *A. adscensionis, Setaria sphacelata var. sphacelata* and *S.sphacelata var. torta* were well represented. In the floodplain depressions wetland indicator species such as *Imperata cylindrical* and the sedges *Cyperus dives and C. longus* were dominant. Weedy species such as *Circium vulgare* and *Gomphocarpus fruticosus* were present, but not in any great quantities. Of particular interest was the recording of *Euphorbia clavaroides* (Vingerpol) which is not often seen (Figure 18).

Birdlife at the site was moderate, however the site was sampled during the middle of the day which is not ideal for recording birds. Bird species observed at the site included *Macronyx croceus* (Yellowthroated longclaw), *Saxicola torquata* (Common stonechat), *Aphus horus* (Horus swift), *Bostrychia hagedash* (Hadeda ibis), *Francolonis Swainsonii* (Swainson's francolin), *Anas sparsa* (African black duck), and *Euplectes progne* (Longtailed widow). No reptiles, mammals, or amphibians were observed during the survey. Spoor of the mammal species *Atilax paludinosis* (Water mongoose) and *Aonyx capensis* (Cape clawless otter) were observed along the channel banks. The butterfly *Acraea eponina eponina* (Small orange butterfly) was also recorded.

Existing impacts on the wetlands in this unit are largely due to agricultural activities (cropping and grazing) (Figure 13).An impoundment in the form of a low stone bridge has caused damming upstream. Bank erosion was noted upstream of the stone bridge.

The site was assessed to have an PES class of A/B and moderate EIS. The wetland unit provides moderate natural services and low human services.

*Figure 17: Photograph of the floodplain within wetland unit NDC05*

*Figure 18: Photograph of Euphorbia clavaroides (Vingerpol)*

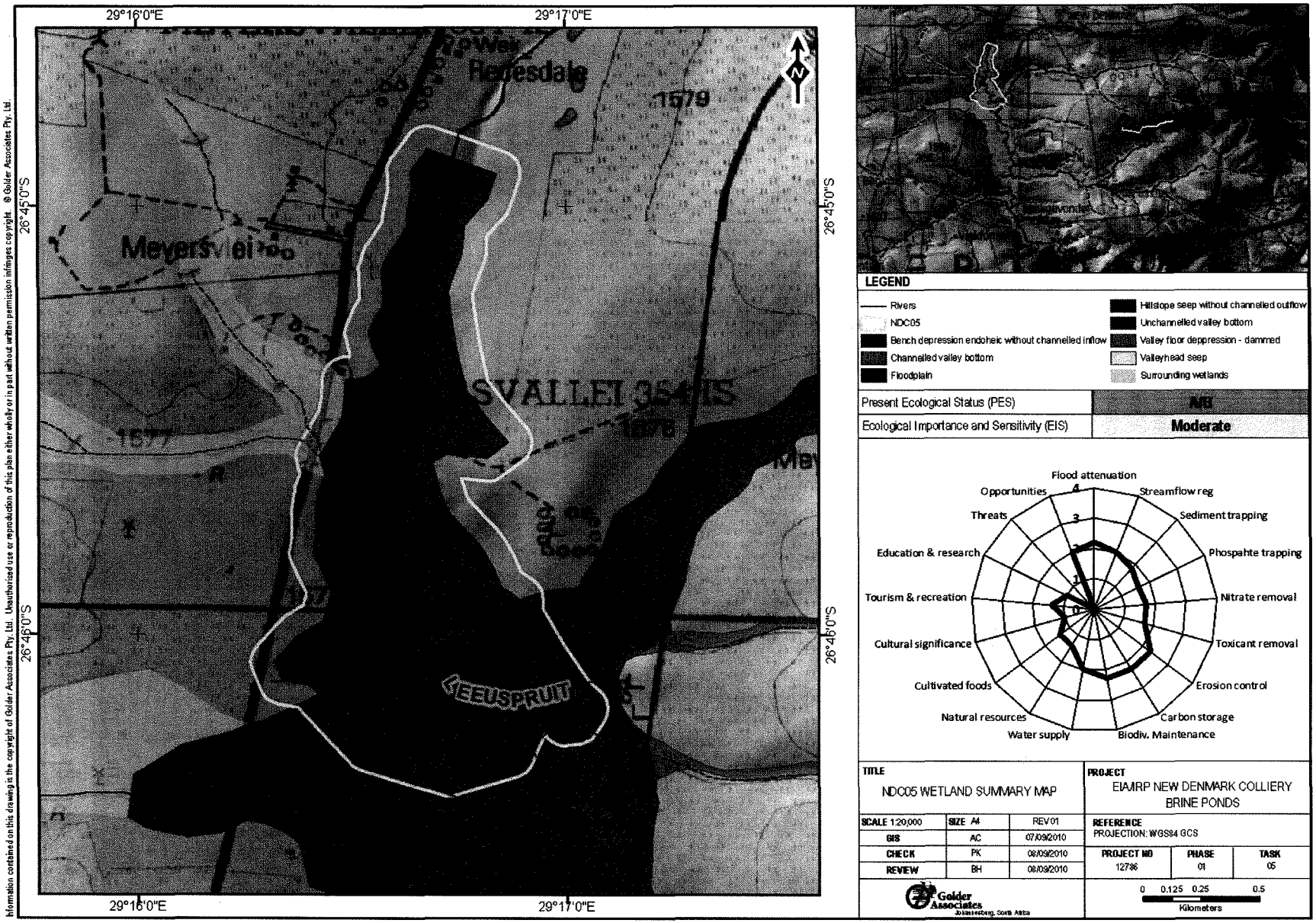





*Figure 19: Wetland unit NDC05 summary map*

### 7.2.6 Wetland Unit NDC06

Wetland unit NDC06 consists of four wetland types but is mostly made up of a channelled valley bottom wetland and a floodplain (Figure 21). There are two dams and some valley head seeps on the tributaries feeding the main channel. The wetland unit is situated approximately 100 m from the proposed development and with the main part of the wetland unit approximately 2 km away, and is 162 ha in size.

The wetland vegetation was moderately diverse with mostly hardy grass species such as *Hyparrhenia hirta* and *Themeda trindra* recorded. Also noted were *Eragrostis curvula*, *Sporobolus africanus*, *Panicum maximum*, and *Setraria sphecelata var. torta.* Hydrophitic plants like *Cyperus longus* and *Typha capensis* were recorded in the more permanent zones and along the banks of the channel. Some exotic and / or weedy species were observed such as *Circium vulgare*, *Verbena bonariensis, and Tagetes minuta.* The invasive woody species *Salix babylonica* and *Populus xcanesense* (Weeping willow and Poplar tree) were noted along the channel banks (Figure 20).

Birdlife was similar to that of wetland unit NDC04 with species such as *Ardea melanocephala* (Black-headed heron), *Euplectes progne* (Longtailed widow),*Vanellus armatus* (Blacksmith plover), and *Saxicola torquata* (Common stonechat) observed. Common species such as *Motacilla capensis* (Cape wagtail), *Ploceus velatus* (Southern Masked weaver), and *Moticola rupestris* (Cape rock thrush) were also recorded. No mammals, amphibians, or reptiles were seen during the survey.

Existing impacts on the wetlands in this unit are largely due to agricultural activities (cropping and grazing) and impoundments such as dams and roads. The site was assessed to have a PES class of B and moderate EIS. The wetland unit provides moderate to low natural services and low human services.

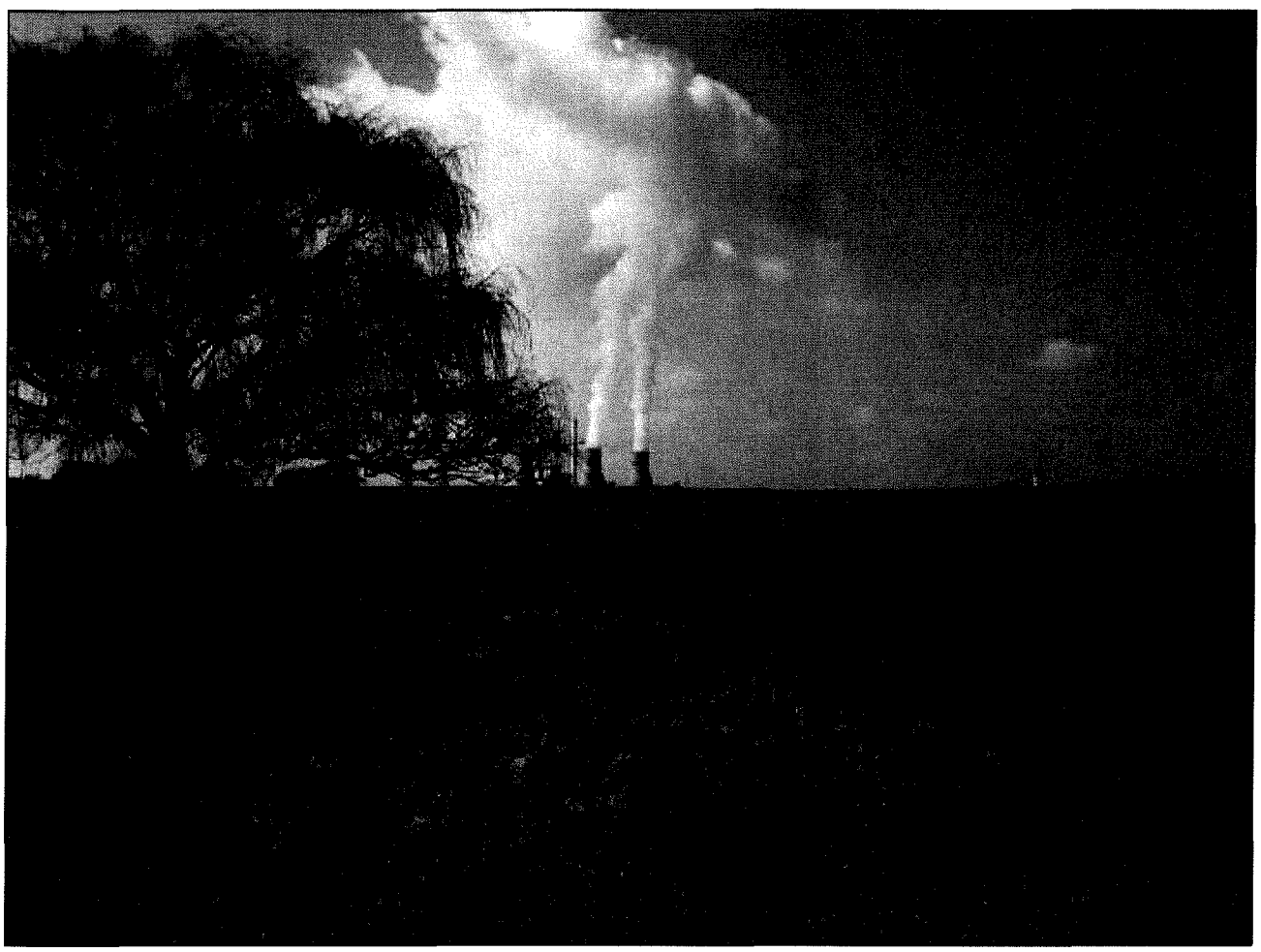


*Figure 20: Photograph of the channelled valley bottom within wetland unit NDC06*

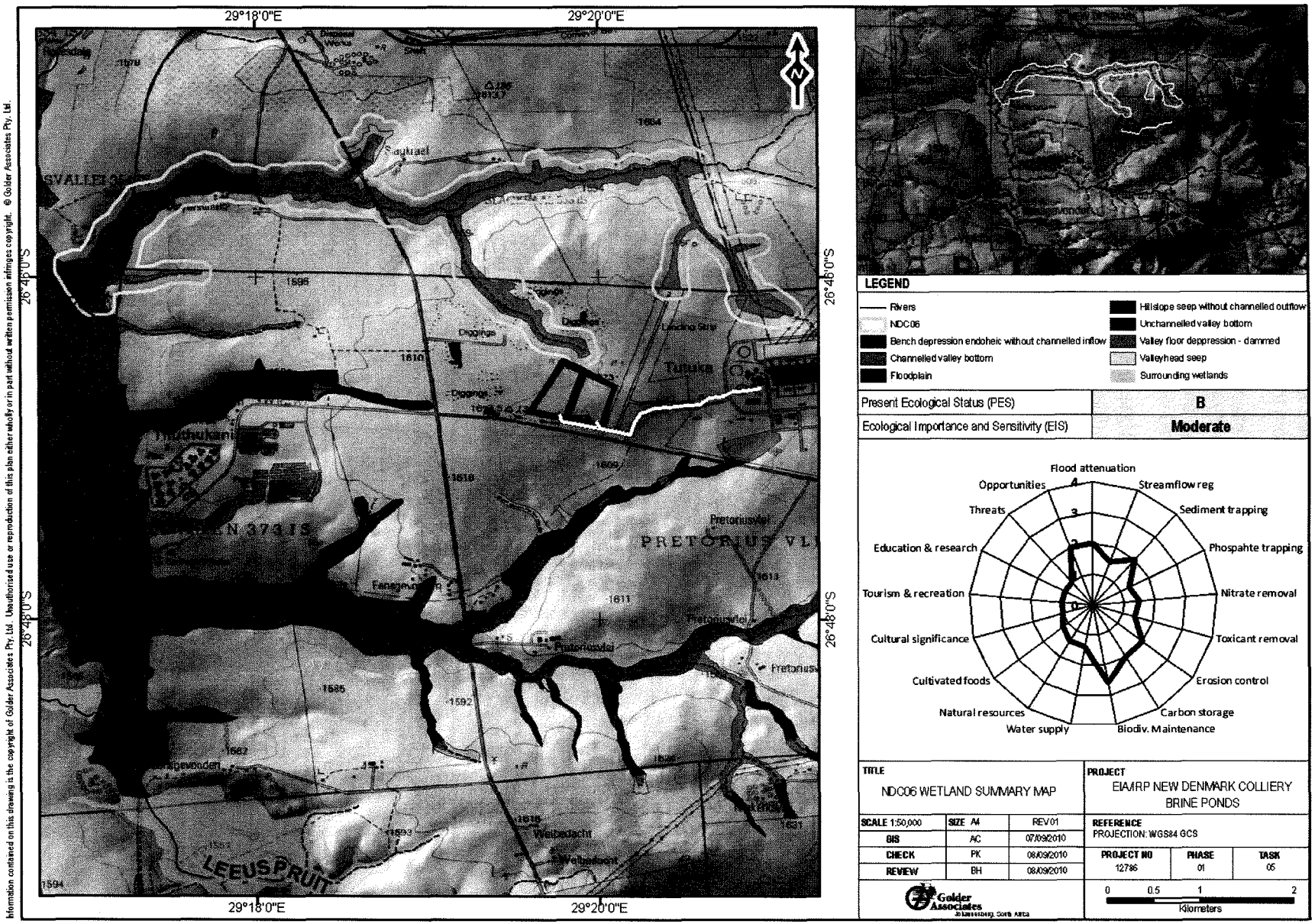





*Figure 21: Wetland unit NDC06 summary map*

### 7.2.7 Wetland Unit NDC07

Wetland unit NDC07 consists of four wetland types but is mostly made up of the Leeuspruit floodplain (Figure 23). Floodplain depressions are seen throughout the floodplain, indicating a well established system. Some hillslope seepage, and channelled and unchanneled valley bottoms also form part of the wetland unit. The wetland unit is situated approximately 4 km away from the proposed development and is 540 ha in size.

The wetland vegetation was found to have good, dense plant growth mostly in the form of grasses such as *Digitaria eriatha*, *Imperata cylindrical*, *Cynodon dactylon*, *Eragrostis tef*, and *E. curvula* (Figure 22). Also in abundance were the hardy species like *Themeda triandra* and *Hyparrhenia hirta*. Wetland indicator species such as *Cyperus longus* and *Schoenoplectus brachyceras* were noted in the permanent zones.

Birdlife at the site was similar to that of wetland units NDC04 and NDC05. Common species such as *Euplectes progne* (Longtailed widow), *Vanellus armatus* (Blacksmith plover), *Saxicola torquata* (Common stonechat), and *Ardea melanocephala* (Black-headed heron) were observed. Also seen was *Anhinga rufa* (African Darter) and *Anas undulata* (Yellowbilled duck). *Aonyx capensis* (Cape clawless otter) tracks were recorded along the banks of the Leeuspruit. No amphibians or reptiles were seen during the survey.

Existing impacts on the wetlands in this unit are largely due to agricultural activities (cropping and grazing) and impoundments such as dams and roads. The site was assessed to have an PES class of A/B and moderate EIS. The wetland unit provides moderate to low natural services and low human services.

*Figure 22: Photograph of the floodplain within wetland unit NDC07*

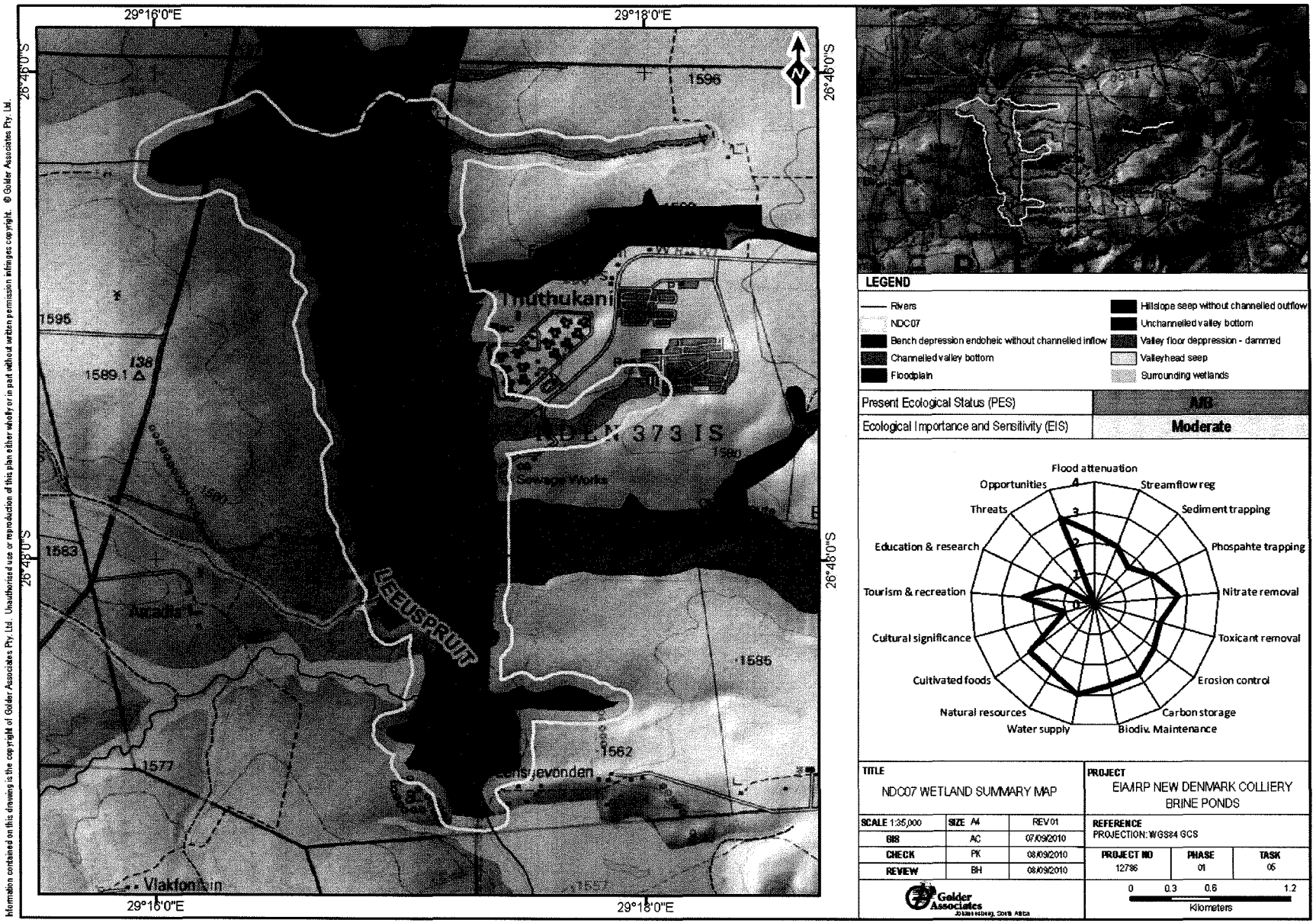





*Figure 23: Wetland unit NDC07 summary map*

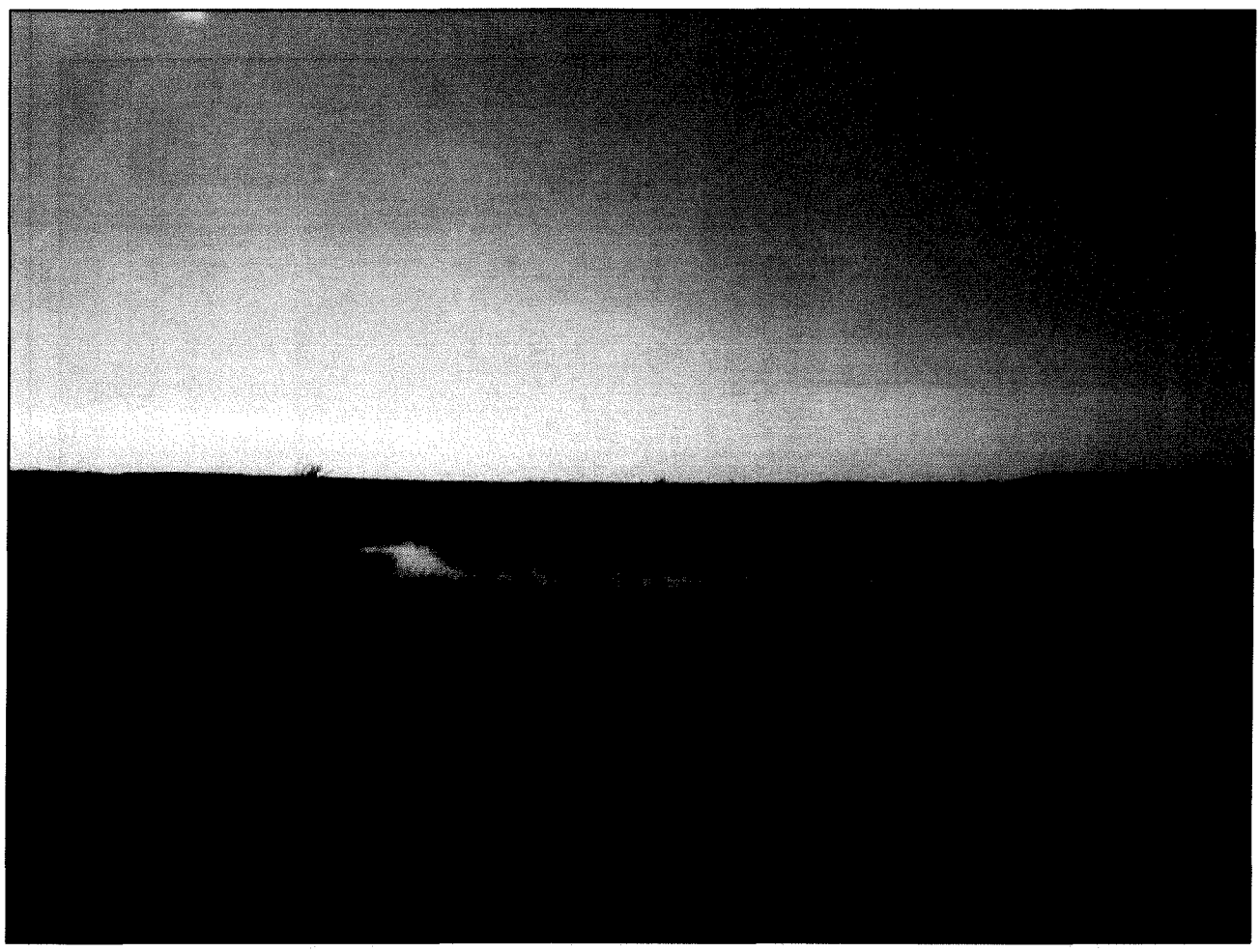
### 7.2.8 Wetland Unit NDC08

Wetland unit NDC08 consists of a number of small artificial wetlands that are the result of diggings. Under the classification system as described by SANBI (2009) these would be classified as endorheic depressions without any channelled outflow, located on a bench in the landscape. The wetland unit is situated approximately 800 m or less away from the proposed development, with the development impeding on some of the wetland areas. The total size of the wetland unit is 4.7 ha in size.

The site has been impacted by grazing and small scale earth works. The vegetation community was dominated by *Themeda triandra*, *Hyparrhenia hirta*, and *Eragrostis* species with weeds such as *Gomphocarpus fruticosus* (Milkweed), *Tagetes minuta* (Khakibos), *Bidens formosa* (Cosmos), and *Bidens bipinata* (Blackjack) in relative abundance. Robust wetland species such as *Typha capensis*, *Schoenoplectus paludicola,* and *Phragmites australis* were recorded in the depressions.

Birdlife at the site was moderate and included *Macronyx capensis* (Orange throated longclaw), *Ardea melanocephala* (Black-headed heron), *Francolonis Swainsonii* (Swainson's francolin), *Burhinus capensis* (Spotted dikkop), *Numeda meleagris* (Helmeted guinea fowl), *Anas sparsa* (African black duck), and *Elanus caeruleus* (Blackshouldered kite) (cf). An adult and juvenile *Sylvicapra grimmia* (Grey duiker) were also recorded within this wetland unit.

The depressions were found to have a Moderate PES [using the methodology as described in DWAF (1999a)] and a low/marginal EIS. The wetlands at NDC08 provide very little human or natural services with the provision of habitat as a service to biodiversity the only real service of note.



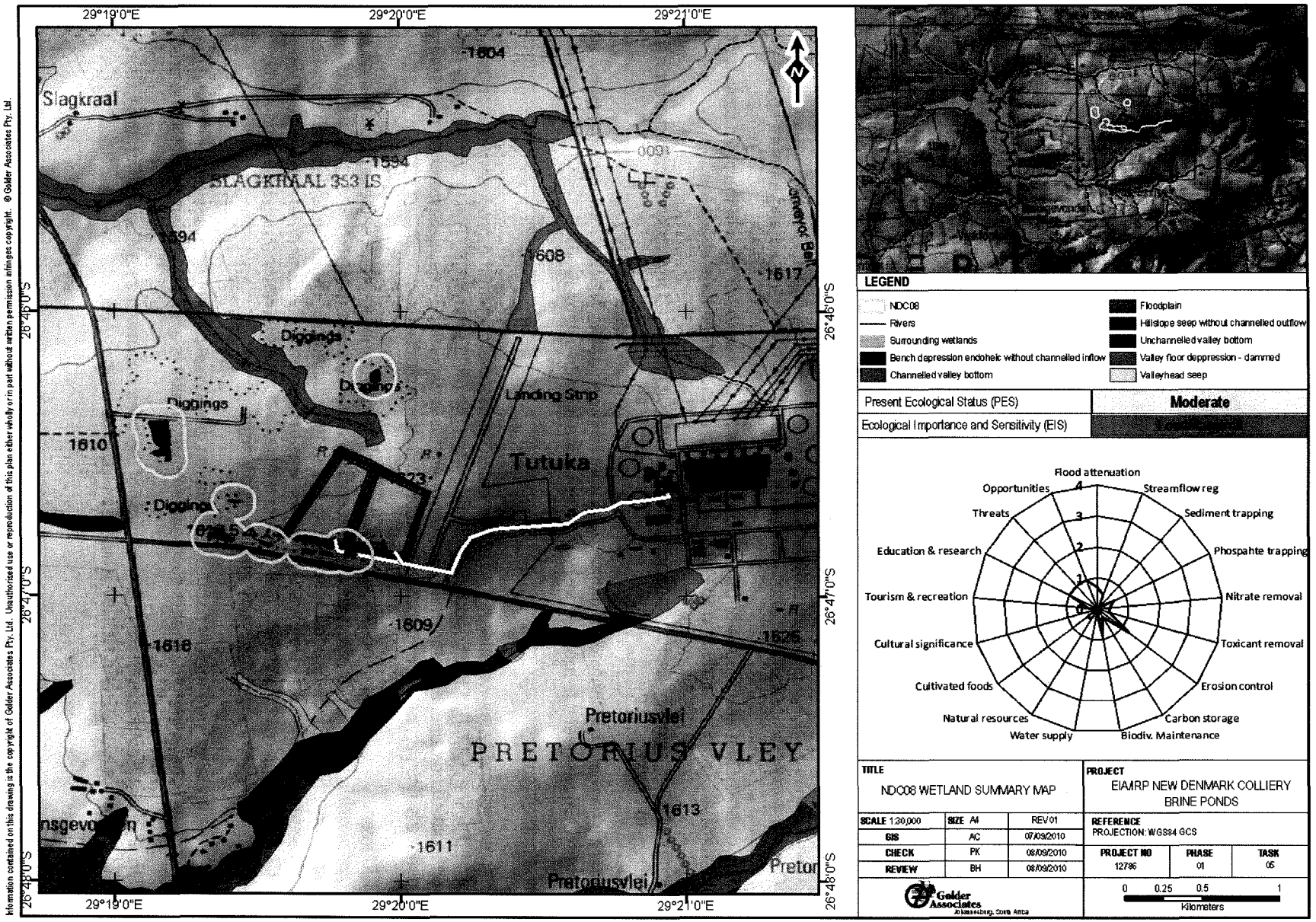





*Figure 24: Wetland unit NDC08 summary map*

## 7.3 Baseline conclusions

The following conclusions were reached based on the baseline assessment results of the aquatic and wetland ecosystems associated with the proposed evaporation ponds:

Aquatic ecosystems:

- The pH in the Leeuspruit increased from 8.7 at site NDC5 to 10.0 at site NDC7. The pH at site NDC7 exceeds the recommended guideline level and may have a limiting effect on aquatic biota at the site. The cause of the increase in pH is unknown;
- The saturation and high oxygen levels recorded at site NDC7 may be limiting to aquatic biota if persistent;
- The availability of habitats for aquatic macroinvertebrates was poor at all the sites except site NDC7 where the habitat was fair / adequate. The poor IHAS scores were attributed to low flow conditions (and variability), eroded channel banks, uniform marginal vegetation and limited variety of substrate types ;
- The aquatic macroinvertebrates diversity was similar at all the sites;
- Aquatic macroinvertebrate data indicated that biotic integrity ranged from moderately modified to largely natural. Site NDC5, which scored as fair (moderately modified), displayed poor habitat availability and was further impacted by cattle watering;
- Of the 11 expected fish species, six species were recorded during the baseline surveys. The fish assemblages at all the sites were dominated by *Barbus anoplus* (Chubbyhead Barb) and *Pseudocrenilabrus philander* (Southern Mouthbrooder), both widespread and tolerant species;
- The diversity and abundance of fish species at site NDC6 was lower than in the main stream of the Leeuspruit. This was attributed to low flow conditions and limited habitat availability;
- Ichthyofaunal diversity and abundance in the Leeuspruit increased in a downstream direction from site NDC5 to NDC7;
- *Clarias gariepinus* (Sharptooth catfish) was only recorded at site NDC5, however skeletal remains at site NDC6 suggest it is more widespread during the high flow season.

Wetland ecosystems:

- Seven wetland types were identified in the wetlands associated with the proposed evaporation ponds and pipeline. Of these the floodplain wetlands were the most prominent. These were largely fed by channelled and unchanneled valley bottom wetlands and hillslope seeps. Seventeen dams were delineated as part of the wetlands associated with the project area.
- Biodiversity was found to be moderate with mostly hardy/common grass and plant species and common bird species present. Of note was the presence of *Asio capensis* (Marsh owl) at NDC04 and *Ardea melanocephala* (Black-headed heron) throughout the study area. These birds depend on wetland ecosystems for their survival. Also of interest was the recording of *Euphorbia claveroides* (Vingerpol) at NDC05, as it is not often seen. The presence *Atilax paludinosis* (water mongoose) and *Aonyx capensis* (Cape clawless otter) in the study area is note worthy.
- Existing impacts were mainly habitat degradation due to agricultural activities (cropping and grazing). Inundation due to impoundments such as dams and roads is also a common impact in the area;
- The Present Ecological State (PES) of most of the sites was rated as a class B with the exception of wetland units NDC05 and NDC07 which was rated as a class A/B;

- The Environmental Importance and Sensitivity (EIS) of the wetland units was found to be moderate with the exception of NDC08 which was ranked as low/marginal.
- Natural ecosystem services supplied by the wetlands were generally moderate to low, while human services were generally moderate to low.

# 8.0 IMPACT ASSESSMENT

## 8.1 Identification of potential impacts

Impacts associated with the construction and operation of the evaporation ponds, are identified below. These impacts would be on the aquatic and wetland ecosystems of the Leeuspruit and associated tributaries, and include impacts on water quality, habitat, and biotic. The significance of the identified impacts will be determined incorporating two aspects namely occurrence and severity, which will be further subdivided as below (DEAT 2002).

| **Occurrence** | | **Severity** | |
|---|---|---|---|
| *Probability of occurrence* | *Duration of occurrence* | *Magnitude (severity) of impact* | *Scale / extent of impact* |

### 8.1.1 Water quality impacts

#### *Construction*

- Increased sedimentation within the water courses and wetland units as a result of the construction activities such as grading and excavation.
- Leaks or spillage of hydrocarbons;
- Dust generation.

#### *Operation*

- In the event of an accidental spill from either the evaporation ponds or pipeline high salinity water will enter the aquatic ecosystems impacting on water quality. This will have an impact on aquatic biota.

### 8.1.2 Habitat impacts

#### *Construction*

- Sedimentation and dust as a result of construction activities may result in increased sedimentation in the channel feeding into wetland unit NDC06 from surface water runoff.
- Habitat loss will occur in wetland unit NDC08. One of the artificial wetlands in wetland unit NDC08 will be destroyed due to the construction of the evaporation ponds and it is likely that two, possibly three others will also be affected by the construction. The artificial wetland has, however, little to no ecosystem function.

#### *Operation*

- Habitat impacts are considered to be minimal during the operational phase as the proposed locations of the evaporation ponds does not site within any drainage line and there are few disturbances to fauna and flora near the ponds during this phase.

### 8.1.3 Biotic changes

The water quality or habitat impacts discussed previously are likely to impact on the aquatic biota at the sites. This will impact on the diversity and abundance of the biota.

#### *Construction*

- Loss or decline of sensitive aquatic species as a result of water quality or habitat impacts;
- Increase in abundance of tolerant and invasive fish species; and
- Shift in community structure to favour tolerant taxa.

### *Operation*

- Biotic integrity should not be influenced during the normal operation of the evaporation ponds;
- Seepage and accidental spills as described above will have negative impacts on water quality and possible habitat thus influencing biota.

### 8.1.4 Cumulative impact

When the proposed project is placed into the context of the surrounding areas and catchments it is not anticipated that the proposed construction and operation of the brine dams will have a negative cumulative impact on the aquatic and wetland ecosystems associated with the project.

## 8.2 Mitigation and monitoring

### 8.2.1 Avoidance

The following measures have been put forward in order to avoid any environmental impacts on the aquatic and wetland ecosystems:

- Prevention of runoff from site entering surrounding ecosystems, particularly the channelled valley bottom to the north of the proposed brine pond. Suitable storm water management, erosion prevention and runoff control measures should be constructed and managed so as to prevent any runoff into the aquatic and wetland ecosystems;
- Exposed soils should be kept to a minimum;
- Prevent any hydrocarbons from entering the aquatic and wetland ecosystems. No oils or fuels from vehicles, machinery or generators should be allowed to enter the aquatic and wetland ecosystems, in the case of accidental spills, immediate clean-up action must be initiated to prevent further spread;
- Preservation of the surrounding ecosystems by adding a buffer zone and limiting unnecessary movement within these areas;
- Limit river and or wetland diversions, additional river and or wetland crossings, and invasive construction activities into river and or wetlands which may be required during the construction phase. Aim to utilise existing roads;
- Seepage and overflow from the evaporation ponds into the downstream ecosystems should be prevented during both the construction and operational phases;
- In order to avoid accidental spills from the proposed evaporation ponds, containment of accidental overflows or spills should be prepared for;

### 8.2.2 Minimization

The following mitigations are suggested in order to minimise the identified impacts on the aquatic and wetland ecosystems:

- All construction and clearing should take place in the necessary designated areas;
  - Construction vehicles and personal should be restricted from entering unnecessary areas, especially wetland and riparian buffer zones, including streams and rivers;
  - Implement best practices for construction, whereby waste, degradation or destruction of the aquatic and wetland ecosystems is minimised or prevented;
  - Dust suppressant should be used during the construction phase on all areas where dust is likely to be generated, so as to minimise the fallout of dust onto the aquatic ecosystem vegetation;

- All construction and clearing should be done in the dry season, so as to minimise surface water runoff of sediments or contaminants into the surrounding ecosystems;
- Silt traps should be put in all drainage areas where silt or sedimentation is likely to wash downstream as a result of the construction;
- The evaporation ponds and associated pipelines should be properly maintained so as to minimise the chance of spills or leaks of the contents into the aquatic and wetland ecosystems;

### 8.2.3 Rectification

It is important that all impacts identified during construction and operation be dealt with and rectified immediately:

- Rehabilitation of impacted areas (construction) should be done as soon as possible;
  - Rehabilitation should include reinstating natural vegetation in exposed areas, using indigenous vegetation that was found in the baseline assessments in consultation with specialists;
- Any spills or leaks (including seepage) which may occur should be contained to prevent downstream contamination and be cleaned up immediately;

While restoration of the original habitats and ecosystem functioning is often not possible, it is extremely important to realise that the correct implementation and execution of the impact avoidance and minimization process will makes rectification more achievable.

### 8.2.4 Reduction

- Implementing long-term monitoring programs for all disciplines of the surrounding ecosystems will further help to identify possible impacts which may arise;
  - Water quality;
    - Sediments during construction;
  - Wetland and riparian systems;
  - Aquatic biota;
  - Possibility of any seepage;
- Wetting of dirt roads with water on a daily basis or sealing with dust sealant will reduce dust fallout within the area,
  - Placing speed limits on all dirt roads within the project area;
  - Vehicle and construction activity near the aquatic and wetland ecosystems should be kept to a minimum;

In order to effectively reduce the identified impacts monitoring and management of all aspects of the aquatic and wetland ecosystems during the construction, operation and closure phases is required. Local or unforeseen impacts can therefore be identified and mitigated immediately and the effects monitored. This process will result in a reduction in impact.

### 8.2.5 Compensation

No compensation measures were considered necessary for this project. If the correct construction methods are used and the recommended avoidance and minimisation techniques implemented, the impact of the proposed evaporation ponds on surrounding wetland and aquatic ecosystems is expected to be low.

## 8.3 Impact Ranking

The potential impacts described in section 8.1 were assessed according to the methodology as described by DEAT (2002). The significance of the potential impacts was assessed before and after the application of the mitigation measures described in section 8.2. Table 21 shows the results of the impact significance ranking.

**Table 21: Significance of the identified impacts on the aquatic and wetland ecosystems associated with the proposed evaporation ponds and pipeline**

| | Before mitigation | | | | | | | After mitigation | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Description of impact** | Magnitude | Duration | Scale | Probability | Score | Significance rating | **Mitigation measures** | Magnitude | Duration | Scale | Probability | Score | Significance rating |
| **Construction-related impacts** | | | | | | | | | | | | | | |
| Smothering of aquatic and wetland biota due to increased sedimentation | 6 | 2 | 2 | 3 | 30 | M | **Avoidance** - Sedimentation of the aquatic and wetland ecosystems during the construction period should be avoided where possible and the prevention of runoff from site entering aquatic and wetland ecosystems be implemented; **Minimization** - Clear only areas necessary for immediate construction All construction should take place in the dry season. Construction vehicles and personnel should be restricted to the construction site. Silt traps should be put into place where runoff of silt or sedimentation is likely to occur as a result of the construction. Sediment traps should be erected around wetland unit NDC06 in particular; **Rectification** - Rehabilitation of impacted areas should be done in conjunction with the construction process; **Reduction** - monitoring of sediment loads and water quality in the adjacent and downstream aquatic and wetland ecosystems will allow for early warning of any potential problems. Wetting of dirt roads and placing speed limits within the project area will reduce dust. Vehicle and construction activity near the aquatic and wetland ecosystems should be kept to a minimum; **Compensation** - N/A | 4 | 1 | 1 | 2 | 12 | L |

| | Before mitigation | | | | | | | After mitigation | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Description of impact** | Magnitude | Duration | Scale | Probability | Score | Significance rating | **Mitigation measures** | Magnitude | Duration | Scale | Probability | Score | Significance rating |
| Smothering of aquatic and wetland biota due to increased dust generation | 4 | 1 | 1 | 3 | 18 | L | **Avoidance** - N/A; **Minimization** - limit clearing and clear only areas necessary for immediate construction, all construction and clearing should be done in the dry season, construction vehicles and personnel should be restricted from entering wetland and riparian buffer zones, including the streams and rivers; **Rectification** - Rehabilitation and the re-implementation of natural vegetation of exposed areas, using indigenous vegetation; **Reduction** - wetting of dirt roads with water on a daily basis or sealing with dust sealant, placing speed limits on all dirt roads within the project area; vehicle and construction activity near the aquatic and wetland ecosystems should be kept to a minimum; **Compensation** - N/A | 2 | 1 | 1 | 2 | 8 | L |
| Contamination of aquatic and wetland ecosystems due to spillage of oils and hydrocarbons from machinery | 4 | 1 | 1 | 2 | 12 | L | **Avoidance** - Prevent any oils or hydrocarbons from entering the aquatic and wetland ecosystems. Conduct maintenance and regular check-ups to eliminate any vehicles, machinery or generators from spilling contaminants. **Minimization** - Implement best practices for construction, construction vehicles and personnel should be restricted from entering wetland and riparian buffer zones, including the streams and rivers; **Rectification** - Any spills or leaks should be contained and addressed immediately. **Reduction** - Vehicle and construction activity near the wetland and aquatic ecosystems should be kept to a minimum. **Compensation** - N/A | 2 | 1 | 0 | 1 | 3 | L |

| | Before mitigation | | | | | | | After mitigation | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Description of impact** | Magnitude | Duration | Scale | Probability | Score | Significance rating | **Mitigation measures** | Magnitude | Duration | Scale | Probability | Score | Significance rating |
| Loss of aquatic and wetland species diversity due to disturbance to the local environment | 6 | 3 | 2 | 2 | 22 | L | **Avoidance** - N/A; **Minimization** - All construction and clearing should be done in the dry season, so as to minimize surface water runoff of sediments or contaminants into the aquatic ecosystems. Implement good construction practices, whereby waste, degradation or destruction of the aquatic and wetland ecosystems is minimized or prevented. Construction vehicles and personnel should be restricted from entering wetland and riparian buffer zones, including the streams and rivers; **Rectification** - Rehabilitation of impacted areas should be done as soon as possible. Any spills or leaks should be contained to prevent downstream contamination and be cleaned up immediately; **Reduction** - Vehicle and construction activity near the wetland and aquatic ecosystems should be kept to a minimum. Noise and vibration levels should be kept to a minimum during the construction phase. Institute a long-term habitat biomonitoring programme to monitor the success of habitat rehabilitation; Mitigate further impacts; **Compensation** - N/A | 4 | 3 | 2 | 2 | 18 | L |

| | Before mitigation | | | | | | | After mitigation | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Description of impact** | Magnitude | Duration | Scale | Probability | Score | Significance rating | **Mitigation measures** | Magnitude | Duration | Scale | Probability | Score | Significance rating |
| Change in species abundances and shifts in community structure due to disturbances | 6 | 3 | 2 | 2 | 22 | L | **Avoidance** - Preservation of the surrounding environment as well as creating an adequate buffer will prevent any degradation of the functioning ecosystems. Sedimentation and contamination as mentioned above should be avoided as to not impact on the surrounding ecosystems. Limit river and or wetland crossings, and invasive construction activities into river and or wetlands which may be required during the construction phase. Discharge from the dams into the surrounding environment should not be allowed; **Minimization** - All construction and clearing should be done in the dry season, so as to minimize surface water runoff of sediments or contaminants into the aquatic ecosystems. Implement good construction practices, whereby waste, degradation or destruction of the aquatic ecosystems is minimized or prevented. Construction vehicles and personnel should be restricted from entering wetland and riparian buffer zones, including the streams and rivers; **Rectification** - Rehabilitation of impacted areas should be done as soon as possible. Any spills or leaks should be contained to prevent downstream contamination and be cleaned up immediately; **Reduction** - Vehicle and construction activity near the wetland and aquatic ecosystems should be kept to a minimum. Institute a long-term habitat biomonitoring program to monitor the success of | 4 | 3 | 2 | 2 | 18 | L |

| | Before mitigation | | | | | | | After mitigation | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Description of impact** | Magnitude | Duration | Scale | Probability | Score | Significance rating | **Mitigation measures** | Magnitude | Duration | Scale | Probability | Score | Significance rating |
| | | | | | | | habitat rehabilitation; Mitigate further impacts; **Compensation** - N/A | | | | | | |
| Loss of artificial wetland habitat | 4 | 5 | 1 | 4 | 40 | M | **Avoidance** - N/A **Minimization** - Keep impacts to the artificial wetland habitats located close to the footprint of the evaporation ponds to a minimum. Conduct a search and rescue operation of the wetlands that will be destroyed in order to rescue any fauna and flora of conservation importance **Rectification** - N/A; **Reduction** N/A; **Compensation** - N/A. | 4 | 5 | 14 | | 40 | M |
| **Operational-related impacts** | | | | | | | | | | | | | |

| | Before mitigation | | | | | | | After mitigation | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Description of impact** | Magnitude | Duration | Scale | Probability | Score | Significance rating | **Mitigation measures** | Magnitude | Duration | Scale | Probability | Score | Significance rating |
| Increased TDS concentrations due to spills or leaks | 10 | 2 | 3 | 3 | 45 | M | **Avoidance** - Prevention of runoff from site entering aquatic and wetland ecosystems. Suitable storm water management, erosion prevention and runoff control measures should be constructed and managed so as to prevent any runoff into the aquatic and wetland ecosystems. Early warning overflow systems should be monitored. An investigation as to whether seepage is occurring should be conducted. Measures for containment of accidental overflow or spill should be implemented around the proposed evaporation ponds; **Minimization** - All pipelines and the proposed evaporation ponds should be properly maintained, so as to minimize the risk of spills or leaks of contaminated water from entering the surrounding ecosystems; **Rectification** - Any spills or leaks should be contained to prevent downstream contamination and be cleaned up immediately; **Reduction** - Monitor the water quality within the surrounding environment as well as the levels of the dams, on a regular basis. Institute a long-term biomonitoring program of the health of the surrounding ecosystems as to detect any trends which may arise; **Compensation** - N/A | 8 | 2 | 2 | 2 | 24 | L |

| | Before mitigation | | | | | | | After mitigation | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Description of impact** | Magnitude | Duration | Scale | Probability | Score | Significance rating | **Mitigation measures** | Magnitude | Duration | Scale | Probability | Score | Significance rating |
| Seepage from evaporation ponds | 6 | 4 | 2 | 3 | 36 | M | **Avoidance** - Prevention of seepage into the surrounding aquatic and wetland ecosystems. Suitable lining and maintenance of the evaporation ponds should be implemented. Monitoring of the surrounding environment will serve as an early warning mechanism if such a leak did occur. An investigation as to whether seepage is occurring should be conducted. ; **Minimization** - All pipelines and the proposed evaporation ponds should be properly maintained, so as to minimize the risk of spills or seepage of contaminated water from entering the surrounding ecosystems; **Rectification** - Any seepage which is detected should be contained to prevent downstream contamination and be cleaned up immediately; **Reduction** - Monitor the water quality within the surrounding environment as well as the levels of the dams, on a regular basis. Institute a long-term biomonitoring program of the health of the surrounding ecosystems as to detect any trends which may arise; **Compensation** - N/A | 4 | 2 | 1 | 2 | 14 | L |

# 9.0 CONCLUSIONS AND RECOMMENDATIONS

The following conclusions were reached based on the impact assessment of the proposed evaporation ponds and associated pipelines on the aquatic and wetland ecosystems:

- There will be loss of wetland habitat at one of the artificial wetlands. The artificial wetland has, however, little to no ecosystem function;
- All of the identified impacts associated with the proposed project were rated as low to moderate before mitigation and, if mitigated, would result in low impacts;
  - Surface runoff carrying sediment away from the construction site and into the surrounding environment was identified as a moderate impact prior to mitigation;
  - Increase TDS levels as a result of seepage or spillage was identified as a moderate impact and the highest concern to the aquatic ecosystems prior to mitigation;
- No impacts associated with the project were rated as highly significant;
- Most of the impacts were related to the construction phase of the project, with operational phase maintenance and risk impacts, been identified; and
- All of the mitigation measures developed and proposed are feasible and should be implemented in order to mitigate the impacts.

Based on the conclusions of the impact assessment, the following recommendations are made:

- Implementation of a long-term monitoring program of the surrounding ecosystems. This will increase the understanding of the surrounding ecosystems and help identify possible impacts which may arise. Parameters to be monitored include:
  - *In situ* water quality;
    - Sediments during construction;
  - Wetland and riparian systems;
  - Aquatic Biomonitoring
    - Ichthyofauna;
    - Aquatic Macroinvertebrates;
    - Diatoms
  - Seepage and overflow from the proposed evaporation ponds.

## Implications for proposed New Denmark Colliery evaporation ponds

The significance of the impacts of the proposed construction and operation of the two evaporation ponds and associated pipeline on the aquatic and wetland ecosystems are expected to be moderate to low, and, if mitigated effectively, will result in a low impact.

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| | | |
|---|---|---|
| W. Aken<br>Group Leader: Aquatics | A. Cochran<br>Group Leader: Wetlands | P. Kimberg<br>Divisional Leader: Ecology<br>Reviewer |

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Reg. No. 2002/007104/07

# APPENDIX A

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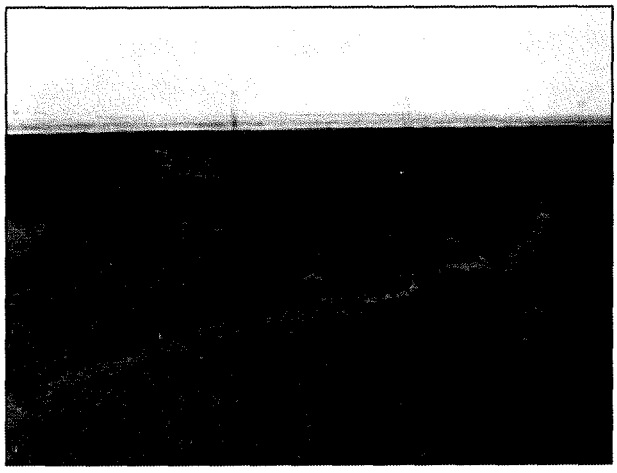
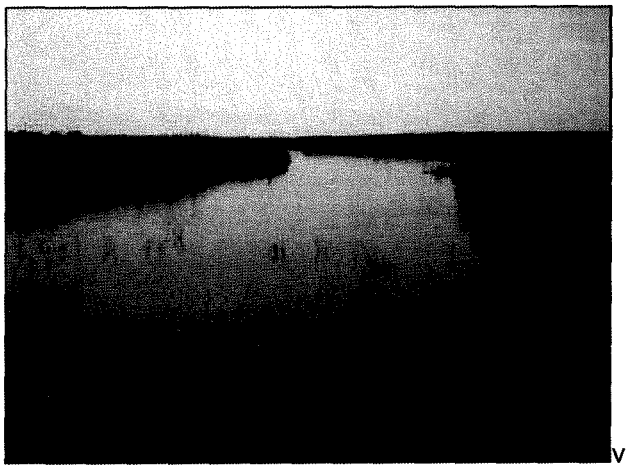
# APPENDIX B

## Site Photographs

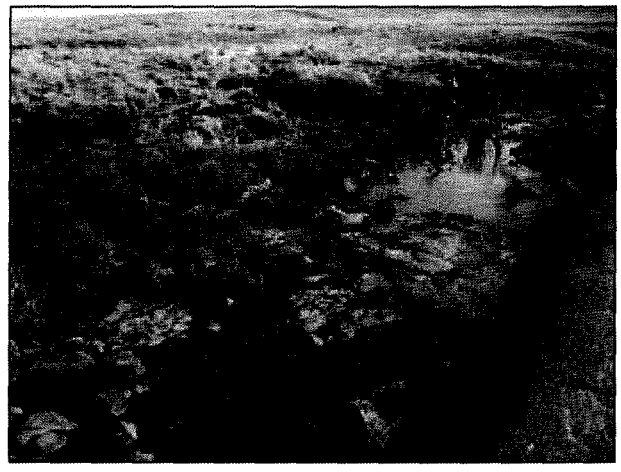


**NDC4** – Upstream (Taken by A. Cochran – 30/08/2010)

**NDC4** – Downstream (Taken by A. Cochran – 30/08/2010)



**NDC5** – Upstream (Taken by A. Cochran – 30/08/2010)



**NDC5** – Downstream (Taken by A. Cochran – 30/08/2010)

**NDC6** – Upstream (Taken by A. Cochran – 30/08/2010)

**NDC6** – Downstream (Taken by A. Cochran – 30/08/2010)

**NDC7** – Upstream (Taken by A. Cochran – 30/08/2010)

**NDC7** – Downstream (Taken by A. Cochran – 30/08/2010)

# APPENDIX C

## Aquatic Macroinvertebrate Data

November 2010
Report No. 12786-9954-4

Golder Associates

| Aquatic macroinvertebrate taxa | August 2010 | | | April 2010 | | |
|---|---|---|---|---|---|---|
| | NDC5 | NDC6 | NDC7 | TuA04 | TuA05 | TuA06 |
| **Turbellaria (Flatworms)** | | | A | | | |
| **ANNELIDA** | | | | | | |
| Oligochaeta (Earthworms) | A | B | | A | 1 | 1 |
| Hirudinea (Leeches) | | | | 1 | | |
| **CRUSTACEA** | | | | | | |
| Potamonautidae* (Crabs) | | | | A | | 1 |
| Atyidae (Freshwater Shrimps) | OBS | OBS | OBS | B | A | B |
| **Hydracarina (Mites)** | | B | | | | |
| **EPHEMEROPTERA (Mayflies)** | | | | | | |
| Baetidae 2 sp | B | B | | B | B | B |
| Baetidae > 2 sp | | | C | | | |
| Caenidae (Squaregills/Cainfles) | B | B | C | A | | A |
| Leptophlebiidae (Prongills) | 1 | | | | | |
| **ODONATA (Dragonflies & Damselflies)** | | | | | | |
| Coenagrionidae (Sprites and blues) | B | B | B | A | B | B |
| Lestidae (Emerald Damselflies/Spreadwings) | | | | 1 | A | 1 |
| Aeshnidae (Hawkers & Emperors) | | 1 | | 1 | A | |
| Gomphidae (Clubtails) | | | | | | |
| Libellulidae (Darters/Skimmers) | | | | 1 | A | 1 |
| **HEMIPTERA (Bugs)** | | | | | | |
| Belostomatidae* (Giant water bugs) | B | | | | A | |
| Corixidae* (Water boatmen) | | D | C | C | C | A |
| Gerridae* (Pond skaters/Water striders) | | | | A | B | A |
| Notonectidae* (Backswimmers) | A | A | A | 1 | A | A |
| Pleidae* (Pygmy backswimmers) | A | | | | 1 | |
| Veliidae/M...veliidae* (Ripple bugs) | | | | 1 | | 1 |
| **TRICHOPTERA (Caddisflies)** | | | | | | |
| Hydropsychidae 1 sp | A | | B | A | | |
| **COLEOPTERA (Beetles)** | | | | | | |
| Dytiscidae/Noteridae* (Diving beetles) | A | A | 1 | B | 1 | B |
| Elmidae (Riffle beetles) | 1 | | A | | | |
| Gyrinidae* (Whirligig beetles) | | | A | | | |
| Hydrophilidae* (Water scavenger beetles) | | | | B | A | A |
| **DIPTERA (Flies)** | | | | | | |
| Ceratopogonidae (Biting midges) | B | B | | | 1 | |
| Chironomidae (Midges) | B | D | B | B | B | B |
| Culicidae* (Mosquitoes) | | | | | A | A |
| Dixidae (Dixid midge) | | B | | | | |
| Simuliidae (Blackflies) | 1 | | C | | | |
| **GASTROPODA (Snails)** | | | | | | |
| Ancylidae (Limpets) | | | 1 | | | |
| Physidae* (Pouch snails) | | A | | | A | |
| Planorbinae* (Orb snails) | | A | | | | A |
| **PELECYPODA (Bivalvies)** | | | | | | |
| Sphaeriidae (Pill clams) | A | | B | A | A | |
| Unionidae (Pearly mussels) | | | | | | |
| **SASS Score** | **76** | **75** | **77** | **86** | **91** | **72** |
| **No. of Taxa** | **16** | **15** | **15** | **19** | **19** | **17** |
| **ASPT** | **4.75** | **5.00** | **5.13** | **4.53** | **4.79** | **4.24** |

# APPENDIX D

## Fauna recorded during the wetland survey

November 2010
Report No. 12786-9954-4

Golder Associates

**Table 22: Birds recorded during the survey**

| Latin name | Common name | TuW04 | TuW05 | TuW06 | NDC4 | NDC5 | NDC6 | NDC7 | NDC8 |
|---|---|---|---|---|---|---|---|---|---|
| *Alopochen aegyptiacus* | Egyptian goose | x | x | | | | | | |
| *Anas sparsa* | African black duck | | | | | x | | | x |
| *Anas undulata* | Yellowbilled duck | | | x | | | | x | |
| *Anhinga rufa* | African darter | | | | | | | x | |
| *Apus horus* | Horus swift | | | | | x | | x | |
| *Ardea melanocephala* | Blackheaded heron | x | x | | x | | x | | x |
| *Asio capensis* | Marsh owl | | | | x | | | | |
| *Bostrychia hagedash* | Hadeda ibis | | | | | x | | | |
| *Bubulcus ibis* | Cattle egret | x | x | x | | | | | |
| *Burhinus capensis* | Spotted dikkop | | | | | | | | x |
| *Elanus caeruleus* | Blackshouldered kite | | | | x | | | | x |
| *Euplectes progne* | Longtailed widow | | | | x | x | x | | |
| *Francolinus swainsonii* | Swainson's francolin | | | | | x | | | x |
| *Fulica cristata* | Redknobbed coot | | | | | | | | |
| *Macronyx capensis* | Orange throated longclaw | | | | | | | | x |
| *Macronyx croceus* | Yellowthroated longclaw | | | | x | x | | | |
| *Motacilla capensis* | Cape wagtail | | | | | | x | | |
| *Moticola rupestris* | Cape rock thrush | | | | | | x | | |
| *Numeda meleagris* | Helmeted guineafowl | | | | | | | | x |
| *Phoenicopterus minor* | Lesser flamingo | | | | | | | | |
| *Ploceus velatus* | Southern masked weaver | | | | | | x | | |
| *Ploceus velatus* | Southern masked weaver | | | x | | | | | |
| *Saxicola torquata* | Common stonechat | | | | x | x | x | | |
| *Vanellus armatus* | Blacksmith plover | | | | x | | x | | |
| *Vanellus coronatus* | Crowned plover | | | | x | | | | |

**Table 23: Mammals recorded during the survey**

| Latin name | Common name | TuW04 | TuW05 | TuW06 | NDC4 | NDC5 | NDC6 | NDC7 | NDC8 |
|---|---|---|---|---|---|---|---|---|---|
| *Aonyx capensis* | *Cape clawless otter* | | | | | x | | x | |
| *Sylvicapra grimmia* | *Grey duiker* | | | | | | | | x |
| *Atilax paludinosus* | *Water mongoose* | | | | | x | | | |

# APPENDIX E

## Flora recorded during the wetland survey



Golder Associates

**Table 24: Flora recorded during the survey**

| Plant | TuW04 | TuW05 | TuW06 | NDC4 | NDC5 | NDC6 | NDC7 | NDC8 |
|---|---|---|---|---|---|---|---|---|
| *Aristida adscensionis* | | | | | x | | | |
| *Aristida congesta subsp. congesta* | | x | | | x | | | |
| *Aristida difusa* | | | | | | | | |
| *Bidens bipinnata* | | x | | | | | x | x |
| *Bidens formosa* | | | | | | | | x |
| *Brachiaria brizantha* | | | | | | | | |
| *Brunsviggia* | | x | | | | | | |
| *Burkei sp* | | x | | | | | | |
| *Circium vulgare* | | x | | x | x | x | | |
| *Crinum bulbispermum* | | | | | | x | | |
| *Cymbopogon plurinodis* | | | | | x | | | |
| *Cynodon dactylon* | | | x | | | | x | |
| *Cyperus dives* | | x | | | x | | | |
| *Cyperus longus* | | | x | | x | x | x | |
| *Digitaria eriantha* | | | | | | | x | |
| *Eragrostis curvula* | | x | x | | x | x | x | x |
| *Eragrostis rigidior* | | x | | | | | | x |
| *Eragrostis tef* | | | | x | | | x | x |
| *Eragrostis trichophora* | | | | | | | | x |
| *Eucalyptus camaldulensis* | | | | | | | | x |
| *Euphorbia clavaroides* | | | | | x | | | |
| *Flaveria bidentis* | | x | | | | | | |
| *Gomphocarpus fruticosus* | | x | x | | x | | | x |
| *Hyparrhenia hirta* | x | x | x | x | x | x | x | x |
| *Hypoxis sp* | | | | | | | | |
| *Imperata cylindrica* | | | | | x | | x | |
| *Leersia hexandra* | | x | | | | | | |
| *Mariscus congestus* | x | x | x | | | | | |
| *Miscanthus junceus* | | | | | | | | |
| *Panicum maximum* | | | | x | | x | | |
| *Paspalum dilatatum* | | x | | | | | | |
| *Persicaria dicipiens* | | | | | | | | |
| *Persicaria senegalensis* | | | x | | | | | |
| *Persicaria sp.* | | | | | | | | |
| *Phragmites auatralis* | x | x | x | x | | | | x |
| *Populus xcanescense* | | | | | | x | | |
| *Salix babylonica* | | | | | | x | | |

| Plant | TuW04 | TuW05 | TuW06 | NDC4 | NDC5 | NDC6 | NDC7 | NDC8 |
|---|---|---|---|---|---|---|---|---|
| *Schoenoplectus brachyceras* | x | x | x | | | | x | |
| *Schoenoplectus corymbosus* | | | | | | | | |
| *Schoenoplectus paludicola* | | | | | | | | x |
| *Setaria pallide-fusca* | | | x | | | | | |
| *Setaria sphacelata var. sphacelata* | | x | | | x | | x | |
| *Setaria sphacelata var. torta* | | x | x | | x | x | | |
| *Sporobolus africanus* | x | x | x | | x | x | | |
| *Tagetes minuta* | | | | | | x | x | x |
| *Themeda triandra* | x | x | x | x | x | x | x | x |
| *Typha capensis* | | x | x | x | | x | | x |
| *Verbena bonariensis* | | x | | | | x | x | |

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# APPENDIX H

## SURFACE WATER ASSESSMENT

December 2010

CELEBRATING 50 YEARS in 2010

## SURFACE WATER SPECIALIST REPORT

# New Denmark Colliery Evaporation Pond EIA

world capabilities locally

**Golder Report Number** 12786-9988-7

Golder Associates

# Executive Summary

Anglo American (Anglo) appointed Golder Associates Africa (Pty) Ltd to conduct an Integrated Regulatory Process for the construction and operation of new evaporation ponds located at New Denmark Colliery (NDC) / Tutuka Power Station near Standerton in the Mpumalanga Province. As part of the Integrated Regulatory Process several specialist studies will be conducted. This report describes the Surface Water Assessment.

The scope of work was to investigate the potential impacts of the two evaporation ponds on the surface water flow in the catchment.

The evaporation ponds are situated in quaternary catchment C11K on the catchment divide between two sub-catchments. The average rainfall in the area is 665 mm per annum with most of the rain (85 %) occurring in the summer months. The mean annual runoff for catchment C11K is 17.4 million $m^3$.

Three potential surface water impacts were identified, namely seepage through the liner system, streamflow reduction due to the reduction in catchment area, and overspill.

It was found that seepage through the liner of the evaporation ponds will have minimal impact on the surface water. The impact from seepage is low because the evaporation ponds will be lined according to the minimum requirements and collection of seepage by underdrains below the liner.

The impact in terms of streamflow reduction due to the reduction in catchment area was found to be low. This is based on the reduction in area of the two sub-catchments. The area of sub-catchment A will be reduced by 0.7 % and the area of sub-catchment B will be reduced by 0.2 %, therefore streamflow reduction will be insignificant.

The impact of an overspill from the evaporation ponds was found to be low. The probability of occurrence was ranked improbable since a freeboard of 600 mm and a spillway will be provided on the dams. A 1:100 year flood event will increase the water level in the ponds with 133.8 mm, much less than the freeboard.

Due to the **low** environmental impact of the evaporation ponds on the surface water in the area, no mitigation or monitoring is recommended. It is, however, recommended to follow good practice by:

- Ensuring proper design and installation of the liner for the evaporation ponds;
- Managing the water level in the ponds to maintain the 600 mm freeboard at all times; and
- Designing the spillway so that maximum floods can pass the ponds.

# Table of Contents



**TABLES**



**FIGURES**

**APPENDICES**

# 1.0 INTRODUCTION

Anglo American (Anglo) appointed Golder Associates Africa (Pty) Ltd to conduct an Integrated Regulatory Process for the construction and operation of new evaporation ponds located at New Denmark Colliery (NDC) / Tutuka Power Station near Standerton in the Mpumalanga Province. As part of the Integrated Regulatory Process several specialist studies will be conducted. This report describes the Surface Water Assessment.

# 2.0 SCOPE OF WORK

The scope of work is to investigate the potential impacts on the surface water hydrology associated with the operation of the evaporation pond (also termed RO reject pond).

# 3.0 REGIONAL SETTING

The proposed site for the evaporation pond is located approximately 20 km North East of Standerton in the Mpumalanga Province. The area is located in the Vaal River catchment or Drainage Region C (Figure 1). The Vaal River System is the main water supply to the Gauteng Province and its main storage unit is the Vaal Dam.

# 4.0 LOCAL SETTING

At a local scale the site falls in the quaternary catchment C11K with the Leeuspruit as the main river which drains into the Grootdraai Dam. The Grootdraai Dam is located on the Vaal River. The proposed evaporation ponds are situated on the catchment divide between two sub-catchments of quaternary catchment C11K. The two sub-catchments (A and B in Figure 2) drain into the Leeuspruit.

# 5.0 CATCHMENT DESCRIPTION

More than 60 % of catchment C11K is owned by NDC. The area is dominated by dry land agriculture and the small built up areas at the Thuthukani village and the Tutuka Power Station. Catchment C11K drains from the north into the Grootdraai Dam in the south.

The areas of the two sub-catchments (A and B) are relatively flat with an overall slope of 0.5 % draining from east to west. However, there are areas such as the last stretch of the river before the sub-catchment outlet that have slopes up to 0.84 %. Slopes were calculated from distances and elevations calculated in Arc-GIS. The elevations vary from 1 660 mamsl in the upper catchment areas to 1 562 mamsl where sub-catchment B drains into the Leeuspruit.

Sub-catchments A and B data are presented in Table 1. The points used are indicated in Figure 2.

**Table 1: Sub-catchments A and B data**

| No | Area, ($km^2$) | Length, (m) | Elevation, (mamsl) | | | | Average slope, (%) | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | At 0.0 L | At 0.1 L | At 0.85 L | At 1.0 L | 0.0 L to 1.0 L | 0.1 L to 0.85 L | 0.0 L to 0.1 L |
| A | 34.37 | 4 800 | 1565 | 1569 | 1584 | 1589 | 0.5 | 0.5 | 0.84 |
| D | 37.12 | 8 100 | 1562 | 1565 | 1593 | 1598 | 0.44 | 0.45 | 0.37 |

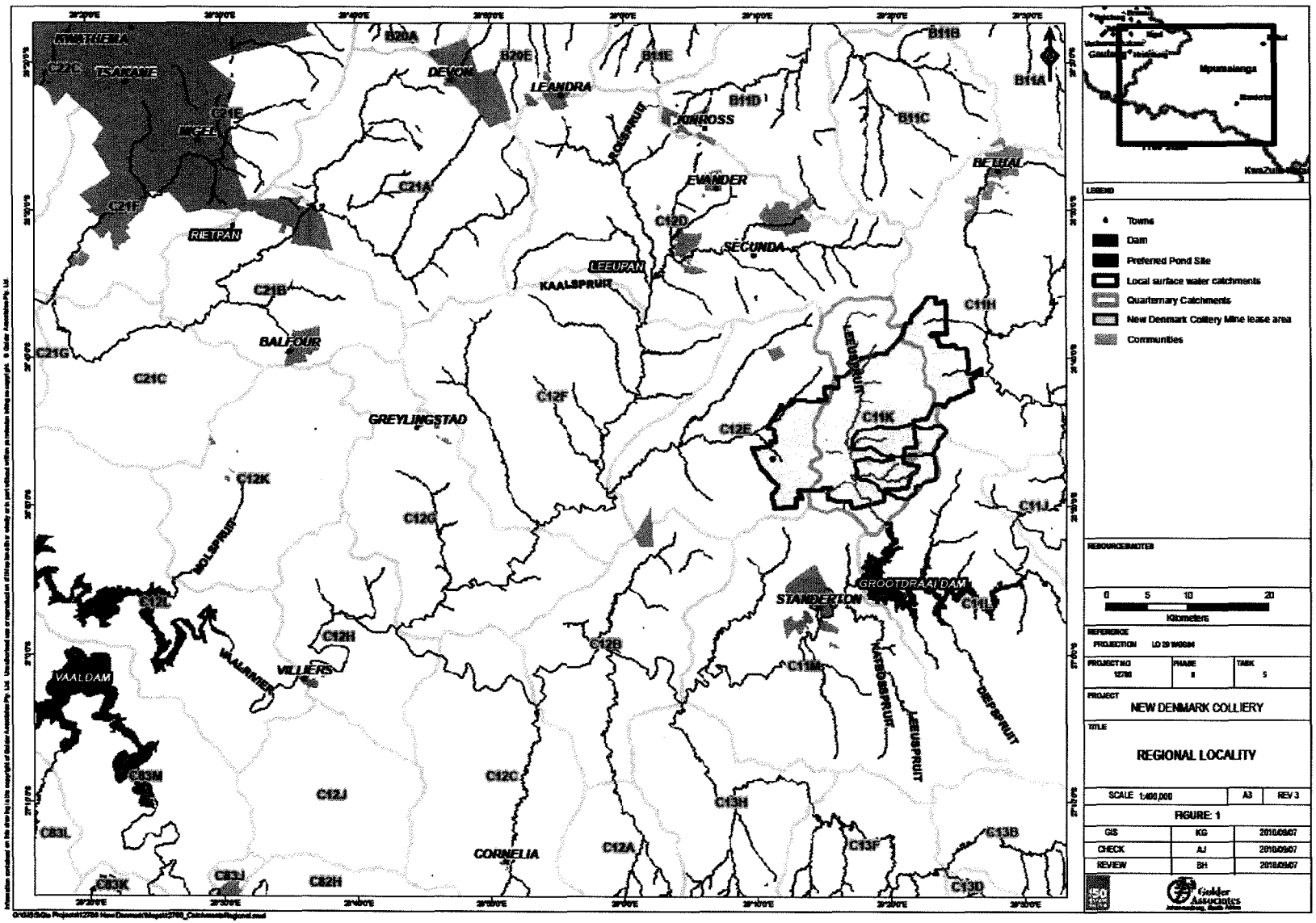


*Figure 1: Regional setting of the New Denmark Colliery and the proposed evaporation ponds*

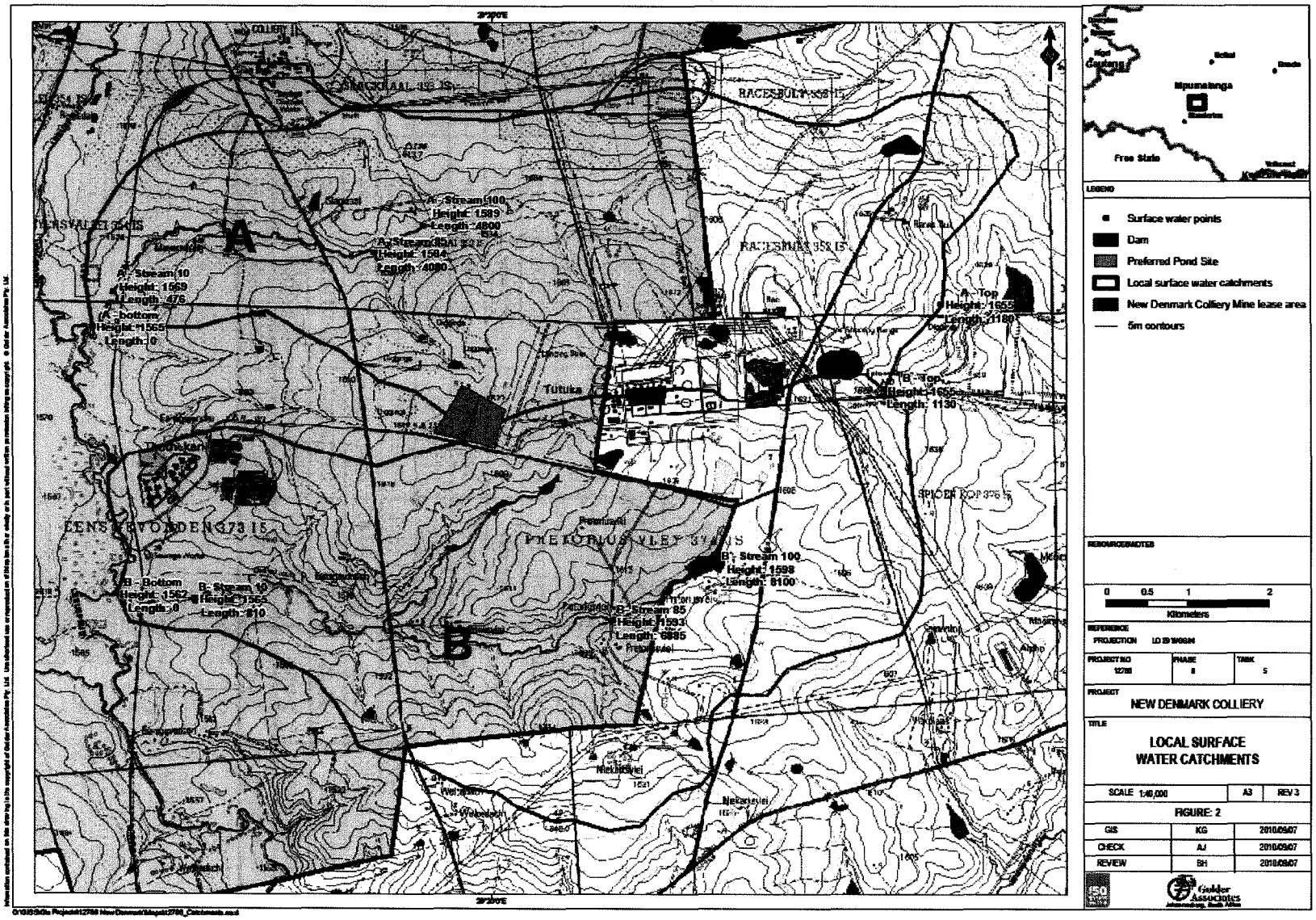


*Figure 2: Local setting indicating the two affected sub-catchments A and B*

## 5.1 Hydrological and meteorological description

A summary of hydrological data of the study area is presented in Table 2.

**Table 2: Hydrological data for the study area**

| Location | Quaternary Catchment | C 11 K |
|---|---|---|
| | **Water Management Area** | **Upper Vaal** |
| **Rainfall** | Rainfall gauge used (Jonkersdam) | 0441261 W |
| | Mean Annual Precipitation (MAP) (Period of record 68 years) | 665 mm |
| | Wet Season Rainfall (October - March) * | 564 mm |
| | Wet Season Rainfall % of MAP | 85 % |
| | Dry Season Rainfall (April - September) * | 102 mm |
| | Dry Season Rainfall % of MAP | 15 % |
| **Evaporation** | Mean Annual Evaporation (MAE) S-Pan | 1520 mm |
| | Evaporation Zone (WR90 study) ≠ | 13 B |

***Note:*** **The sum of the average monthly rainfall does not necessarily correspond to the MAP*
*≠ Midgley et al, 1994*

The area is situated on the Highveld where most of the rainfall falls in the summer months. The summer temperatures can reach as high as 40°C during the day with winter high temperatures reaching 20°C. Frost occurs in winter, but generally for less than 30 days per year (Aurecon, 2010).

The rainfall stations closest to the NDC site and with a rainfall record of longer than 15 years were extracted from the CCWR database and they are listed in Table 3. The locations of the nearby stations are indicted in Figure 3.

**Table 3: Rainfall stations in a 22 km radius from the NDC site**

| Number | Station Name | Distance from Site (km) | Direction | Start of Record | End of Record | Number of Years | Altitude (mamsl) | MAP |
|---|---|---|---|---|---|---|---|---|
| 0441523W | New Denmark | 4.96 | 315.0 (NW) | 01/01/1905 | 31/12/1950 | 45 | 1 582 | 667.3 |
| 0441580W | Standershoop | 9.23 | 0 (N) | 01/03/1962 | 31/05/1979 | 17 | 1 647 | 618.4 |
| 0441650W | Niekerksvlei | 9.38 | 168.7 (S) | 01/07/1911 | 31/10/1967 | 56 | 1 622 | 686.2 |
| 0441377W | Beginsel | 12.18 | 254.1 (W) | 01/12/1904 | 31/01/1931 | 26 | 1 594 | 782.6 |
| 0441578W | Top Fontein | 13.03 | 8.1 (N) | 01/07/1946 | 28/02/1962 | 15 | 1 645 | 761.1 |
| 0441667 W | Vlakspruit | 16.19 | 26.6 (NE) | 01/03/1915 | 30/06/1940 | 35 | 1 632 | 665 |
| 0441285 W | Irene Dale | 16.58 | 270.0 (W) | 01/10/1921 | 30/11/1948 | 27 | 1 568 | 666.3 |
| 0441860 W | Rietvlei (Skl) | 17.54 | 119.1 (SE) | 01/07/1907 | 30/06/1939 | 32 | 1 601 | 676.7 |
| 0441309 W | Charl Cilliers | 17.55 | 299.1 (NW) | 01/02/1956 | 31/12/1997 | 41 | 1 617 | 693.9 |
| 0441596 W | Kareebos | 20.58 | 169.7 (S) | 01/03/1955 | 30/04/1979 | 24 | 1 575 | 643.3 |
| 0441261 W | Jonkersdam | 21.02 | 235.0 (SW) | 01/10/1917 | 30/06/2000 | 83 | 1 585 | 659.2 |
| 0441694 W | Sterkfontein | 21.37 | 20.0 (N) | 01/03/1929 | 30/04/1965 | 36 | 1 664 | 701.9 |

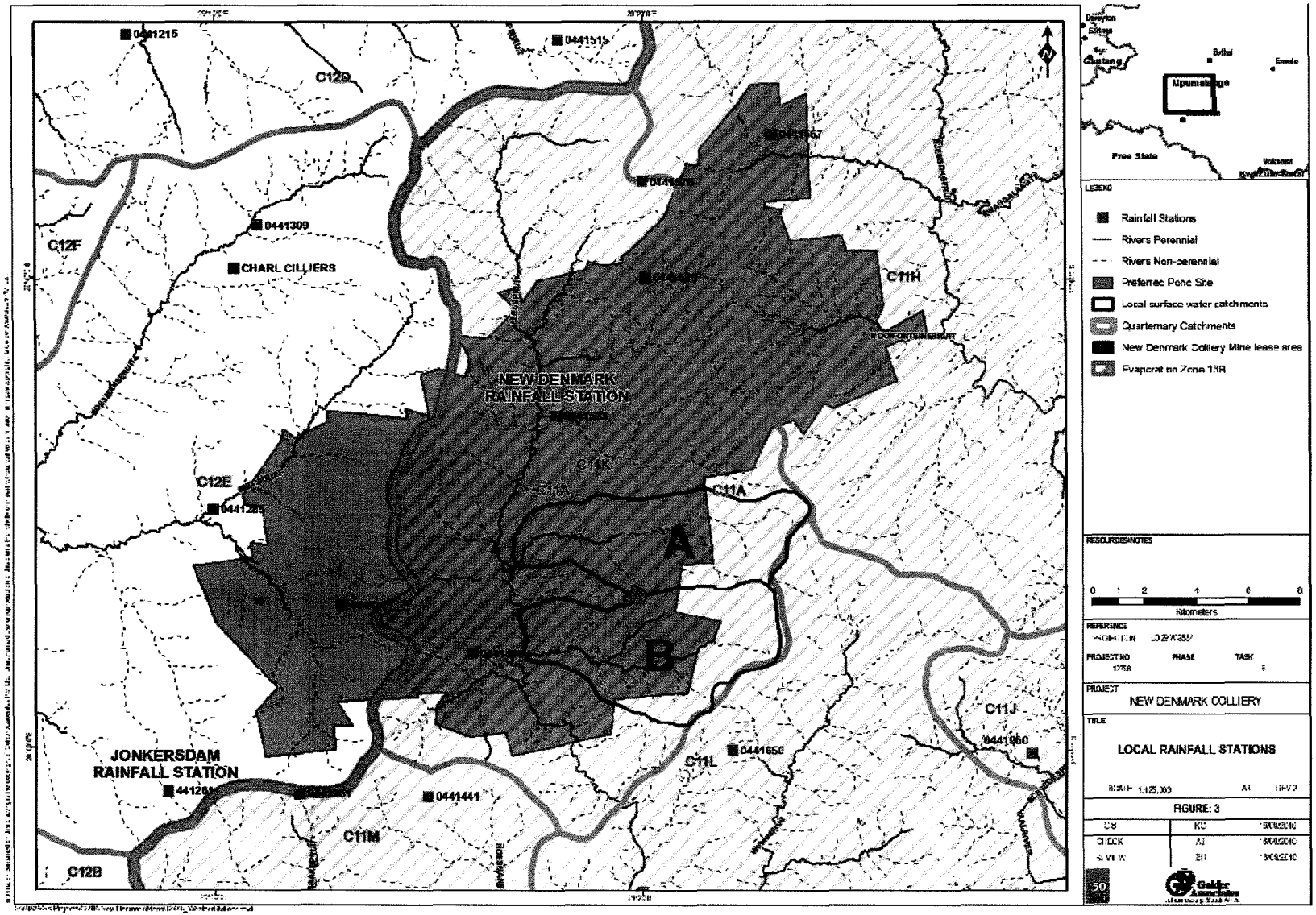


*Figure 3: Location of rainfall stations near the NDC site*

Daily rainfall data was extracted for the Jonkersdam rainfall station (0441261 W). Although the latter is 21 km south west of the site, the station has a long rainfall record of 83 years and the altitude and Mean Annual Precipitation (MAP) at the site is similar to that of the New Denmark rainfall station.

The cumulative rainfall and the time series of daily rainfall data measured at the Jonkersdam rainfall station are shown in Figure 4 and Figure 5 respectively. Figure 4 is plotted with the linear fit.

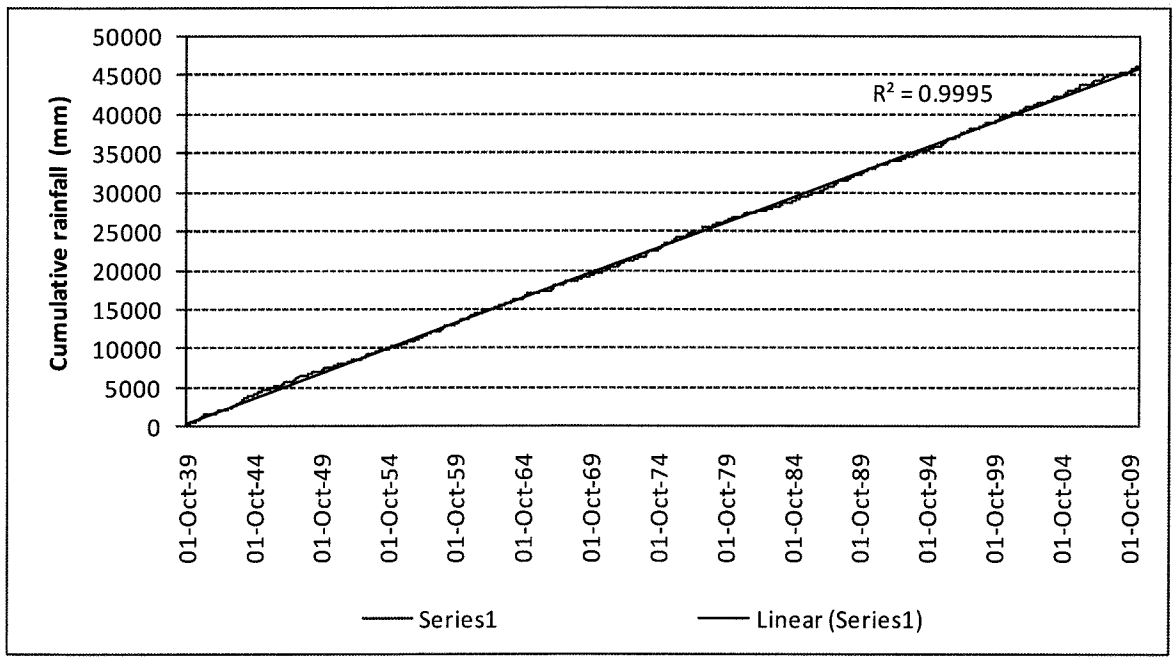


*Figure 4: Cumulative rainfall for the Jonkersdam station from 1939 to 2000*

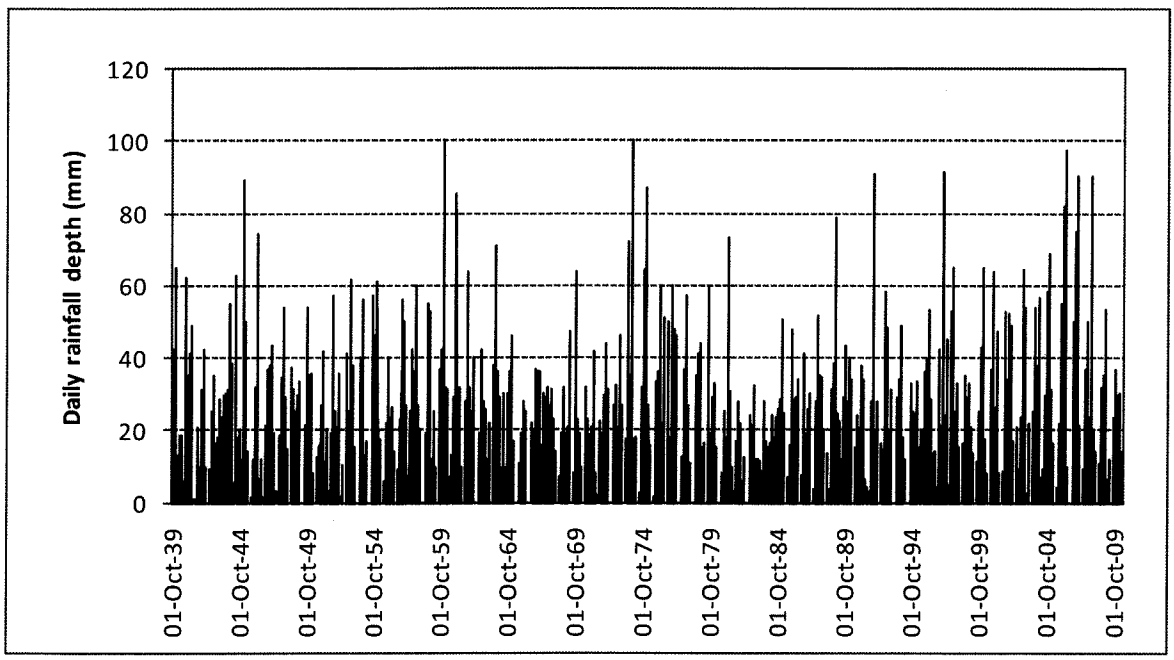


*Figure 5: Daily rainfall for the Jonkersdam station from 1939 to 2000*

Monthly minimum, average and maximum rainfall data for the Jonkersdam rainfall station (0441261 W) were plotted in Figure 6. The Mean Annual Evaporation for catchment 13B is 1 520 mm/a.

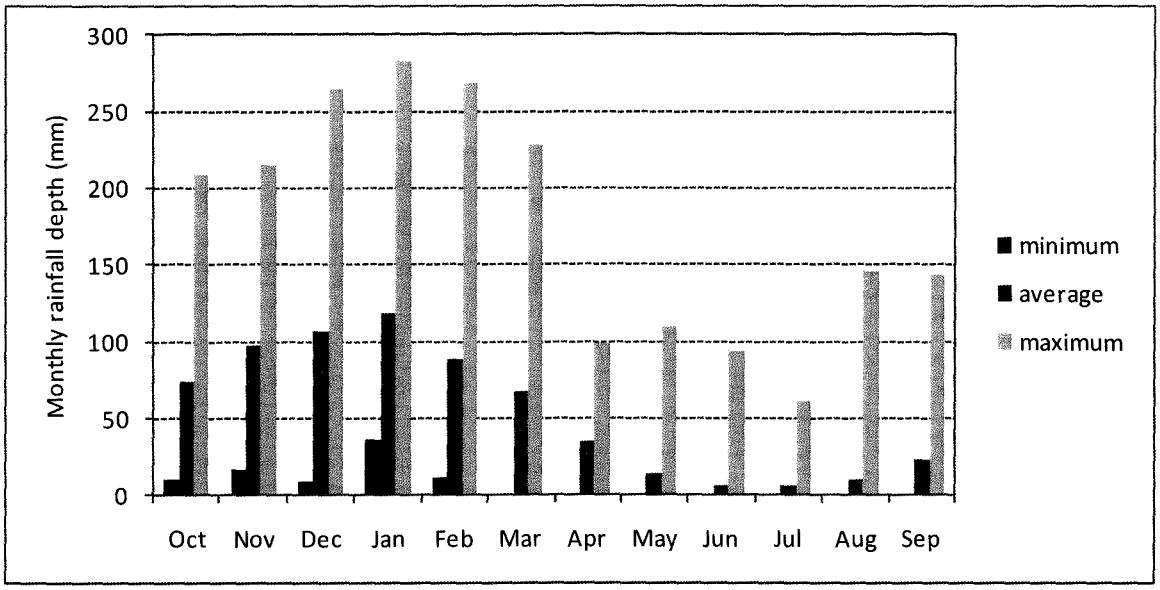


*Figure 6: Minimum, average and maximum monthly rainfall measured at the Jonkersdam station*

The average monthly rainfall depth recorded at the Jonkersdam rainfall station are presented in Table 4.

**Table 4: Average monthly rainfall depth recorded at the Jonkersdam (in mm/month)**

| Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 74.3 | 99.5 | 105.9 | 119.3 | 87.8 | 68.0 | 33.8 | 13.6 | 6.7 | 5.9 | 10.5 | 23.3 | **648.6** |

The minimum, maximum and average annual rainfall depths recorded at the Jonkersdam rainfall station are presented in Table 5.

**Table 5: 5, 50 and 95 percentile rainfall values for the Jonkersdam (in mm/a)**

| Number | Station name | 5% | 50% | 95% |
|---|---|---|---|---|
| 0441261 W | Jonkersdam | 438.1 | 614.2 | 916.4 |

The monthly evaporation for evaporation zone 13B (Midgley et al., 1994) is given in Table 6.

**Table 6: Monthly evaporation for Zone 13B (in mm/month)**

| Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 157.3 | 155.0 | 167.2 | 165.2 | 142.6 | 135.9 | 104.6 | 88.9 | 73.3 | 80.4 | 110.4 | 139.2 | **1520** |

The 24-hour rainfall depths for various recurrence intervals are given in Table 7.

**Table 7: 24 hour rainfall depths for different recurrence intervals in mm/day**

| Recurrence interval (years) | 1 | 2 | 5 | 10 | 20 | 50 | 100 | 200 |
|---|---|---|---|---|---|---|---|---|
| 24 hour rainfall depth (mm) | | 51 | 68 | 80 | 93 | 110 | 124 | 139 |

The dates when greater than 50 mm of rainfall was recorded in a 24 hour period for Jonkersdam is indicated in Table 8.

**Table 8: Rainfall days with more than 50 mm of rain**

| Date | Rain (mm) | Date | Rain (mm) | Date | Rain (mm) | Date | Rain (mm) |
|---|---|---|---|---|---|---|---|
| 22/02/1960 | 100 | 12/03/1939 | 66.5 | 24/02/1953 | 59.7 | 13/11/1949 | 53.6 |
| 29/01/1974 | 100 | 20/12/1997 | 65 | 30/01/1934 | 58.9 | 11/02/1996 | 53.5 |
| 27/02/1997 | 91.5 | 04/03/2000 | 65 | 07/11/1992 | 58 | 01/01/1959 | 52.5 |
| 12/01/1992 | 91 | 05/01/1940 | 64.8 | 07/02/2000 | 58 | 25/10/1997 | 52.5 |
| 02/02/1945 | 88.9 | 25/12/1974 | 64.5 | 22/01/1938 | 57.2 | 24/05/1936 | 52.1 |
| 14/02/1975 | 87 | 18/10/1969 | 64 | 12/10/1951 | 57.2 | 21/02/1981 | 52 |
| 15/01/1961 | 85 | 29/10/1961 | 63.5 | 16/10/1954 | 57 | 13/10/1987 | 51.5 |
| 30/03/1936 | 83.8 | 14/06/1944 | 62.7 | 31/12/1977 | 57 | 24/11/1961 | 51.3 |
| 13/02/1989 | 78.5 | 09/11/1940 | 62.2 | 21/11/1933 | 56.4 | 03/05/1976 | 51 |
| 10/01/1974 | 75 | 22/01/1934 | 62 | 22/01/1954 | 56 | 25/10/1934 | 50.8 |
| 15/03/1946 | 74.4 | 10/02/1953 | 61.7 | 05/12/1956 | 56 | 09/02/1953 | 50.8 |
| 10/02/1937 | 74.2 | 09/02/1955 | 61 | 24/01/1939 | 55.6 | 07/02/1985 | 50.5 |
| 02/03/1981 | 73 | 11/01/1958 | 60 | 06/12/1958 | 55 | 04/03/1945 | 50 |
| 27/09/1973 | 72 | 31/01/1976 | 60 | 15/01/1944 | 54.9 | 25/02/1957 | 50 |
| 27/11/1963 | 71 | 22/12/1976 | 60 | 16/12/1973 | 54 | 18/12/1960 | 50 |
| 18/12/1973 | 71 | 17/08/1979 | 60 | 27/11/1937 | 53.8 | 02/10/1976 | 50 |
| 07/10/1937 | 70.6 | 29/11/1997 | 60 | 18/02/1948 | 53.6 | | |

From the above information, the following conclusions regarding the rainfall can be made:

- Rainfall is strongly seasonal (Figure 6). The wet and dry seasons are between October and March, and April and September respectively;
- The wet season (October – March) contributes 85 % of the rainfall; and
- The average rainfall depth over the recorded wet (October and March) and dry (April and September) periods are 92.5 mm and 15.6 mm respectively (Table 4).

Streamflow was recorded at the outlet of catchment C11K from 1964 to 1989 and the monthly flows measured flows at this gauge (C1H005) is shown in Figure 7. The mean annual runoff is 17.4 million $m^3$.

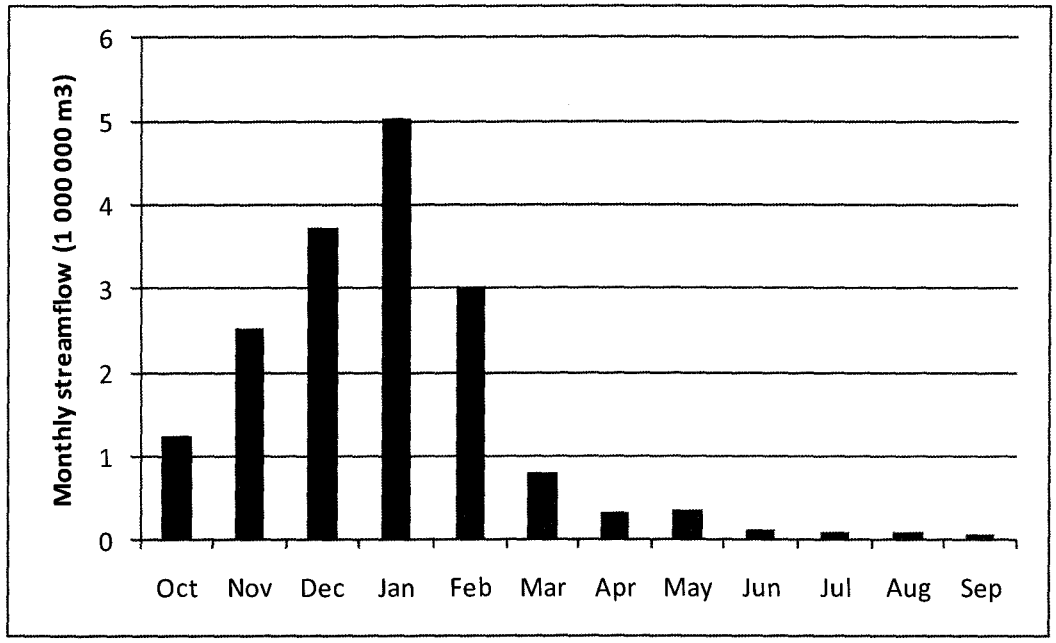


*Figure 7: Monthly streamflow at gauge C1H005*

# 6.0 IMPACT ASSESSMENT

Three potential surface water impacts were identified, namely seepage through the liner system, streamflow reduction due to the reduction in catchment area, and overspill. Each of these impacts was assessed separately.

The significance of the identified impacts will be determined using an accepted methodology from the Department of Environmental Affairs and Tourism Guideline document on EIA Regulations, April 1998. As with all impact methodologies, the impact is defined in a semi-quantitative way and will be assessed according to:

- The probability of occurrence;
- The duration of occurrence;
- The severity of the impact with respect to its magnitude on the receiver; and
- The severity of the impact with respect to its scale in geographical sense.

For each of the above a factor is applied based on the results from the specialist studies and professional judgement. The factors to be assigned are presented in Table 3. The factors are then combined to determine the significance points for the impact according to the following equation:

***SP (significance points) = (probability + duration + scale) x magnitude***

The maximum value is 150 significance points (SP) the significance points are assigned a rating of high, medium or low with respect to their environmental impact, the ranking system to be used in the study is presented in Table 4.

**Table 9: Impact assessment methodology factors**

| Probability | Duration |
|---|---|
| 5 - Definite/don't know | 5 - Permanent |
| 4 - Highly probable | 4 - Long-term |
| 3 - Medium probability | 3 - Medium-term (8-15 years) |
| 2 - Low probability | 2 - Short-term (0-7 years) (impact ceases after the operational life of the activity) |
| 1 - Improbable | 1 – Immediate |
| 0 - None | |

| Scale | Magnitude |
|---|---|
| 5 - International | 10 - Very high/don't know |
| 4 - National | 8 - High |
| 3 - Regional | 6 - Moderate |
| 2 - Local | 4 - Low |
| 1 - Site only | 2 - Minor |
| 0 - None | |

**Table 10: Description of significance rankings**

| Significance Points | Environmental Significance | Implication |
|---|---|---|
| **SP >75** | **High** | An impact which could influence the decision about whether or not to proceed with the project regardless of any possible mitigation. |
| **SP 30 – 75** | **Moderate** | An impact or benefit which is sufficiently important to require management and which could have an influence on the decision unless it is mitigated |
| **SP <30** | **Low** | Impacts with little real effect and which should not have an influence on or require modification of the proposed alignment. |

## 6.1 Seepage through liner

The evaporation ponds will be lined according to the minimum requirements and therefore seepage through the liner will be limited. The small amount of seepage that does get through the liner will be collected in the underdrains and pumped back into the ponds. Seepage to the shallow groundwater system will therefore be minimal. Table 13 shows the ranking of the factors and the calculated SP for seepage through the liner.

**Table 11: Factors and ranking used to calculate significance points for seepage through the liner**

| Factor | Ranking | Mark |
|---|---|---|
| Probability | Low probability | 2 |
| Duration | Short term | 2 |
| Scale | Local | 2 |
| Magnitude | Low | 4 |
| **Significance points** | | **24** |

Significance points below 30 indicate a **low** environmental significance. Therefore the impact from seepage through the liner of the evaporation ponds will have minimal impact on the surface water hydrology. Seepage through the liner will have a larger impact on the groundwater than on the surface water.

## 6.2 Streamflow reduction

The location of the proposed evaporation ponds are on the boundary between the two sub-catchments. The impact in terms of streamflow reduction will be caused by the reduction of the catchment area. The two sub-catchments combined represent 21 % of the area of catchment C11K. If it is assumed that the flow is proportional to the area, these two catchments will produce an annual average contribution to the catchment runoff of 4.29 million $m^3$.

Sub-catchment A has an area of 3 437 ha of which the evaporation ponds will take up 23 ha or 0.7 % of the area. Sub-catchment B has an area of 3 712 ha of which the evaporation ponds will take up 6 ha or 0.2 % of the area. Since the area is reduced by less than 1 %, the streamflow reduction will be insignificant.

Table 13 shows the ranking of the factors and the calculated SP for streamflow reduction.

**Table 12: Factors and ranking used to calculate significance points for streamflow reduction**

| Factor | Ranking | Mark |
|---|---|---|
| Probability | Improbable | 1 |
| Duration | Permanent | 5 |
| Scale | Local | 2 |
| Magnitude | Minor | 2 |
| **Significance points** | | **16** |

Significance points below 30 indicate a **low** environmental significance. Therefore the streamflow reduction impact of the evaporation ponds will have minimal impact and should not require modification.

## 6.3 Overspill

The last impact foreseen is overspill from the evaporation ponds in the case of an intense rainfall event. However, the probability of such an occurrence is very low, since a 1:100 year flood event will increase the water level in the ponds with 133.8 mm and a freeboard of 600 mm will be provided on the dams. A spillway will be provided. Table 13 shows the ranking of the factors and the calculated SP for overspill from ponds.

**Table 13: Factors and ranking used to calculate significance points for overspill from ponds**

| Factor | Ranking | Mark |
|---|---|---|
| Probability | Improbable | 1 |
| Duration | Immediate | 1 |
| Scale | Local | 2 |
| Magnitude | Moderate | 6 |
| **Significance points** | | **24** |

Significance points below 30 indicate a **low** environmental significance. Therefore the impact of overspill from the evaporation ponds on the surface water will have minimal impact and should not require modification.

# 7.0 MITIGATION AND MONITORING

No mitigation or monitoring is recommended since the evaporation ponds will have a **low** environmental impact on the surface water in the area. The following good practice is recommended:

- To prevent pollution of the ground water, the liner for the evaporation ponds has to be properly designed and developed according to the minimum requirements (DWAF, 1998). The liner specifications for hazardous waste lagoons require at least (from top to bottom):
  - A 2 mm geomembrane;
  - A 600 mm compacted clay liner;
  - A 150 mm leakage detection layer;
  - A second geomembrane of 1 mm; and
  - A 300 mm compacted clay liner.
- To prevent pollution of the surface water, the operational water level in the ponds should be managed in such a way to maintain the 0.6 m freeboard.
- The Dam Safety Office of DWA normally requires a spillway on evaporation ponds. If required, a spillway should be sized for the ponds to pass the probable maximum flood.

# 8.0 REFERENCES

Aurecon. 2010. Environmental Impact Assessment Process: Proposed Brine and Groundwater Treatment Works at Tutuka Power Station, Mpumalanga. Final Scoping Report. Report No. 5107A/105684.

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Midgely, DC, Pitman, WV and Middleton, BJ. 1994. Surface Water Resources of South Africa 1990. Volume II. WRC Report No. 298/2.1/94.

Smithers JC and Schulze RE. (2003) Design rainfall and flood estimation in SA (Regionalisation of rainfall statistics for design flood estimation), Water Research Commission Report No1060/1.

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Reg. No. 2002/007104/07

# APPENDIX A

## Document Limitations

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Golder Associates

# APPENDIX I
## VISUAL IMPACT STATEMENT

December 2010

CELEBRATING 50 YEARS in 2010

# NEW DENMARK COLLIERY EVAPORATION POND EIA

# VISUAL IMPACT STATEMENT

**Golder Report Number** 12786-9964-5

world capabilities locally

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# Executive Summary

The applicant, Anglo American (Anglo), appointed Golder Associates Africa (Pty) Ltd (Golder), an independent environmental consultant, to undertake the Environmental Impact Assessment for the proposed evaporation pond at New Denmark Colliery. As part of this application process Golder has been appointed to conduct a Visual Assessment specialist study which will inform the EIA for the project.

The terms of reference for the assessment were to determine the potential visual impacts of the proposed project components on potential viewers or receptors, in terms of the visual context within which the activity will take place and to develop mitigation strategies to address these. In order to achieve this aim, the following four steps were followed:

- Describing the landscape as visual resource by way of a baseline investigation, and characterising the nature and quality of the landscape and the visual sensitivity of the resource;
- Determining the change in the visual resource that would be brought about by elements of the proposed project, and how visible this change will be from the surrounding areas;
- Describing the expected visual impacts of key components of the proposed project; and
- Recommending mitigation measures to reduce the potential visual impacts of the project.

The visual quality of the study area is of a **low to medium** value. Although the majority of the study area has a predominantly rural character, it is dominated by the power station and has been visually altered by a number of other linear and other infrastructure features. Furthermore it is not characterised by features that are visually exciting, such as prominent topography or attractive vegetation cover.

Due to the generally low levels of development in the area it is unlikely that a large amount of people will be visually affected by the proposed project. Standerton is the largest settlement in the vicinity of the site; and is connected to Ermelo via the R39 Road; and Bethal via the R38 Road. It is therefore likely that residents of the aforementioned towns as well as Thuthukani Township will constitute the greatest percentage of receptors. However most receptors will only drive by and there are very few resident receptors within the study area. It is therefore expected that the receptor sensitivity for this project will be **low**.

The results of the viewshed analysis clearly indicate the visual significance of Tutuka Power Station as it noticeably affects the visibility within the study area. The great height of the burner structure and especially the cooling towers is evident in the manner in which the viewshed is fragmented by it. Based on the above assessment, in summary it is stated that the level of visibility of the project components from within the study area is expected to be **medium**.

Due to the close proximity of the Tutuka power station to the proposed site for the new evaporation pond it is not anticipated that the evaporation ponds will cause significant visual intrusion. Compared to the power station infrastructure the evaporation ponds and associated infrastructure are small in scale and not for the most do not consist of visually complex shapes. Furthermore the evaporation ponds will be similar in appearance to a number of the existing artificial water bodies found in the area. As a result the level of visual intrusion caused by the project is expected to be **low**.

The majority of travellers through the study (along the R38 and R39 Roads) area will not come within 3 kilometres of the evaporation ponds, pipeline and additional infrastructure; and as a result will only experience a very low visual exposure to the proposed project. Only persons travelling along the smaller roads passing closer to the site, and many of whom it can be expected are travelling to the power station, will be visually exposed to the new infrastructure to any significant degree. As a result it is expected that the overall visual exposure of receptors to the proposed infrastructure will be **low**.

As a consequence of the above assessment, the magnitude of the visual impact that is likely to be caused by the project will be **low**.

From the impact assessment it is anticipated that the most determining factor in terms visual impact caused by the proposed evaporation pond, will be the degree to which it will be visible within the study area. The pipeline and additional infrastructure will not be of a significantly intrusive nature and only relatively small amount of receptors will be exposed to it. As a result the overall visual impact of the proposed evaporation pond and supporting infrastructure is expected to be **low**.

A number of mitigation strategies are suggested, the extent and applicability of which need to be confirmed as part of the detail design phase of the project:

- Berms and embankments;
- Vegetative screening;
- Reduction of construction related impacts; and
- Ongoing maintenance and monitoring.

Subsequently, from a visual perspective, the proposed project can be **supported**, provided that the recommended mitigation measures are implemented.

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# 1.0 INTRODUCTION

Anglo Coal's New Denmark Colliery (NDC) proposes to construct new infrastructure on Eskom's Tutuka site. The site is located in the Mpumalanga Province approximately 20 km north east of Standerton (Figure 1). NDC is located near the Tutuka site and provides coal to Eskom's Tutuka Power Station for daily operations. The excess mine water that accumulates in the underground mine workings as a result of coal mining activities, is pumped to surface and treated. Treatment of the mine water takes place at a reverse osmosis (RO) water treatment plant at Tutuka Power Station, and the clean water is reused in the plant while the "reject water" (dirty water) is currently disposed of in an underground compartment in the NDC known as the 321 compartment.

In November 2009, NDC received a Directive from the Department of Water Affairs (DWA) instructing the mine to implement an alternative management option for the RO reject, by October 2011. In response to the Directive, Eskom is proposing to construct and operate a secondary RO reject concentrator plant at Tutuka Power Station and dispose of the remaining reject water in evaporation ponds located on Eskom's land which has been leased to Anglo Operations Limited.

The construction of such infrastructure has the potential to affect the environmental and social setting in the region. According to the National Environmental Management Act (Act No 28 of 2002) (NEMA), a scoping and Environmental Impact Assessment (EIA) process is required to obtain authorisation for the proposed activity. In addition, an amendment to the current Environmental Management Plan (EMP) will be required according to the Mineral and Petroleum Resources Development Act (Act No 28 of 2002,) (MPRDA), as amended.

The applicant, Anglo Operations (Pty) Ltd. (Anglo Coal), appointed Golder Associates Africa (Pty) Ltd (Golder), an independent environmental consultant, to undertake the Environmental Impact Assessment for the proposed expansion of the eMalahleni Mine Water Reclamation Scheme. As part of this application process Golder has been appointed to conduct the Visual Impact Assessment (VIA) specialist study which will inform the EIA for the project.

# 2.0 PROJECT DESCRIPTION

The NDC produces approximately 16.4 mega litres (Mℓ) per day of excess underground mine water that requires management. Eskom requires water for power generation operations and reuses the mine water at the Tutuka site. The mine water contains some elevated concentrations of salts (e.g. sodium sulphate) and therefore requires treatment prior to use in the plant. Currently the mine water is combined with cooling water (approximately 6 Mℓ/day) and treated by RO at the site. A total of 26 Mℓ/day is treated. The treatment system separates the "clean" water from the reject water and results in approximately 23 Mℓ/day of clean water for reuse and 3 Mℓ/day of reject water to be managed. With the secondary RO reject concentrator plant being installed at Tutuka the reject stream will reduce to 1 Ml/day. The following visible infrastructure will be constructed as part of the project:

- **Evaporation pond:** The proposed evaporation pond will comprise two or four cells with a combined area of approximately 30 hectares. The lifespan of the cells will vary from approximately 2.5 to 5 years and will have a combined capacity of 1.8 million cubic meters and a depth of approximately 15 meters.
- **Pipeline:** A pipeline will be constructed to transport the reject from the RO reject concentrator plant to the evaporation pond. This pipeline will be a high density polyethylene (HDPE) pipeline and will be buried below ground. A back-up pipeline will be installed alongside the main pipeline in the event of a pipeline leak/burst or during times of maintenance. The pipeline will be approximately 2.2 km long with an internal diameter of 150mm.
- **Other infrastructure:** Supporting infrastructure for the proposed project will include an access road, storm water management structures at and around the pond site, a security fence and groundwater monitoring boreholes. The fence will be 1.8 m high and 2.5 km long constructed out of straining wire. A gravel ring-road, 6 m wide and 2.8 km in length, will surround the pond site to ensure easy access for maintenance.

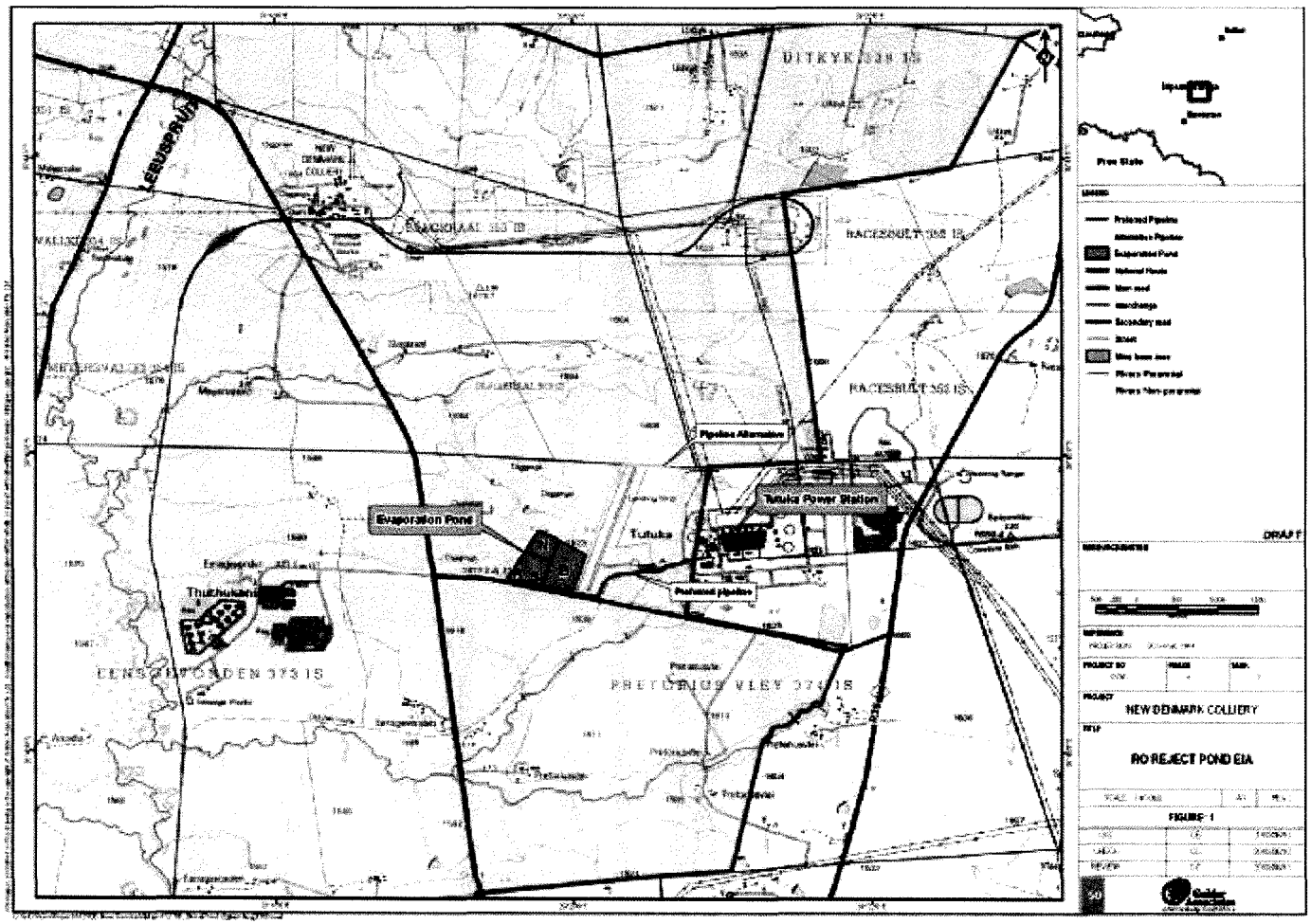



*Figure 1: Location map of the proposed evaporation pond*

# 3.0 DEFINITION AND STUDY AREA

The overall study area for the VIA is based on the spatial extent of the infrastructure footprint and an associated buffer that includes potential indirect effects on the receiving environment. The direct study area is defined as the footprint of all infrastructural components that will be erected as part of the project, as well as all areas where the physical appearance of the landscape will be altered by earthworks and construction activities. In the areas where these elements are to be constructed or activities take place, the existing environment will be altered and land cover replaced and will therefore be directly impacted upon.

Areas that will be indirectly affected by the project are defined as the indirect study area. For the purposes of the VIA, only a local study area was defined, and consists of a 10 km radius around any evaporation pond infrastructure or activities. The distance of 10 km was selected based on the assumption that the human eye cannot distinguish much detail beyond this range. Even though the flat to gently rolling topography of the study area may make it possible to see over greater distances, structures that are this far away are no longer clearly discernible or are at most inconspicuous and therefore the visual impact beyond this range is considered negligible (Figure 2).

For the purposes of this VIA, the term "site" refers to the entirety of the subject property that will physically be affected by the project activities; as well as any areas outside of the subject property affected (where the text so indicates) and therefore corresponds with the direct study area. The term "study area" refers to the entire area potentially affected by the project and is inclusive of the indirect study area.

# 4.0 TERMS OF REFERENCE

Due to the limited scope of the project and as per the applicant's instruction, a limited VIA (or visual impact statement) is being conducted. The terms of reference for the VIA were to determine the potential visual impacts of the proposed project components on potential viewers or receptors, in terms of the visual context within which the activity will take place and to develop mitigation strategies to address these. In order to achieve this aim, the following four steps were followed:

- Describing the landscape as visual resource by way of a baseline investigation, and characterising the nature and quality of the landscape and the visual sensitivity of the resource;
- Determining the change in the visual resource that would be brought about by elements of the proposed project, and how visible this change will be from the surrounding areas;
- Describing the expected visual impacts of key components of the proposed project; and
- Recommending mitigation measures to reduce the potential visual impacts of the project.

# 5.0 LIMITATIONS AND ASSUMPTIONS

The following assumptions and qualifications are relevant specifically to the field of VIA and the findings of this study:

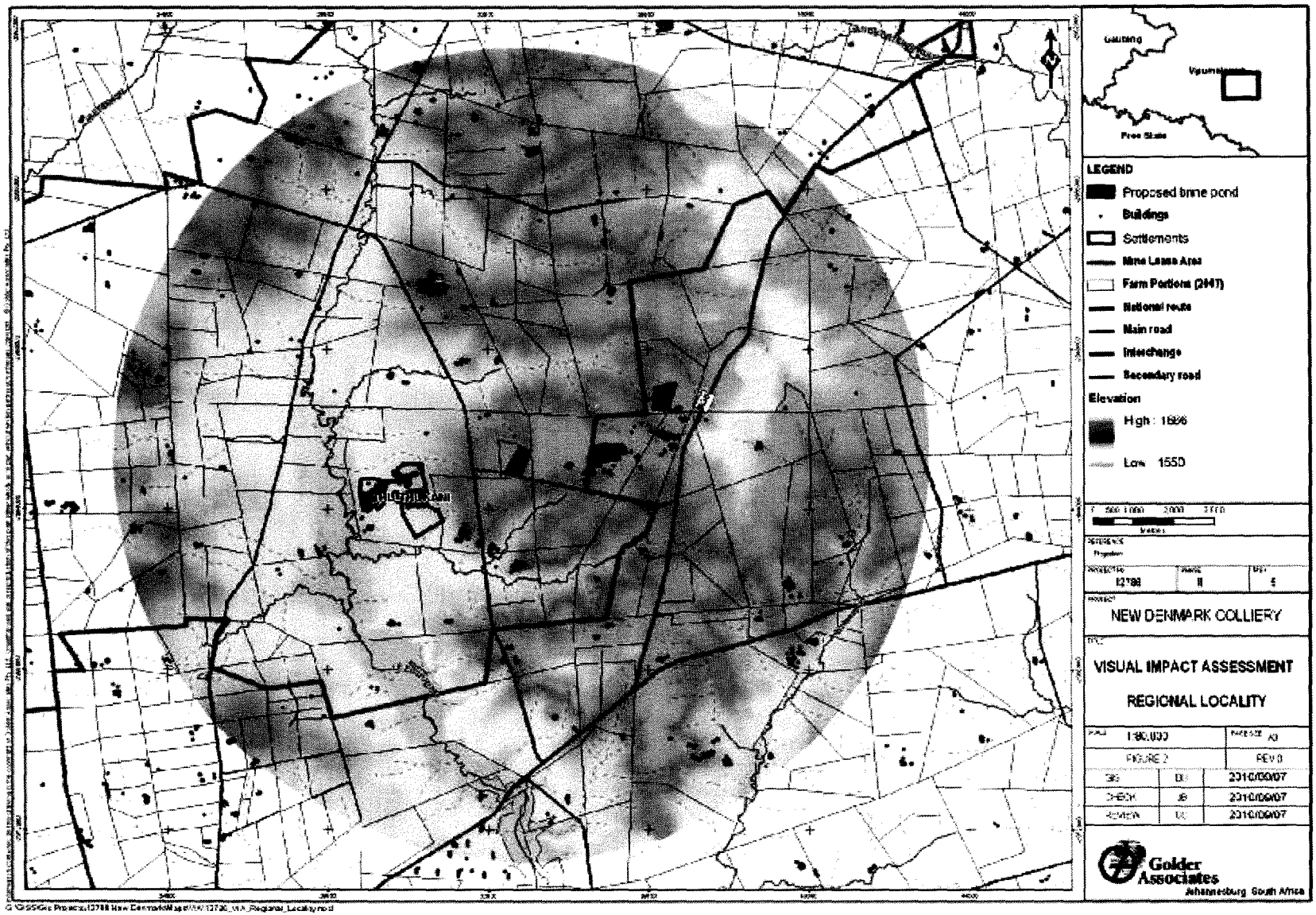



*Figure 2: The study area for the visual impact assessment*

- Determining the value, quality and significance of a visual resource or the significance of the visual impact that any activity may have on it, in absolute terms, is not achievable. The value of a visual resource is partly determined by the viewer and is influenced by that person's socio-economic, cultural and specific family background and is even subject to fluctuating factors such as emotional mood. This situation is compounded by the fact that the conditions under which the visual resource is viewed can change dramatically due to natural phenomena such as weather, climatic conditions and seasonal change (CKA, 2008). Visual impact cannot therefore be measured simply and reliably, as is for instance the case with water, noise or air pollution. It is therefore impossible to conduct a visual assessment without relying to some extent on the expert professional opinion of a qualified consultant, which is inherently subjective. It is unlikely to materially influence the findings and recommendations of this study, as a wide body of scientific knowledge exists in the industry of visual impact assessment, on which findings are based.
- Certain of the parameters and criteria used to evaluate the visual quality of the landscape, as well as the magnitude of any potential visual impact caused, are specific to the study area and proposed interventions of this project. Interpretation of some of the concepts in this document would not apply when determining for instance the visual impact of an industrial development in a largely built-up visual setting.
- The viewshed analysis has been derived from a digital elevation model (DEM) developed using a combination of:
  - 1m survey contours for the site and surrounds, and also extending significantly North and Westwards; and
  - 5m contours from the Chief Directorate of Surveys and Mapping (CDSM 2007) for regions to the South and East of the site.
- The transmitter height (referring to the height of the specific structure used in modelling) is determined by using design drawings and other information for the project currently available. The receiver height, which represents persons visually affected by the structures, was set at natural ground level plus the height of the average human viewer (1.8 meters);
- The effects of the Tutuka Power Station have been incorporated into the viewshed analysis, by digitising the following structures into the digital terrain model, with the following assumed heights:
  - Burner infrastructure: 80 meters
  - Cooling towers: 180 meters
  - Stack: 275 meters
- Due to the conceptual nature of the layout and designs used for the proposed project, the findings of this report are of a general nature and proposed mitigation may need to be reviewed and updated when final construction drawings have been produced for the actual project implementation.

# 6.0 BASELINE INVESTIGATION

## 6.1 Landscape visual character

To determine the value of a landscape as a visual resource, it is described and assessed in terms of a number of factors. This assessment is based on information obtained from an on-site photographic assessment, as well as available aerial photo imagery and topographical maps. The summary below is done from a visual perspective only and does not attempt to describe underlying ecological or geophysical processes.

### 6.1.1 Topographic ruggedness and landforms

The area surrounding the Tutuka power station is located at some 1 640 metres above mean sea level with the slope very gradually falling to the south towards the Grootdraai Dam. The power station precinct and ash dump are located at the highest point in the immediate surrounds. The study area is characterised by gently undulating topography with no prominent topographical features present and although drainage lines form localised low-lying areas, these are not visually distinct. Furthermore the study area for the propose project is representative of the topography in the greater area (Figure 3).

*Figure 3: The topography of the study area is very gently undulating to flat with no prominent features. The runway situated along the eastern border of the site is also visible in this view.*

Due to the gently rolling and largely featureless nature of the landscape the topography is not visually distinct and as such is not considered to be a significant visual resource.

### 6.1.2 Presence of water bodies

The only visually significant drainage features in the study area is the Leeu Spruit, which drains northwards, as well as two east-west running tributary drainage lines situated north and south of the site respectively. However both tributary drainage lines are non-perennial and are not considered prominent visual features in the study area. Several small pans are present in the study area and are considered to be localised visual resources but are not significant within the context of the entire study area.

A number of small artificial dams also occur within the study area, but they are not significant within the context of the project study area. The Grootdraai Dam is located south of the site but is some 8 kilometres away and is not visible from the site. The project study area is therefore not considered to have any significant water body visual resources.

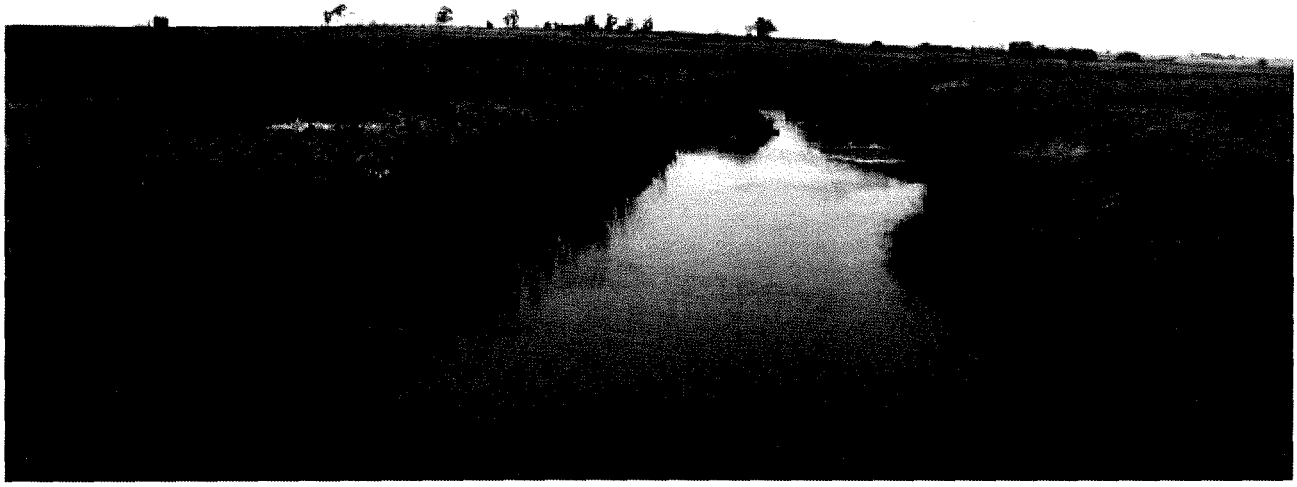


*Figure 4: The Leeu Spruit is the only visually significant water body in the immediate vicinity of the site, but is only visually prominent in short range views*

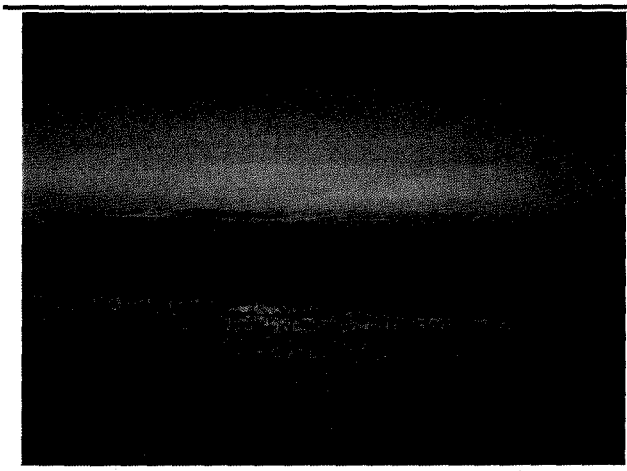
### 6.1.3 Vegetation cover

On a regional level, the study area falls within the Grassland Biome, which is typical of much of the high central plateau of South Africa.

The majority of plants in these grasslands are perennial, non-grassy herbaceous species with large underground storage structures. Tree species are limited due to frost, fire and grazing, which maintains the herbaceous grass and forb layer and ultimately prevents the establishment of tall woody plants.

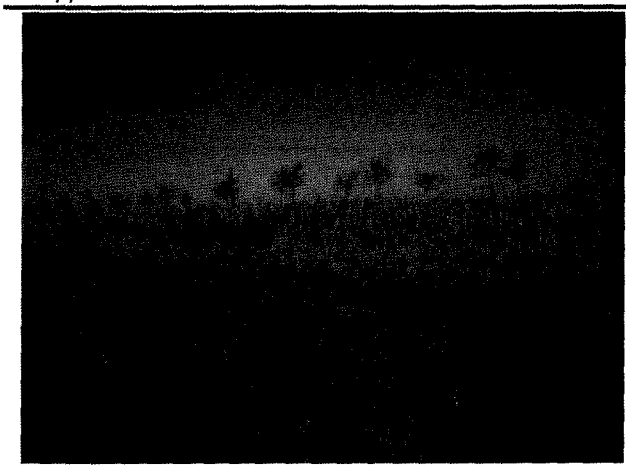
Although endowed with a wide variety of species, as a "visual community" the natural vegetation of the region does not vary much and appears relatively uniform at a glance. A multitude of different textures and colours can however be discerned upon closer inspection.

The natural vegetation cover of most of the study area has been replaced by either cultivated maize fields, or is used for livestock grazing purposes as is primarily the case with the site itself; or has otherwise been degraded by industrial and mining-related activities. Small areas of somewhat disturbed, natural vegetation occur along watercourses or fringes of other activities. Visually, these areas are largely homogenous in appearance and localised clumps of alien invader trees and human-made infrastructure become prominent elements in the landscape.

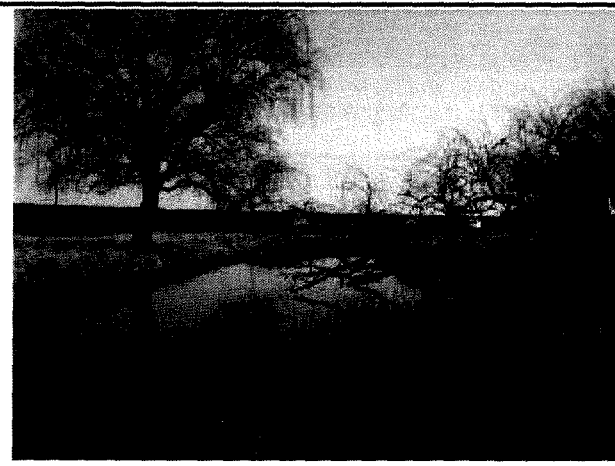


*The majority of the study area is characterised by monoculture maize fields, which are visually homogenous in appearance*

*Livestock grazing also takes place within the study area although the visual effect is somewhat limited due to the visually homogenous appearance of the vegetation cover*



*The remaining natural vegetation in the study area is largely confined to water bodies and drainage lines, as well as along fringes of roads and other infrastructure*



*Localised clumps of alien invader trees and human-made infrastructure become prominent elements in the landscape*

*Figure 5: Typical vegetation cover within the study area*

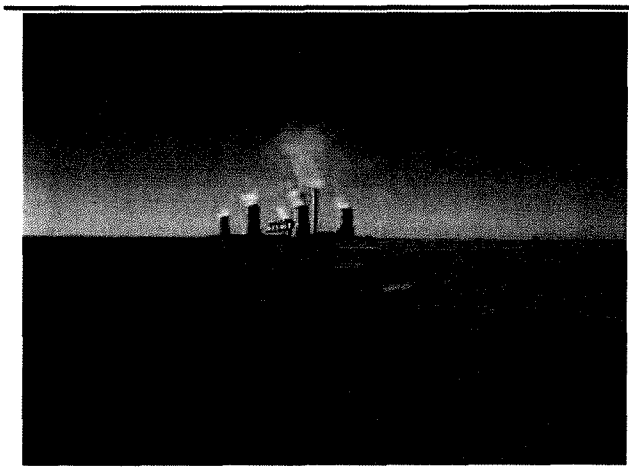
### 6.1.4 Prevalence of natural landscapes and human-made elements

The most significant settlement situated within the region is Standerton although it does not fall within the study area although a number of small townships occur both within the study area and in the greater locality. The result is that the area is largely rural in character, as there are no large central business districts or tall, visually prominent buildings. The only significant exception is the Tutuka power station, which due to its vertical height and footprint size; and the flat topography, forms a prominent landmark and is visible over great distance.

Other significant anthropogenic features situated in close vicinity of the site include:

- Thuthukani township, situated some 2 kilometres west of the site;
- The R39 and R38 Regional roads, which are situated south and east of the site respectively;
- The R546 Road, which is situated to the west and falls outside of the study area of the VIA;
- Various secondary asphalt roads, one of which forms the southern boundary of the site;
- An aircraft landing strip, which is situated along the eastern boundary of the site;

- High voltage high mast power lines leading to the north and south from Tutuka power station;
- A railway line passing north and west of the site.



*The Tutuka power station is the most significant human-made element in the study area and is visible over great distance*

*The majority of other anthropogenic elements in the landscape are linear infrastructure such as roads, railway lines and power lines*

*Figure 6: Built elements within the study area*

### 6.1.5 Sense of place / Genus loci

According to Lynch (Lynch, 1992), sense of place is "the extent to which a person can recognise or recall a place as being distinct from other places, as having a vivid or unique, or at least particular character of its own". Thus, sense of place means that a site has a uniqueness or distinctiveness, which distinguishes it from other places. The primary informant of these qualities is the spatial form and character of the natural landscape together with the cultural transformation associated with historic use and habitation. A landscape can be said to have a strong sense of place, regardless of whether it is considered to be scenically beautiful or not. Where high landscape quality and strong sense of place coincides, the visual resource is considered to be high.

The sense of place of a site is determined during the site assessment, by considering the site itself in terms of its broader context. This step is at least partially subjective, as individuals may attach different values to a landscape due to their cultural and socio-economic background, personal experiences, etc.

Although most of the area is generally of a visually pleasing nature due to its largely rural character, it is similar in character to the surrounding undeveloped areas. Tutuka power station, due to its very strongly geometric shapes and visual prominence, lends a very strongly defined sense of place to the study area; however would not necessarily be considered as pleasing or aesthetically beautiful. For this reason the study area is not considered to possess a significant genus loci from a visual resource point of view.

### 6.1.6 Visual absorption capacity (VAC)

Visual absorption capacity (VAC) can be defined as "an estimation of the capacity of the landscape to absorb development without creating a significant change in visual character or producing a reduction in scenic quality" (Oberholzer, 2005). The ability of a landscape to absorb development or additional human intervention is primarily determined by the vegetation cover, topographical landforms and existing human structures.

A further major factor is the degree of visual contrast between the proposed new project and the existing elements in the landscape. If, for example, a visually prominent industrial development already exists in an area, the capacity of that section of landscape to visually "absorb" additional industrial structures is higher than that of a similar section of landscape that is still in its natural state. VAC is therefore primarily a function of the existing land use and cover, in combination with the topographical ruggedness of the study area and immediate surroundings.

The VAC of a landscape is again determined by taking a series of representative photographs during the site visit and then relating them to available aerial photographs or topographical maps. In this fashion, areas of differing VAC potential can be spatially delineated, if relevant.

The VAC of the study area is almost exclusively low due to the largely visually uniform landscape character. The low height of the vegetation cover, general lack of trees and few human-made elements all result in the landscape not being able to absorb or "camouflage" visual changes, especially not the addition of extensive elements and infrastructure. The only exception is the immediate vicinity of Tutuka power station, which due to the extent to which it has been transformed and visually altered; is able to "absorb" a significant amount of visual change.

## 6.2 Landscape visual quality statement

Visual quality is assessed by considering the visual quality attributes (views, sense of place, visual absorption capacity and aesthetic appeal) together with the physical landscape character and gives the landscape a high, medium or low visual quality value. When considering attempts to classify or score the value of something that is inherently subjective and influenced by individual interpretation, results will not be absolute and can only be measured against the criteria and parameters that have been assigned for their assessment. The assessment criteria are based on principles commonly used in visual assessment and addresses concepts that are expected to be universally understood and experienced. Table 1 below summarises the criteria used to assess the visual quality of the landscape:

**Table 1: Visual quality assessment criteria**

| Level | Criteria |
|---|---|
| High | Pristine or near-pristine condition / little to no visible human intervention visible/ characterised by highly scenic or attractive features / Areas that exhibit a strong positive character with valued features that combine to give the experience of unity, richness and harmony. These are landscapes that may be considered to be of particular importance to conserve and which may be sensitive to change. |
| Medium | Partially transformed or disturbed landscape / human intervention visible but does not dominate view / scenic appeal of landscape partially compromised / noticeable presence of incongruous elements / Areas that exhibit positive character but which may have evidence of degradation / erosion of some features resulting in areas of more mixed character. These landscapes are less important to conserve, but may include certain areas or features worthy of conservation. |
| Low | Extensively transformed or disturbed landscape / human intervention dominates available views / scenic appeal of landscape greatly compromised / visual prominence of widely disparate or incongruous land uses and activities / Areas generally negative in character with few, if any, valued features. Scope for positive enhancement frequently occurs. |

Keeping the criteria of Table 1 and the above assessment of the study area visual character in mind, in summary it can be stated that the visual quality of the study area is of a **low to medium** value. Although the majority of the study area has a predominantly rural character, it is dominated by the power station and has been visually altered by a number of other linear and other infrastructure features. Furthermore it is not characterised by features that are visually exciting, such as prominent topography or attractive vegetation cover.

## 6.3 Receptor sensitivity

Receptors for visual impacts are people that might see the proposed development, as visual impact is primarily an impact concerned with human interest. The potential sensitivity of receptors to a project is a

factor of two criteria, namely the amount of people exposed to the project and perceived landscape value factor (Table 2):

**Table 2: Receptor Sensitivity Criteria**

| Visual Quality Score | Site Specific Criteria |
|---|---|
| **Amount of people that will see the project (exposure factor):** | |
| High | Towns and cities, along major national roads (e.g. thousands of people) |
| Medium | Villages, typically less than 1000 people. |
| Low | Less than 100 people (e.g. a few households) |
| **Receptor perception regarding the project and visual landscape (perceived landscape value factor):** | |
| High | People attach a high value to aesthetics, such as in or around a game reserve or conservation area, and the project is perceived to significantly impact on this value of the landscape. |
| Medium / Moderate | People attach a moderate value to aesthetics, such as smaller towns, where natural character is still plentiful and in close range of residency. |
| Low | People attach a low value to aesthetics, when compares to employment opportunities, for instance. Environments have already been transformed, such as cities and towns. |

Due to the generally low levels of development in the area it is unlikely that a large amount of people will be visually affected by the proposed project. Standerton is the largest settlement in the vicinity of the site; and is connected to Ermelo via the R39 Road; and Bethal via the R38 Road. It is therefore likely that residents of the aforementioned towns as well as Thuthukani Township will constitute the greatest percentage of receptors. However most receptors will only drive by and there are very few resident receptors within the study area. It is therefore expected that the receptor sensitivity for this project will be **low**.

# 7.0 IMPACT STATEMENT

## 7.1 Visibility analysis

The modelled results of the viewshed analysis carried out for the evaporation ponds (Figure 7) indicate that the visibility of the evaporation ponds will be high within short to medium range views (<2.5 km radius from the ponds) due to the flat topography and lack of visual obstruction in this area. Within the larger study area the visibility of the ponds diminish somewhat over distance as the degree of visual obstruction caused by the topography increases. The ponds are generally more visible from the west than the east, however only from a distance of approximately 4.5 km and further.

The viewshed analysis indicates that the evaporation ponds will be visible to a significant extent from Thuthukani township, however the visual impact is expected to be limited due to the distance between the township and evaporation ponds (refer to section 7.3 below).

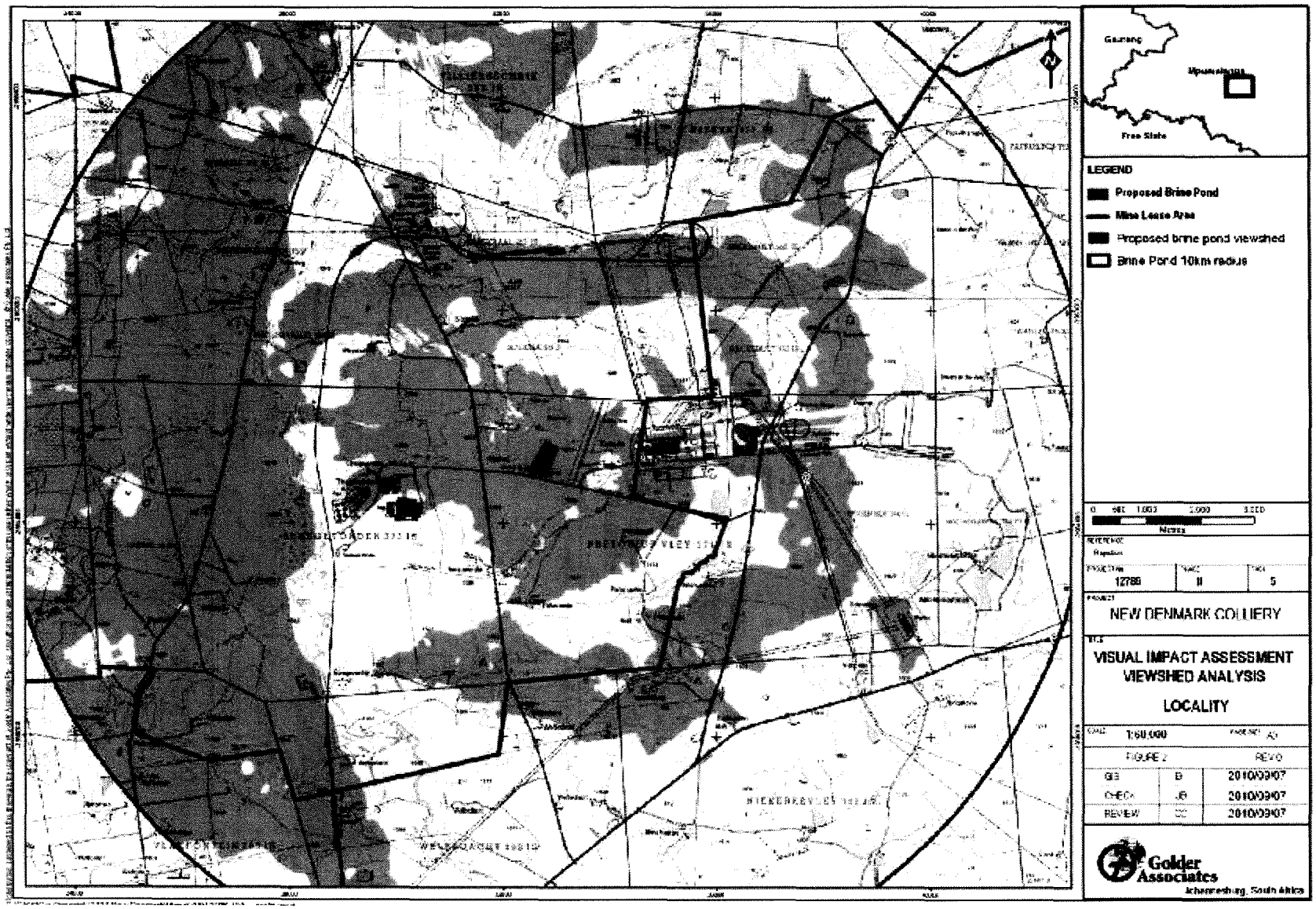



*Figure 7: Viewshed analysis of the proposed New Denmark Colliery evaporation pond*

The results of the viewshed analysis clearly indicate the visual significance of Tutuka Power Station as it noticeably affects the visibility within the study area. The great height of the burner structure and especially the cooling towers is evident in the manner in which the viewshed is fragmented by it. Based on the above assessment, in summary it is stated that the level of visibility of the project components from within the study area is expected to be **medium**.

## 7.2 Visual Intrusion

Visual intrusion deals with how well the project components fit into the ecological and cultural aesthetic of the landscape as a whole. An object will have a greater negative impact on scenes considered to have a high visual quality than on scenes of low quality because the most scenic areas have the "most to lose".

The visual impact of a proposed landscape alteration also decreases as the complexity of the context within which it takes place, increases. If the existing visual context of the site is relatively simple and uniform any alterations or the addition of human-made elements tend to be very noticeable, whereas the same alterations in a visually complex and varied context do not attract as much attention. Especially as distance increases, the object becomes less of a focal point because there is more visual distraction, and the observer's attention is diverted by the complexity of the scene (Hull and Bishop, 1998).

Due to the close proximity of the Tutuka power station to the proposed site for the new evaporation pond it is not anticipated that the evaporation ponds will cause significant visual intrusion. Compared to the power station infrastructure the evaporation ponds and associated infrastructure are small in scale and not for the most do not consist of visually complex shapes. Furthermore the evaporation ponds will be similar in appearance to a number of the existing artificial water bodies found in the area. As a result the level of visual intrusion caused by the project is expected to be **low**.

## 7.3 Visual Exposure

The visual impact of a development diminishes at an exponential rate as the distance between the observer and the object increases – refer to Figure 8. Relative humidity and fog in the area directly influence the effect. Increased humidity causes the air to appear greyer, diminishing detail. Thus, the impact at 1000 m would be 25 % of the impact as viewed from 500 m. At 2000 m it would be 10 % of the impact at 500 m. The inverse relationship of distance and visual impact is well recognised in visual analysis literature (Hull and Bishop, 1988) and was used as important criteria for this study.

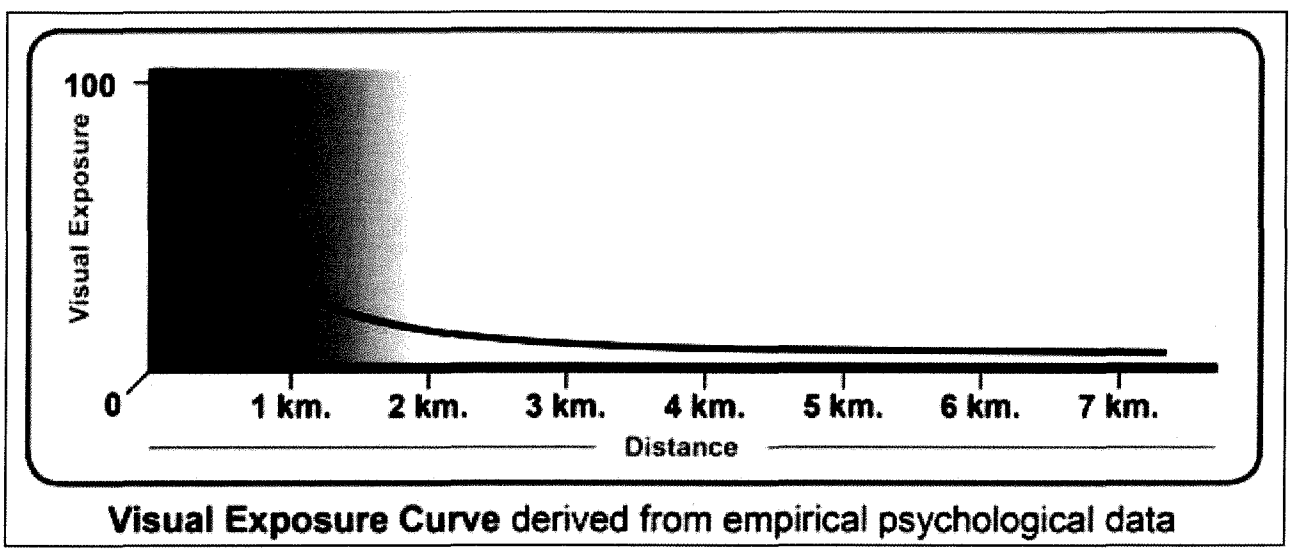



*Figure 8: Visual Exposure Graph*