# *WETLAND DELINEATION IN THE RUSTENBURG PLATINUM MINE PROJECT AREA AND A HIGH LEVEL ASSESSMENT OF SELECTED RIVER CROSSINGS, NORTH-WEST PROVINCE*

Prepared for

**SRK Consulting (Pty) Ltd**

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## Declaration

This report has been prepared according to the requirements of Section 23 (5) of the Environmental Impact Assessments (EIA) Regulations, 2014 (No. R. 982). We (the undersigned) declare the findings of this report free from influence or prejudice.

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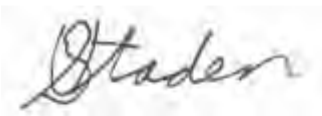

___________________ Date: 08/06/2015

Stephen van Staden

# EXECUTIVE SUMMARY

**Based on the findings of this study, it can be concluded that the water resources within the study area are in a moderate to seriously modified condition. The RPM operations have augmented most of these resources with increased water input, which led to bank incision. In addition the water quality has also been altered by deposition of contaminants from the mining area. The crossings within the RPM operation's boundary has affected the river and stream ecosystems through the loss and degradation of habitats and by disrupting ecological processes that structure and maintain these systems over time. Despite these disturbances, the watercourses are still able to provide ecological services at moderately low levels. With the implementation of mitigation measures stipulated in the report, the integrity of some of these watercourses can be enhanced and rehabilitated.**

**Based on the findings of this study, it can be concluded that the aquatic resources within the study area is in a poor condition with a low PES. The RPM operations may potentially impact on these resources with reference to dissolved salt concentration as well as the introduction of specific contaminants. However, prior to impact from any RPM activities, the aquatic resources are already heavily impacted upon by other diffuse and point sources within the larger study area, and thus potential impacts from the RPM activities are difficult to quantify. The crossings within the RPM operation's boundary have affected the river and stream ecosystems through the loss and degradation of habitats and by disrupting ecological processes that structure and maintain these systems over time.**

Scientific Aquatic Services (SAS) was appointed to conduct an aquatic ecological, wetland delineation, Present Ecological State (PES) and function assessment of selected wetland and riverine crossings (aquatic resources for the Rustenburg Platinum Mines Limited (RPM) eastern limb operations (hereinafter referred to as the “study area”) in order to address the 32m buffer rule of the National Environmental Management Act, Act 107 of 1998, (NEMA) in which activities within 32m of a wetland or watercourse require authorisation, the 100m buffer rule of Regulation GN704 of the National Water Act, Act 36 of 1998(NWA) in which mining operations within 100m of a watercourse requires exemption and the 500m buffer rule of Regulation GN1199 of the NWA which states that all activities within 500m of a wetland need to be authorised by a Water Use Licence (WUL). The RPM crossings comprise of various infrastructure types including pipelines, roadways, railway lines and electrical supply crossings.

The study area is situated adjacent to the towns Rustenburg, Phokeng, Freedom Park and Tlhabane, and the R510 roadway traverses the study area in a north to a southerly direction. In addition, the study area is situated adjacent to the R565 and R104 roadway in the North West Province.

## WETLAND ASSESSMENT

Specific outcomes required for this report in terms of the wetland assessment include the following:

- To identify Management Units within the study area, according to Hydrogeomorphic (HGM) units following the guidelines in the Classification System for Wetlands and other Aquatic Ecosystems in South Africa. User Manual: Inland Systems (Ollis *et al*., 2013) and according to location in relation to mine infrastructure;
- To delineate all wetlands and riparian zones within the study area, according to the guidelines as defined by DWA (2005;
- Determine function and service provision of wetland and riparian features according to the method supplied by Kotze *et al* (2005);
- To define the health of the systems within the study area, according to the Wet-health method described by Macfarlane *et al*., (2008) as well as a Wetland Index of Habitat Integrity (IHI) according to the method described by the DWA (2007) and thereby define the Present Ecological State (PES) of the aquatic resources to be affected by the current mining activities;
- To define the Ecological Importance and Sensitivity (EIS) and Recommended Ecological Category (REC) for the features (DWA, 1999);

- To consider potential impacts on the wetland and riparian habitat and the ecological communities likely as a result of the activities within the study area;
- To present mitigation measures in order to minimise the impact on the receiving environment; and
- To provide a brief assessment of the PES of 84 existing watercourse crossings within the study area as well as an analysis of the crossing condition impacts on the system being caused by the crossing and to define any mitigatory and management measures necessary to support the Recommended Ecological Category (REC) for each system.

<u>The following general conclusions were drawn upon completion of the literature review:</u>

- The study area falls within the Bushveld Basin and the Western Bankenveld Aquatic Ecoregion, and within the A22H, A22J, A21K quaternary catchments;
- According to the National Freshwater Ecosystem Priority Areas (NFEPA) database the study area falls within the Elands and Crocodile Water Management Area (WMA), and the subWMA indicated for the study area is the Crocodile West and Marico;
- The subWMA is not regarded important in terms of fish sanctuaries, rehabilitation or corridors;
- The subWMA is not considered important in terms of translocation and relocation zones for fish;
- The subWMA is not listed as a fish Freshwater Ecosystem Priority Area (FEPA);
- The NFEPA database indicates the presence of one river, namely the Hex River; which is not classified as a FEPA river;
- The NFEPA database indicates the presence of several wetland features within the study area, with both natural and artificial features present. The artificial wetland features were identified during the site assessment and were found to be impoundments related to mining infrastructure;
- The NFEPA database indicates that there are no Ramsar wetlands within the study area or within 500m of the study area;
- The NFEPA database indicates that the wetland features within the study area are not within 500m of an International Union for Conservation of Nature (IUCN) threatened frog point locality, or within 500m of a threatened waterbird point locality;
- According to the National List of Threatened Terrestrial Ecosystems (2011) the study area falls within the remaining extent of the vulnerable Marikana Thornveld ecosystem;
- According to the Mining Biodiversity Guidelines (2013) the majority of the study area falls within a region considered to be of High Biodiversity Importance, portions within a region considered to be of moderate Biodiversity Importance and the remainder of the study area is not classified;
- According to the National Biodiversity Assessment (2011), the study area is not located within either a formal or an informal protected area. The study area is currently not protected with isolated sections that are currently not protected; and
- According to the North-west Conservation Plan (2009) the majority of the study area is classified as a Critical Biodiversity Area (CBA) 2.

<u>The following general conclusions were drawn upon completion of the wetland assessment:</u>

Numerous ephemeral drainage lines with riparian characteristics and poorly-defined ephemeral drainage lines were identified during the assessment, in addition to the Brakspruit, Dorpspruit, Hex, Hoedspruit, Klipgatspruit, Klipfonteinspruit, Paardekraalspruit and Wildebeesfonteinspruit rivers. These features were assessed during the field assessment and the relevant assessment protocols applied. The following points summarise the results obtained:

- All wetland and riparian features were classified according to the Classification System for Wetlands and other Aquatic Ecosystems in South Africa. User Manual: Inland Systems (Ollis *et al.,* 2013), as Inland Systems falling within the Bushveld Basin and the Western Bankenveld Aquatic Ecoregion, and within the Central Bushveld Group 2 WetVeg group;
- At Level 4 of the Classification System, the features within the study area were classified as: Rivers (major river systems), ephemeral drainage lines; and dams;
- The results of the Riparian Vegetation Response Index (VEGRAI) applied to the major river systems indicate that the riparian vegetation associated with these features has undergone severe loss and transformation. The Paardekraalspruit obtained a VEGRAI score placing the vegetation within Ecological Category (ECat) C, Klipfonteinspruit obtained a score that places the vegetation within Category C/D, Brakspruit, Dorpspruit, Hex, Hoedspruit and Klipgatspruit

obtained a score that falls within Category D and Wildebeesfonteinspruit obtained a score that falls within Category D/E;

- The Present Ecological State (PES) of the dams was assessed collectively using WET-Health assessment. The results of this assessment indicate that the overall PES fall within category B, which implies that the wetlands are largely natural with few modifications;
- The Index of Habitat Integrity (IHI) was applied to the major rivers and ephemeral drainage lines to assess the PES of these features. The rivers were assessed on a broad scale and the results of the assessment are in the table below, and indicate that the features within the study area have undergone moderate to large modifications to vegetation, hydrology and geomorphology;

**Summary of the results of the WET-IHI assessments conducted for the rivers and ephemeral drainage line features within the study area.**

| Feature | PES Category |
|---|---|
| Brakspruit River | C/D |
| Dorpspruit River | C |
| Hex River | C |
| Hoedspruit River | D |
| Klipfonteinspruit River | C/D |
| Klipgatspruit River | C |
| Paardekraalspruit River | C/D |
| Wildebeesfonteinspruit River | C |
| Drainage line | B |

- Wetland functionality and ecological service provision were assessed utilising the method described by Kotze *et al.* (2008). The results of the ecoservices assessment indicate that all features have a moderately low level of service provision;

**Summary of the wetland function and service provision assessments for each group of wetland/riparian features assessed.**

| Feature | Score | Category |
|---|---|---|
| Brakspruit River | 0.8 | Moderately low |
| Dorpspruit River | 1.0 | Moderately low |
| Hex River | 1.1 | Moderately low |
| Hoedspruit River | 1.0 | Moderately low |
| Klipfonteinspruit River | 1.1 | Moderately low |
| Klipgatspruit River | 1.1 | Moderately low |
| Paardekraalspruit River | 1.1 | Moderately low |
| Wildebeesfonteinspruit River | 1.1 | Moderately low |
| Dams | 0.9 | Moderately low |
| Drainage line | 0.8 | Moderately low |

- The EIS assessment was applied to all wetlands and riparian features within the study area in order to ascertain the levels of sensitivity and ecological importance of the features, as well as to assist in informing a suitable REC for each. The results of these assessments are summarised in the table below;
- The REC for the drainage lines and riparian features were determined taking into account the results of the IHI and/or WET-health, wetland function, and EIS assessments. The REC deemed appropriate for the wetland and riparian features are presented in the table below; and

**Summary of the EIS scores for all wetlands and riparian features within the study area.**

| Feature | Score | EIS Category | REC Category |
|---|---|---|---|
| Brakspruit River | 1.4 | C | D |
| Dorpspruit River | 1.3 | C | D |
| Hex River | 1.3 | C | D |
| Hoedspruit River | 1.4 | C | D |
| Klipfonteinspruit River | 1.0 | D | D |
| Klipgatspruit River | 1.1 | C | C |
| Paardekraalspruit River | 1.3 | C | C |
| Wildebeesfonteinspruit River | 1.0 | D | D |
| Dams | 1.1 | C | B |
| Drainage line | 1.2 | C | C |

- A 100m buffer zone was allocated to all the watercourses in the vicinity of the mining operations area. The buffer was allocated according to the 100m buffer rule of Regulation GN704 of the National Water Act (NWA) in which mining operations within 100m of a watercourse (in which mining operations within 100m of a watercourse requires exemption).

# AQUATIC ECOLOGICAL ASSESSMENT

The following general conclusions were drawn upon completion of the literature review:

The PES/EIS database, as developed by the Department of Water and Sanitation (DWS) Resource Quality Information Services (RQIS) department, was utilised to obtain background information on the project area. According to the ecological importance classification for the quaternary catchment, the system can be considered to be a Class E (seriously modified) stream according to the PES classification. In terms of the default EC classification, the system has the potential to attain Class C conditions.

The following general conclusions were drawn upon completion of the aquatic assessment of the receiving environment:

**Biota specific water quality variables assessed:**

- The water quality data indicates that the electrical conductivity (EC) at all the sites is significantly elevated from expected natural conditions (EC < 40 mS/m);
- The EC values of the sites located on the Hex River increases significantly in a downstream direction. The EC increased by 8.1% between the SASS 22 and SASS 26 sites, by 49.3% between site SASS 26 and SASS 27A, and by 7.0% between site SASS 27A and SASS 29. Overall the EC increased by 72.6% between the upstream site SASS 22 and the downstream site SASS 29. This spatial change exceeds the target water quality requirements (TWQR) for aquatic ecosystems (DWAF, 1996), which advocate no change greater than 15% from the reference value;
- The increased EC indicates that dissolved salts are entering the system, and is likely due to activities associated with the RPM operations. However, the contribution from these sources are difficult to quantify as run-off from various diffuse and point sources from the surrounding areas most likely also contributes to the salt load;
- The EC values of sites located on the Dorpspruit increase significantly in a downstream direction by 41.5%. This spatial change exceeds the TWQR (DWAF, 1996). The elevated EC value at site SASS 32 is likely due to the construction activities taking place at the time of the assessment;
- The EC value at site SASS 9 is critically elevated from natural conditions and is the highest EC recorded at the time of the assessment. It is possible that the run-off from the UG2 Concentrator and surrounding RPM activities are reaching the Klipfonteinspruit;
- The EC recorded at site SASS 21 is elevated from natural conditions, indicating that dissolved salts are entering the system. Run-off and/or seepage from the Paardekraal Tailings Dam PK4 is likely entering the system. However, the contribution from these sources are difficult to quantify as run-off from various diffuse and point sources from the surrounding areas possibly also contribute to the salt load;

- The pH values recorded at all the sites can be considered as largely natural, with the exception of site SASS 9 which is slightly acidic;
- Spatially, pH values of sites located on the Hex River increases by 5.9% between sites SASS 22 and SASS 26, decrease by 0.7% between sites SASS 26 and SASS 27A, and decreased by 5.4% between sites SASS 29 and SASS 27A. Overall the pH has decreased by 0.5% between the upstream site SASS 22 and the downstream site SASS 29. This change complies with the TWQR (DWAF, 1996) for aquatic ecosystems which advocate no change greater than 5% from spatial or temporal data. No impact on the aquatic community as a result of altered pH values are likely at the time of the assessment;
- The pH values of sites located on the Dorpspruit decreased slightly by 2.0% in a downstream direction. This change complies with the TWQR (DWAF, 1996) for aquatic ecosystems. No impact on the aquatic community as a result of altered pH values are likely at the time of the assessment;
- The pH recorded at site SASS 9 on the Klipfonteinspruit can be considered as slightly acidic at the time of the assessment. It is possible that the run-off from the UG2 Concentrator and surrounding RPM activities are reaching the Klipfonteinspruit;
- The pH recorded at site SASS 21 on the Paardekraalspruit can be considered as largely natural at the time of the assessment. No impact on the aquatic community as a result of altered pH values are likely at the time of the assessment;
- The DO concentrations at most of the sites do not comply with the TWQR (DWAF, 1996) for aquatic ecosystems, only sites SASS 27A and SASS 9 exceed the minimum guideline requirements of 80% saturation;
- DO concentrations of sites SASS 31 and SASS 32 on the Dorpspruit and site SASS 21 on the Paardekraalspruit are significantly lower than the TWQR (DWAF, 1996) for aquatic ecosystems. This is likely due to diffuse and point impacts from the surrounding settlements, from Prison Dam as well as the RPM operations. Some impact on the aquatic community is likely at the time of the assessment;
- The DO concentration recorded at site SASS 29 is critically low at the time of the assessment, thus some impact on the diversity and sensitivity of the aquatic community is likely at this point. The reduced DO at the downstream site SASS 29 is likely as a result of cumulative impacts from other diffuse and point impacts in the larger RPM operations area as this site is located downstream of the confluence with the Dorpspruit, Klipfonteinspruit and Paardekraalspruit;
- Temperatures can be regarded as normal for the time of year when sampling took place.

<u>Indices employed:</u>

**Intermediate habitat integrity assessment (IHIA):**
Overall, for habitat integrity the Hex River scored 57.1% (Class D), the Dorpspruit scored 67.8% (Class C), the Klipfonteinspruit scored 46.9% (Class D), and the Paardekraalspruit scored 59.0% (Class D).

**Invertebrate habitat assessment (IHAS):**

- The habitat structure and diversity of the Hex River sites are adequate (SASS 22) and highly suited (SASS 26, 27A and 29) for supporting a diverse and sensitive aquatic community. Spatially the IHAS increased in a downstream direction and as a result species diversity and sensitivity is expected to increase in a downstream direction;
- The habitat structure and diversity of the Dorpspruit can be regarded as adequate for supporting a diverse and sensitive aquatic community at both sites. Spatially the IHAS decreased between the two sites, as a result the species diversity and sensitivity is expected to decrease in a downstream direction;
- The habitat structure and diversity in both the Klipfonteinspruit (SASS 9) and Paardekraalspruit (SASS 21) can be regarded as inadequate for supporting a diverse and sensitive aquatic community.

**South African scoring system (SASS5):**

- The upstream (SASS 22) and downstream (SASS 29) sites of the Hex River may be considered to be in a Class E/F (severely impaired) condition according to the Dallas (2007) classification system. Both sites can be classified as a Class E (seriously impaired) conditions according to the Dickens & Graham (2001) classification system. Site SASS 26 can be considered as Class D (largely impaired) according to the Dallas (2007) classification, and as a Class C (moderately impaired) condition according to the Dickens & Graham (2001) classification system. Site SASS 27A can be considered as Class C (moderately impaired) according to the Dallas (2007) classification, and as a Class B (largely natural) condition according to the Dickens & Graham (2001) classification system;

- Spatially between the upstream and the downstream sites of the Hex River, the SASS5 score increased by 48.9% between the SASS 22 and SASS 26 sites, by 35.7% between the SASS 26 and SASS 27A sites, while decreasing by 57.9% between SASS 27A and SASS 29. Overall between the upstream SASS 22 site and the downstream SASS 29 site the SASS5 score decreased by 14.9%. It is clear that the macro-invertebrate diversity increases in a downstream direction on the Hex River, and decreases significantly once the Hex River confluences with the Dorpspruit, Klipfonteinspruit and Paardekraalspruit. This is likely as a result of the increased salt loading and possibly the addition of specific toxicants to the system;
- Spatially the ASPT score increased by 11.6% between sites SASS 22 and SASS 26, and decreased by 8.3% between sites SASS 26 and SASS 27A. The ASPT has remained unchanged between sites SASS 27A and SASS 29. Overall, between sites SASS 22 and SASS 29 the ASPT score has increased slightly by 2.3%, this is likely due to the increased habitat suitability at the downstream site;
- Both the upstream (SASS 31) and downstream (SASS 32) sites of the Dorpspruit may be considered to be in a Class E/F (severely impaired) condition according to the Dallas (2007) classification system. Both sites can be classified as a Class E (seriously impaired) conditions according to the Dickens & Graham (2001) classification system.
- Spatially between the upstream (SASS 31) and downstream (SASS 32) sites of the Dorpspruit, the SASS5 score has increased slightly by 2.9%, while the ASPT score has decreased by 25.0%. The decrease in macro-invertebrate sensitivity is likely due to the increased salt loading and possibly the addition of specific toxicants to the system. This is likely to be partially as a result of the bridge construction activities present at the time of the assessment;
- The SASS 9 site of the Klipfonteinspruit may be considered to be in a Class C (moderately impaired) condition according to the Dallas (2007) classification system. The site can be classified as a Class C (moderately impaired) conditions according to the Dickens & Graham (2001) classification system;
- The SASS 21 site of the Paardekraalspruit may be considered to be in a Class D (largely impaired) condition according to both the Dallas (2007) and Dickens & Graham (2001) classification systems.

**Macro-invertebrate Response Assessment Index (MIRAI):**

The MIRAI results are similar to those of the SASS5 indices employed, as measured by the Ecological Category classification. A trend of general deterioration from expected natural conditions in terms of macro-invertebrate community integrity is clearly evident. This is due to the modified flow conditions experienced at the time of the assessment, the decreased water quality with special mention of increased salt loading within all the systems and low dissolved oxygen concentrations especially within the Dorpspruit and the limited habitat availability at the Paardekraalspruit and Klipfonteinspruit biomonitoring sites. This general deterioration in integrity is evident at all sites assessed, indicating that the entire system suffers from negative impacts. The aaquatic assessment indicated severely modified conditions that correspond with the PES category median classification of E (DWS RQIS PES/EIS database).

**Summary of the results (ecological categories) obtained from the application of the MIRAI to the assessment sites, compared to classes awarded using SASS5.**

| Variable / Index | SASS 22 | SASS 26 | SASS 27A | SASS 29 | SASS 31 | SASS 32 | SASS 9 | SASS 21 |
|---|---|---|---|---|---|---|---|---|
| Ecological category (MIRAI) | E | D | D | E | E | E | D | D |
| Dickens and Graham (SASS5) | E | C | B | E | E | E | C | D |
| Dallas (SASS5) | E/F | D | C | E/F | E/F | E/F | C | D |

**Fish Response Assessment Index (FRAI):**

- Results indicate that the fish integrity at both the upstream and downstream sites are currently in a critically modified state (Class F);
- The absence of a fish community at both sites is likely due to poor water quality as a result of high dissolved salt concentrations observed at these points. The shallow water and lack of cover in the muddy substrate observed in the system during the current assessment is also deemed likely to have had an impact on the presence and distribution of the fish at both sites;
- Some restriction on the fish community may be present due to these habitat and water quality limitations with species relying on cleaner, deeper water and vegetative cover being limited; and
- Upstream and downstream migration barriers on the Hex River may also affect the fish diversity along this section of the river, although the natural variation in distribution patterns, as well as seasonal variation in fish movement in the system may also be influencing the absence of fish in this section of the catchment.

<u>The following general conclusions were drawn upon completion of the impact statement:</u>

- After the assessment of the crossings it was concluded that the crossings are mostly impacted by
  - Erosion as a result of heavy livestock grazing and trampling;
  - Soil and water contamination due to waste dumping underneath the bridges/culverts;
  - Increased runoff from hardened surfaces;
  - Migration barriers as a result of collapsed structures within stream channels;
  - Culvert blockages due to increased sediment load deposition and debris.
- As long linear ecosystems, rivers and streams are particularly vulnerable to fragmentation. A number of human activities can disrupt the continuity of river and stream ecosystems. There is growing concern about the role of road crossings, and especially culverts, in altering habitats and disrupting river and stream continuity; and
- Road crossings can affect river and stream ecosystems through the loss and degradation of habitats, erosion and sedimentation, system hydrology, alteration of water quality and by disrupting ecological processes that structure and maintain these systems over time. The movement of organisms within rivers and streams is an important ecological process that can be significantly affected by road crossings.
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<u>Key mitigation measures to be implemented include</u>**:**

- Sensitivity maps have been developed for the study area, indicating the drainage lines and riparian systems, and their relevant buffer zones as shown in Figures 42 to 46 of section 4.9 above. It is recommended that this sensitivity map be considered during rehabilitation, to aid in the conservation of wetland and aquatic habitat and resources within the study area;
- A minimum buffer of 100 m around all riparian systems should be maintained in line with the requirements of regulation GN704 of the National Water Act wherever possible;
- Any areas where bank failure is observed, due to the effects of bridge crossings, should be immediately repaired by reducing the gradient of the banks to a 1:3 slope and where deemed necessary, installing support structures;
- Reconstruct collapsed roads and culverts;
- Regularly desilt all clogged culverts and clean up litter below bridges. Communities must be urged not to litter and only use municipal waste sites to dump waste;
- Edge effects of activities, particularly erosion and alien/weed control need to be strictly managed.
- To prevent the further erosion of soils, management measures may include berms, soil traps, hessian curtains and stormwater diversion away from areas particularly susceptible to erosion;
- Clear out any overgrown or alien vegetation, reducing the flow of water within the watercourses. During the removal of alien and weed species care should be taken with the choice of herbicide to ensure that no additional impact and loss of indigenous plant species occurs due to the herbicide used. The process must comply with existing legislation

(amendments to the regulations under the Conservation of Agricultural Resources Act, Act 43 (CARA) of 1983 and Section 28 of the NEMA);

- Stabilisation of river banks in the vicinity of any bridge crossings over riparian or ephemeral drainage line resources by employing one of the individual techniques below or a combination thereof, is essential, given the inherent susceptibility of the soils to erosion. Such measures include:
  - Re-sloping of banks to a maximum of a 1:3 slope;
  - Revegetation of re-profiled slopes;
  - Temporary stabilisation of slopes using geotextiles; and
  - Installation of gabions and reno mattresses.
- Monitor all areas for erosion and incision, particularly any riparian/wetland crossings. Any areas where erosion is occurring excessively quickly should be rehabilitated as far as possible during the current dry season and in conjunction with other role players in the catchment
- Rehabilitate all drainage lines and riparian habitat areas to ensure that the ecology of these areas is re-instated during all phases;
- As far as possible, all rehabilitation activities should occur in the low flow season, during the drier winter months;
- As much vegetation growth as possible should be promoted in the vicinity of the crossings in order to protect soils;
- Tend to bridge crossings that affect migration of aquatic fauna;
- Regular physico-chemical monitoring of aquatic resources in the vicinity of the RPM operations must be implemented in order to keep track of water quality. A close investigation and monitoring of the Electrical Conductivity (EC) levels, pH and Dissolved Oxygen (DO) levels of surface water bodies in the area is advised;
- No water from any RPM process activities should be allowed to enter into the receiving aquatic environment;
- Definitive testing on all four trophic levels is strongly recommended if discharge is expected to occur at any time. The definitive tests will allow the required dilution volumes to be determined to prevent an acute toxicological risk to the receiving aquatic environment. It is further recommended that the definitive toxicity testing be run according to the direct estimation of Ecological Effect Potential (DEEEP) as advocated by the DWS;
- It is recommended that ongoing aquatic ecological monitoring takes place on a 6 monthly basis by an SA RHP Accredited assessor; and
- Results should be compared spatially and temporally to the results of this document. If it is observed through biomonitoring information that significant negative changes are taking place in ecological integrity (Change of Class), it should be taken as an indication that the system is suffering stress and mitigatory actions should be identified and where possible implemented.

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# GLOSSARY OF TERMS & ACRONYMS

| | |
|---|---|
| **Alien vegetation** | Plants that do not occur naturally within the area but have been introduced either intentionally or unintentionally. Vegetation species that originate from outside of the borders of the biome -usually international in origin. |
| **Alluvial soil** | A deposit of sand, mud, etc. formed by flowing water, or the sedimentary matter deposited thus within recent times, especially in the valleys of large rivers. |
| **Base flow** | Long-term flow in a river that continues after storm flow has passed. |
| **Biodiversity** | The number and variety of living organisms on earth, the millions of plants, animans and micro-organisms, the genes they contain, the evolutionary history and potential they encompass and the ecosystems, ecological processes and landscape of which they are integral parts. |
| **Buffer** | A strip of land surrounding a wetland or riparian area in which activities are controlled or restricted, in order to reduce the impact of adjacent land uses on the wetland or riparian area. |
| **Catchment** | The area contributing to runoff at a particular point in a river system. |
| **Delineation (of a wetland)** | To determine the boundary of a wetland based on soil, vegetation and/or hydrological indicators. |
| **Ecoregion** | An ecoregion is a "recurring pattern of ecosystems associated with characteristic combinations of soil and landform that characterise that region". |
| **Ephemeral stream** | A stream that has transitory or short-lived flow. |
| **Facultative species** | Species usually found in wetlands (76%-99% of occurrences) but occasionally found in non-wetland areas. |
| **Fluvial** | Resulting from water movement. |
| **Gleying** | A soil process resulting from prolonged soil saturation which is manifested by the presence of neutral grey, bluish or greenish colours in the soil matrix. |
| **Groundwater** | Subsurface water in the saturated zone below the water table. |
| **Hydromorphic soil** | A soil that in its undrained condition is saturated or flooded long enough to develop anaerobic conditions favouring the growth and regeneration of hydrophytic vegetation (vegetation adapted to living in anaerobic soils). |
| **Hydrology** | The study of the occurrence, distribution and movement of water over, on and under the land surface. |
| **Hydromorphy** | A process of gleying and mottling resulting from the intermittent or permanent presence of excess water in the soil profile. |
| **Hydrophyte** | Any plant that grows in water or on a substratum that is at least periodically deficient of oxygen as a result of soil |

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|---|---|
| | saturation or flooding; plants typically found in wet habitats. |
| **Intermittent flow** | Flows only for short periods. |
| **Indigenous vegetation** | Vegetation occurring naturally within a defined area. |
| **Mottles** | Soils with variegated colour patterns are described as being mottled, with the “background colour” referred to as the matrix and the spots or blotches of colour referred to as mottles. |
| **Obligate species** | Species almost always found in wetlands (>99% of occurences). |
| **Perched water table** | The upper limit of a zone of saturation that is perched on an unsaturated zone by an impermeable layer, hence separating it from the main body of groundwater. |
| **Perennial** | Flows all year round. |
| **RAMSAR** | The Ramsar Convention (The Convention on Wetlands of International Importance, especially as Waterfowl Habitat) is an international treaty for the conservation and sustainable utilisation of wetlands, i.e., to stem the progressive encroachment on and loss of wetlands now and in the future, recognising the fundamental ecological functions of wetlands and their economic, cultural, scientific, and recreational value. It is named after the city of Ramsar in Iran, where the Convention was signed in 1971. |
| **RDL (Red Data listed) species** | Organisms that fall into the Extinct in the Wild (EW), critically endangered (CR), Endangered (EN), Vulnerable (VU) categories of ecological status. |
| **Seasonal zone of wetness** | The zone of a wetland that lies between the Temporary and Permanent zones and is characterised by saturation from three to ten months of the year, within 50cm of the surface. |
| **Temporary zone of wetness** | the outer zone of a wetland characterised by saturation within 50cm of the surface for less than three months of the year. |
| **Indigenous vegetation** | Vegetation occurring naturally within a defined area |
| **Riparian system** | Riparian wetlands are recognised as boundaries between the terrestrial and riverine systems |
| **Ecoregion** | An ecoregion is a "recurring pattern of ecosystems associated with characteristic combinations of soil and landform that characterise that region |

# LIST OF ACRONYMS

| | |
|---|---|
| **BMP** | Best Management Practice |
| **CBA** | Critical Biodiversity Area |
| **CSIR** | Council of Scientific Industrial Research |
| **DEEEP** | Direct Estimation of Ecological Effect Potential |
| **DO** | Dissolved Oxygen |
| **DWA** | Department of Water Affairs |
| **DWAF** | Department of Water Affairs and Forestry |
| **DWS** | Department of Water and Sanitation |
| **EAP** | Environmental Assessment Practitioner |
| **EC** | Electrical Conductivity |
| **ECat** | Ecological Category |
| **EI** | Ecological Importance |
| **ES** | Ecological Sensitivity |
| **EIA** | Environmental Impact Assessment |
| **EIS** | Ecological Importance and Sensitivity |
| **EMC** | Ecological Management Class |
| **ESA** | Ecological Support Area |
| **EWRS** | Environmental Water Requirement Site |
| **FEPA** | Fresh Water Priority Areas |
| **FHA** | Fish Habitat Assessment |
| **FRAI** | Fish Response Assessment Index |
| **GIS** | Geographic Information System |
| **GPS** | Global Positioning System |
| **ha** | Hectares |
| **HCR** | Habitat Cover Rating |
| **HGM** | Hydro-geomorphic |
| **IHAS** | Invertebrate Habitat Assessment System |
| **IHI** | Index of Habitat Integrity |
| **IHIA** | Intermediate Habitat Integrity Assessment |
| **IUCN** | International Union for Conservation of Nature |
| **m** | Metres |
| **mm** | Millimetres |
| **MEA** | Millennium Ecosystem Assessment |
| **MIRAI** | Macro-Invertebrate Response Assessment Index |
| **NAEHMP** | National Aquatic Ecosystem Health Monitoring Programme |
| **NBA** | National Biodiversity Assessment |
| **NEMA** | National Environmental Management Act |

| | |
|---|---|
| **NFEPA** | National Freshwater Ecosystem Priority Areas |
| **NWA** | National Water Act |
| **NWCP** | North West Conservation Plan |
| **PEMC** | Present Ecological Management Class |
| **PES** | Present Ecological State |
| **RDM** | Resource Directed Measures |
| **REC** | Recommended Ecological Category |
| **RHP** | River Health Program |
| **RPM** | Rustenburg Platinum Mines |
| **RQIS** | Resource Quality Information Services |
| **SAIAB** | South African Institute of Aquatic Biodiversity |
| **SANBI** | South African National Biodiversity Institute |
| **SANParks** | South African National Parks |
| **SA RHP** | South African River Health Programme |
| **SAS** | Scientific Aquatic Services |
| **SASS** | South African Scoring System |
| **SDF** | Spatial Development Framework |
| **TWQR** | Target Water Quality Requirements |
| **USEPA** | United States Environmental Protection Agency |
| **VEGRAI** | Riparian Vegetation Response Assessment Index |
| **WMA** | Water Management Area |
| **WMS** | Water Monitoring Sites |
| **WRC** | Water Research Council |
| **WUL** | Water Use Licence |

# 1 INTRODUCTION

Scientific Aquatic Services (SAS) was appointed to conduct a wetland delineation, Present Ecological State (PES) and function assessment of selected wetland and riverine crossings for the Rustenburg Platinum Mines Limited (RPM) eastern limb operations (hereinafter referred to as the "study area"). The crossings comprise of various infrastructure types including pipelines, roadways, railway lines and electrical supply crossings. The study area is extensive and various RPM managed surface infrastructure operations, including Tailings Storage facilities, processing and beneficiation plants, shaft complexes workshops, offices and other supporting infrastructure are scattered throughout the area (Figures 1 and 2). The study area is situated adjacent to the towns Rustenburg, Phokeng, Freedom Park and Tlhabane, and the R510 roadway traverses the study area in a north to southerly direction. In addition, the study area is situated adjacent to the R565 and R104 roadways in the North West Province.

According to the Anglo American Platinum Rustenburg Operations External Water Use Licence Audit Report (SRK, 2014) the Anglo American Platinum Ltd (AAP) Rustenburg Operations 100% owned and operated by RPM was issued a Water Use Licence (WUL), No. 03/A22H/ACGIJ/926 (File No. 16/2/7/A210/C5), signed 6 March 2012 and received by the Licensee 22 March 2012. In terms of the WUL RPM is required to assess the authorised Section 21(c) and (i) uses from a wetland and aquatic ecology perspective as per the applicable conditions in Appendix IV of the WUL.

RPM has mined the Merensky Reef in the Rustenburg area since 1929, and since 1949 mining has been continuous and at an increasing rate until the present day. The mining business was restructured in 2013 with three shafts placed on Care and Maintenance in 2014.

A site visit was conducted during April 2015, where the wetland, watercourse and riparian areas were delineated and an assessment was conducted in order to define the PES and Ecostatus (EC) of the features within the study area, with special focus on the crossings, and diversions. The wetland, watercourse and riparian features were characterised according to the Classification System for Wetlands and other Aquatic Ecosystems in South Africa. User Manual: Inland Systems (Ollis *et. al.,* 2013) and system modifiers were noted. In addition aspects which define the Ecological Importance and Sensitivity (EIS) of the system were noted to inform the impact assessment.

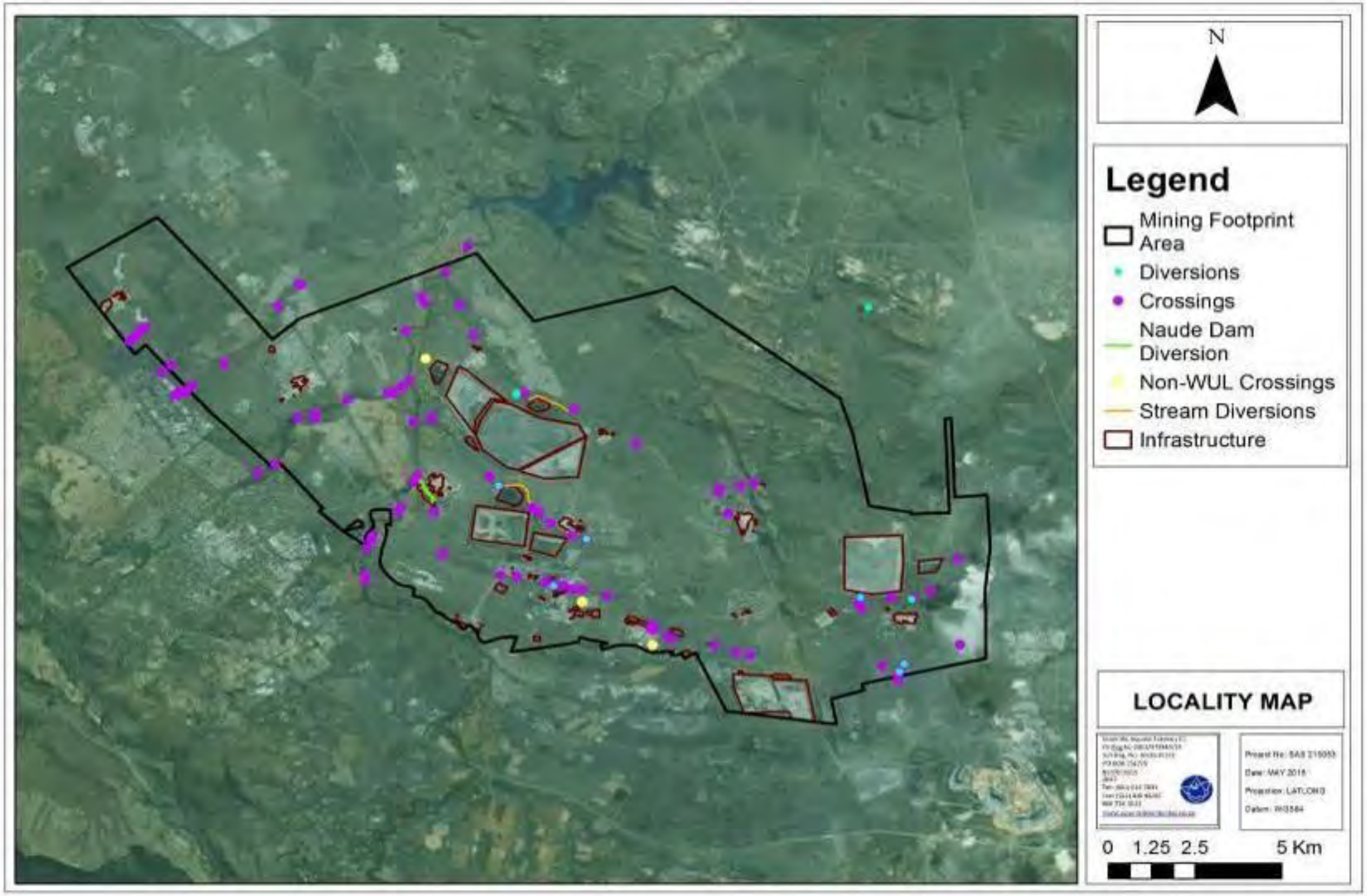


**Figure 1: Digital satellite image depicting the location of the RPM Project Area and the crossings and diversion localities in relation to surrounding areas.**

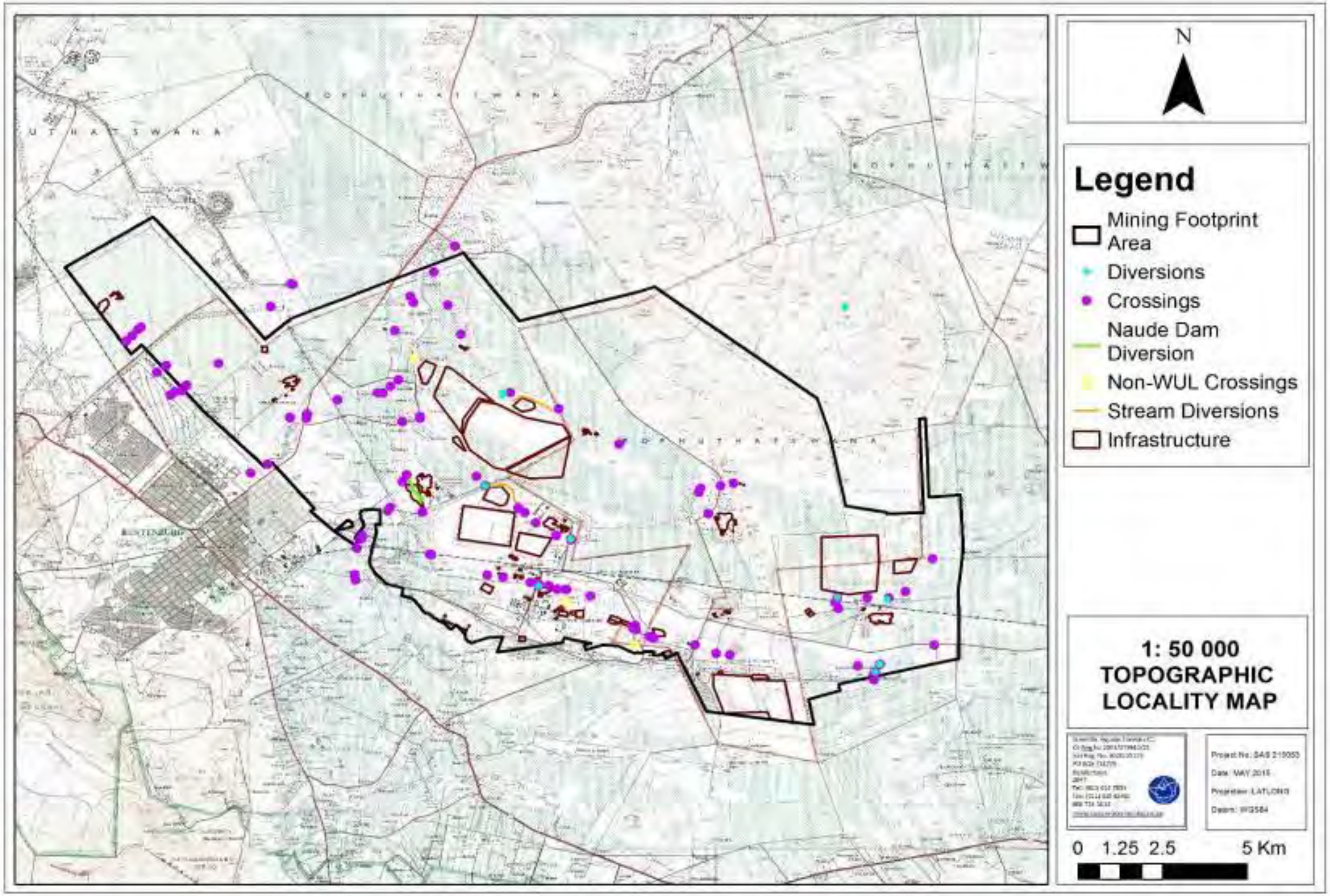


**Figure 2: The study area depicted on a 1:50 000 topographic map in relation to the surrounding area.**

## 1.1 Scope

The main goal of this assessment was to determine the status of the aquatic environment and evaluate the extent of site-related effects in terms of selected ecological indicators, as well as to identify specific important aquatic ecological attributes.

Initially background information and digital satellite imagery was gathered in order to select representative crossings. Specific outcomes in terms of this report are as follows:

**Wetland and riparian resource assessment**

- To identify Management Units within the study area according to Hydrogeomorphic (HGM) units following the guidelines in the Classification System for Wetlands and other Aquatic Ecosystems in South Africa. User Manual: Inland Systems (Ollis *et al*., 2013) and according to location in relation to mine infrastructure;
- To delineate all wetland and riparian zones within the study area according to the guidelines as defined by Department of Water Affairs and Forestry(DWAF, 2008);
- Determine function and service provision of wetland and riparian features according to the method supplied by Kotze *et al* (2005);
- To define the health of the systems within the study area according to the Wet-health method described by Macfarlane *et al*., (2008) and Wetland Index of Habitat Integrity according to the method described by the DWAF[1] (2007) and thereby define the Present Ecological State (PES) of the aquatic resources affected by the current mining activities;
- To define the Ecological Importance and Sensitivity (EIS) and Recommended Ecological Category (REC) for the features (DWAF, 1999);
- To consider potential impacts on the wetland and riparian habitat and the ecological communities likely as a result of the activities within the study area;
- To present mitigation measures in order to minimise the impact on the receiving environment;
- A brief consideration of potential water quality impacts and risks was undertaken;
- Characterisation of the aquatic environment, the aquatic habitat and related biota. The Ecological Importance and Sensitivity will be defined, as well as the determination of the Present Ecological State of the various aquatic systems;
- All work will be undertaken by a South African River Health Programme (SA RHP)

[1] The Department of Water Affairs (DWA) is currently known as the Department of Water and Sanitation (DWS) and prior to being known as DWA, it was known as the Department of Water Affairs and Forestry (DWAF). For the purposes of referencing in this report, the name under which the Department was known during the time of publication of reference material, will be used.

Accredited assessor; and

- The crossing assessment will be undertaken by a wetland specialist, using Wet-Health and/or Index of Habit Integrity (IHI) for the Present Ecological state as well as Wet-ecoservices for functionality of the features.

## 1.2 Assumptions and Limitations

The following assumptions and limitations are applicable to this report:

- Due to the extent of the study area, use was made of aerial photographs, digital satellite imagery as well as provincial and national wetland databases to identify areas of interest prior to the field survey. Any additional wetland areas, watercourses and drainage lines noted during the field survey were also assessed and added to the number of survey points. Although all possible measures were undertaken to ensure all wetland features, riparian zones and drainage lines (watercourses) were assessed and delineated, some smaller ephemeral features may have been overlooked. However, if the sensitivity map is consulted during the planning phases of any mine expansions, the majority of watercourse/riparian habitat considered to be of increased EIS will be safeguarded;
- The wetland delineations as presented in this report are regarded as a best estimate of the wetland boundaries based on the site conditions present at the time of assessment. It must be noted that due to the extent of the study area extensive use was made of digital Satellite imagery to delineate wetland boundaries and not all areas were delineated in detail;
- Global Positioning System (GPS) technology is inherently inaccurate and some inaccuracies, due to the use of handheld GPS instrumentation, may occur. If more accurate assessments are required the wetlands will need to be surveyed and pegged according to surveying principles. The delineations are however deemed sufficiently accurate to ensure that the wetland resources are adequately protected if the management and mitigation measures of this report are adhered to and adequate buffers are implemented;
- Due to the majority of drainage features being non perennial within the region, not all features encountered displayed more than one wetland characteristic as defined by the DWA (2008) method. In addition, significant transformation of the vegetation communities and soil profiles arising from historical and current agricultural practices as well as mining activities within the study area, was apparent. As a result, identification of the outer boundary of temporary wetland zones and riparian zones

proved difficult in some areas and in particular in the areas where wetland conditions and riparian zones are marginal. Therefore, the wetland/riparian delineations as presented in this report are regarded as a best estimate of the wetland/riparian boundaries based on the site conditions present at the time of assessment;

- Wetlands and terrestrial zones create transitional areas where an ecotone is formed as vegetation species change from terrestrial to wetland species. Within this transition zone some variation of opinion on the wetland/riparian boundary may occur, however if the DWA 2008 method is followed, all assessors should get largely similar results; and
- Aquatic, wetland and riparian ecosystems are dynamic and complex. Some aspects of the ecology of these systems, some of which may be important, may have been overlooked. The wetland data presented in this report are based on a 4 day site visit, undertaken in April 2015, at a time when low flows were being experienced. The effects of natural seasonal and long-term variation in the ecological conditions are therefore largely unknown.

## *1.3 Indemnity and Terms of use of this report*

The findings, results, observations, conclusions and recommendations given in this report are based on the author's best scientific and professional knowledge as well as available information. The report is based on survey and assessment techniques which are limited by time and budgetary constraints relevant to the type and level of investigation undertaken and SAS and its staff reserve the right to modify aspects of the report including the recommendations if and when new information may become available from ongoing research or further work in this field, or pertaining to this investigation.

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## 1.4 Legislative requirements

### 1.4.1 National Water Act (NWA, Act 36 of 1998)

- The NWA; Act 36 of 1998 recognises that the entire ecosystem and not just the water itself in any given water resource, constitutes the resource and as such needs to be conserved. No activity may therefore take place within a watercourse unless it is authorised by the Department of Water and Sanitation (DWS).
- Any area within a wetland or riparian zone is therefore excluded from development unless authorisation is obtained from DWS in terms of Section 21 of the NWA.

### 1.4.2 National Environmental Management and Waste Act (NEMWA, Act 14 of 2009)

- All emergency incidents that releases hazardous substances should be reported to the regulating authority as per section 30 of Act 107 of 1998, amended by section 13 of Act 14 of 2009. Whereas, an incident is defined as "An unexpected, sudden and uncontrolled release of a hazardous substance, including from a major emission, fire or explosion, that causes, has caused or may cause significant harm to the environment, human life or property".
- Leaking pipes conveying toxic substances should be reported and attended to urgently so as prevent contamination of the receiving environment.

### 1.4.3 General Notice (GN) 1199 as published in the Government Gazette 32805 of 2009 as it relates to the NWA, 1998 (Act 36 of 1998)

Wetlands are extremely sensitive environments and as such, the Section 21 (c) and (i) water use General Authorisation does not apply to any wetland or any water resource within a distance of 500 m upstream or downstream from the boundary of any wetland.

### 1.4.4 GN 704 – Regulations on use of water for mining and related activities aimed at the protection of water resources, 1999

- These regulations, forming part of the National Water Act, were put in place in order to prevent the pollution of water resources and protect water resources in areas where mining activity is taking place from impacts generally associated with mining.

It is recommended that the project complies with Regulation GN 704 of the NWA, 1998 (Act no. 36 of 1998) which contains regulations on use of water for mining and related activities aimed at the protection of water resources. GN 704 states that:
*No person in control of a mine or activity may:*

*(a) locate or place any residue deposit, dam, reservoir, together with any associated structure or any other facility within the 1:100 year floodline or within a horizontal distance of 100 metres (m) from any watercourse or estuary, borehole or well, excluding boreholes or wells drilled specifically to monitor the pollution of groundwater, or on waterlogged ground, or on ground likely to become waterlogged, undermined, unstable or cracked;*

According to the above, the activity footprint must fall outside of the 1:100 year floodline of the drainage feature or 100m from the edge of the feature, whichever distance is the greatest, unless authorised by DWS.

### 1.4.5 National Environmental Management Act (Act 107 of 1998)

The National Environmental Management Act (NEMA) (Act 107 of 1998) and the associated Regulations (GNR 982) as amended in 2014, states that prior to any development taking place within a wetland or riparian area, an environmental authorisation process needs to be followed. This could follow either the Basic Assessment Report (BAR) process (GNR 983) or the Environmental Impact Assessment (EIA) process (GNR 984) depending on the scale of the impact. Provincial regulations as set out in GNR 985 must also be considered.

### 1.4.6 Mineral and Petroleum Resources Development Act (2002)

The primary environmental objective of the Minerals and Petroleum Resource Development Act (MPRDA) is to give effect to the environmental right contained in the South African Constitution. Furthermore, Section 37(2) of the MPRDA states that “any prospecting or mining operation must be conducted in accordance with generally accepted principles of sustainable development by integrating social, economic and environmental factors into the planning and implementation of prospecting and mining projects in order to ensure that exploitation of mineral resources serves present and future generations".

# 2 METHOD OF INVESTIGATION

The methodology undertaken for the study are presented in Appendix A of this report. The following methods were applied during the investigation of the wetland crossings:

- Wetland characterisation
- Riparian Vegetation Response Assessment Index (VEGRAI)
- Index of Habitat Integrity (IHI)
- WET-Health
- Wetland function assessment
- Ecological Importance and Sensitivity (EIS)
- Recommended Ecological Category (REC)
- Wetland and riparian resource delineation
- Impact assessment

The following methods were applied during the investigation of the aquatic resources:

- Aquatic ecological assessment sites and site selection
- Visual Assessment
- Physico Chemical Water Quality Data
- Habitat Integrity
- Habitat for Aquatic Macro-invertebrate
- Aquatic Macro-invertebrate Response Assessment Index (MIRAI)
- Fish Biota: Habitat Cover Rating (HCR) and Fish Habitat Assessment (FHA)
- Fish Biota: Fish Response Assessment Index (FRAI)

# 3 BACKGROUND STUDY

A desktop study was done, and detailed information is provided in Appendix B of this report. The following point's forms part of the background information compiled for the importance of the study area:

- Ecoregions
- National Freshwater Ecosystem Priority Areas (NFEPA)

- National List of Threatened Ecosystems of South Africa
- Importance to the Mining and Biodiversity Guidelines
- National Biodiversity Assessment (NBA)
- North West Conservation Plan (NWCP)

# 4 RESULTS: WETLAND ASSESSMENT

## 4.1 Wetland System Characterisation

Due to the extent of the study area, the numerous features present, and the relatively homogenous characteristics of these resources, the features were grouped into HGM units for the purposes of assessment, and were assessed as systems and based on their location in relation to the mining infrastructure. It should be noted that although the features identified may extend beyond the study area, only portions located within and in close proximity of the study area were assessed and groundtruthed. Nonetheless, the potential impacts of activities such as surface hardening, construction of structures and clearing of natural vegetation within the greater catchment were taken into consideration during the assessment.

All wetland and watercourse/riparian features identified within the study area were classified as Inland Systems falling within the Bushveld Basin and the Western Bankenveld Aquatic Ecoregions, and within the Central Bushveld Group 2 WetVeg group. This WetVeg group is classified by SANBI (2013) as “Vulnerable”. The table below presents the classification on level 3 and 4 of the wetland classification system.

**Table 1: Characterisation of the wetland and riparian systems within the study area, according to the Classification System (Ollis *et al*., 2013).**

| Group | Level 3: Landscape unit | Level 4: Hydrogeomorphic Unit |
|---|---|---|
| Group 1: Rivers (Brakspruit, Dorpspruit, Hex River, Hoedspruit, Klipfonteinspruit, Klipgatspruit, Paardekraalspruit, Wildebeesfonteinspruit) | Valley floor: The typically gently sloping, lowest surface of a valley. | River: a linear landform with clearly discernible bed and banks, which permanently or periodically carries a concentrated flow of water |
| Group 2: Ephemeral drainage lines | Valley floor: The typically gently sloping, lowest surface of a valley | River: a linear landform with clearly discernible bed and banks, which permanently or periodically carries a concentrated flow of water |
| Group 3: Artificial Wetlands | Plain: An extensive area of low relief, characterised by relatively level, gently undulating or uniformly sloping land with a very gentle gradient that is not located within a valley. | Depression: a landform with closed elevation contours that increases in depth from the perimeter to a central area of greatest depth, and within which water typically accumulates. |

The features identified during the assessment where further divided into either wetland or riparian habitat based on the characteristics as defined by the NWA No 36 of 1998, provided below.

**Wetland habitat** is a 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 (NWA; Act No. 36 of 1998).

**Riparian habitat** includes the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterised 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. The rivers and ephemeral drainage lines with riparian characteristics are defined as watercourses, whilst the smaller ephemeral drainage lines *without* riparian zones are not considered wetlands or systems with an associated riparian zone but may still be defined as watercourses if the features have floodlines applicable to them.

The rivers identified within the study area were Brakspruit, Dorpspruit, Hex River, Hoedspruit, Klipfonteinspruit, Klipgatspruit, Paardekraalspruit, Wildebeesfonteinspruit. The rivers were grouped and assessed according to their location within and in relation to the study area. Each river was divided and assessed depending on the length of the river and the complexity and/or similarity of the characteristics that the sites possess. The sites comprised of structures such as railway crossings, road culverts, pipelines and weirs. A single river may have more than one of the mentioned structures. Therefore, during assessment all structures and their associated disturbances were taken into consideration. Artificial features such as diversions and dams associated with this riparian areas, formed part of the assessment but they were not assessed individually.

The NFEPA wetlands identified were artificial wetlands classified as level 4 depressions. Two of these wetlands are situated west of the Waterval West Tailings Dam, one on the south of the Waterval West Tailings Dam on the border of the study area approximately 200m from Hex River and the other one was situated west of the PK4 Paardekraal Return Water Dam (RWD). Although the features were artificial, they were assessed since they are used as Return Water Dams (RWD) for mining activities. These dams were assessed collectively as they possess the same characteristics.

One of the drainage lines identified was situated west of the PK4 Paardekraal Return Water Dam (RWD), the other drainage line situated north of PK4 Paardekraal RWD. Both drainage lines were classed as ephemeral drainage lines and only have seasonal surface flow.

Two artificial wetlands were identified south of Khuseleka 1 shaft. However, the dams did not display wetland characteristics as defined by DWS 2008, therefore they were not considered as natural wetlands. These dams might have been constructed for pollution control in the mining area. In one of the dams, sewage discharge activities were observed on site. Since these features are artificial, they did not form part of the present ecological state and ecological services provision assessments.

Figures 3 to 6 below illustrate the approximate localities of the wetland and riparian features in relation to the study area and mining infrastructure.

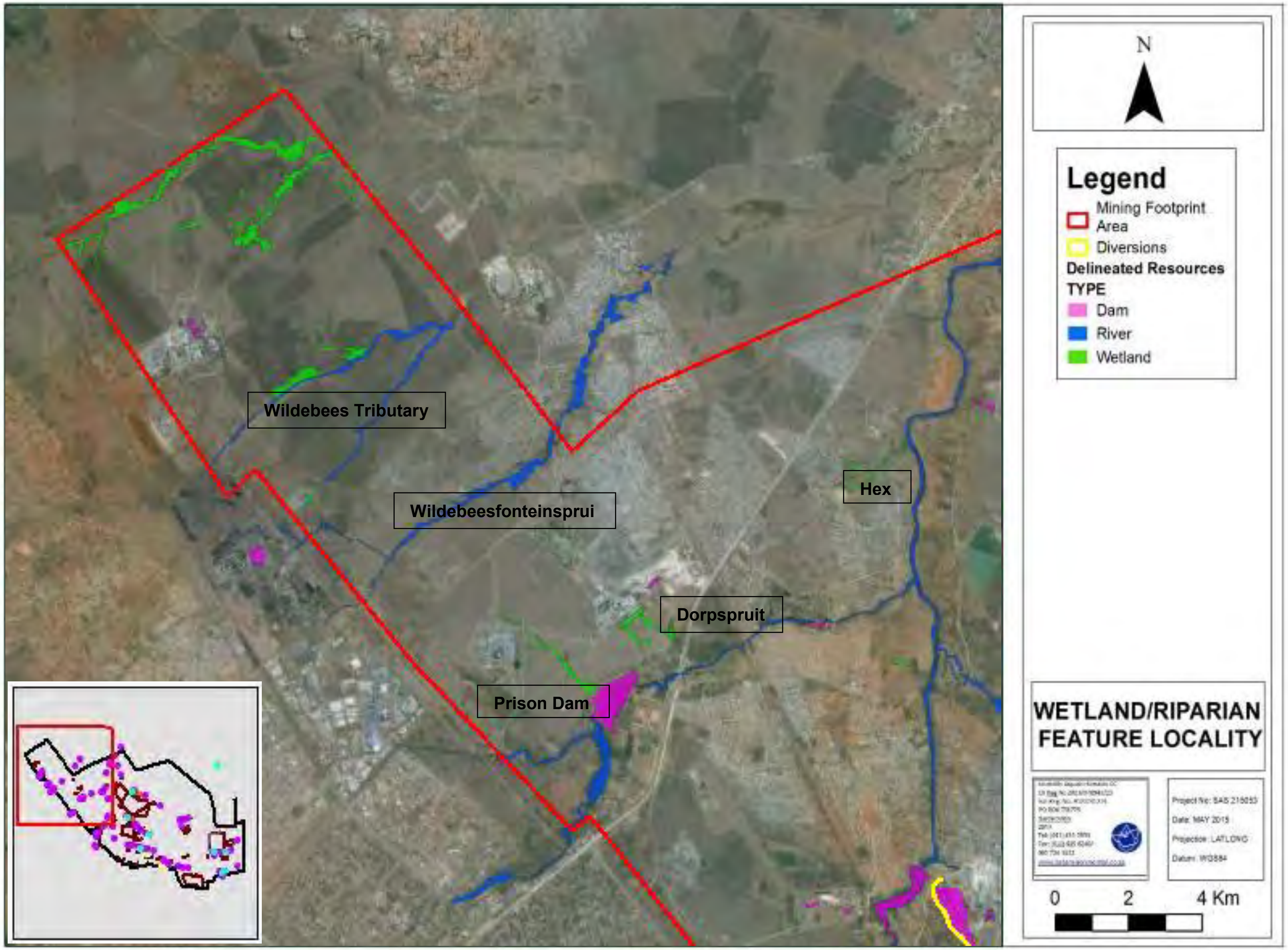



**Figure 3: Approximate location of wetland and watercourse/riparian features assessed in relation to the study area.**

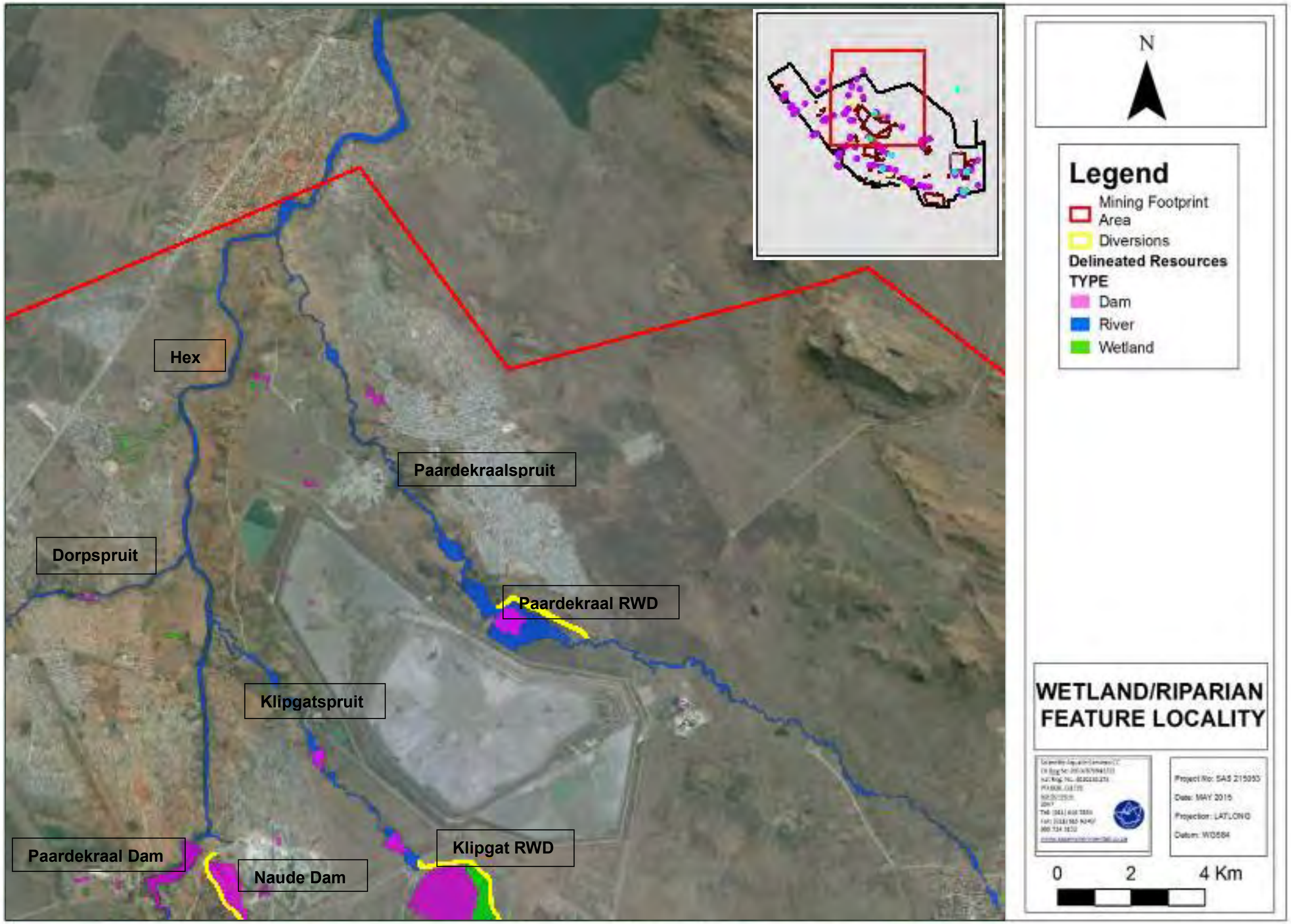



**Figure 4: Approximate location of wetland and watercourse/riparian features assessed in relation to the study area.**

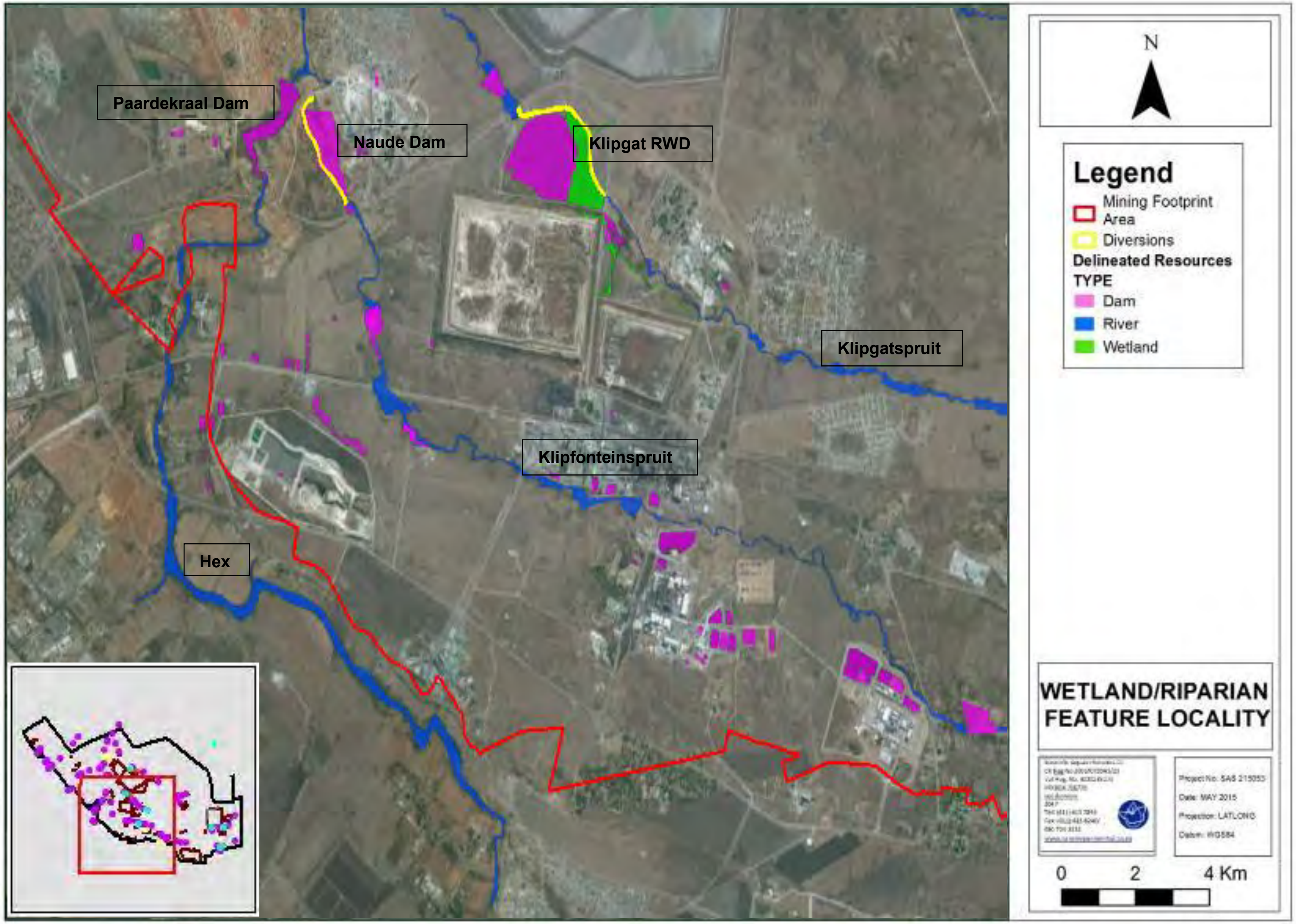



**Figure 5: Approximate location of wetland and watercourse/riparian features assessed in relation to the study area.**

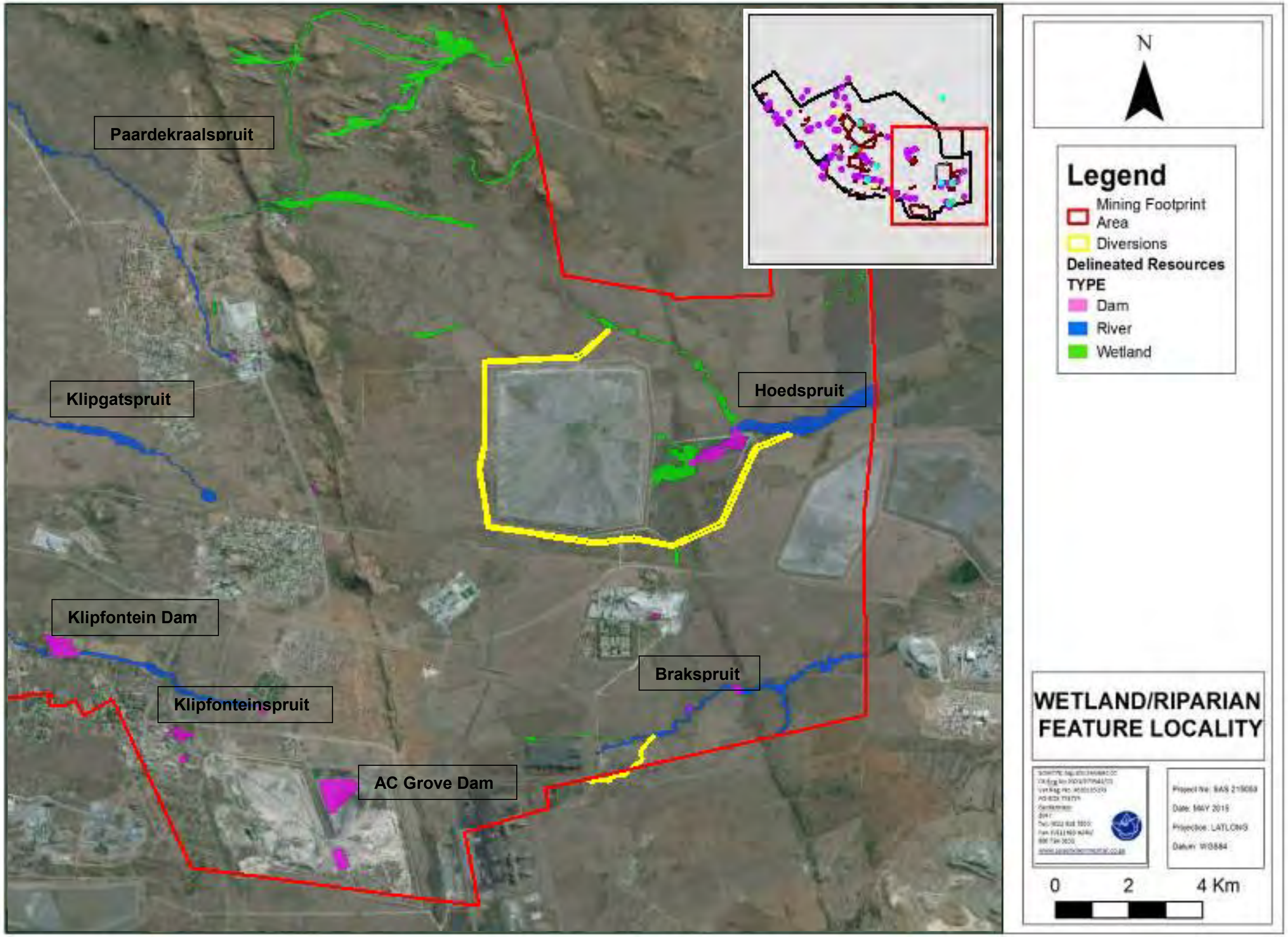



**Figure 6: Approximate location of wetland and watercourse/riparian features assessed in relation to the study area.**

## 4.2 Vegetation Community Considerations

The floral community structure and composition throughout the study area, in both terrestrial and wetland/riparian ecosystems, has been significantly transformed as a result of overgrazing by livestock and mining activities. Loss of vegetation cover resulting primarily from overgrazing has resulted in large expanses of exposed soils, leading to severe and widespread erosion in many areas, whilst levels of bush encroachment by indigenous species such as *Acacia karoo, Asparagus laricinus* and proliferation of alien vegetation such as *Flaveria bidentis* and *Bonariensis verbena* in some areas is high.

Floral species identified in the assessed portions of the rivers surveyed and their associated tributaries varied depending primarily on proximity to disturbances and the nature and/or severity of these disturbances. For example, portions of the rivers which were in close proximity to local communities and therefore subjected to regular disturbances such as trampling or overgrazing by livestock and littering, tend to be highly eroded. The vegetation community in the portions of the river which have been subjected to fewer, or less severe, disturbances have a higher component of indigenous floral species.

The artificial wetlands were dominated by typical facultative and/or obligate floral species such as *Typha capensis* and *Persicaria lapathifolia*, although it was apparent that these wetlands too were affected by alien vegetation encroachment.

The following tables present the dominant floral species identified within each HGM type, although it should be noted that these lists are not an exhaustive listing of the floral species found within the study area.

**Table 2: Dominant floral species identified within the ephemeral drainage lines present within the study area (alien species are indicated with an asterisk).**

| Trees / Shrubs | Forbs | Grasses / Sedges |
|---|---|---|
| *Acacia karoo* | *Xanthium strumarium** | *Cynodon dactylon* |
| *Asparagus laricinus** | *Flaveria bidentis** | *Eragrostis curvula* |
| | *Cirsium vulgare** | *Chloris virgata** |
| | *Helichrysum sp* | *Hyparrhenia hirta* |

**Table 3: Dominant floral species identified within the dams present within the study area (alien species are indicated with an asterisk).**

| Trees / Shrubs | Forbs | Grasses / Sedges |
|---|---|---|
| *Acacia karoo* | *Tithonia rotundifolia* * | *Typha capensis* |
| | *Ricinus communis* var. *communis** | *Leersia hexandra* |
| | *Leonotis dysophylla* | *Setaria sphacelata* |
| | *Asclepias fruticosa* | *Cynodon dactylon* |
| | *Persicaria lapathifolia** | *Eragrostis bipartita* |
| | *Flaveria bidentis** | *Fimbristylis complanata* |
| | *Solanum sysimbrifolium* | *Fimbristylis dichotoma* |
| | | *Bothriochloa insculpta* |

**Table 4: Dominant floral species identified within the riparian features present within the study area (alien species are indicated with an asterisk).**

| Marginal Zone: Woody | Marginal Zone: Non-woody | Non-Marginal Zone: Woody | Non-Marginal Zone: Non-woody |
|---|---|---|---|
| *Acacia karroo* | *Persicaria serrulata* | *Acacia karroo* | *Tithonia rotundifolia* |
| *Ulmus Parviflora* | *Typha capensis* | *Searsia lancea* | *Cynodon dactylon* |
| *Searsia lancea* | *Ipomoea purpurea* | *Searsia sersiapyroides* | *Heteropogon contortus* |
| *Melia azedarach* | *Asclepias fruiticosa** | | *Schoenoplectus corymbosus* |
| *Tamarix ramosissima* | *Cyperus denudatus* | | *Chloris virgate* |
| | *Setaria sphacelata* | | *Paspalum urvillei* |
| | *Sesbania sesban* | | *Urochloa panicoides* |
| | *Typha capensis* | | *Bothriochloa insculpta* |
| | *Parthenium hysterophorus** | | *Setaria sphacelata* |
| | *Solanum sysimbrifolium* | | *Aristida congesta* |
| | *Albuca glauca* | | *Sporopolus pyramidalis* |
| | *Andropogon eucomus* | | *Phragmites australis* |

## 4.3 Riparian Vegetation Response Index (VEGRAI)

The VEGRAI ecostatus tool was applied in order to assess the impacts of modifications to the system on the riparian vegetation of the Brakspruit, Dorpspruit, Hex, Hoedspruit, Klipfonteinspruit, Paardekraalspruit, and Wildebeesfonteinspruit Rivers. Due to the homogenous nature of the vegetation throughout the study area, as well as the extent of these systems, the smaller, unnamed tributaries of these rivers were not assessed separately, but were included in the assessment of the primary river systems. All of these systems have undergone similar impacts arising from livestock grazing and mining activities.

Brakspruit, Dorpspruit, Hex River, Hoedspruit and Klipgatspruit obtained scores that indicates that the VEGRAI ECat for the features is Category D (Largely modified), which implies that a large loss of natural habitat, biota and basic ecosystem functions has occurred.

Klipfonteinspruit obtained a score that indicates that the VEGRAI ECat for the feature is Category C/D (moderately to largely modified), which implies that a moderate to large loss of natural habitat, biota and basic ecosystem functions has occurred.

Paardekraalspruit obtained a score that indicates that the VEGRAI ECat for the feature is Category C (moderately modified), which implies that loss and change of natural habitat have occurred, but the basic ecosystem functions are still predominately unchanged.

Wildebeesfonteinspruit obtained a score that indicates that the VEGRAI ECat for the feature is Category D/E (largely to seriously modified), which implies that loss of natural habitat, biota and basic ecosystem functions is extensive.

Loss of marginal and non-marginal vegetation, through removal for construction of infrastructure such as conveyers and bridge crossings, overgrazing by livestock etc. has resulted in encroachment of both invasive indigenous species and alien species in many sections of the riparian zones. Furthermore, bank incision and erosion is severe throughout the systems; thus, conditions are not conducive for the establishment of indigenous riparian vegetation and in turn, soils remain exposed leading to further erosion. The table below provides a summary of the VEGRAI results for each river (please see Appendix A for the detailed results).

**Table 5: Summary of results of the VEGRAI assessments conducted for the riparian features within the study area.**

| River | VEGRAI (%) | VEGRAI ECat |
|---|---|---|
| Brakspruit | 54.3 | D |
| Dorpspruit | 44.3 | D |
| Hex River | 56.4 | D |
| Hoedspruit | 51.2 | D |
| Klipfonteinspruit | 61.6 | C/D |
| Klipgatspruit | 44.4 | D |
| Paardekraalspruit | 62.9 | C |
| Wildebeesfonteinspruit | 39.9 | D/E |

## *4.4 Wetland Index of Habitat Integrity*

The Index of Habitat Integrity (IHI) as described by the DWA (2007) was utilised to assess the PES of ephemeral drainage lines with riparian characteristics and riparian features. Due to the numerous riparian features identified during site inspection, as well as the relatively homogeneous characteristics of these features, the methodology was not applied to each group or divisions as explained in appendix A4.

It should be noted however that although the IHI method considers water quality when assessing the overall state of a wetland / riparian resource, no surface water was encountered at the time of the assessment in any of the ephemeral drainage lines. Furthermore, whilst surface water was present in some sections of the rivers, testing of water quality parameters did not take place. Therefore, the scores assigned for water quality in the IHI assessment are estimates based on observation of activities within the catchment which are likely to have an impact on water quality.

Wetland health is defined as a measure of the similarity of a wetland to a natural or reference condition. “Deviations” from this natural or reference state, particularly the extent of human impacts which may have caused the wetland to differ from this natural state, are considered when ascertaining the “health” of a wetland (Macfarlane *et al.*, 2008).

The table below provides a summary of the IHI results for each group of features and the rivers which are discussed in detail in the sub-sections that follow (please see Appendix D for the detailed results for each group). Figure 7 and Figure 8 below illustrates the PES categories of the features.

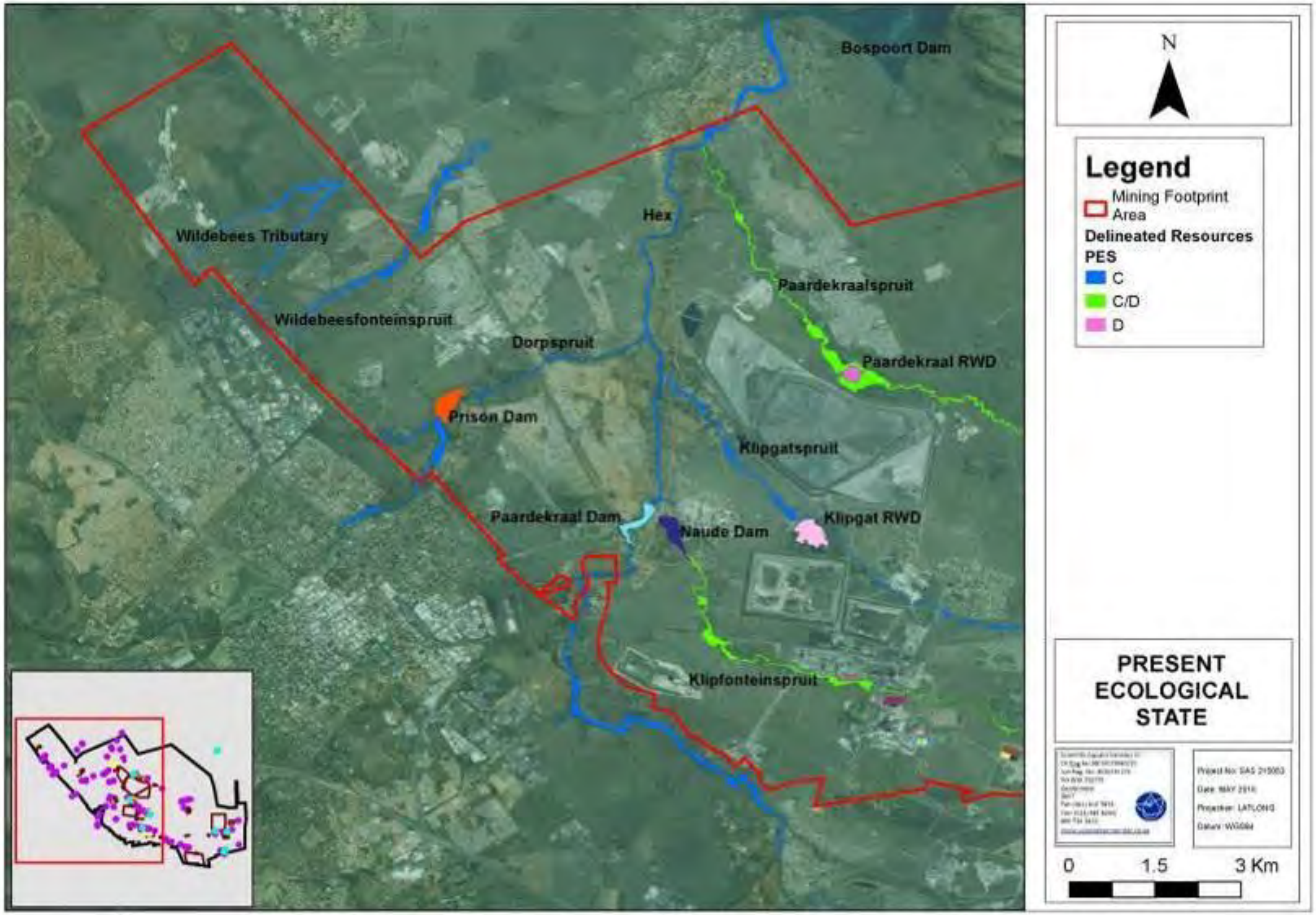



**Figure 7: Illustration of the PES categories of the Wildebees Tributary, Wildebeesfonteinspruit, Hex, Klipgatspruit, Klipfonteinspruit, Paardekraalspruit and Dorpspruit features.**

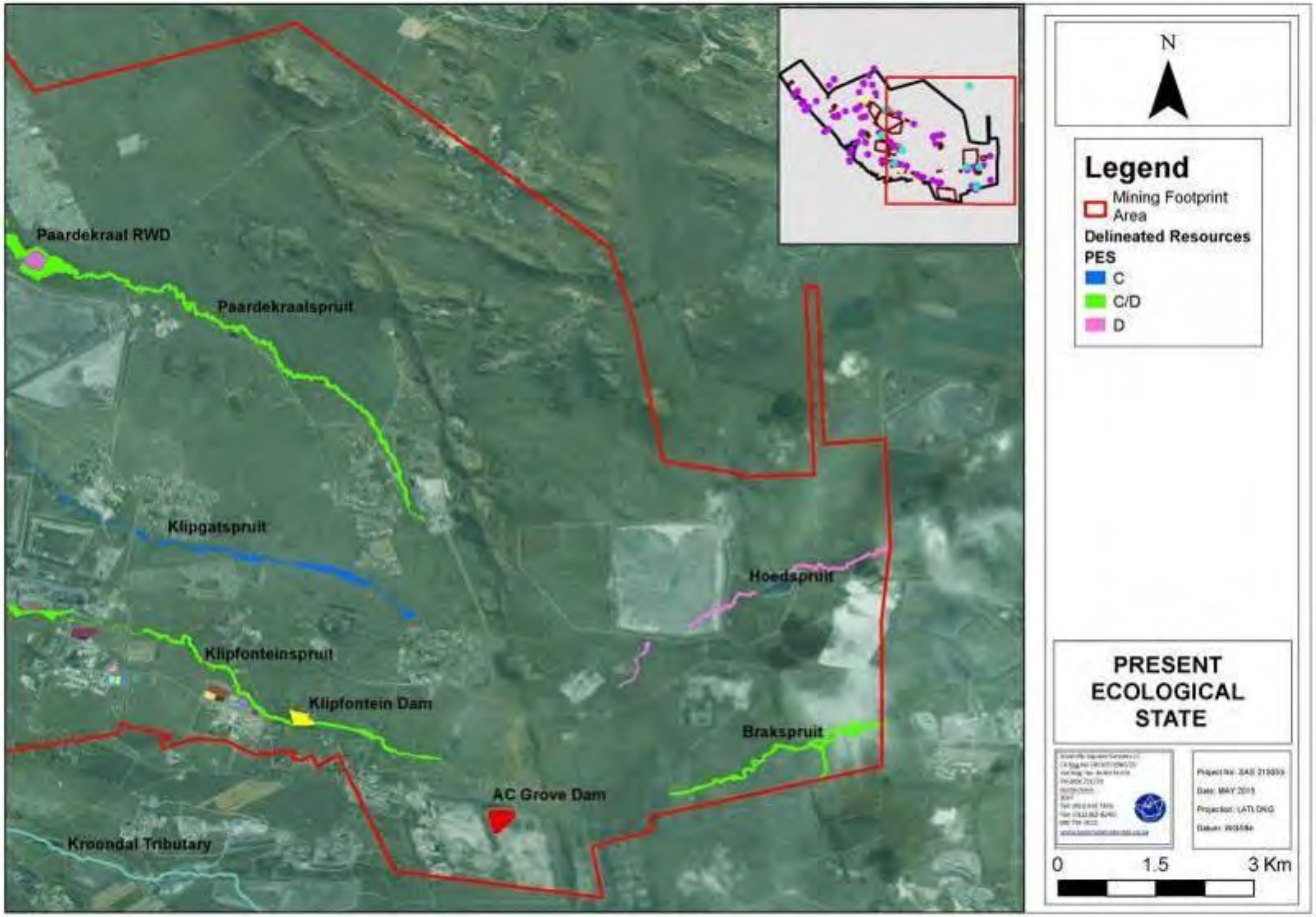



**Figure 8: Illustration of the PES categories of the lower Klipgatspruit, lower Klipfonteinspruit, lower Paardekraalspruit, Brakspruit, Hex River and Hoedspruit features.**

### Brakspruit: South of Siphumelele 2

The WET-IHI calculations for the Brakspruit indicates that the system has been moderately/largely modified, and that loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged. The feature has been disturbed by erosion which has occurred as a result of increased water input as well as heavy grazing and trampling by livestock. These activities have resulted in the moderate modification of the geomorphology of the feature. Furthermore alien vegetation invasion has occurred especially along these structures since the soil profile has been altered. The constructions of road crossings and pipelines along this system has resulted in a large modification of the hydrology of the system. Stockpiling in mining areas might lead to sediment deposition within systems if located within 100m of the floodline, and as a result water quality might be altered. However, no soil dumping or stockpiling was evident within the feature. The figures below represent the disturbance observed within the system.

**Figure 9: Representative photographs of erosion disturbances within the Brakspruit system.**

### Hoedspruit: South of Hoedspruit Tailings Dam

The feature obtained an average percentage that places the feature within category D which implies that the feature has been largely modified, and large loss of natural habitat, biota and basic ecosystem functions has occurred: 20-40% seriously modified. Most of the vegetation within this feature has been cleared during the construction of a railway crossing and development of a road that traverses the feature below the railway crossing. As a result the area has been largely eroded and alien species such as *Flaveria bidentis* have invaded. This species was identified along the edges of the feature and has led to the destabilization of soils within the feature. Due to the road there is increased water input within feature as well as sediment deposition which moderately altered the geomorphology of the area. The figure below represents the Hoedspruit system.

**Figure 10: Representative photographs of the Hoedspruit system.**

### Wildebeesfonteinspruit (Site 35, 35a, 35b, 36) South of Khuseleka 2

The WET-IHI calculations for the Wildebeesfonteinspruit indicates that the feature obtained an average percentage that places the feature within category C, which implies that the system has been moderately modified, and that loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.

The hydrology of the system has been moderately modified by the construction of the bridges/road crossings which increases the width and in some portions the depth of the channel. There were water abstraction activities observed on site which might be used by the community for crop irrigation. This activity contributes to the modification of the hydrology of the system. Potential influences on water quality are sedimentation and runoff from the neighbouring communities as well as waste dumping. Furthermore, livestock grazing and trampling as well as increased runoff have resulted in the formation of erosion gullies within the system. The vegetation component of the system has been moderately disturbed, by the construction of the bridges as well as the effects of erosion. Alien vegetation such as *Xanthium strumarium, Asclepias fruiticosa* and *Tagetes minuta* were observed on site. Due to the presence of the culverts and road crossings as well as sediment deposition, the geomorphology of the system has been moderately modified. The figure below represents the disturbances within the Wildebeesfontein system.

**Figure 11: Representative photographs of the Wildebeesfonteinspruit (South of Khuseleka 2).**

## Wildebeesfonteinspruit (Site 34 & 33) North-west of Khuseleka 1

The feature (where Site 33 and Site 34 are located) consists of an artificial canal, created to convey water from the open flooded pit into the nearby watercourse, and it was mainly encroached and dominated by alien vegetation such as *Melia azedarach, Datura stramonium, Ipomoea purpurea*, and *Flaveria bidentis*. There were soil stockpiling observed adjacent to the upper portions of the feature which deposits sediment into the feature and also reduces the quality of water passing through the channel. Since this feature was artificially constructed it did not indicate any wetland characteristics and cannot be considered to be a natural watercourse. The figure below represent the artificial channel that forms part of the system.

**Figure 12: Representative photograph of the Wildebeesfonteinspruit (North-west of Khuseleka 1)**

**Wildebeesfonteinspruit: Site 34f, 34g, 34h**

The system obtained an average score that places the system within category B/C. the entire system appears to be in good condition, apart from the presence of structures such as roads and culverts. The vegetation component of this feature was in a largely natural condition with only a few eroded areas along the road crossings. The water quality was largely modified by potential sources such as sedimentation and runoff from the neighbouring communities as well as deposition of untreated sewage effluent from leaking pipes in the upstream areas of the system. The hydrology of the feature is moderately modified by increased water input within the feature as a result of hardened surfaces within the catchment. Increased runoff from the tarred road has led to increased water input, whereas dirt roads traversing the feature have increased the availability of sediment, thus modifying the geomorphology of the feature. The figure below represents the vegetation and sewage effluent that is being discharged within the system.

**Figure 13: Representative photographs of the Wildebeesfonteinspruit.**

**Dorpspruit River: South-east of Khuseleka 1 shaft (Site 32a & 32b)**

The feature obtained an average score that places the feature within category D which implies that the feature has been largely modified, and large loss of natural habitat, biota and basic ecosystem functions has occurred. The loss of natural habitat, biota and basic ecosystem functions is extensive, and this is mainly due to the road bridge construction activities that are currently taking place within the feature. The system experienced low flow at the time of the assessment therefore there was limited disturbance on stream flow. The feature has been subjected to vegetation clearing and as a result, alien vegetation species have established. The geomorphology of the feature has been largely modified by the excavations as well as sediment deposition and infilling from the construction. The catchment area will have increased water input as a result of runoff from the road and paved surfaces. Since the feature is hydrologically linked to an upstream dam, in which sewage effluent is being discharged, the water quality of the feature was largely modified and falls within category D. Potential influences on water quality are sedimentation and runoff from the neighbouring communities. The figure below represent the construction activities that are currently taking place within the system.

**Figure 14: Representative photograph of the construction activities within the Dorpspruit**

**Dorpspruit River (Site 32d, 32e & 32f) East of Khuseleka 1 and West of Paardekraal Return Water Dam (RWD)**

The system has been largely modified by the collapsing of a road crossing and a weir at Site 32e and Site 32f as observed during the site visit. This activity has led to the formation of erosion gullies and sedimentation within the system and increased channel depth and width. As a result, the geomorphology of the system has been seriously modified.

The hydrology of the system has been largely modified and this has resulted in the alteration of water flow patterns. Furthermore, the collapsed structures will eventually cause migration barriers for aquatic species. Due to erosion, vegetation has been modified especially along the river banks and where the crossings/roads occur along the river. Alien vegetation species have established including *Eichhornia crassipes.* This plant can block sunlight from reaching native aquatic plants, and removes oxygen from the water eventually killing aquatic species. The water quality within the system has been modified, and potential influences on water quality are sedimentation and runoff from the neighbouring communities.

The figure below represent disturbances within the Dorpspruit.

**Figure 15: Dorpspruit East of Khuseleka 1 and West of Paardekraal Return Water Dam (RWD)**

**Dorpspruit River: South of Khuseleka 1 (Site 30 & Site 31)**

The river obtained an overall score that indicates that the feature falls within the PES Category C (moderately modified), this implies that there has been loss and change of natural habitat and biota, but the basic ecosystem functions are still predominantly unchanged. The hydrology of the feature has been altered by the construction of the railway crossing as well as a road and associated weir. These structures have led to changes in water flow pattern and trap sediment which obstructs water flow. There has been sediment and debris deposition observed as illustrated in the figures below, following heavy rains resulting in altered geomorphology of the feature. Due to the construction of these structures, the vegetation component has been reduced through clearing and as a result a few alien species such as *Tithonia rotundiflora* and *Conyza bonariensis* have invaded the area. Water quality was altered by sewage effluent and other potential sources such as sedimentation and runoff from neighbouring communities. The figures below represent disturbances within Dorpspruit

**Figure 16: Sediment deposition and debris within the stream.**

**Figure 17: A weir and road crossing as modifications to the hydrology of the stream.**

**Hex River: North of Paardekraal RWD (Sites: 28, 28a, 28b, 28c)**

The river obtained an overall score that indicates that the feature falls within the PES Category C (moderately modified), this implies that there has been loss and change of natural habitat and biota, but the basic ecosystem functions are still predominantly unchanged. A few structures such as road bridge crossings and pipelines have resulted in the moderate modification of the feature. Algal proliferation has been observed in a few areas which implies that the water has an overabundance of nutrients such as nitrate and phosphate. Soil stockpiling along with construction rubble as well as litter were observed adjacent to **Site 28** where there is a road crossing. It is anticipated that during heavy rainfall, runoff from the stockpiling area will result in erosion as well as sediment deposition within the feature, which would potentially alter the water quality. In the upper portions of the system the water quality seemed to be moderately modified as opposed to the largely modified portions upstream (Site 28). The hydrology as well as morphology of the feature has also been moderately modified by the presence of the pipes and roads. In some cases these pipes cause a migration barrier and traps debris since they are placed within the river bed and not elevated on plinths. In addition, the water flow pattern changes due to the presence of these pipes, thus resulting in erosion of the river banks. Vegetation removal has occurred in the vicinity of the road crossings, and although alien species were observed on site, indigenous vegetation still occurs in some areas where anthropogenic activity has been less. The figures below represent the Hex River.

**Figure 18: Representation of the Hex River.**

**Klipgatspruit: South of Paardekraal Tailings Dam & North-west of Klipgat RWD (Site 14, 14a, weir)**

The river obtained an overall score that indicates that the feature falls within the PES Category C (moderately modified), this implies that there has been loss and change of natural habitat and biota, but the basic ecosystem functions are still predominantly unchanged. The feature has been mostly disturbed along the pipeline structure. Erosion has been observed along this area which modifies the morphology of the area. In addition, activities such as livestock grazing and trampling have contributed to vegetation removal and erosion of the area. Furthermore, vegetation removal at the time of the pipeline construction has led to erosion that resulted in the channel width increase. Leaks were observed along some portions of the pipeline and this might lead to the contamination of water if the pipes are conveying hazardous substances. The Klipgat RWD which is found within the

Klipgatspruit River was identified by NFEPA as an artificial wetland. However, during operational phase the reeds must be allowed to proliferate in order to provide habitat for water fowl. The figure below illustrate the disturbances within Klipgatspruit

**Figure 19: Erosion observed along the pipeline crossing within Klipgatspruit.**

**Klipgatspruit: East & South of Klipgat RWD (Site 12, 12a, 12b, 12c, 13, 41)**

The river obtained an overall score that indicates that the feature falls within the PES Category D (largely modified) A large loss of natural habitat, biota and basic ecosystem functions has occurred. The loss of natural habitat, biota and basic ecosystem functions is extensive. Most of the portions of this feature are surrounded by soil dumping from the mining operational area. The activities taking place impact the feature in a negative way, with disturbances more especially on the vegetation, morphology and contamination of water and soils of the receiving environment. As observed in field, most of the area has been seriously eroded. In addition, due to soil stockpiling, during rainfall events, the area will be prone to erosion and deposition of sediments as well as contaminants within the feature, which then poses more risk on water quality as well as geomorphology of the area. The road crossing at Site 41 has partially collapsed (one of two culverts has collapsed at the outlet), resulting in partial water flow obstruction but does not represent formation of a migration barrier as the other culvert is clear and aligned with the river bed.. Sedimentation within the channel provides substrate for the proliferation of alien species as observed at **Site 13** (presented in the figures below).

**Figure 20: Disturbances within Klipgatspruit.**

**Klipfonteinspruit: North of Klipfontein Tailings Dam, South of Siphumelele 3 (Site 1, 2, 3)**

The river obtained an overall score that indicates that the feature falls within the PES Category C (moderately modified), this implies that there has been loss and change of natural habitat and biota, but the basic ecosystem functions are still predominantly unchanged. The hydrology of the feature has been moderately modified by the construction of road crossings/bridges as well as surface hardening within the catchment which causes increased water input within the feature. Furthermore, canals have been created to decrease water retention on the floodplain surface, however, flow capture and removal is ineffective. Mowing along the edges of the road and pipeline as observed at Site 3 has led to the modification of the vegetation structure of the system. In some portions, indigenous vegetation still persists although alien species proliferation has occurred and was observed throughout the system; *Flaveria bidentis* was the dominant species. Erosion observed was mainly within community areas, and is attributed to cattle trampling and grazing. In addition, waste dumping was observed beneath the road crossings, which alters water quality of the system.

**Figure 21: Photographs representing Klipfonteinspruit.**

**Paardekraalspruit: North-west of Siphumelele 3 Waste Rock Dump (Site 15, 16, 17)**

The river obtained an overall score that indicates that the feature falls within the PES Category C/D (moderately to largely modified), this implies that there has been loss and change of natural habitat and biota, but the basic ecosystem functions are still predominantly unchanged. The feature is located in an urbanised area, and due to hardened surfaces, there is increased water input into the feature. Vegetation clearing within the catchment and around the feature decreases surface roughness, which leads to an increased erosion risk to the feature. Extensive livestock grazing and trampling has also contributed to erosion within the feature and this has led to alien invasion as presented in the figures below.

**Figure 22: Alien invasion and erosion within Paardekraalspruit.**

**Paardekraalspruit: North of Siphumelele 1 Waste Rock Dump (Site 18, 19)**

The river obtained an overall score that indicates that the feature falls within the PES Category C (moderately modified). The feature seems to be in moderate condition apart from the waste and debris accumulation below the bridge which obstructs water flow. Vegetation has been disturbed along the road crossing, with clearings and alien invasion visible. However, the vegetation cover within the feature was moderately low, which plays a significant role in protecting the area against erosion. Due to the feature being located in an urbanised location, it will definitely receive increased runoff and will be affected by altered runoff peaks during heavy rainfall events. Waste dumping observed in the lower portions of the feature, is likely to modify the water quality within this feature. In addition, runoff from the mining area and sediment deposition will further deteriorate the water quality. The figure below represents the Paardekraalspruit system.

**Figure 23: Representation of Paardekraalspruit.**

**Paardekraalspruit: North and South of Paardekraal Tailings Dam PK4 (Site 19a, 20, 20a, 21, 21a)**

The river obtained an overall score that indicates that the feature falls within the PES Category D (largely modified) A large loss of natural habitat, biota and basic ecosystem functions has occurred: 20-40% seriously modified. Some portions of the feature seemed to be in a moderate condition, such as in the vicinity of **site 21a** where there is a pipeline crossing. The presence of this structure does not inhibit the flow of water in any way, and in addition, the vegetation was in a good condition. However, the hydrology and geomorphology of the system has been largely/seriously modified by the presence of structures such as weirs, road crossings, dams as well as stream diversion activities. The disturbance was quite severe along **site 20a** where the diversion starts. This area has been excavated and cleared which poses the risk of erosion as well as increased runoff. Vegetation has been moderately modified in some portions whereas in some portions it was largely modified. Along the vicinity of the weir, dam and road crossings, vegetation has been trampled and these areas had bare soil patches as a result of livestock grazing. However, although the vegetation has been disturbed, only a minimum extent of alien vegetation was observed, and indigenous vegetation still persists. Water quality has been modified by sediment deposition from the mining areas as well as the neighboring residential areas. The figures below represent erosion as well and ponding as a result of excavations on site.

**Figure 24: Representation of disturbances observed within Paardekraalspruit.**

**Figure 25: Representation of Paardekraalspruit.**

**Klipfonteinspruit: South of Siphumelele 3 and East of PMR (Site 3a, 3b, 3c, 3d, 4, 4a, 5)**

The river obtained an overall score that indicates that the feature falls within the PES Category C/D (moderately to largely modified), this implies that there has been loss and change of natural habitat and biota, but the basic ecosystem functions are still predominantly unchanged. The feature has been modified by the presence of road crossings/culverts as a result, runoff from the road increases water input within the feature. The dam upstream captures sediment before it enters the stream, hence there was less sediment deposition observed. The vegetation has been disturbed by the invasion of alien species which seems to inhibit natural vegetation especially along the culvert.

**Figure 26: Representation of Klipfonteinspruit.**

**Klipfonteinspruit: South of Waterval Smelter (Site: 6, 7a, 7b, 8, 8a, 8b, 8c)**

The river obtained an overall score that indicates that the feature falls within the PES Category D (largely modified) A large loss of natural habitat, biota and basic ecosystem functions has occurred: 20-40% seriously modified. Increased runoff and water input increases the erodability of the system, and this is mainly due to surface hardening and soil compaction within the catchment. The channel has been modified at Site 2, where berms were constructed to control erosion. Vegetation has been modified by the construction of road crossings and pipelines, and in addition, alien vegetation has invaded. Due to mining activities, the water quality has been modified by discharging mining effluent into the system as well as sediment deposition and runoff from surrounding communities. Disturbances observed on site are illustrated in the figures below.

**Figure 27: Disturbances within Klipfonteinspruit.**

**Drainage lines**

The features obtained an average score that falls within category A/B which implies that the features are largely natural with few modifications. The hydrology of the drainage lines has been slightly modified by the increased water input as a result of runoff from surface hardening within the catchment. In addition vegetation has been slightly modified by livestock grazing as well as minor invasion of alien species such as *Xanthium strumarium* and *Flaveria bidentis.* The geomorphology of the feature was natural but modified by livestock trampling to a limited extent.

**Figure 28: Representation of the drainage lines.**

## *4.5 Wet-Health Assessment*

Due to the limited time available on site to assess the wetland features, a Level 1 WET-Health assessment was applied to the dams to assess their integrity. Three modules were assessed, namely hydrology, geomorphology and vegetation. The results of this assessment are summarised in the table below.

**Table 6: Summary of the results of the WET-Health Assessment applied to the natural dams.**

| Feature | Hydrology | | Geomorphology | | Vegetation | | Overall PES Category |
|---|---|---|---|---|---|---|---|
| | Impact Score | Change Score | Impact Score | Change Score | Impact Score | Change Score | |
| Dams | B | ↓ | | | C | ↓ | B |

The dams were in a good state at the time of the assessment and were not affected by the current disturbances within the catchment. This may be due to their hydrological isolation from other wetland/riparian features. The hydrology of the features was largely natural with a few modifications. In addition, the geomorphology was slightly modified by compaction as a result of livestock trampling and grazing. The vegetation cover was moderately modified and this is mainly due to livestock grazing.

**Figure 29: Representation of the dams observed during site visit.**

## 4.6 Wetland Function Assessment

The wetland functions and service provision of each group of features were assessed utilising the WET-Ecoservices (Kotze *et. al.* 2009) method as described in the methodology (Appendix A7) of this report. The summarised results of the assessments are tabulated below, and the detailed results are presented in each relevant subsection. As with the WET-IHI methodology, this assessment was applied to each individual river system and its associated tributaries individually, whilst the ephemeral drainage lines were grouped and assessed on a broad scale. In addition, whilst it is not possible to assess the "health" *per se* of artificial wetlands, they nevertheless may provide important ecological services, and this methodology allows for the assessment of such features. Thus each of the artificial wetlands was assessed.

**Klipfonteinspruit: South of Siphumelele 3 and South of Waterval Smelter**

**Table 7: Results of the wetland function and service provision assessments applied to Klipfonteinspruit**

| Ecosystem services | South of Siphumelele 3 & East of PMR | South of Waterval Smelter & PMR |
|---|---|---|
| Flood attenuation | 1,7 | 1,6 |
| Streamflow regulation | 1,4 | 1,4 |
| Sediment trapping | 1,8 | 2 |
| Phosphate assimilation | 1,7 | 1,7 |
| Nitrate assimilation | 1,5 | 1,5 |
| Toxicant assimilation | 1,9 | 1,9 |
| Erosion control | 2,2 | 2,5 |
| Carbon Storage | 1,7 | 1,3 |
| Biodiversity maintenance | 1,3 | 0,9 |
| Water Supply | 0,8 | 0,8 |
| Harvestable resources | 0 | 0,2 |
| Cultural value | 0 | 0 |
| Cultivated foods | 0 | 0 |
| Tourism and recreation | 0 | 0 |
| Education and research | 0 | 0 |
| SUM | 16,0 | 15,8 |
| Average score | 1,1 | 1,1 |

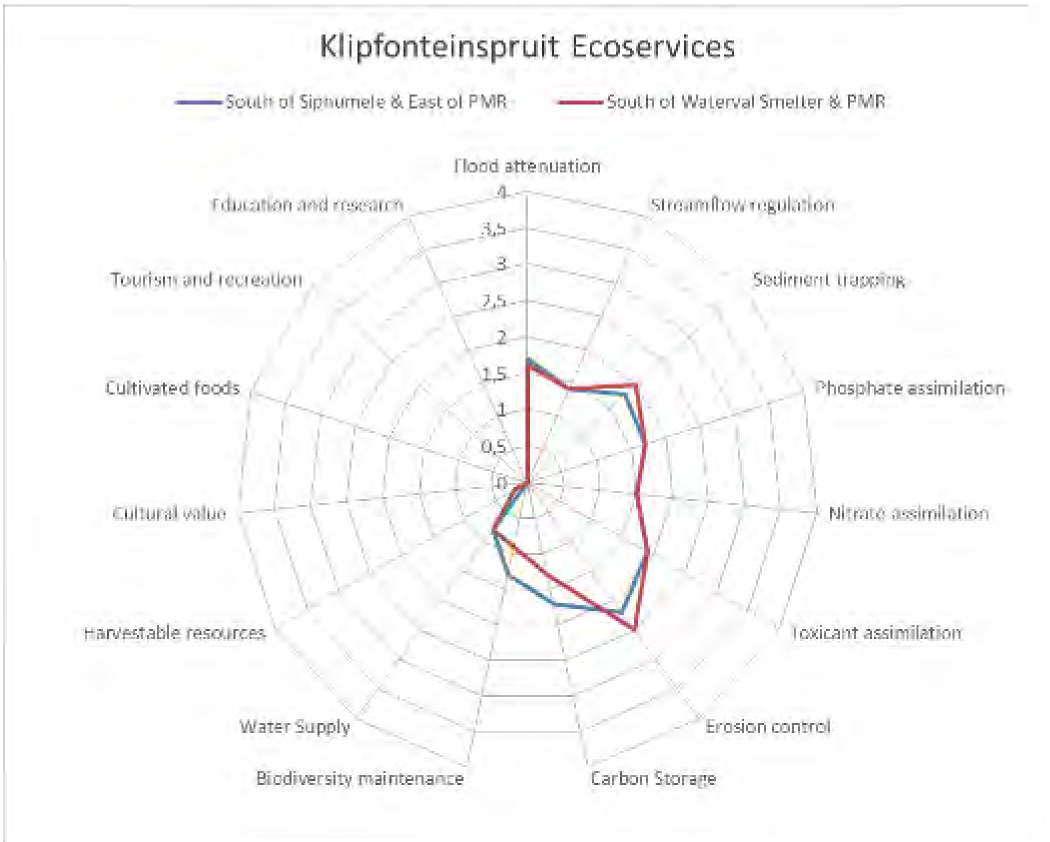



**Figure 30: Radar plot of wetland services provided by the dams**

The features obtained an average scores of 1.1 which implies that the features have a moderately low level of service provision. The system has been moderately disturbed, by erosion especially in downstream areas since they receive increased water input from upstream areas. In addition, the vegetation cover and surface roughness was moderately low, and this resulted in moderately low level of assimilation functions and sediment trapping. Due to the location of the system, the system has no importance in terms of direct services like harvestable resources and cultural value. The score for water quality enhancement (i.e. sediment trapping and the assimilation of toxicant, nitrate, phosphate) was moderately low.

The portion on the south of Waterval Smelter obtained a moderately low score for biodiversity maintenance.

### Dorpspruit: South and East of Khuseleka 1

**Table 8: Results of the wetland function and service provision assessments applied to the Dorpspruit**

| Ecosystem services | Dorpspruit Ecoservices |
|---|---|
| Flood attenuation | 2 |
| Streamflow regulation | 1,4 |
| Sediment trapping | 1,6 |
| Phosphate assimilation | 1,3 |
| Nitrate assimilation | 1,2 |
| Toxicant assimilation | 1,6 |
| Erosion control | 2,5 |
| Carbon Storage | 1,3 |
| Biodiversity maintenance | 0,8 |
| Water Supply | 0,8 |
| Harvestable resources | 0 |
| Cultural value | 0 |
| Cultivated foods | 0 |
| Tourism and recreation | 0 |
| Education and research | 0 |
| SUM | 14,5 |
| Average score | 1,0 |

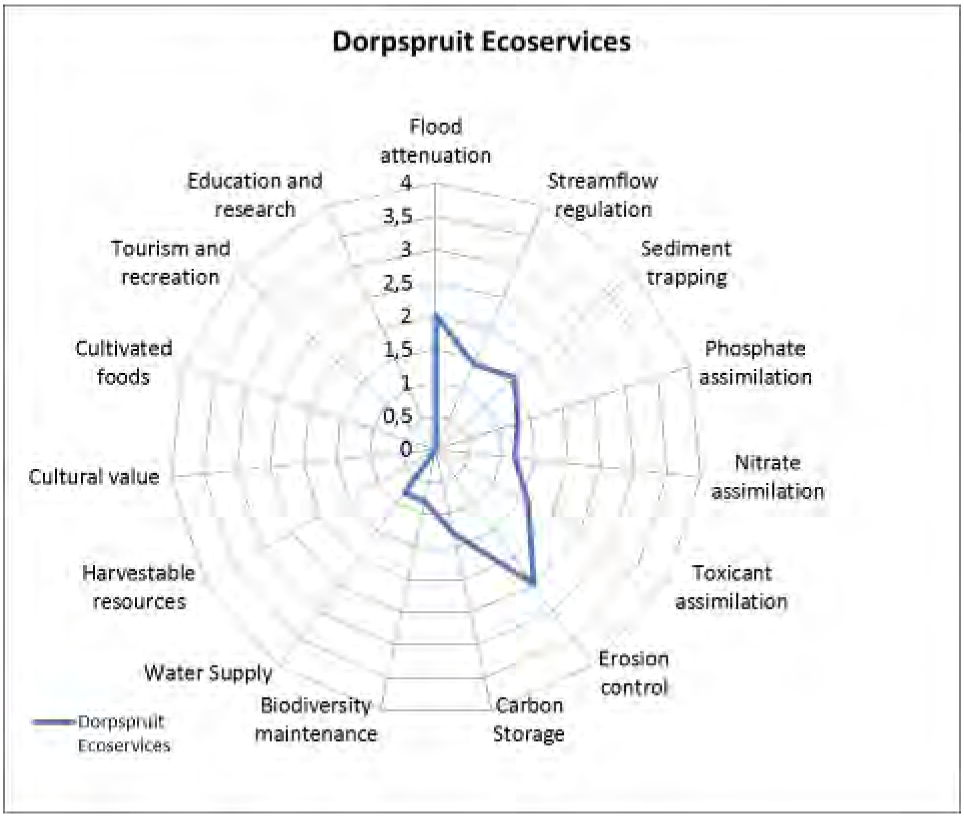



**Figure 31: Radar plot of wetland services provided by the Dorpspruit**

The system obtained an average score of 1.0 which implies that the system has a moderately low level of service provision. The system obtained an intermediate score for most of the aspects assessed. This is mainly attributed to the disturbances that the system experienced such as vegetation removal leading to erosion of the system and more sediment load transported downstream. An intensive level of erosion was identified east of Khuseleka 1, which has led to the culvert of the crossing collapsing, diverting water flow and thus eroding the banks. In addition, there was a high level of invasion of alien species in this area, which leads to the moderately low level of maintenance of biodiversity.

**Hex River: West of Paardekraal Tailings Dam and North and West of Paardekraal RWD**

**Table 9: Results of the wetland function and service provision assessments applied to the Hex River**

| Ecosystem services | West of Paardekraal Tailings Dam | North & West of PK4 Paardekraal RWD | West of Paardekraal Tailings Dam PK4 |
|---|---|---|---|
| Flood attenuation | 1,7 | 1,7 | 1,3 |
| Streamflow regulation | 1,3 | 1,3 | 1,5 |
| Sediment trapping | 2 | 1,8 | 2,8 |
| Phosphate assimilation | 1,3 | 1,3 | 1,7 |
| Nitrate assimilation | 1,2 | 1,2 | 1,3 |
| Toxicant assimilation | 1,6 | 1,6 | 2,1 |
| Erosion control | 2,7 | 2,7 | 2 |
| Carbon Storage | 1,7 | 2 | 1,3 |
| Biodiversity maintenance | 1,4 | 1,6 | 1 |
| Water Supply | 1,2 | 0,8 | 1 |
| Harvestable resources | 0 | 0 | 0 |
| Cultural value | 0 | 0 | 0 |
| Cultivated foods | 0 | 0 | 0 |
| Tourism and recreation | 0 | 0 | 0 |
| Education and research | 0 | 0 | 0 |
| SUM | 16,1 | 16,0 | 16,0 |
| Average score | 1,1 | 1,1 | 1,1 |

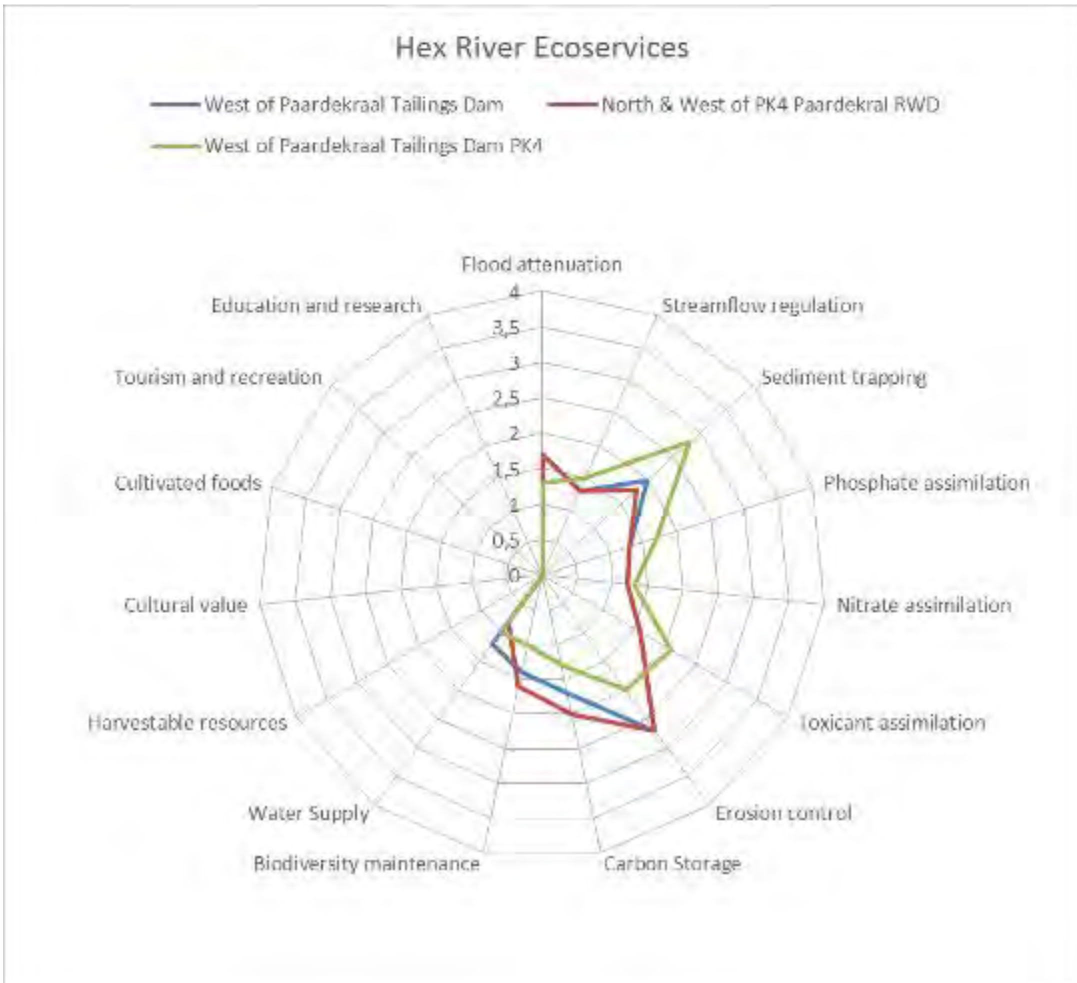



**Figure 32: Radar plot of wetland services provided by the dams**

The features obtained average scores of 1.1 which implies that the system has a moderately low level of service provision. The score obtained for flood attenuation was intermediate and this is mainly due to the low sinuosity of the feature along west of Paardekraal Tailings Dam, which implies that water will flow through the channel without obstructions to slow it down. The water in this system is being utilised at moderately low levels, for industrial purpose rather than domestic purposes as it is not located within a residential area. Evidence of water abstraction was identified west of Paardekraal Tailings Dam, during site visit. The portion along the North of Paardekraal RWD is situated within a residential area. The feature along this portion is used mainly for livestock grazing and as an informal laundry as observed on site. Due to the high level of vegetation cover within the system, nutrient assimilation and sediment trapping abilities obtained an intermediate score. For biodiversity maintenance the feature obtained an intermediate score, and this is mainly attributed to the moderately high level of vegetation cover as well as the extent and amount of water within the system. Furthermore, the system will be able to provide suitable habitat to both terrestrial and aquatic species.

The portion along the west of Paardekraal Tailings Dam PK4 has been largely modified by collapsed culverts/roads, sediment load deposition and alien species invasion. This feature scored moderately high for sediment trapping as a result of these activities. The stockpiling adjacent to Site 28 offered greater opportunity for the feature to trap sediment. Although the vegetation cover within the feature was moderately high, erosion gullies were created due to the road collapsing, and thus altered the integrity of the feature which led to the moderately low score for biodiversity maintenance.

**Klipgatspruit: North and north-west of Waterval east Tailings Dam & east of Klipgat RWD**

**Table 10: Results of the wetland function and service provision assessments applied to the Klipgatspruit.**

| Ecosystem services | Klipgatspruit |
|---|---|
| Flood attenuation | 2,1 |
| Streamflow regulation | 1,6 |
| Sediment trapping | 2,6 |
| Phosphate assimilation | 2 |
| Nitrate assimilation | 1,5 |
| Toxicant assimilation | 2,1 |
| Erosion control | 2,2 |
| Carbon Storage | 1 |
| Biodiversity maintenance | 0,5 |
| Water Supply | 1,2 |
| Harvestable resources | 0 |
| Cultural value | 0 |
| Cultivated foods | 0 |
| Tourism and recreation | 0 |
| Education and research | 0 |
| SUM | 16,8 |
| Average score | 1,1 |

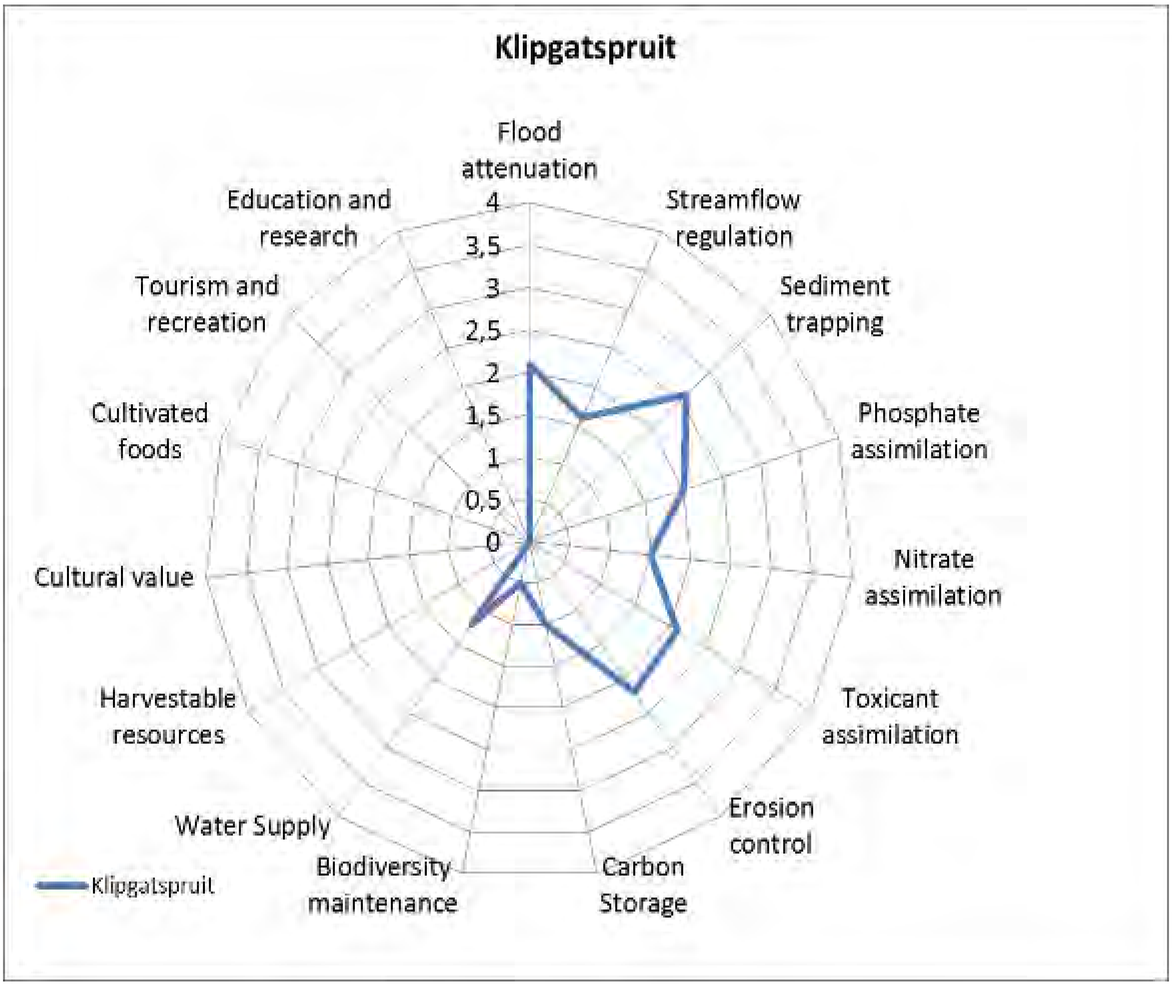



**Figure 33: Radar plot of wetland services provided by the Klipgatspruit**

The system obtained an average score of 1.1 which implies that the system has a moderately low level of service provision.The system is moderately diffuse and has a moderately high surface roughness which makes it possible for it to attenuate floods. Due to the watercourse being located adjacent to a mining area, there is an elevated sediment load being deposited within the system. In addition, the area has been subjected to heavy grazing and trampling by livestock as well as construction of structures like weirs, pipeline and railway crossings contributes to erosion and sediment deposition within the system. The system scored low for biodiversity maintenance and this is due to the alteration of the habitat and invasion of alien species which renders the area incompatible to support species. Due to the location of the watercourse, altered water quality, the water within the system cannot be used for domestic purposes and is only being used for industrial purposes as there was evidence of abstraction observed on site. The score for sediment trapping and toxicant assimilation was moderately high, however, this is attributed to the opportunity rather than effectiveness of the system to trap sediments and toxicants.

## Brakspruit: South of Siphumelele 2

**Table 11: Results of the wetland function and service provision assessments applied to Brakspruit**

| Ecosystem services | Brakspruit (South of Siphumelele 2) |
|---|---|
| Flood attenuation | 1,6 |
| Streamflow regulation | 0,8 |
| Sediment trapping | 1,6 |
| Phosphate assimilation | 1,3 |
| Nitrate assimilation | 0,8 |
| Toxicant assimilation | 1,6 |
| Erosion control | 1,8 |
| Carbon Storage | 0,7 |
| Biodiversity maintenance | 1,4 |
| Water Supply | 0,2 |
| Harvestable resources | 0 |
| Cultural value | 0 |
| Cultivated foods | 0 |
| Tourism and recreation | 0 |
| Education and research | 0 |
| SUM | 11,8 |
| Average score | 0,8 |

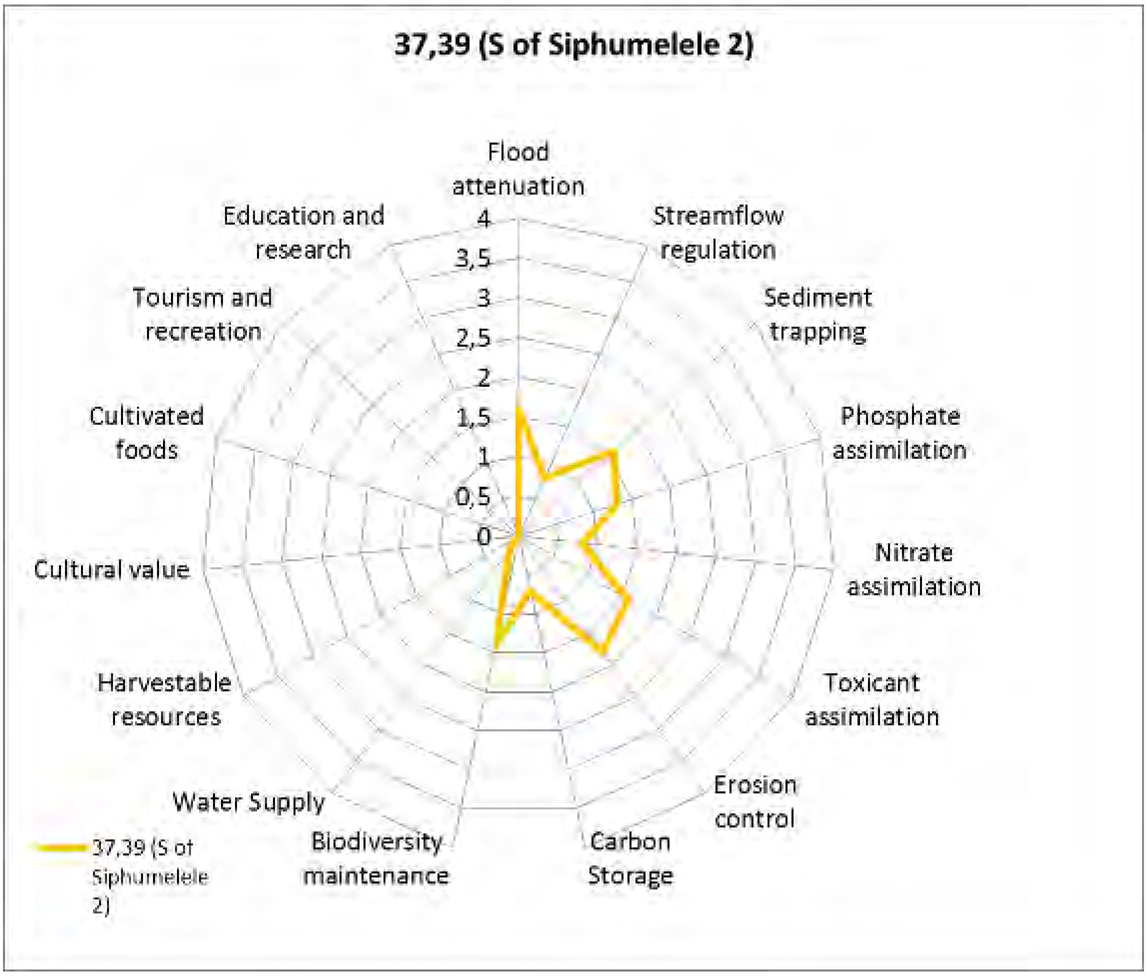



**Figure 34: Radar plot of wetland services provided by the Brakspruit**

The feature obtained an average score of 0.8 which implies that the feature has a moderately low level of service provision. The vegetation cover of the area was moderately low, and this is mainly due to the erodability of the soils within the area, therefore, the assimilation capabilities of the feature was intermediate as the vegetation will not trap sediments effectively. The feature is located in an area with extensive mining activities and there are no households that depend on the feature. As a result, it has no importance in terms of direct service provision (Cultivated foods, cultural value education and research). Since the system is non-perennial, it has moderately low importance in terms of streamflow regulation, this implies that feature will not be able to maintain wetland conditions and provide water to downstream areas during low flow periods. In addition, the area will only be able to provide suitable habitat to species at an intermediate level due to the disturbances and the nature of the feature.

## Hoedspruit: South of Hoedspruit Tailings Dam

**Table 12: Results of the wetland function and service provision assessments applied to Hoedspruit**

| Ecosystem services | Hoedspruit (South of Hoedspruit Tailings Dam) |
|---|---|
| Flood attenuation | 1,3 |
| Streamflow regulation | 1,4 |
| Sediment trapping | 1,8 |
| Phosphate assimilation | 1,5 |
| Nitrate assimilation | 1,5 |
| Toxicant assimilation | 1,7 |
| Erosion control | 2,5 |
| Carbon Storage | 1,7 |
| Biodiversity maintenance | 1,3 |
| Water Supply | 0,8 |
| Harvestable resources | 0 |
| Cultural value | 0 |
| Cultivated foods | 0 |
| Tourism and recreation | 0 |
| Education and research | 0 |
| SUM | 15,5 |
| Average score | 1,0 |

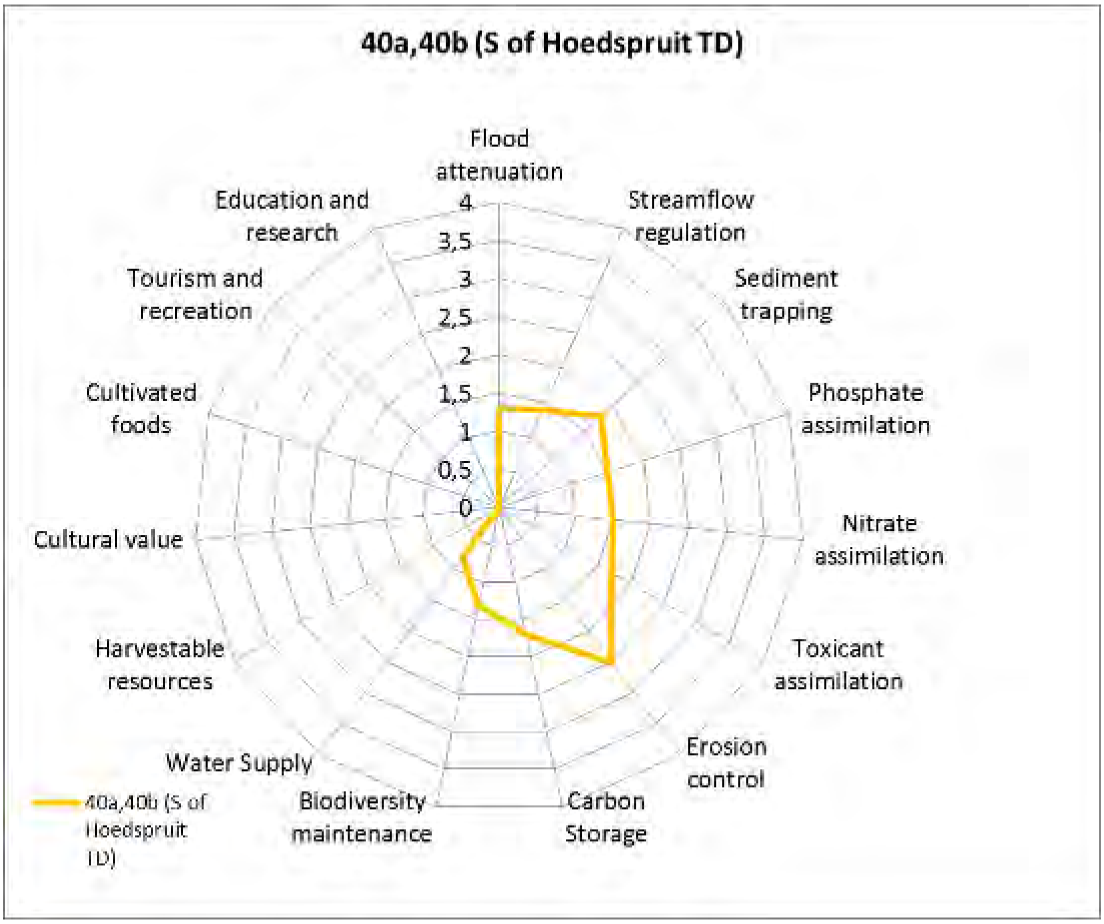



**Figure 35: Radar plot of wetland services provided by Hoedspruit**

The feature obtained an average score of 1.0 which implies that the feature has a moderately low level of service provision.The feature obtained an intermediate score for service provision, which is mainly influenced by the disturbances identified during site visit. The area has been disturbed by the presence of the railway crossing and the culvert as well as trampling along the edges of the dam as a result of livestock grazing. Due to these disturbances, the vegetation has been removed and a severe proliferation of alien vegetation has occurred which impacts on the survival of natural vegetation, therefore the assimilation capabilities of the feature has been impacted, nonetheless, they persist on an intermediate level. The feature is very diffuse in the vicinity of site 40 but has a moderately low level of vegetation cover, however the score for flood attenuation was intermediate which implies that the feature will be able to attenuate flow.

## Wildebeesfonteinspruit: South of Khuseleka 2 and West of Khuseleka 1

**Table 13: Results of the wetland function and service provision assessments applied to the Wildebeesfonteinspruit.**

| Ecosystem services | South of Khuseleka 2 | West of Khuseleka 1 |
|---|---|---|
| Flood attenuation | 1,6 | 1,8 |
| Streamflow regulation | 1,2 | 1,8 |
| Sediment trapping | 2,6 | 2,2 |
| Phosphate assimilation | 2 | 1,8 |
| Nitrate assimilation | 1,2 | 1,5 |
| Toxicant assimilation | 1,7 | 2 |
| Erosion control | 1,8 | 2,6 |
| Carbon Storage | 1,3 | 1 |
| Biodiversity maintenance | 1 | 1,1 |
| Water Supply | 0,5 | 0,8 |
| Harvestable resources | 0 | 0 |
| Cultural value | 0 | 0 |
| Cultivated foods | 0 | 0 |
| Tourism and recreation | 0 | 0 |
| Education and research | 0 | 0 |
| SUM | 14,9 | 16,6 |
| Average score | 1,0 | 1,1 |

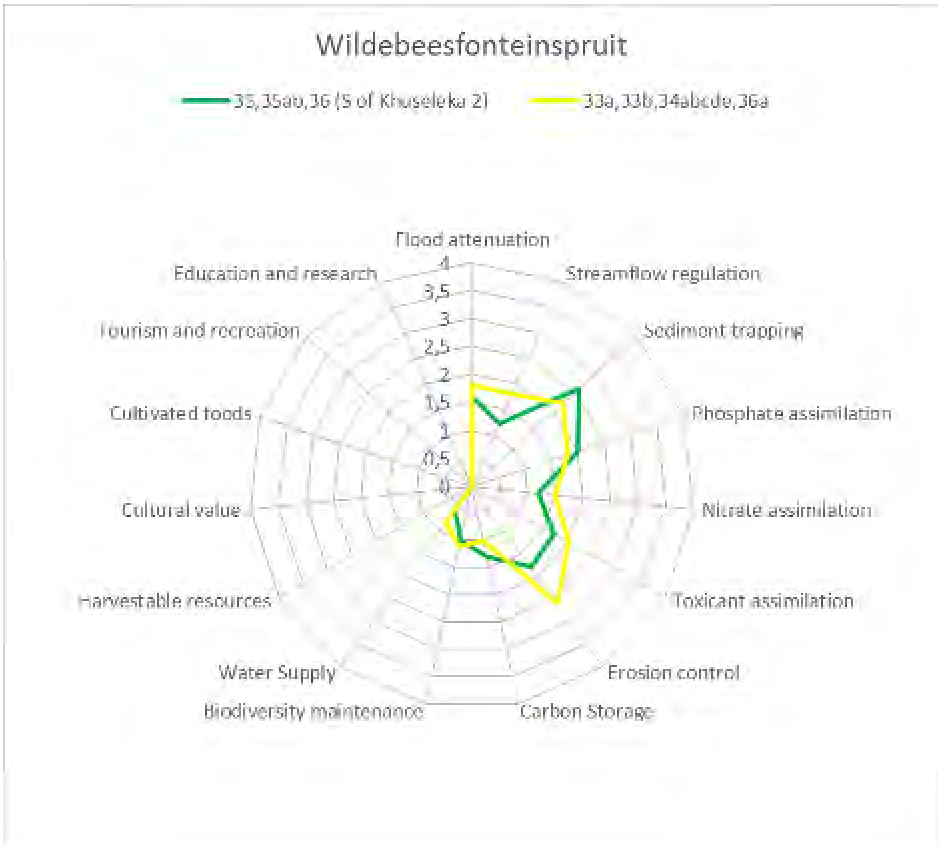



**Figure 36: Radar plot of wetland services provided by Wildebeesfonteinspruit**

### Wildebeesfonteinspruit: South of Khuseleka 2

The feature obtained an average score of 1.0 which implies that the feature has a moderately low level of service provision. The system is located adjacent to a mining stockpiling area which deposits sediment within the feature during high rainfall events. Due to this activity, the culvert pipes at site 35a have been blocked which leads to the obstruction of water flow through the channel. In addition, the areas downstream will not have enough water to support wetland conditions and will eventually dry up if these pipes are not desilted. Due to this activity, the score for stream flow regulation is moderately low. The vegetation cover within the feature was moderately low during the site visit, and this affects the ability of the feature to trap sediments hence the significant sediment load observed. The score for biodiversity maintenance is moderately low, since there was a moderately high disturbance on the sediment regime as well as the hydrology regime of the feature.

### Wildebeesfonteinspruit: West of Khuseleka 1

The feature obtained an average score of 1.1 which implies that the feature has a moderately low level of service provision. The feature seemed to be in good condition in some portions whereas some portions have been largely modified by the development of artificial channels, roads/culverts and railway crossings. As a result of these modifications, certain functions that are expected to be performed by the feature have been lost and/or performed at reduced levels. The score for biodiversity maintenance was moderately low and this is mainly due to the artificial state of the wetland as well as the other disturbances in the vicinity, such as vegetation removal, deterioration of water quality and barriers like fences. Despite the disturbances observed, the feature obtained moderately high scores for sediment trapping and erosion control. This was based on the opportunity given to the wetland to perform those services due to surrounding anthropogenic impacts rather than the effectiveness of the service provision. The score for water quality enhancement service was intermediate and this is attributed to the moderately high vegetation cover. The feature is however utilized for livestock grazing, particularly in portions located within residential areas.

### Paardekraalspruit

**Table 14: Results of the wetland function and service provision assessments applied to the Paardekraalspruit**

| Ecosystem services | N & NW of Siphumelele 1 WRD | N of Paardekraal Tailings Dam |
|---|---|---|
| Flood attenuation | 2,2 | 2,1 |
| Streamflow regulation | 1 | 1,6 |
| Sediment trapping | 2 | 1,8 |
| Phosphate assimilation | 1,8 | 1,5 |
| Nitrate assimilation | 1,7 | 1,5 |
| Toxicant assimilation | 1,7 | 1,7 |
| Erosion control | 2,8 | 2,3 |
| Carbon Storage | 1 | 2,3 |
| Biodiversity maintenance | 1,3 | 1,6 |
| Water Supply | 0,3 | 0,8 |
| Harvestable resources | 0,2 | 0,2 |
| Cultural value | 0 | 0 |
| Cultivated foods | 0 | 0 |
| Tourism and recreation | 0 | 0 |
| Education and research | 0 | 0 |
| SUM | 16,0 | 17,4 |
| Average score | 1,1 | 1,2 |

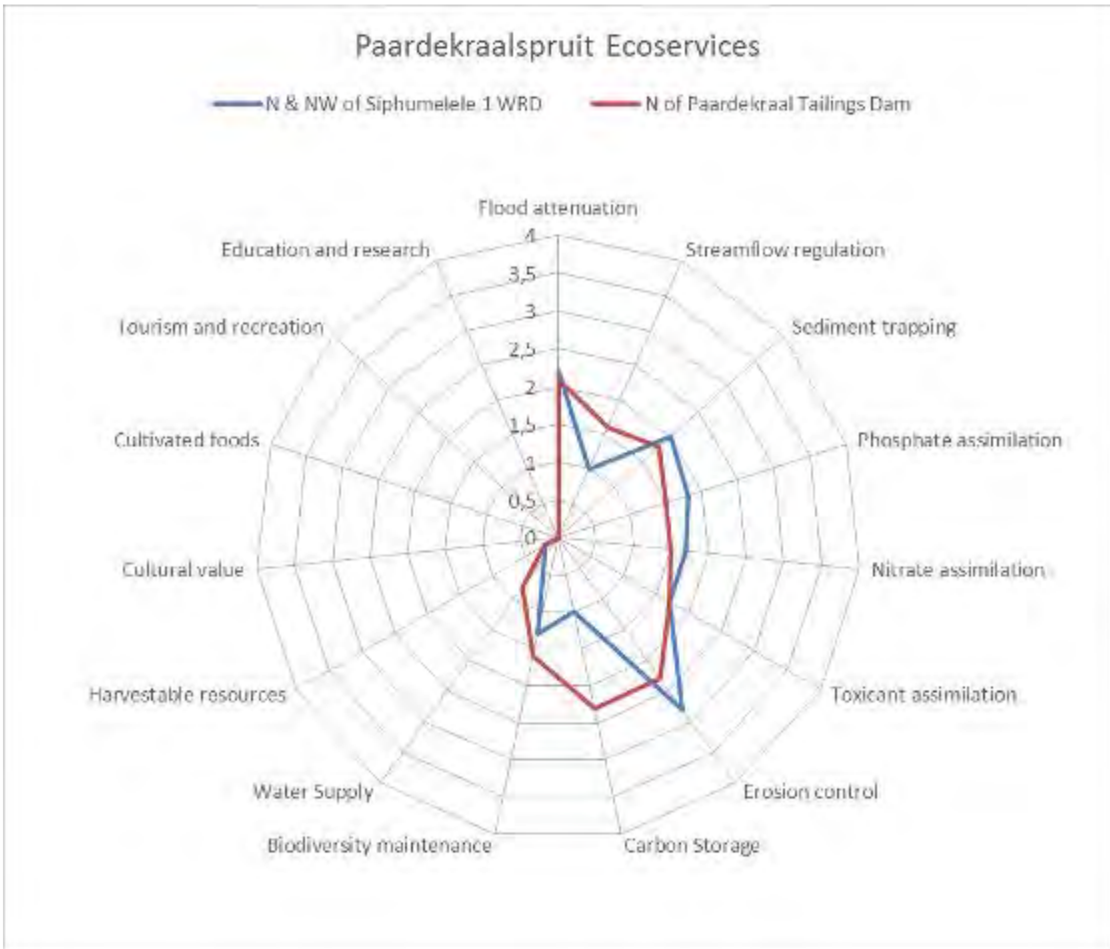



**Figure 37: Radar plot of wetland services provided by Paardekraalspruit**

The portion of the system located north and northwest of Siphumelele 1 obtained an average score of 1.1, whereas the portion located north of Paardekraal Tailings Dam obtained an average score of 1.2. The scores implies that the system has a moderately low level of service provision. After the assessment it was concluded the feature has a moderately low score for ecological services provision. The system appears to be seasonal and can only provide water during rainfall events. However, due to the location of the feature, it is utilised for livestock grazing as vegetation is available for use. The feature has been largely trampled along culvert crossings and within the channel (Site 15) which poses more risks for erosion. Due to the moderately high vegetation cover as well as the diffuse nature of the feature, the feature is able to attenuate floods during flood peaks. For assimilation purposes and sediment trapping (i.e. water quality enhancement service) the feature has obtained an intermediate score. The feature obtained an intermediate score for biodiversity maintenance as a result of vegetation disturbance and deposition of debris and sediment which alters migration routes for mobile species.

## Ephemeral drainage lines

**Table 15: Results of the wetland function and service provision assessments applied to the drainage lines**

| Ecosystem services | Drainage Lines |
|---|---|
| Flood attenuation | 1,5 |
| Streamflow regulation | 0 |
| Sediment trapping | 1,2 |
| Phosphate assimilation | 1,2 |
| Nitrate assimilation | 1,2 |
| Toxicant assimilation | 1,1 |
| Erosion control | 2,3 |
| Carbon Storage | 1,7 |
| Biodiversity maintenance | 2,3 |
| Water Supply | 0,2 |
| Harvestable resources | 0 |
| Cultural value | 0 |
| Cultivated foods | 0 |
| Tourism and recreation | 0 |
| Education and research | 0 |
| SUM | 12,7 |
| Average score | 0,8 |

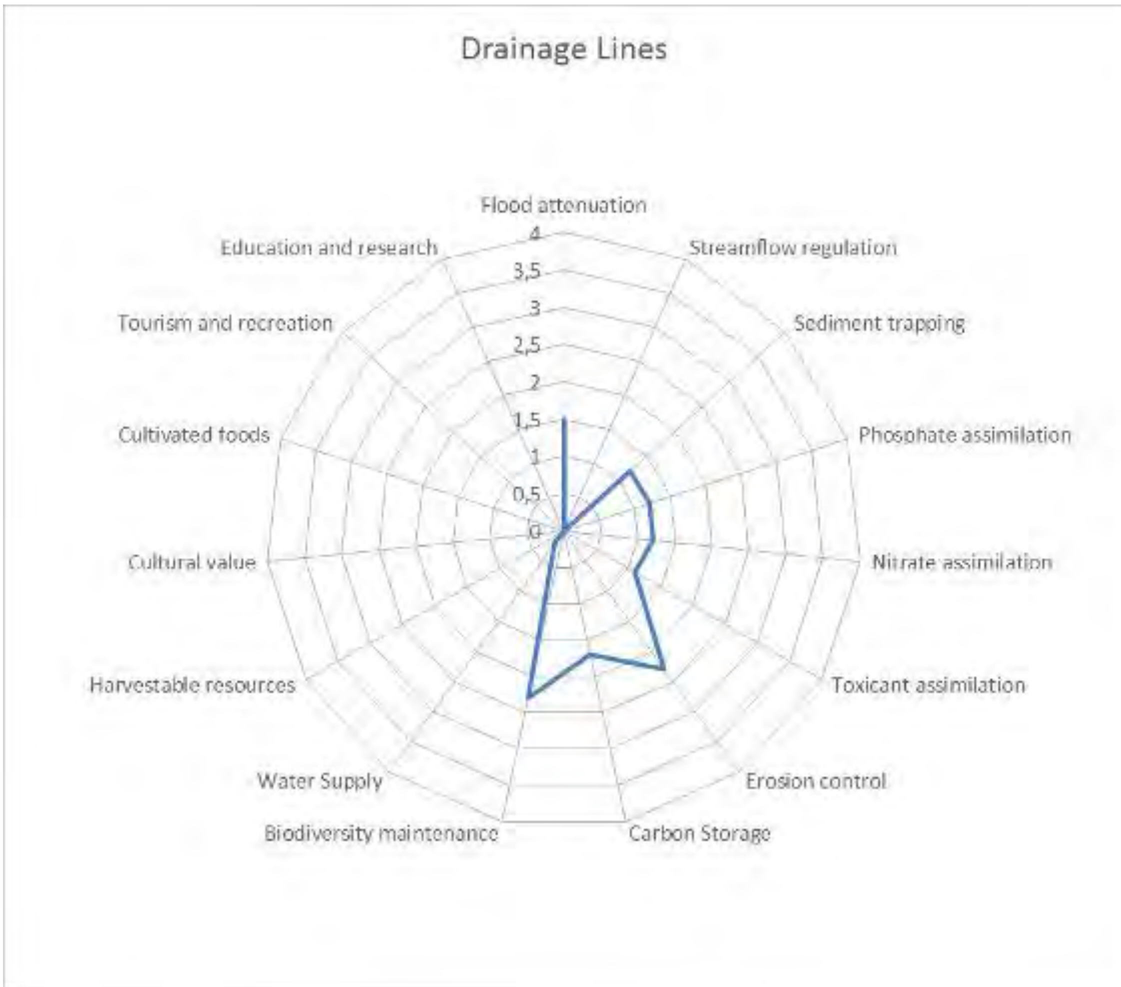



**Figure 38: Radar plot of wetland services provided by the drainage lines**

The features obtained an average score of 0.8 which implies that the drainage lines have a moderately low level of service provision. The features scored moderately high for biodiversity maintenance and erosion control, this is mainly attributed to the vegetation cover observed on site as well as the fact that the area was less invaded by alien vegetation. Due to the isolation and location of these features, they have not been subjected to any disturbance.

The features scored intermediate for flood attenuation, and this attributed to the diffuse nature of flow in the systems, which makes it easy and possible for water to spread and slow down during heavy rainfall. For water quality enhancement service the features scored moderately low since there are no sources of sediment and contaminants in close proximity, therefore these systems have limited opportunity to assimilate these substances.

## Dams

**Table 16: Results of the wetland function and service provision assessments applied to the dams**

| Ecosystem services | Dams |
|---|---|
| Flood attenuation | 1,9 |
| Streamflow regulation | 0 |
| Sediment trapping | 1,8 |
| Phosphate assimilation | 1,5 |
| Nitrate assimilation | 1 |
| Toxicant assimilation | 1,3 |
| Erosion control | 2 |
| Carbon Storage | 1,3 |
| Biodiversity maintenance | 2,1 |
| Water Supply | 0 |
| Harvestable resources | 0 |
| Cultural value | 0 |
| Cultivated foods | 0 |
| Tourism and recreation | 0 |
| Education and research | 0 |
| SUM | 12,9 |
| Average score | 0,9 |

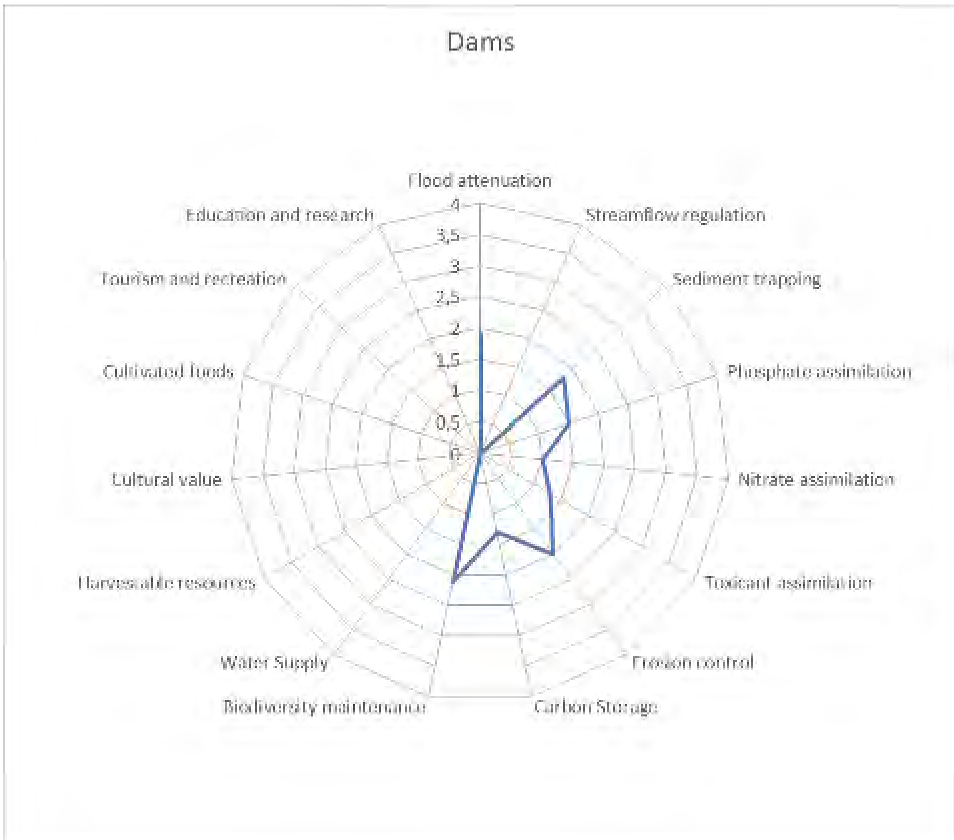



**Figure 39: Radar plot of wetland services provided by the dams**

The ecoservices provision of these features were assessed collectively as they indicated similar characteristics and landscape features. The average score obtained for the assessment was 0.9 which implies that the features are able to provide ecoservices at a moderately low level. The features are being utilized for livestock grazing as observed during site visit. The scores for biodiversity maintenance was moderately high which implies that features are able to provide suitable habitat to faunal species within the area. The features have intermediate importance in terms of assimilation capabilities.

## 4.7 Ecological Importance and Sensitivity (EIS) Assessment

The EIS assessment was applied to all wetlands, drainage lines and watercourse/riparian features within the study area in order to ascertain the levels of sensitive and ecological importance of the features, as well as to assist in informing a suitable REC for each. The results of these assessments are summarised in the table below (please see Appendix C for the detailed results of these assessments).

**Table 17: Summary of the EIS scores for all wetland and riparian features within the study area.**

| Group | Score | EIS Category |
|---|---|---|
| Brakspruit | 1.4 | C (Moderate) |
| Dorpspruit | 1.3 | C (Moderate) |
| Hex River | 1.3 | C (Moderate) |
| Hoedspruit | 1.7 | C (Moderate) |
| Klipfonteinspruit | 1.0 | D (Low/Marginal) |
| Klipgatspruit | 1.1 | C (Moderate) |
| Paardekraalspruit | 1.3 | C (Moderate) |
| Wildebeesfonteinspruit | 1.0 | D (Low/Marginal) |
| Drainage lines | 1.2 | C (Moderate) |
| Dams | 1.1 | C (Moderate) |

These results indicate that Brakspruit, Dorpspruit, Hex River, Hoedspruit, Klipgatspruit, Paardekraalspruit as well as Drainage lines and Dams are deemed to fall within an EIS Category C, indicating that these rivers are considered to be ecologically important and sensitive on a provincial and local scale. Klipfonteinspruit and Wildebeesfonteinspruit fall within an EIS Category D, which implies that these rivers are not ecologically important and sensitive at any scale. The EIS of the assessed features is conceptually presented in the figures below.

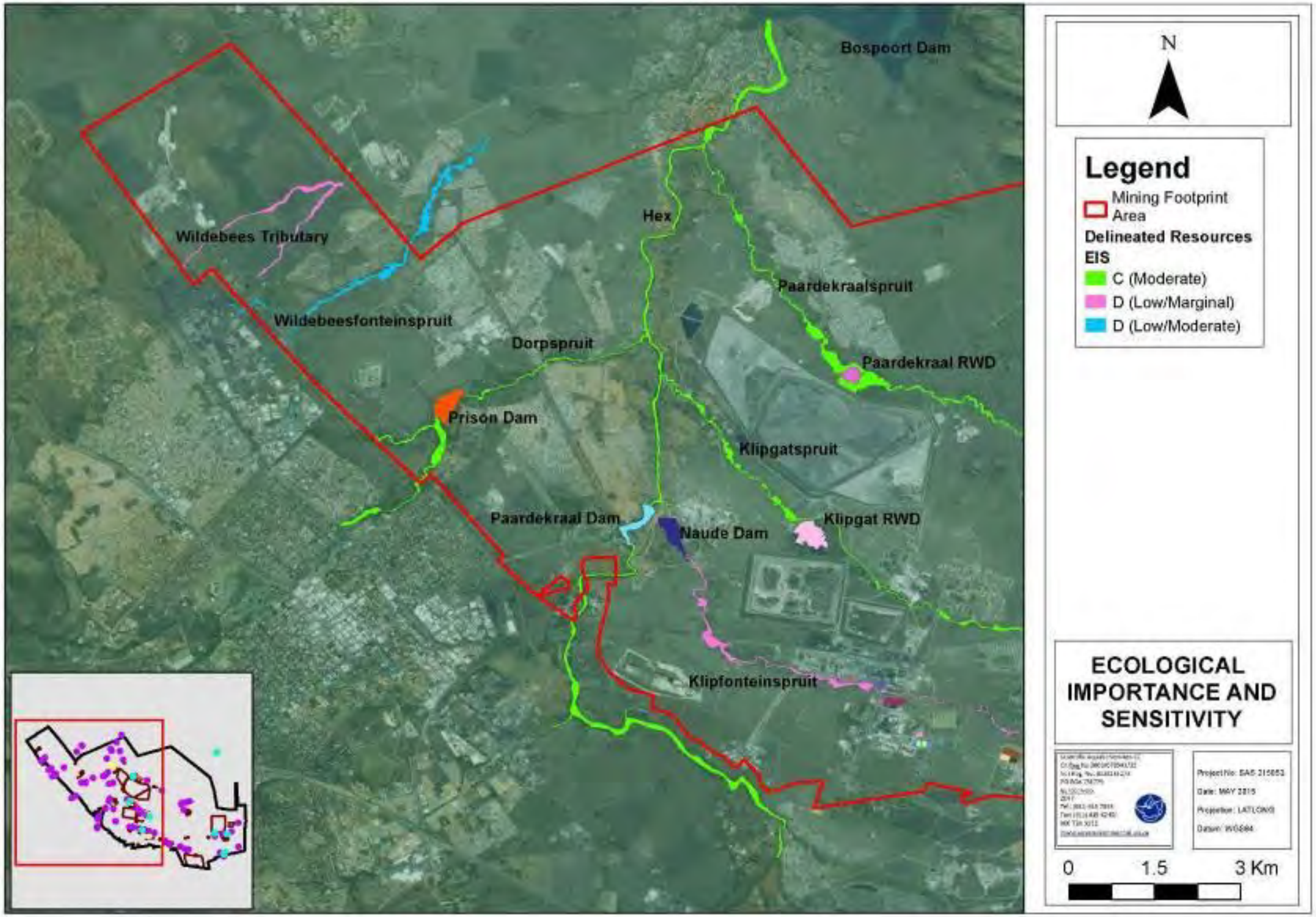



Figure 40: Conceptual presentation of the Ecological Importance and Sensitivity of the features assessed.

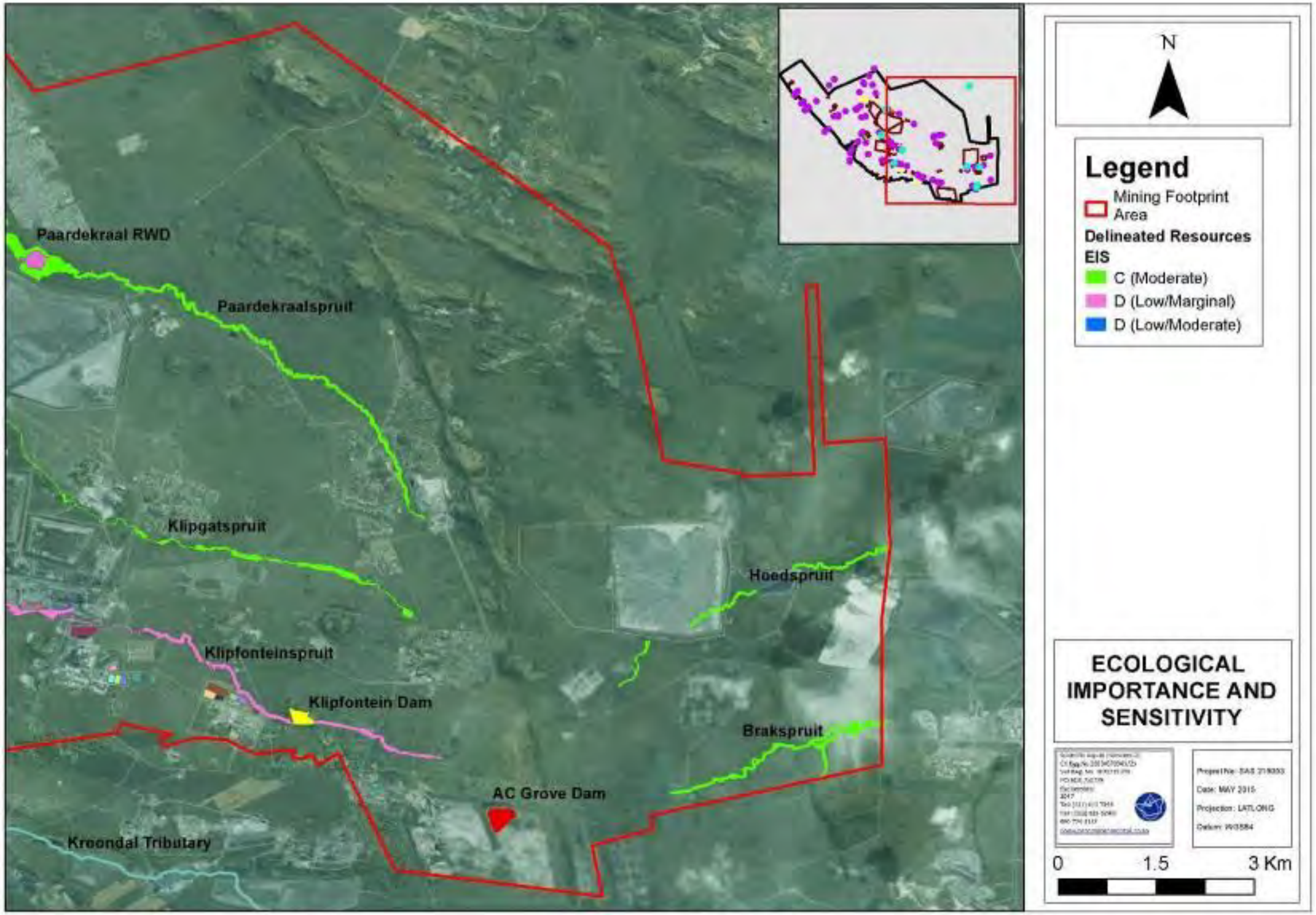



**Figure 41: Conceptual presentation of the Ecological Importance and Sensitivity of the features assessed.**

## 4.8 Recommended Ecological Category (REC)

The REC for the dams, ephemeral drainage lines and riparian features were determined taking into account the results of the IHI, Wet-Health, wetland function, and EIS assessments. These assessments show that all wetland and riparian features within the study area have undergone significant levels of transformation as a result of anthropogenic and current mining activities. Furthermore, all catchments apart from Dorpspruit have mine residue deposits that have the potential to impact the water features. Nevertheless, despite lowered ecological integrity of these systems, all are considered to provide important ecological services. The REC deemed appropriate for the wetland and watercourse/riparian features are presented in the table below.

**Table 18: Summary of the REC categories assigned to the various features within the study area.**

| Group | REC |
|---|---|
| Brakspruit | D |
| Dorpspruit | D |
| Hex River | D |
| Hoedspruit | D |
| Klipfonteinspruit | D |
| Klipgatspruit | C |
| Paardekraalspruit3 | C |
| Wildebeesfonteinspruit | D |
| Drainage lines | B |
| Dams | C |

*The Ecological Categories were recommended based on the following on site observations within each system*:

- Brakspruit has been largely modified by heavy grazing, trampling and increased water input that contributes to erosion as observed on site. In addition, the system has been disturbed by the stream diversion;
- Dorpspruit was modified by sediment deposition and sewage discharge, collapsed culverts as well as alien invasion. Although there is a portion that is moderately modified, the disturbances within the system are extensive;
- Hex River has been largely modified by the presence of the Paardekraal Dam and vegetation encroachment as well as severe sediment deposition after heavy rains;
- Hoedspruit modified by erosion due to grazing and trampling. Alien vegetation has occurred;
- Klipfonteinspruit was modified by heavy grazing as well as increased runoff from mining areas and exposed pipes in certain areas, impeding the flow of water;

- Klipgatspruit and Paardekraalspruit have been largely modified by erosion, sediment deposition and alien invasion; and
- Wildebeesfonteinspruit has been modified by sewage effluent discharge, creation of artificial channel.

Where applicable and feasible, mitigation measures to minimise the impacts associated with the RPM activities must be implemented in order to maintain and improve current levels of ecological integrity and functioning.

## *4.9 Delineation and Sensitivity Mapping*

All features were delineated on a desktop level with the use of digital satellite imagery and topographical maps. Portions of the features were then verified during the field survey according to the guidelines advocated by DWA (2008) and the wetland/riparian delineations as presented in this report are regarded as a best estimate of the temporary and riparian zone boundaries based on the site conditions present at the time of assessment and based on the digital satellite imagery used for delineation. Ground-truthing of wetland/riparian boundaries focused on those areas within the study area.

During the assessment, the following indicators were used to ascertain the boundaries of the temporary zones of the riparian features, ephemeral drainage lines and dams:

- Terrain units were used as the primary indicator, as both soil profiles and vegetation communities have been transformed, and therefore it was difficult in many areas to discern wetland/riparian boundaries utilising these indicators;
- Vegetation, although transformed throughout the study area, was considered informative at many features, although in most instances the change in vegetation communities between terrestrial and wetland ecosystems was subtle;
- Soil forms were considered; however, the vertic soils within the study area do not show soil variations such as gleying (leaching out of iron) and the presence of mottles (soils with variegated colour patterns). Therefore, this indicator was not used extensively to determine wetland boundaries as differences between terrestrial and wetland soils could not be reliably discerned using soil morphology.

Legislative requirements were used to determine the extent of buffer zone required for each group depending on whether a group is considered wetland/riparian habitat or not. If any activities are to take place within 100 m or the 1:100 year flood lines exemption in terms of Regulation GN 704 of the NWA, 1998 (act no. 36 of 1998) needs to be obtained. Section 21 of the NWA (Act 36 of 1998) as well as General Notice no. 1199 of 2009 as it relates to the NWA will also apply.

Smaller, ephemeral drainage lines *without* riparian zones or characteristics are not considered wetlands or systems with an associated riparian zone but may still be defined as watercourses if there are floodlines applicable to them. If any activities are to take place with the 1:100 year flood line exemption in terms of Regulation GN 704 of the NWA, 1998 (act no. 36 of 1998) needs to be obtained as well as a WUL in terms of Section 21 (c & i) of the NWA (Act 36 of 1998) while General Notice no. 1199 of 2009 as it relates to the NWA does not apply since the resource is not defined as a wetland.

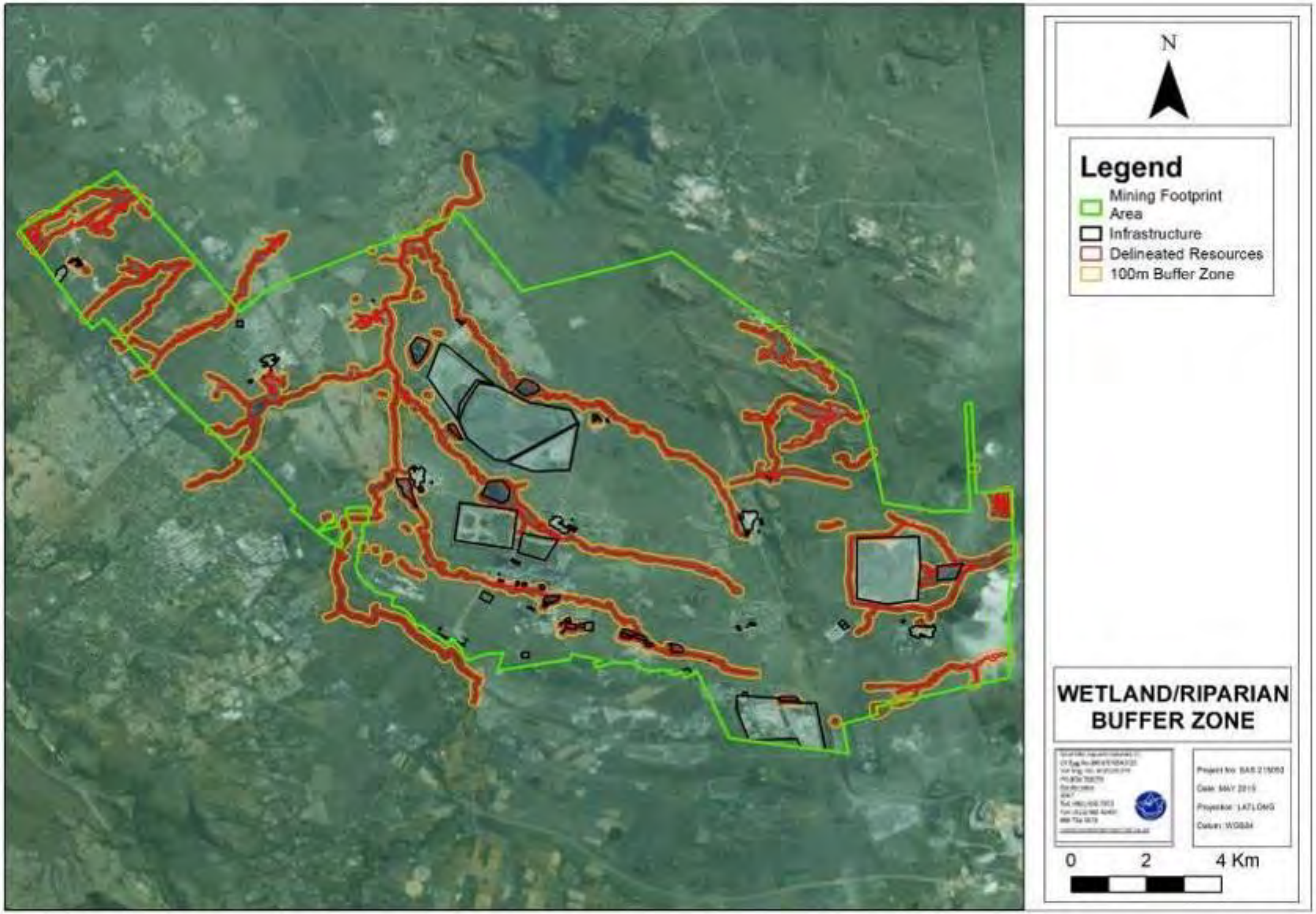



**Figure 42: Conceptual presentation of the watercourses within the study area and the associated 100m buffer zone.**

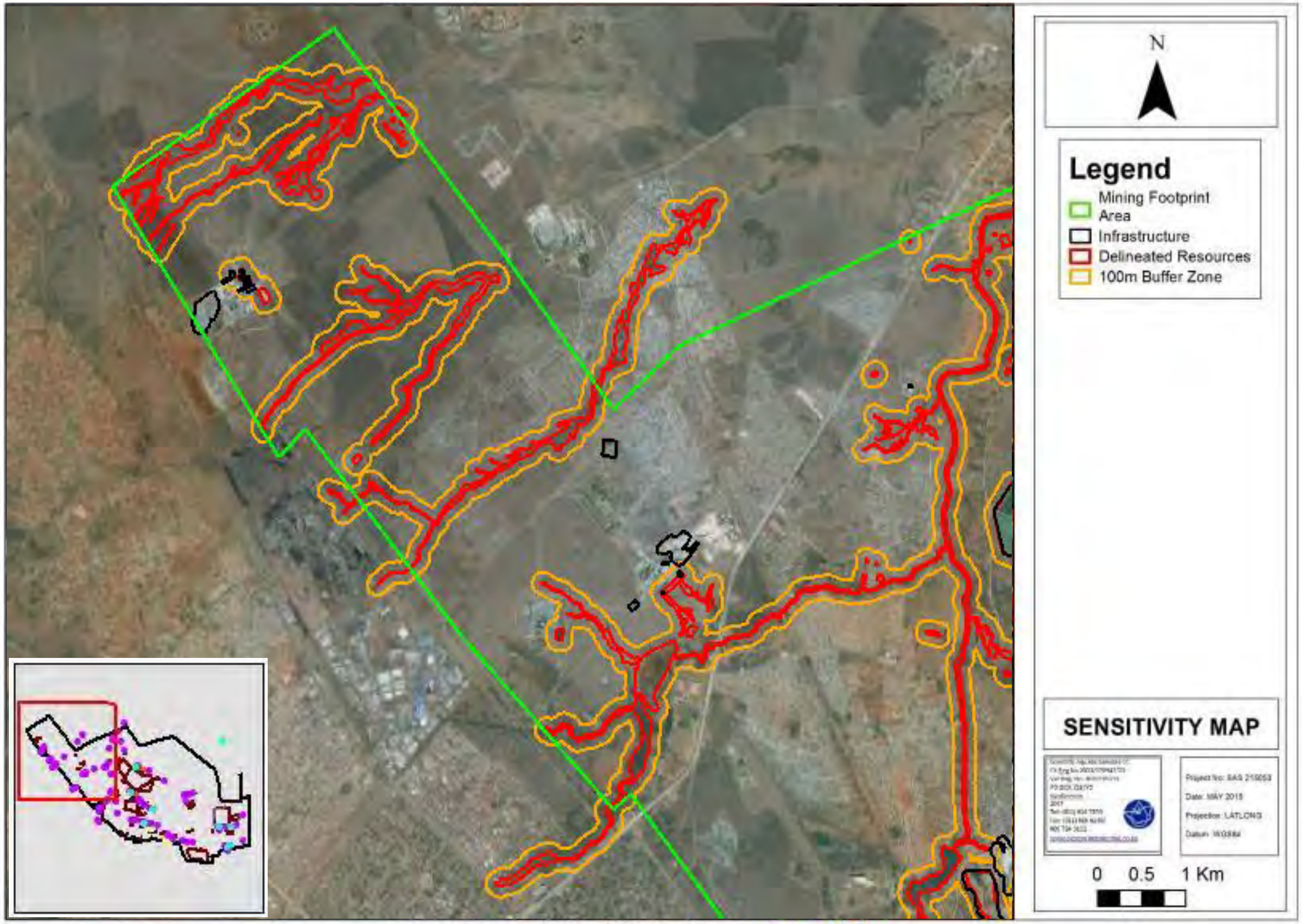



**Figure 43: Conceptual presentation of the watercourses within the study area and the associated 100m buffer zone.**

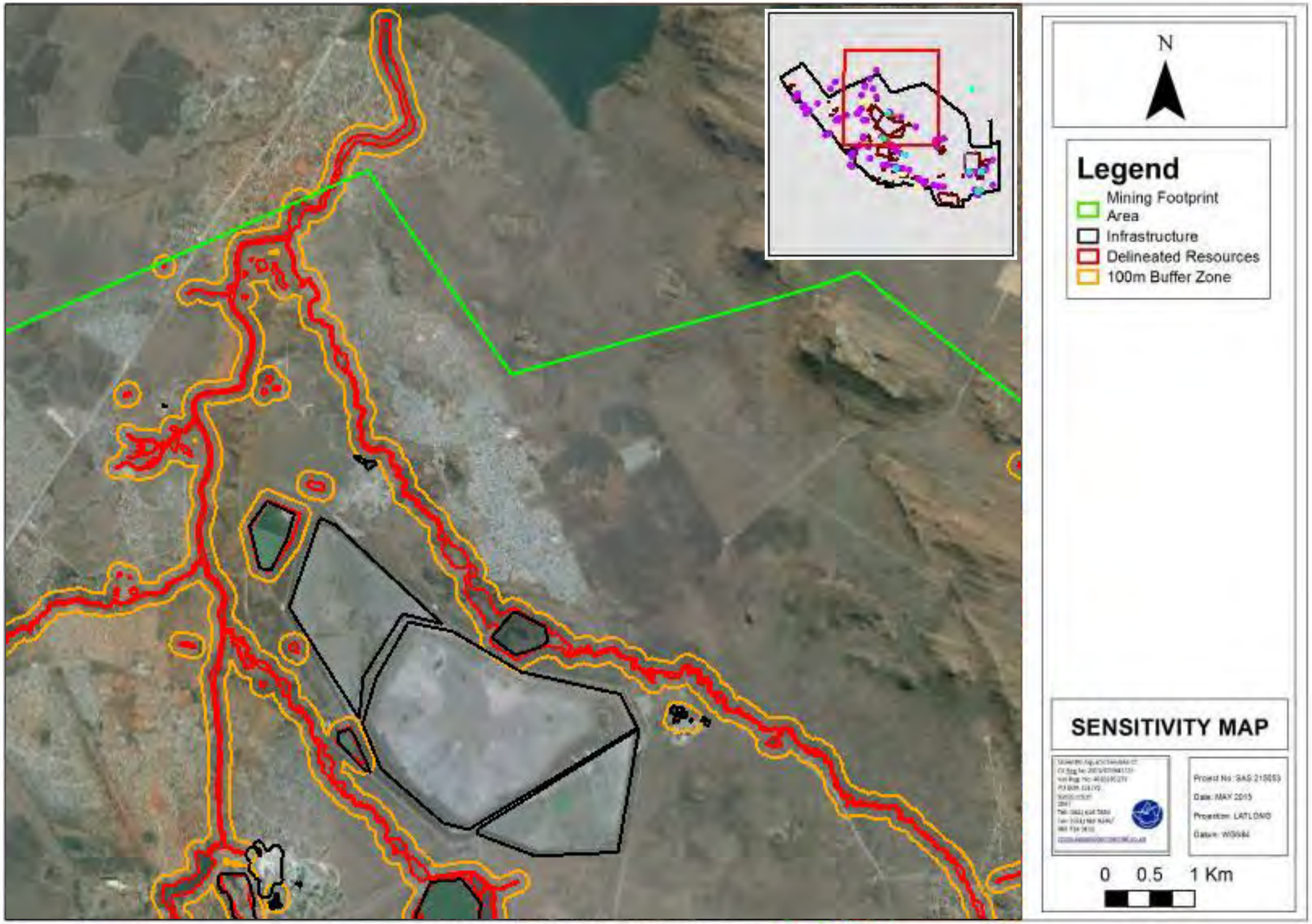



**Figure 44: Conceptual presentation of the watercourses within the study area and the associated 100m buffer zone.**

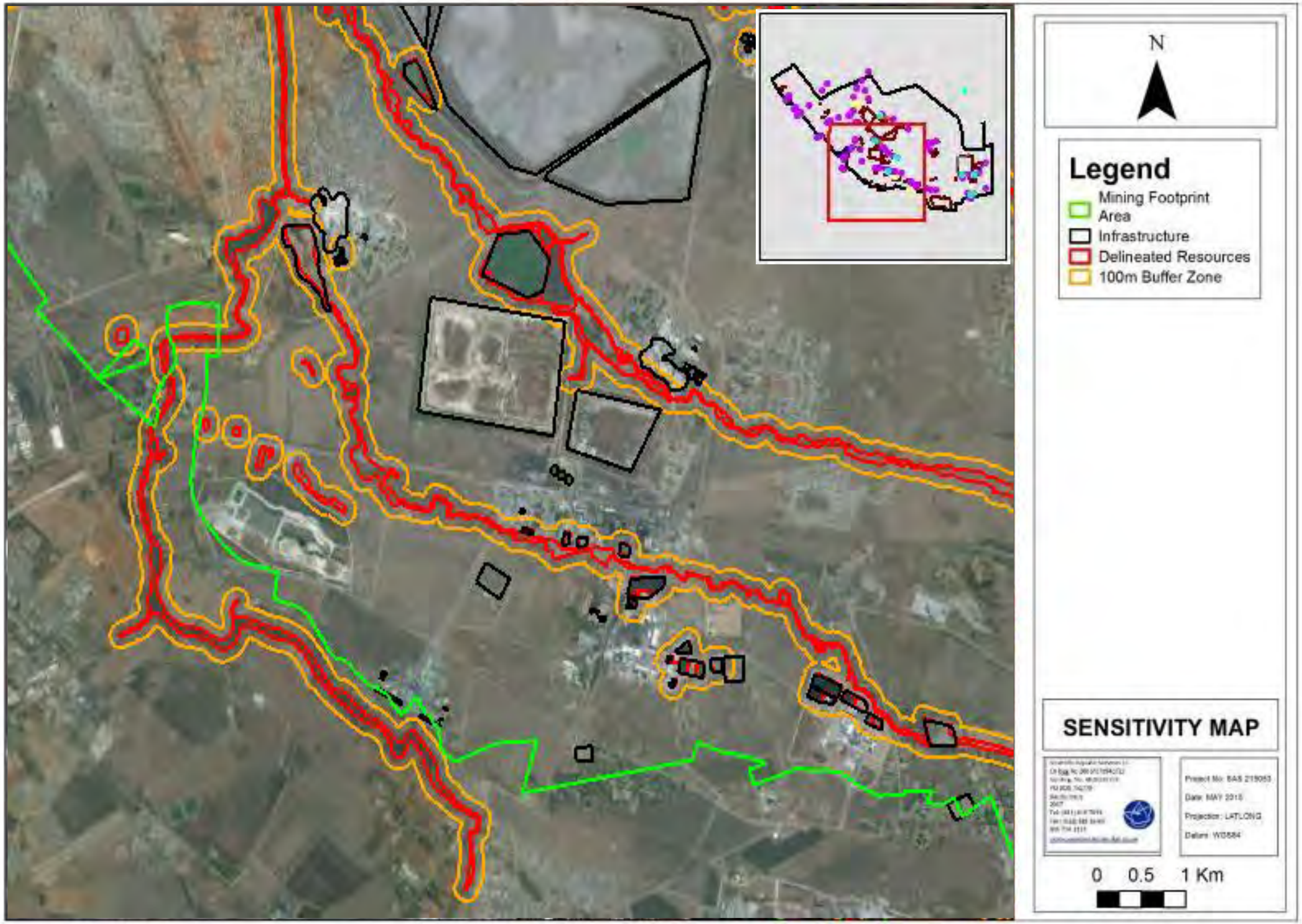



**Figure 45: Conceptual presentation of the watercourses within the study area and the associated 100m buffer zone.**

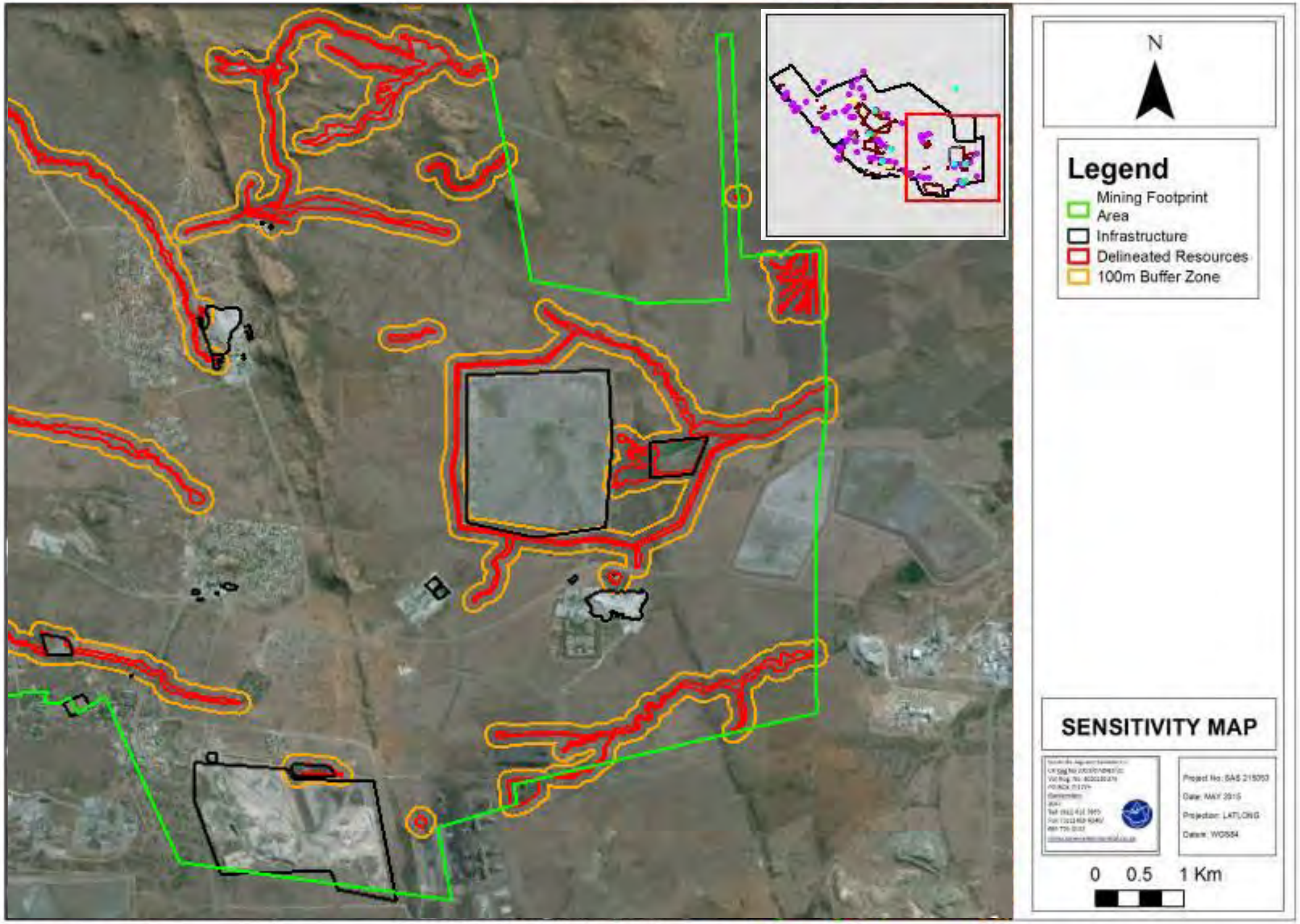



**Figure 46: Conceptual presentation of the watercourses within the study area and the associated 100m buffer zone.**

# 5 WATERCOURSE CROSSINGS ANALYSIS

The existing WUL (Licence Number 03/A22H/ACGIJ/926) permitted several watercourses crossings in terms of Sections 21 (c) and (i) of the NWA (1998).

SAS was requested to provide a brief assessment of each of these crossings and diversions. In addition, as part of the amendment to the WUL, new crossings were included in the assessment. The crossing locations as provided by SRK, and the associated water uses as per the WUL, are indicated in the tables below.

Based on observations of the surrounding areas and sections of the applicable channels further up/downstream of these points, it is likely that these crossings, together with other contributing factors, have caused moderate to severe modifications to the vegetation and geomorphology of the channels.

**Table 19: Summary of the assessment undertaken at Site 01.**

| | |
|---|---|
| Site number: 01 | Coordinates:<br>25°41'50.69"S 27°22'39.13"E |
| Crossing Type: Culvert/Road | |
| Site Photo:<br> | |
| Present Ecological State | D |
| Wetland type | River |
| Riparian and in Stream Habitat | *Acacia* spp. dominated bushveld vegetation; alien vegetation component high. Instream ecology: the wetland was moderately channelled upstream and diffuse downstream. |
| Vegetation | *Cynodon dactylon* dominated the wetland; alien vegetation was observed but only for a limited extent. |
| System Modifiers | Littering, cemented artificial channel, culvert altering waterflow .due to runoff from the road, erosion was observed in the area just adjacent to the culvert and the road. |
| Potential impacts of water use on environment | The bridge will not significantly negatively impact on any water users. |
| Socio-economic impacts of water use | The bridge will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The bridge plays an important role in providing connectivity in the area thereby allowing economic activity in the area |
| Potential impacts of water use on water resource | The culvert is constructed in a way that it constricts water flow especially in the immediate area of the culvert. |
| Summary of proposed impact on water use will have on other users | The bridge will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Invasive vegetation control. Litter control and removal, erosion monitoring. |

**Table 20: Summary of the assessment undertaken at Site 02.**

| Site number: 02 | Coordinates: 25°41'49.41"S 27°22'25.60"E |
|---|---|
| Crossing Type: Railway/Culvert | |
| Site Photo:  | |
| Present Ecological State | C |
| Wetland type | River |
| Morphology | Wide, shallow banks, ephemeral river. Culvert/bridge well-constructed; however the area adjacent to the culvert has been eroded due to the inherent vulnerability of the soils to erosion. |
| Riparian and in Stream Habitat | Acacia spp dominated bushveld vegetation; Instream ecology: well vegetated. |
| Vegetation | Alien species such as *Bonariensis verbena and Asparagus laricinus* have invaded the area, with *Acacia* tree species observed along the banks along the erosion gullies. |
| System Modifiers | Erosion, trampling and grazing by livestock. |
| Potential impacts of water use on environment | The culvert/bridge will not significantly negatively impact on any water users. |
| Socio-economic impacts of water use | The culvert/bridge will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The culvert/bridge plays an important role in providing connectivity in the area thereby allowing economic activity in the area |
| Potential impacts of water use on water resource | The bridge is well constructed. Due to inherent erodability of the soils, bank incision during high-flow events and sedimentation of downstream resources is anticipated. However this is not as a direct consequence of the culvert/bridge. |
| Summary of proposed impact on water use will have on other users | The culvert/bridge will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Erosion control and ongoing monitoring. Invasive vegetation control. |

**Table 21: Summary of the assessment undertaken at Site 03.**

| | |
|---|---|
| Site number: 03 | Coordinates: 25°41'40.69"S 27°22'05.90"E |
| Crossing Type: Road crossing | |
| Site Photo:  | |
| Present Ecological State | C |
| Wetland type | River |
| Morphology | Relatively shallow channel, well vegetated. |
| Riparian and in Stream Habitat | Instream ecology: dominated by *Cyperus sexangularis* |
| Vegetation | The stream is dominated by *Sexangularis* and *Flaveria bidentis.* |
| System Modifiers | Mowing. Waste dumping. Erosion along the culvert. |
| Potential impacts of water use on environment | The road crossing will not significantly negatively impact on the receiving environment; provided it is adequately maintained. |
| Socio-economic impacts of water use | The road crossing will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The road crossing will not significantly negatively impact on any water users. |
| Potential impacts of water use on water resource | The road crossing will lead to increased water input within the river. |
| Summary of proposed impact on water use will have on other users | The road crossing will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Clean up litter. Minimize the extent of vegetation clearing (curb side maintenance/grass mowing) next to the road to reduce runoff. Monitor erosion. Clear vegetation within the stream to promote clear stream flow. |

**Table 22: Summary of the assessment undertaken at Site 3a.**

| | |
|---|---|
| Site number: 3a | Coordinates: 25°41'41.32"S 27°22'06.46"E |
| Crossing Type: Pipeline | |
| Site Photo:  | |
| Present Ecological State | C |
| Wetland type | River |
| Morphology | Wide, relatively shallow channel. |
| Riparian and in Stream Habitat | Instream ecology: dominated by *Cyperus sexangularis* |
| Vegetation | The stream is dominated by *Sexangularis* and *Flaveria bidentis.* |
| System Modifiers | Mowing. |
| Potential impacts of water use on environment | The pipeline will not significantly negatively impact on the receiving environment; provided it is adequately maintained and there are no leaks detected during monitoring. |
| Socio-economic impacts of water use | The pipeline will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The sewer line is necessary for the safe disposal of sewage. |
| Potential impacts of water use on water resource | The support structures within the channel will result in some but not major alterations to streamflow patterns; however these are not deemed to have a significant impact on downstream resources. |
| Summary of proposed impact on water use will have on other users | The pipeline crossing will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Minimize the extent of vegetation clearing (curb side maintenance/grass mowing) next to the road to reduce runoff. |

**Table 23: Summary of the assessment undertaken at Site 3c.**

| | |
|---|---|
| Site number: 3c | Coordinates: 25°41'33.32"S 27°21'23.65"E |
| Crossing Type: Culvert | |
| Site Photo:  | |
| Present Ecological State | C |
| Wetland type | River |
| Morphology | Wide, deeply incised channel. |
| Riparian and in Stream Habitat | *Acacia* spp. dominated bushveld vegetation. Instream ecology: lowered water level during assessment, exposed bedrock. |
| Vegetation | *Typha capensis,* dominated and alien species such *Asparagus laricinus* and *Conyza bonariensis* were observed. |
| System Modifiers | Encroachment. |
| Potential impacts of water use on environment | The culvert has been broken or removed on purpose since there is no obstruction of waterflow. |
| Socio-economic impacts of water use | The culvert will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The culvert will not significantly negatively impact on any water users |
| Potential impacts of water use on water resource | The culvert will not significantly negatively impact on the water resource. |
| Summary of proposed impact on water use will have on other users | The culvert will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Control alien vegetation. |

**Table 24: Summary of the assessment undertaken at Site 3d.**

| | |
|---|---|
| Site number: 3d | Coordinates: 25°41'34.44"S 27°21'25.99"E |
| Crossing Type: Dam wall | |
| Site Photo:  | |
| Present Ecological State | D |
| Wetland type | River/dam |
| Morphology | Very rocky area. |
| Riparian and in Stream Habitat | *Acacia* spp. dominated bushveld vegetation. Instream ecology: A puddle of water behind the dam wall, but most of the area was dry.at the time of the study. |
| Vegetation | *Acacia* spp dominated the area and a stand of *Typha capensis* was observed just adjacent the dam wall. |
| System Modifiers | Dam wall. Overgrazing and trampling. |
| Potential impacts of water use on environment | The dam wall alters the flow of water. |
| Socio-economic impacts of water use | The dam wall might cause ponding upstream and dry conditions downstream. |
| Socio–economic advantages of water use | The dam wall might cause ponding upstream and dry conditions downstream. |
| Potential impacts of water use on water resource | The dam wall will cause a migration barrier. |
| Summary of proposed impact on water use will have on other users | The dam wall will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Control erosion behind the dam wall. Control alien vegetation |

**Table 25: Summary of the assessment undertaken at Site 4/4a.**

| | |
|---|---|
| Site number: 4/4a | Coordinates: 25°41'26.54"S 27°21'10.01"E |
| Crossing Type: Road crossing | |
| Site Photo:  | |
| Present Ecological State | C |
| Wetland type | River |
| Morphology | Wide, relatively shallow channel. Dry river bed. |
| Riparian and in Stream Habitat | Instream ecology: riverbed dry at the time of the study. |
| Vegetation | *Typha capensis* and *Cyperus sexangularis* dominated. Alien species such as *Tagetes minuta* and *Bidens pilosa* were observed on site. |
| System Modifiers | Culvert. Increased runoff from road. |
| Potential impacts of water use on environment | The road crossing will not significantly negatively impact on any water users. |
| Socio-economic impacts of water use | The road crossing will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The road crossing plays an important role in providing connectivity in the area thereby allowing economic activity in the area |
| Potential impacts of water use on water resource | The road crossing is well constructed and berms are constructed to prevent erosion. |
| Summary of proposed impact on water use will have on other users | The road crossing will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Control alien vegetation |

**Table 26: Summary of the assessment undertaken at Site 05.**

| Site number: 05 | Coordinates: 25°41'26.59"S 27°21'11.30"E |
|---|---|
| Crossing Type: Road crossing | |
|  | |
| Present Ecological State | C |
| Wetland type | River |
| Morphology | Wide, relatively shallow channel. Dry river bed. |
| Riparian and in Stream Habitat | Instream ecology: riverbed dry at the time of the study. |
| Vegetation | *Typha capensis* dominated. |
| System Modifiers | Culvert. Increased runoff from road. Stock piling |
| Potential impacts of water use on environment | The road crossing will not significantly negatively impact on any water users. |
| Socio-economic impacts of water use | The road crossing will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The road crossing plays an important role in providing connectivity in the area thereby allowing economic activity in the area |
| Potential impacts of water use on water resource | The road crossing is well constructed. However stock piling adjacent the stream will result in sediment deposition. |
| Summary of proposed impact on water use will have on other users | The road crossing will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Control alien vegetation. Remove stock piled adjacent the feature to avoid sediment deposition and further erosion of the area. |

**Table 27: Summary of the assessments undertaken at Site 06**

| | |
|---|---|
| Site number: 06 | Coordinates: 25°40'52.34"S 27°20'25.70"E |
| Crossing Type: Road crossing | |
| Site Photo:  | |
| Present Ecological State | C |
| Wetland type | River |
| Morphology | Wide, shallow banks. Dry river bed. |
| Riparian and in Stream Habitat | Riparian vegetation dominated by *Asparagus laricinus* and *Acacia* spp. In-stream ecology: riverbed dry at the time of the study. |
| Vegetation | *Hyperhenia hirta, Eragrostis curvula,* and *Cyperus sexangularis* dominated. |
| System Modifiers | In-stream flow altered moderately due to infrastructure (old bridge) within macro-channel. Some alien vegetation present. Trampling by livestock resulting in erosion and sedimentation. |
| Potential impacts of water use on environment | The bridge will not significantly negatively impact on any water users. |
| Socio-economic impacts of water use | The bridge will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The bridge plays an important role in providing connectivity in the area thereby allowing economic activity in the area |
| Potential impacts of water use on water resource | The bridge is likely to have moderately altered streamflow patterns. |
| Summary of proposed impact on water use will have on other users | The bridge does not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Monitor erosion, alien vegetation control programme. |

**Table 28: Summary of the assessment undertaken at site 07.**

| | |
|---|---|
| Site number: 07 | Coordinates:<br>25°40'45.84"S 27°20'01.63"E |
| Crossing Type: Railway/Culvert | |
| Site Photo:<br> | |
| Present Ecological State | C |
| Wetland type | River |
| Morphology | Trampling by livestock and resulting erosion. |
| Riparian and in Stream Habitat | *Cyperus sexangularis* dominated. |
| Vegetation | *Asclepias fruiticosa, Xanthium strumarium, Asparagus laricinus, Flaveria bidentis, Conyza bonariensis, Cyperus sexangularis* |
| System Modifiers | Trampling and overgrazing by livestock. |
| Potential impacts of water use on environment | The culvert has changed the geomorphology as well as vegetation on site. |
| Socio-economic impacts of water use | The culvert will not significantly impact negatively on any water users. |
| Socio–economic advantages of water use | The bridge plays an important role in providing connectivity in the area thereby allowing economic activity in the area. |
| Potential impacts of water use on water resource | The culvert has altered water flow patterns line on the water resource. |
| Summary of proposed impact on water use will have on other users | The culvert will not significantly impact negatively on any water users. |
| Mitigation and Rehabilitation plan | Erosion monitoring and control |

**Table 29: Summary of the assessment undertaken at site 7a and site 7b.**

| | |
|---|---|
| Site number: 7a & 7b | Coordinates: 25°40'45.58"S 27°19'54.23"E |
| Crossing Type: Pipeline | |
| Site Photo:  | |
| Present Ecological State | D (largely modified) |
| Wetland type | River |
| Morphology | Wide eroded channel. |
| Riparian and in Stream Habitat | Riparian vegetation sparse due to overgrazing and erosion; consists primarily of pioneer graminoid species and alien invasive species. Instream ecology: river dry at the time of the assessment. |
| Vegetation | *Asparagus laricinus, Cyperus sexangularis Flaveria bidentis* |
| System Modifiers | Trampling by livestock; erosion which puts a strain on the plinth supporting the pipeline. |
| Potential impacts of water use on environment | The pipeline will not significantly negatively impact on any water users. |
| Socio-economic impacts of water use | The pipeline will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The pipeline will not significantly negatively impact on any water users. |
| Potential impacts of water use on water resource | The pipeline might collapse if the erosion along the plinths is not controlled. Due to inherent erodability of the soils, bank incision during high-flow events and sedimentation of downstream resources is anticipated. |
| Summary of proposed impact on water use will have on other users | The pipeline will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Erosion repair & controls at pipeline plinths, erosion monitoring, alien invasive vegetation control monitor pipes for leakages |

**Table 30: Summary of the assessment undertaken at site 08.**

| | |
|---|---|
| Site number: 8/8c | Coordinates: 25°40'42.79"S 27°19'34.97"E |
| Crossing Type: Bridge/Road crossing and weir | |
| Site Photo:  | |
| Present Ecological State | C |
| Wetland type | River |
| Morphology | The channel is mostly eroded on the area just below the bridge. |
| Riparian and in Stream Habitat | Primarily herbaceous and graminoid floral species, little to no overhanging vegetation. Instream ecology: inundation below the bridge |
| Vegetation | *Phragmites australis, Cyperus sexangularis, Asclepias fruiticosa, Tagetes minuta*. |
| System Modifiers | The feature is augmented due to discharge from the mining area. Bridge crossing increasing water input within the river. |
| Potential impacts of water use on environment | The road crossing will not significantly negatively impact on any water users. |
| Socio-economic impacts of water use | The road crossing will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The road crossing plays an important role in providing connectivity in the area thereby allowing economic activity in the area |
| Potential impacts of water use on water resource | The road crossing will not significantly negatively impact on any water users |
| Summary of proposed impact on water use will have on other users | The road crossing will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Invasive vegetation control. Monitor pipe leakages. Test the water for toxicity. |

**Table 31: Summary of the assessment undertaken at site 8a.**

| | |
|---|---|
| Site number: 8a | Coordinates: 25°40'43.43"S 27°19'36.40"E |
| Crossing Type: Pipeline | |
| Site Photo:  | |
| Present Ecological State | D |
| Wetland type | River |
| Morphology | Narrow, ephemeral channel. |
| Riparian and in Stream Habitat | Riparian habitat dominated by pioneer graminoid species. Instream ecology: riverbed dry at the time of the study; terrestrial plants found in the channel. |
| Vegetation | *Hyparrhenia hirta, Phragmites australis, Flaveria bidentis, Coenyza bonariensis, Cynodon dactylon, Sesbania sesban* |
| System Modifiers | Erosion. Grazing and trampling by livestock has altered the vegetation. Sediment deposition. Berm not functioning well. |
| Potential impacts of water use on environment | The pipeline will not significantly negatively impact on any water users. |
| Socio-economic impacts of water use | The pipeline will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The pipeline will not significantly negatively impact on any water users. |
| Potential impacts of water use on water resource | The pipeline will not significantly negatively impact on any water users. |
| Summary of proposed impact on water use will have on other users | The road crossing will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Invasive vegetation control. Fix berm where the other canal enters the stream. Monitor erosion. |

**Table 32: Summary of the assessment undertaken at site 8b.**

| Site number: 8b | Coordinates: 25°40'42.44"S 27°19'27.71"E |
|---|---|
| Crossing Type: Pipeline | |
| Site Photo:  | |
| Present Ecological State | C |
| Wetland type | River |
| Morphology | Fairly vegetated area. |
| Riparian and in Stream Habitat | Not applicable. |
| Vegetation | *Cyperus sexangularis, Cynodon dactylon, Sesbania sesban* |
| System Modifiers | Leaking pipes, trampling. |
| Potential impacts of water use on environment | The pipeline crossing might alter water flow patterns since it is not elevated and it lies on the ground. |
| Socio-economic impacts of water use | The pipeline will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The pipeline will not significantly negatively impact on any water users. |
| Potential impacts of water use on water resource | Due to the inherent erodability of the soils in the area, the pipeline might trap sediment during rainfall events. The pipe will not cause a migration barrier since this is not a crossing with flow. |
| Summary of proposed impact on water use will have on other users | The pipeline will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Monitor erosion and pipe leakages. |

**Table 33: Summary of the assessment undertaken at site 09.**

| | |
|---|---|
| Site number: 09 | Coordinates: 25°40'31.53"S 27°18'46.76"E |
| Crossing Type: Pipeline & conveyer belt | |
| Site Photo:  | |
| Present Ecological State | C |
| Wetland type | River |
| Morphology | Moderately incised channel. |
| Riparian and in Stream Habitat | Inundation below the bridge. Well vegetated in-stream habitat. |
| Vegetation | *Sporobolus pyramidalis,, Cynodon dactylon, Phragmites australis, Melinis repens* |
| System Modifiers | Erosion along culvert due to grazing and trampling |
| Potential impacts of water use on environment | The conveyor line crossing will not significantly negatively impact on any water users, provided it is well maintained. |
| Socio-economic impacts of water use | The conveyor line crossing will not significantly negatively impact on any water users, however, the bridge will alter water flow patterns. |
| Socio–economic advantages of water use | The conveyor line as well as the road/bridge crossing is essential for continued mining operations, thus continuing economic development in the area. |
| Potential impacts of water use on water resource | The conveyor line crossing plinths do not pose any significant risk to the resource. Due to inherent erodability of the soils, bank incision during high-flow events and sedimentation of downstream resources is anticipated; however this is not as a direct consequence of the support structures. |
| Summary of proposed impact on water use will have on other users | The conveyor line crossing will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Control erosion if possible (The activity may be out of RPM control as the feature is used by livestock for regular watering and crossing point) |

**Table 34: Summary of the assessment undertaken at site 10.**

| Site number: 10 | Coordinates: 25°40'11.56"S 27°17'54.24"E |
|---|---|
| Crossing Type: Railway/Culvert | |
| Site Photo:  | |
| Present Ecological State | D |
| Wetland type | River |
| Morphology | The channel is not deep and it is more tramped below the crossing. |
| Riparian and in Stream Habitat | Acacia species dominated bushveld vegetation. Instream ecology: |
| Vegetation | *Cyperus sexangularis, Cynodon dactylon, Typha capensis, Acacia* spp. |
| System Modifiers | Infiltration due to paved surface which further increases runoff. Erosion. Livestock grazing and trampling. |
| Potential impacts of water use on environment | The railway crossing will not significantly negatively impact on any water users. |
| Socio-economic impacts of water use | The railway will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The railway line is utilised for the mining operations. |
| Potential impacts of water use on water resource | The railway is not considered likely to have a significant impact on the resource; however the culvert will alter water flow patterns and there will be reduced infiltration since the area is cemented just below the culvert. |
| Summary of proposed impact on water use will have on other users | The railway will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Monitor erosion. |

**Table 35: Summary of the assessment undertaken at site 11/a/b.**

| Site number: 11/a/b | Coordinates: 25°39'28.41"S 27°17'47.97"E |
|---|---|
| Crossing Type: Railway/Weir/Pipeline | |
| Site Photo:  | |
| Present Ecological State | D |
| Wetland type | River |
| Morphology | Shallow, wide channel. |
| Riparian and in Stream Habitat | Predominantly terrestrial, alien floral species. |
| Vegetation | *Cyperus sexangularis, Tagetes minuta, Melinis repens, Hyparrhenia hirta, Brachiaria brizantha, Rhus lancea, Typha capensis, Phragmites australis, Aloe spp, Asparagus laricinus, Coenyza bonariensis, Asclepias fruiticosa, Eragrostis curvula* |
| System Modifiers | Erosion. Livestock grazing and trampling. Leaking pipes. Weir altering water flow patterns |
| Potential impacts of water use on environment | The weir and the culvert will alter water flow pattern. However the railway line and the pipeline will not significantly negatively impact on any water users. |
| Socio-economic impacts of water use | The structures will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The railway line is utilised for the mining operations. |
| Potential impacts of water use on water resource | Alteration to streamflow patterns during flow periods is anticipated due to the presence of the culvert and the weir. |
| Summary of proposed impact on water use will have on other users | The railway crossing will not impact significantly on other water users, in addition, the pipeline will not have any significant impact provided it is well maintained. |
| Mitigation and Rehabilitation plan | Monitor erosion. Monitor pipes for leaks. Insert erosion control berms. |

**Table 36: Summary of the assessment undertaken at Site 12/12b.**

| | |
|---|---|
| Site number: 12/12a | Coordinates: 25°39'56.50"S 27°20'07.59"E |
| Crossing Type: Road crossing culvert & pipeline | |
| Site Photo:  | |
| Present Ecological State | C |
| Wetland type | River |
| Morphology | Wide, relatively shallow channel. Dry river bed. |
| Riparian and in Stream Habitat | *Dichrostachys* spp. dominated bushveld vegetation. Instream ecology: riverbed dry at the time of the study. |
| Vegetation | *Cyperus sexangularis, Hyparrhenia hirta, Acacia spp, Coenyza bonariensis, Cynodon dactylon, Verbena bonariensis, Setaria sphacelata, Helichrysum* spp, *Typha capensis* |
| System Modifiers | Livestock grazing. Erosion. |
| Potential impacts of water use on environment | The road crossing will not significantly negatively impact on the receiving environment. |
| Socio-economic impacts of water use | The road crossing will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The pipeline will not significantly negatively impact on the receiving environment provide it is well maintained |
| Potential impacts of water use on water resource | The road crossing as well as the pipeline plinths within the channel will result in some alterations to streamflow patterns during flow periods; however these are not deemed to have a significant impact on downstream resources. |
| Summary of proposed impact on water use will have on other users | The pipeline will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Monitor erosion. |

**Table 37: Summary of the assessment undertaken at Site 12b.**

| Site number: 12b | Coordinates: 25°39'30.67"S 27°19'16.36"E |
|---|---|
| Crossing Type: Road crossing | |
|  | |
| Present Ecological State | C |
| Wetland type | River |
| Morphology | Wide, relatively shallow channel, mixture of alluvial sand and bedrock. Dry river bed. |
| Riparian and in Stream Habitat | *Dichrostachys* spp. dominated bushveld vegetation. Instream ecology: riverbed dry at the time of the study. |
| Vegetation | *Phragmites australis, Cynodon dactylon, Conyza bonariensis, Panicum maxima, Cyperus sexangularis, Flaveria bidentis, Typha capensis.* |
| System Modifiers | Road traversing feature. Livestock grazing and trampling. Erosion. |
| Potential impacts of water use on environment | The road crossing will not significantly negatively impact on the receiving environment. |
| Socio-economic impacts of water use | The road crossing will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The road crossing is necessary to connect the mining area to the neighbouring community. |
| Potential impacts of water use on water resource | The road crossing will not significantly negatively impact on any water users. |
| Summary of proposed impact on water use will have on other users | The road crossing will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Monitor erosion. And control alien vegetation. |

**Table 38: Summary of the assessment undertaken at Site 12c.**

| | |
|---|---|
| Site number: 12c | Coordinates:<br>25°39'30.67"S 27°19'16.36"E |
| Crossing Type: Pipeline | |
| Site Photo:  | |
| Present Ecological State | C |
| Wetland type | River |
| Morphology | Wide, relatively shallow channel. Dry river bed. |
| Riparian and in Stream Habitat | Instream ecology: riverbed dry at the time of the study. |
| Vegetation | *Phragmites australis, Cyperus sexangularis, Cynodon dactylon, typha capensis, Acacia* spp. |
| System Modifiers | Erosion and alien invasion along the pipeline. |
| Potential impacts of water use on environment | The pipeline will not significantly negatively impact on the receiving environment; provided it is adequately maintained. |
| Socio-economic impacts of water use | The pipeline will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The pipeline will not significantly negatively impact on any water users. |
| Potential impacts of water use on water resource | The plinths within the channel will result in some alterations to streamflow patterns during flow periods; however these are not deemed to have a significant impact on downstream resources. |
| Summary of proposed impact on water use will have on other users | The pipeline crossing will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Monitor erosion. Control alien vegetation |

**Table 39: Summary of the assessment undertaken at Site 13/13a.**

| | |
|---|---|
| Site number: 13/13a | Coordinates: 25°39'30.18"S 27°19'15.73"E |
| Crossing Type: Culvert and pipeline | |
| Site Photo:  | |
| Present Ecological State | D |
| Wetland type | River |
| Morphology | Wide, relatively shallow channel, mixture of alluvial sand and bedrock. Dry river bed. |
| Riparian and in Stream Habitat | *Acacia* spp. dominated bushveld vegetation. Instream ecology: flowing water |
| Vegetation | *Phragmites australis, Cyperus sexangularis, Asparagus laricinus, Conyza bonariensis, Tagetes minuta, Melinis repens, Eragrostis curvula, Panicum maxima* |
| System Modifiers | Sedimentation. Erosion. Alien invasion. |
| Potential impacts of water use on environment | The pipeline will not significantly negatively impact on the receiving environment; provided it is adequately maintained. |
| Socio-economic impacts of water use | The pipeline will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The pipeline is necessary for the safe disposal of sewage. |
| Potential impacts of water use on water resource | The plinths within the channel will result in some alterations to streamflow patterns during flow periods. The culvert is very narrow and low and will cause a constriction on water flow. |
| Summary of proposed impact on water use will have on other users | The pipeline will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Monitor pipes for leakage. Control alien vegetation. redesign and reconstruct the culvert |

**Table 40: Summary of the assessment undertaken at Site 14/a/weir.**

| | |
|---|---|
| Site number: **14/a/weir** | Coordinates: 25°39'03.71"S 27°18'45.09"E |
| Crossing Type: Culvert & pipeline & weir | |
| Site Photo:  | |
| Present Ecological State | C |
| Wetland type | River |
| Morphology | Wide, relatively shallow channel. |
| Riparian and in Stream Habitat | Instream ecology: there is water within the channel. |
| Vegetation | *Cyperus sexangularis, Melinis repens, Typha capensis, Phragmites australis, Acacia* spp., *Cynodon dactylon.* |
| System Modifiers | Culvert. Erosion. Cattle trampling. Increased water input due to runoff from road. |
| Potential impacts of water use on environment | The pipeline crossing will not significantly negatively impact on the receiving environment; provided it is adequately maintained. The culvert and the weir will alter water flow patterns. |
| Socio-economic impacts of water use | The pipeline and culvert will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The pipeline and culvert will not significantly negatively impact on any water users. |
| Potential impacts of water use on water resource | The plinths within the channel will result in some alterations to streamflow patterns during flow periods; however these are not deemed to have a significant impact on downstream resources. |
| Summary of proposed impact on water use will have on other users | The structures will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Monitoring of erosion. Monitor pipes for leaks |

**Table 41: Summary of the assessment undertaken at Site 14b/c.**

| | |
|---|---|
| Site number: **14b/c** | Coordinates: 25°38'0.36"S 27°17'39.04"E |
| Crossing Type: Road crossing | |
| Site Photo:  | |
| Present Ecological State | C |
| Wetland type | River |
| Morphology | Wide, relatively shallow channel, mixture of alluvial sand and bedrock. Dry river bed. |
| Riparian and in Stream Habitat | *Dichrostachys* spp. dominated bushveld vegetation. Instream ecology: riverbed dry at the time of the study. |
| Vegetation | *Cyperus sexangularis, Melinis repens, Typha capensis, Phragmites australis, Acacia* spp. *Cynodon dactylon.* |
| System Modifiers | Culvert. Erosion. Cattle trampling. Increased water input due to runoff from road. |
| Potential impacts of water use on environment | The sewer line crossing will not significantly negatively impact on the receiving environment; provided it is adequately maintained. |
| Socio-economic impacts of water use | The sewer line crossing will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The sewer line is necessary for the safe disposal of sewage. |
| Potential impacts of water use on water resource | The support structures within the channel will result in some alterations to streamflow patterns during flow periods; however these are not deemed to have a significant impact on downstream resources. |
| Summary of proposed impact on water use will have on other users | The sewer line crossing will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Monitoring of erosion. Monitor pipes for leaks |

**Table 42: Summary of the assessment undertaken at Site 15.**

| | |
|---|---|
| Site number: **15** | Coordinates:<br>25°39'09.61"S 27°22'09.61"E |
| Crossing Type: Road culvert | |
| Site Photo:<br> | |
| Present Ecological State | C |
| Wetland type | River |
| Morphology | Narrow shallow channel. Dry river bed. |
| Riparian and in Stream Habitat | Instream ecology: riverbed dry at the time of the study. |
| Vegetation | *Typha capensis, Flaveria bidentis, Cyperus sexangularis, Brachiarai brizantha, Cynodon dactylon, Xanthium strumarium, Heteropogon contortus, Bidens pilosa* |
| System Modifiers | Increased runoff from the road. Cattle trampling and grazing. |
| Potential impacts of water use on environment | The culvert/road crossing will not significantly negatively impact on the receiving environment. |
| Socio-economic impacts of water use | The culvert/road crossing will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The culvert/road crossing plays an important role in providing connectivity in the area thereby allowing economic activity in the area |
| Potential impacts of water use on water resource | The culvert will result in some alterations to streamflow patterns during flow periods. |
| Summary of proposed impact on water use will have on other users | The culvert/road crossing will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Monitor erosion and control alien vegetation |

**Table 43: Summary of the assessment undertaken at Site 16.**

| | |
|---|---|
| Site number: **16** | Coordinates: 25°39'09.61"S 27°22'09.61"E |
| Crossing Type: Road crossing | |
| Site Photo:  | |
| Present Ecological State | C |
| Wetland type | River |
| Morphology | Shallow channel. Dry river bed. |
| Riparian and in Stream Habitat | Well vegetated. Instream ecology: riverbed dry at the time of the study. |
| Vegetation | *Chloris gayana, Cyperus sexangularis, Flaveria bidentis, Hetoropogon contortus, Asclepias fruiticosa, Opuntia ficus-indica.* |
| System Modifiers | Littering. Alien species invasion. |
| Potential impacts of water use on environment | The road crossing will not significantly negatively impact on the receiving environment; provided it is adequately maintained. |
| Socio-economic impacts of water use | The road crossing will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The road crossing plays an important role in providing connectivity in the area thereby allowing economic activity in the area |
| Potential impacts of water use on water resource | The culvert will result in some alterations to water flow patterns during flow periods; however these are not deemed to have a significant impact on downstream resources. |
| Summary of proposed impact on water use will have on other users | The road crossing will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Clean up litter. Control alien species |

**Table 44: Summary of the assessment undertaken at Site 17.**

| | |
|---|---|
| Site number: **17** | Coordinates: 25°39'06.22"S 27°22'11.14"E |
| Crossing Type: road crossing | |
| Site Photo:  | |
| Present Ecological State | C |
| Wetland type | River |
| Morphology | Shallow channel. Dry river bed. |
| Riparian and in Stream Habitat | *Acacia* spp. dominated bushveld vegetation. Instream ecology: riverbed dry at the time of the study. |
| Vegetation | *Heteropogon contortus, Aslepias fruiticosa, Hyparrhenia hirta, Cynodon dactylon* |
| System Modifiers | Exposed pipe just beneath the culvert. Livestock grazing and trampling. |
| Potential impacts of water use on environment | The road crossing will not significantly negatively impact on the receiving environment. |
| Socio-economic impacts of water use | The road crossing will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The road crossing plays an important role in providing connectivity in the area thereby allowing economic activity in the area. |
| Potential impacts of water use on water resource | The road crossing will result in some alterations to water flow patterns during flow periods; however these are not deemed to have a significant impact on downstream resources. |
| Summary of proposed impact on water use will have on other users | The road crossing will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Monitor the area for erosion. |

**Table 45: Summary of the assessment undertaken at Site 18.**

| Site number: **18** | Coordinates:<br>25°39'03.03"S 27°22'30.54"E |
|---|---|
| Crossing Type: Road culvert | |
| Site Photo:<br> | |
| Present Ecological State | C |
| Wetland type | River |
| Morphology | Wide, relatively shallow channel, mixture of alluvial sand and bedrock. Dry river bed. |
| Riparian and in Stream Habitat | *Rhus lancea* and *Acacia* spp. dominated bushveld vegetation. Instream ecology: riverbed dry at the time of the study. |
| Vegetation | *Datura stramonium, Persicaria lapathifolia, Conyza bonariensis, tithonia rotundifolia, Eragrostis curvula, Rhus lancea, Sporobolus pyramidalis, Tagetes minuta, Verbena bonariensis, Acacia* spp. |
| System Modifiers | Increased runoff from the road. Debris blocking water flow and causing a migration barrier. Erosion and river bed scouring. Waste dumping. |
| Potential impacts of water use on environment | The road culvert crossing will not significantly negatively impact on the receiving environment. |
| Socio-economic impacts of water use | The road culvert crossing will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The road culvert plays an important role in providing connectivity in the area thereby allowing economic activity in the area |
| Potential impacts of water use on water resource | The road culvert crossing will result in some alterations to water flow patterns during flow periods. In addition, the eroded culvert will cause a migration barrier during high flow periods. |
| Summary of proposed impact on water use will have on other users | The road culvert crossing will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Remove waste. Remove a concrete slab that forms a weir as it traps debris and blocks water flow. Remove waste. Monitor erosion. |

**Table 46: Summary of the assessment undertaken at Site 19.**

| | |
|---|---|
| Site number: **19** | Coordinates:<br>25°39'00.83"S 27°22'42.64"E |
| Crossing Type: Road culvert | |
| Site Photo:<br> | |
| Present Ecological State | C |
| Wetland type | River |
| Morphology | Wide, relatively shallow channel, mixture of alluvial sand and bedrock. Dry river bed. |
| Riparian and in Stream Habitat | *Rhus lancea* and *Acacia* spp. dominated bushveld vegetation. Instream ecology: riverbed dry at the time of the study. |
| Vegetation | *Cyperus sexangularis, Asclepias fruiticosa, Sporobolus africanus* |
| System Modifiers | Increased runoff from the road. Littering. Stockpiling. Erosion. |
| Potential impacts of water use on environment | The road culvert crossing will not significantly negatively impact on the receiving environment. |
| Socio-economic impacts of water use | The road culvert crossing will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The road culvert plays an important role in providing connectivity in the area thereby allowing economic activity in the area |
| Potential impacts of water use on water resource | The road culvert crossing will result in some alterations to water flow patterns during flow periods, and increase water input within the water resource. |
| Summary of proposed impact on water use will have on other users | The road culvert crossing will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Clean up litter. Remove piled soil to prevent sedimentation. Monitor erosion |

**Table 47: Summary of the assessment undertaken at Site 19a.**

| | |
|---|---|
| Site number: **19a** | Coordinates: 25°38'21.79"S 27°20'53.49"E |
| Crossing Type: road crossing | |
| Site Photo:  | |
| Present Ecological State | C |
| Wetland type | Pan |
| Morphology | Wide, relatively shallow channel, mixture of alluvial sand and bedrock. Dry river bed. |
| Riparian and in Stream Habitat | *Acacia* spp. dominated bushveld vegetation. Instream ecology: riverbed dry at the time of the study. |
| Vegetation | *Heteropogon contortus, Typha capensis, Melinis repens, Persicaria lapathifolia, Themeda triandra, Setaria sphacelata, Tagetes minuta* |
| System Modifiers | Erosion. Livestock grazing and trampling. |
| Potential impacts of water use on environment | The road crossing is not well constructed and since it is a dirt road there will be sediment deposition during rainfall events. |
| Socio-economic impacts of water use | The road crossing will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The road crossing will not negatively impact on water users. |
| Potential impacts of water use on water resource | There will be increase sediment deposition within the water resource since the road is a dirt road. |
| Summary of proposed impact on water use will have on other users | The road will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Monitor the area for erosion. |

**Table 48: Summary of the assessment undertaken at Site 20/20a.**

<table>
<tr><td>Site number: 20/20a</td><td>Coordinates:<br>25°37'51.76"S 27°19'54.92"E - 25°37'40.12"S 27°19'13.92"E</td></tr>
<tr><td colspan="2">Crossing Type: Stream diversion</td></tr>
<tr><td colspan="2">Site Photo:<br></td></tr>
<tr><td>Present Ecological State</td><td>D</td></tr>
<tr><td>Wetland type</td><td>River</td></tr>
<tr><td>Morphology</td><td>Wide, relatively shallow channel, Inundation.</td></tr>
<tr><td>Riparian and in Stream Habitat</td><td>Inundated with runoff from the road and overflow from the adjacent dam.</td></tr>
<tr><td>Vegetation</td><td>Phragmites australis, Rhus lancea, Cynodon dactylon, Tamarix ramosissima, Asparagus laricinus</td></tr>
<tr><td>System Modifiers</td><td>Excavations. Erosion.</td></tr>
<tr><td>Potential impacts of water use on environment</td><td>The diversion will redirect the flow of water and cause drying up in areas where there used to be flowing water or water available to users.</td></tr>
<tr><td>Socio-economic impacts of water use</td><td>The diversion will result in lack of water in certain areas as a result of water not being able to flow to those areas.</td></tr>
<tr><td>Socio–economic advantages of water use</td><td>The diversion will not significantly negatively impact on any water users</td></tr>
<tr><td>Potential impacts of water use on water resource</td><td>Alterations to streamflow patterns during flow periods.</td></tr>
<tr><td>Summary of proposed impact on water use will have on other users</td><td>The diversion will not impact other water users.</td></tr>
<tr><td>Mitigation and Rehabilitation plan</td><td>Monitor the area for erosion.</td></tr>
</table>

**Table 49: Summary of the assessment undertaken at Site 21.**

| | |
|---|---|
| Site number: **21** | Coordinates: 25°36'35.53"S 27°18'21.15"E |
| Crossing Type: Culvert road | |
| Site Photo:  | |
| Present Ecological State | C |
| Wetland type | River |
| Morphology | Wide, moderately diffuse channel, inundation below the culvert |
| Riparian and in Stream Habitat | The stream channel was well vegetated |
| Vegetation | *Heteropogon contortus, Cyperus sexangularis, Typha capensis, Eragrostis curvula, Melinis repens, Xanthium strumarium, Conyza bonariensis, Asclepias fruiticosa* |
| System Modifiers | Livestock grazing and trampling. Littering |
| Potential impacts of water use on environment | The road crossing will not significantly negatively impact on the environment. |
| Socio-economic impacts of water use | The road crossing will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The road crossing plays an important role in providing connectivity in the area, particularly to the local community, thereby allowing economic activity in the area. |
| Potential impacts of water use on water resource | The culvert will result in some alterations to streamflow patterns during flow periods; however these are not deemed to have a significant impact on downstream resources. |
| Summary of proposed impact on water use will have on other users | The road crossing will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Monitor the area for erosion. Control alien invasion. |

**Table 50: Summary of the assessment undertaken at Site 21a.**

| | |
|---|---|
| Site number: **21a/b** | Coordinates:<br>25°36'05.18"S 27°18'10.04"E |
| Crossing Type: Pipeline | |
| Site Photo:<br> | |
| Present Ecological State | B |
| Wetland type | River |
| Morphology | Narrow moderately incised, shallow channel. |
| Riparian and in Stream Habitat | *Acacia karroo* dominated bushveld vegetation. |
| Vegetation | *Setaria sphacelata, Flaveria bidentis, Typha capensis, Conyza bonariensis, Cyperus sexangularis* |
| System Modifiers | Livestock grazing |
| Potential impacts of water use on environment | The pipeline will not significantly negatively impact on the receiving environment; provided it is adequately maintained. |
| Socio-economic impacts of water use | The pipeline will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The pipeline will not significantly negatively impact on any water users |
| Potential impacts of water use on water resource | The support structures within the channel will result in some alterations to streamflow patterns during flow periods; however these are not deemed to have a significant impact on downstream resources. |
| Summary of proposed impact on water use will have on other users | The pipeline will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Monitor pipes for leaks |

**Table 51: Summary of the assessment undertaken at Site 22 and Site 23.**

| | |
|---|---|
| Site number: **Site 22 and Site 23** | Coordinates: 25°40'34.99"S 27°16'40.43"E |
| Crossing Type: Road crossing | |
| Site Photo:  | |
| Present Ecological State | B |
| Wetland type | River |
| Morphology | Wide, relatively shallow channel, inundation below bridge. |
| Riparian and in Stream Habitat | *Melia azedarach* in the terrestrial area. Inundation below bridge. |
| Vegetation | *Phragmites australis, Cyperus sexangularis, Asparagus laricinus Xanthium strumarium,, Rhus lancea,* |
| System Modifiers | Water abstraction. Vegetation clearing. Erosion. Runoff from the road. Livestock grazing. |
| Potential impacts of water use on environment | The road crossing will not significantly negatively impact on the environment. |
| Socio-economic impacts of water use | The road crossing will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The road crossing plays an important role in providing connectivity in the area, particularly to the local community, thereby allowing economic activity in the area. |
| Potential impacts of water use on water resource | The support structures within the channel will result in some alterations to streamflow patterns during flow periods; however these are not deemed to have a significant impact on downstream resources. |
| Summary of proposed impact on water use will have on other users | The road crossing will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Re-vegetate where necessary. Monitor erosion. |

**Table 52: Summary of the assessment undertaken at Site 24.**

| | |
|---|---|
| Site number: **Site 24** | Coordinates: 25°40'05.75"S 27°16'40.08"E |
| Crossing Type: Railway/Culvert | |
| Site Photo:  | |
| Present Ecological State | C |
| Wetland type | River |
| Morphology | Wide, relatively shallow channel. Paved road below the railway crossing reducing infiltration. |
| Riparian and in Stream Habitat | Inundation below crossing |
| Vegetation | *Rhus lancea, Persicaria lapathifolia, Panicum maxima, Morus alba, Cyperus sexangularis, Phragmites australis, Themeda triandra* |
| System Modifiers | Road beneath the railway traversing the river. Erosion. Cattle trampling and grazing. Leaking pipes. |
| Potential impacts of water use on environment | The railway crossing will not significantly negatively impact on the environment. |
| Socio-economic impacts of water use | The railway crossing will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The railway crossing is necessary for transporting mining goods. |
| Potential impacts of water use on water resource | The support structures within the channel will result in some alterations to streamflow patterns during flow periods; however these are not deemed to have a significant impact on downstream resources. |
| Summary of proposed impact on water use will have on other users | The railway crossing will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Control alien vegetation. Monitor erosion. Monitor leaking pipes. Re-vegetate the banks. |

**Table 53: Summary of the assessment undertaken at Site 24a/24b.**

| | |
|---|---|
| Site number: **Site 24a/24b** | Coordinates:<br>25°39'55.43"S 27°16'46.30"E |
| Crossing Type: Bridge/road crossing | |
| Site Photo:<br> | |
| Present Ecological State | D |
| Wetland type | River |
| Morphology | Wide, relatively shallow channel, mixture of alluvial sand and bedrock. Dry river bed. |
| Riparian and in Stream Habitat | *Dichrostachys* spp. dominated bushveld vegetation. Instream ecology: riverbed dry at the time of the study. |
| Vegetation | |
| System Modifiers | Weir. Debris within the stream. Cattle trampling and grazing. Water abstraction. Alien vegetation. |
| Potential impacts of water use on environment | The sewer line crossing will not significantly negatively impact on the receiving environment; provided it is adequately maintained. |
| Socio-economic impacts of water use | The sewer line crossing will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The sewer line is necessary for the safe disposal of sewage. |
| Potential impacts of water use on water resource | The support structures within the channel will result in some alterations to streamflow patterns during flow periods; however these are not deemed to have a significant impact on downstream resources. |
| Summary of proposed impact on water use will have on other users | The sewer line crossing will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Remove debris. Monitor erosion. Control alien vegetation. |

**Table 54: Summary of the assessment undertaken at Site 25.**

| | |
|---|---|
| Site number: **Site 25** | Coordinates: 25°39'53.01"S 27°16'46.74"E |
| Crossing Type: Road crossing | |
| Site Photo:  | |
| Present Ecological State | C |
| Wetland type | River |
| Morphology | Wide, shallow channel. |
| Riparian and in Stream Habitat | *Dichrostachys* spp. dominated bushveld vegetation. Instream ecology: riverbed dry at the time of the study. |
| Vegetation | *Lantana camara, Cyperus sexangularis, Tagetes minuta* |
| System Modifiers | Encroachment. |
| Potential impacts of water use on environment | The road crossing will not significantly negatively impact on the environment. |
| Socio-economic impacts of water use | The road crossing will not significantly negatively impact on the on any water users. |
| Socio–economic advantages of water use | The road crossing plays an important role in providing connectivity in the area, particularly to the local community, thereby allowing economic activity in the area. |
| Potential impacts of water use on water resource | The support structures within the channel will result in some alterations to streamflow patterns during flow periods; however these are not deemed to have a significant impact on downstream resources. |
| Summary of proposed impact on water use will have on other users | The road crossing will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Control alien vegetation. |

**Table 55: Summary of the assessment undertaken at Site 26/26weir.**

| | |
|---|---|
| Site number: **Site 26/26weir** | Coordinates: 25°39'24.47"S 27°17'14.53"E |
| Crossing Type: Road crossing + weir | |
| Site Photo:  | |
| Present Ecological State | C |
| Wetland type | River |
| Morphology | Wide, relatively shallow channel, mixture of alluvial sand and bedrock. Dry river bed. |
| Riparian and in Stream Habitat | *Acacia* spp. dominated bushveld vegetation. Instream ecology: inundation underneath the bridge. |
| Vegetation | *Tagetes minuta, Cyperus sexangularis, Phragmites australis, Flaveria bidentis* |
| System Modifiers | Rock dumping. Leaking pipes. Alien vegetation. |
| Potential impacts of water use on environment | The road crossing will not significantly negatively impact on the environment. |
| Socio-economic impacts of water use | The road crossing will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The road crossing plays an important role in providing connectivity in the area, particularly to the local community, thereby allowing economic activity in the area. |
| Potential impacts of water use on water resource | The weir and support structures within the channel will result in some alterations to streamflow patterns during flow periods; however these are not deemed to have a significant impact on downstream resources. |
| Summary of proposed impact on water use will have on other users | The road crossing will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Control alien vegetation. Monitor pipes for leakages. |

**Table 56: Summary of the assessment undertaken at Site 26a.**

| | |
|---|---|
| Site number: **Site 26a** | Coordinates:<br>25°38'57.41"S 27°17'22.82"E |
| Crossing Type: Dam crossing | |
| Site Photo:<br> | |
| Present Ecological State | C |
| Wetland type | River |
| Morphology | Wide, relatively shallow channel, inundation behind the dam wall. Flowing water. Exposed bed rock within the stream channel. |
| Riparian and in Stream Habitat | Exposed bedrock within the stream channel |
| Vegetation | *Typha capensis, Rhus lancea, Cyperus sexangularis* |
| System Modifiers | Weir. Waste dumping. Alien vegetation. |
| Potential impacts of water use on environment | The dam will not significantly negatively impact on the r environment. |
| Socio-economic impacts of water use | The dam will capture flow during low flow periods, leading to less water flowing to downstream areas. |
| Socio–economic advantages of water use | N/A. |
| Potential impacts of water use on water resource | The support structures within the channel will result in some alterations to streamflow patterns during flow periods. |
| Summary of proposed impact on water use will have on other users | The dam will capture flow during low flow periods, resulting in less water flowing to downstream areas. |
| Mitigation and Rehabilitation plan | Clean up litter. Control alien vegetation. |

**Table 57: Summary of the assessment undertaken at Site 26b.**

| | |
|---|---|
| Site number: **Site 26b** | Coordinates: 25°38'52.20"S 27°17'29.00"E |
| Crossing Type: Weir | |
| Site Photo:  | |
| Present Ecological State | D |
| Wetland type | River |
| Morphology | Wide, relatively shallow channel, mixture of alluvial sand and bedrock. Dry river bed. |
| Riparian and in Stream Habitat | Exposed bedrock within the stream channel |
| Vegetation | *Persicaria lapathifolia, Cyperus sexangularis, Phragmites australis, Melinis repens* |
| System Modifiers | Weir. Change in water quality due to use for laundry purposes. Alien vegetation. |
| Potential impacts of water use on environment | The weir will not significantly negatively impact on the environment. |
| Socio-economic impacts of water use | The weir will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | N/A. |
| Potential impacts of water use on water resource | The weir result in some alterations to streamflow patterns during flow periods; however these are not deemed to have a significant impact on downstream resources. |
| Summary of proposed impact on water use will have on other users | The weir will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Monitor water quality. Control alien vegetation. |

**Table 58: Summary of the assessment undertaken at Site 27.**

| | |
|---|---|
| Site number: **Site 27** | Coordinates: 25°37'18.86"S 27°17'22.07"E |
| Crossing Type: Road crossing | |
| Site Photo:  | |
| Present Ecological State | E |
| Wetland type | River |
| Morphology | Wide, relatively shallow channel, mixture of alluvial sand and bedrock. Dry river bed. |
| Riparian and in Stream Habitat | *Eucalyptus* spp on the terrestrial area. *Eichhornia crassipes* |
| Vegetation | *Rhus lancea, Sesbania sesban, Chloris gayana, Tagetes minuta, Phragmites australis, Eichhornia crassipes* |
| System Modifiers | Collapsed road causing flow diversion which further erodes the banks and creates gullies. Algae proliferation. Sewage effluent. Cattle trampling and grazing. |
| Potential impacts of water use on environment | The road crossing will result in bank erosion, thus depositing sediment within the stream channel. |
| Socio-economic impacts of water use | The road crossing will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The collapsed road causes water flow obstruction |
| Potential impacts of water use on water resource | Alterations to streamflow patterns during flow periods; however these are not deemed to have a significant impact on downstream resources. |
| Summary of proposed impact on water use will have on other users | Causes migration barrier. |
| Mitigation and Rehabilitation plan | If the crossing is no longer required remove the structure and rehabilitate the area to minimize erosion. Control alien vegetation. Monitor erosion. Re-vegetate the banks. |

**Table 59: Summary of the assessment undertaken at Site 27a.**

| Site number: **Site 27a** | Coordinates:<br>25°37'59.54"S 27°17'24.99"E |
|---|---|
| Crossing Type: Culvert road crossing | |
| Site Photo:<br> | |
| Present Ecological State | E |
| Wetland type | River |
| Morphology | Wide, relatively shallow channel, mixture of alluvial sand and bedrock. Dry river bed. |
| Riparian and in Stream Habitat | *Acacia* spp. And asparagus laricinus dominated bushveld vegetation. Inundation below bridge. |
| Vegetation | *Phragmites australis, Typha capensis, Flaveria bidentis, Morus alba, Sesbania sesban, Eucalyptus spp.* |
| System Modifiers | Erosion. Altered water quality due to usage for laundry washing purposes. |
| Potential impacts of water use on environment | The road crossing will not significantly negatively impact on the environment. |
| Socio-economic impacts of water use | The road crossing will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The road crossing plays an important role in providing connectivity in the area, particularly to the local community, thereby allowing economic activity in the area. |
| Potential impacts of water use on water resource | The culvert within the channel will result in some alterations to streamflow patterns during flow periods; however these are not deemed to have a significant impact on downstream resources. |
| Summary of proposed impact on water use will have on other users | The road crossing will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Control alien vegetation. Monitor erosion. |

**Table 60: Summary of the assessment undertaken at Site 28.**

<table>
<tr><td>Site number: Site 28</td><td>Coordinates:<br>25°36'29.48"S 27°17'18.84"E</td></tr>
<tr><td colspan="2">Crossing Type: Road crossing</td></tr>
<tr><td colspan="2">Site Photo:<br></td></tr>
<tr><td>Present Ecological State</td><td>C</td></tr>
<tr><td>Wetland type</td><td>River</td></tr>
<tr><td>Morphology</td><td>Wide, relatively shallow channel flowing water within the channel</td></tr>
<tr><td>Riparian and in Stream Habitat</td><td>Acacia spp. dominated bushveld vegetation. Instream ecology: Phragmites australis dominating instream habitat</td></tr>
<tr><td>Vegetation</td><td>Phragmites australis, Cynodon dactylon, Cyperus sexangularis, Asclepius fruiticosa</td></tr>
<tr><td>System Modifiers</td><td>Soil dumping adjacent to feature. Erosion below bridge. Waste dumping. Leaking drain next to the river. Grazing.</td></tr>
<tr><td>Potential impacts of water use on environment</td><td>The road crossing will not significantly negatively impact on the environment</td></tr>
<tr><td>Socio-economic impacts of water use</td><td>The road crossing will not significantly negatively impact on any water users.</td></tr>
<tr><td>Socio–economic advantages of water use</td><td>The road crossing plays an important role in providing connectivity in the area, particularly to the local community, thereby allowing economic activity in the area.</td></tr>
<tr><td>Potential impacts of water use on water resource</td><td>The culverts within the channel will result in some alterations to streamflow patterns during flow periods; however these are not deemed to have a significant impact on downstream resources.</td></tr>
<tr><td>Summary of proposed impact on water use will have on other users</td><td>The road crossing will not impact significantly on other water users.</td></tr>
<tr><td>Mitigation and Rehabilitation plan</td><td>Monitor erosion below the bridge. Clean up litter. Remove soil piles to prevent sedimentation. Monitor drain leakage to prevent contamination of water.</td></tr>
</table>

**Table 61: Summary of the assessment undertaken at Site 28a.**

| | |
|---|---|
| Site number: **Site 28a** | Coordinates: 25°36'01.36"S 27°17'37.67"E |
| Crossing Type: Pipeline crossing | |
| Site Photo:  | |
| Present Ecological State | C |
| Wetland type | River |
| Morphology | Wide, relatively deep channel. |
| Riparian and in Stream Habitat | *Rhus lancea* and *Acacia* spp. dominated bushveld vegetation. Instream ecology: Water within the channel |
| Vegetation | *Flaveria bidentis, Cyperus sexangularis, Cynodon dactylon* |
| System Modifiers | Water contamination. Algae proliferation. |
| Potential impacts of water use on environment | The pipeline crossing will not significantly negatively impact on the receiving environment; provided it is adequately maintained. |
| Socio-economic impacts of water use | The pipeline crossing will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The pipeline is necessary for the safe disposal of sewage. |
| Potential impacts of water use on water resource | The support structures within the channel will result in some alterations to streamflow patterns during flow periods; however these are not deemed to have a significant impact on downstream resources. |
| Summary of proposed impact on water use will have on other users | The pipeline crossing will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Monitor water quality |

**Table 62: Summary of the assessment undertaken at Site 28b.**

| Site number: **Site 28b** | Coordinates:<br>25°35'55.85"S 27°17'33.01"E |
|---|---|
| Crossing Type: Battery of pipes which possibly formed part of a historical road crossing | |
| Site Photo:<br> | |
| Present Ecological State | C |
| Wetland type | River |
| Morphology | Wide, relatively shallow channel, mixture of alluvial sand and bedrock. Flowing water |
| Riparian and in Stream Habitat | *Acacia* spp dominated bushveld vegetation. |
| Vegetation | *Conyza bonariensis, Cyperus sexangularis, Phragmites australis* |
| System Modifiers | Erosion. Algae proliferation. Exposed pipes. |
| Potential impacts of water use on environment | The pipeline crossing will not significantly negatively impact on the environment. |
| Socio-economic impacts of water use | The pipeline crossing will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | N/A |
| Potential impacts of water use on water resource | The pipes within the channel will result in some alterations to streamflow patterns during flow periods; however these are not deemed to have a significant impact on downstream resources. |
| Summary of proposed impact on water use will have on other users | The pipeline crossing will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Monitor erosion. Construct a proper crossing and/or make sure the pipes are underground to allow proper flow of water. If crossing is no longer required remove pipes from the watercourse. If crossing is required, construct a proper crossing to enable proper flow of water and movement of biota. |

**Table 63: Summary of the assessment undertaken at Site 28c.**

| | |
|---|---|
| Site number: **Site 28c** | Coordinates:<br>25°35'31.42"S 27°17'55.09"E |
| Crossing Type: Weir crossing | |
| Site Photo: | |

| | |
|---|---|
| Present Ecological State | C |
| Wetland type | River |
| Morphology | Wide, relatively shallow channel, exposed bedrock. |
| Riparian and in Stream Habitat | *Eucalyptus* spp. dominated bushveld vegetation. Instream ecology: Exposed bedrock. |
| Vegetation | *Phragmites australis, Cyperus sexangularis* |
| System Modifiers | Broken weir. Alien vegetation. |
| Potential impacts of water use on environment | The weir will not significantly negatively impact on the environment. |
| Socio-economic impacts of water use | The weir will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The weir will not significantly negative impact on any water users |
| Potential impacts of water use on water resource | The weir will result in some alterations to streamflow patterns during flow periods; however these are not deemed to have a significant impact on downstream resources. |
| Summary of proposed impact on water use will have on other users | The weir will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Control alien vegetation. |

**Table 64: Summary of the assessment undertaken at Site 29.**

| | |
|---|---|
| Site number: **Site 29** | Coordinates:<br>25°35'07.16"S 27°18'16.92"E |
| Crossing Type: Road crossing | |
| Site Photo:<br> | |
| Present Ecological State | C |
| Wetland type | River |
| Morphology | Wide, relatively shallow channel, inundation below bridge |
| Riparian and in Stream Habitat | *Acacia* spp. dominated bushveld vegetation. Instream ecology: Inundation below dam. |
| Vegetation | *Themeda triandra, Cyperus sexangularis, Phragmites australis, Typha capensis* |
| System Modifiers | Trampling. Erosion. Waste dumping. |
| Potential impacts of water use on environment | The road crossing will not significantly negatively impact on the environment. |
| Socio-economic impacts of water use | The road crossing will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The road crossing plays an important role in providing connectivity in the area, particularly to the local community, thereby allowing economic activity in the area. |
| Potential impacts of water use on water resource | The support structures within the channel will result in some alterations to streamflow patterns during flow periods; however these are not deemed to have a significant impact on downstream resources. |
| Summary of proposed impact on water use will have on other users | The road crossing will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Control alien vegetation along river banks. Re-vegetate eroded banks. |

**Table 65: Summary of the assessment undertaken at Site 30.**

| | |
|---|---|
| Site number: **Site 30** | Coordinates: 25°38'50.46"S 27°15'12.10"E |
| Crossing Type: Road/weir crossing | |
| Site Photo:  | |
| Present Ecological State | C |
| Wetland type | River |
| Morphology | Wide, relatively shallow channel. |
| Riparian and in Stream Habitat | *Rhus lancea* dominated bushveld vegetation. Instream ecology: flowing water |
| Vegetation | *Tagetes minuta, Datura stramonium, Cynodon dactylon, Coenyza bonariensis* |
| System Modifiers | Erosion. Waste dumping. Sewage effluent. Road construction. |
| Potential impacts of water use on environment | The road/weir crossing will not significantly negatively impact on the environment. |
| Socio-economic impacts of water use | The road/weir crossing will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The road crossing plays an important role in providing connectivity in the area, particularly to the local community, thereby allowing economic activity in the area. |
| Potential impacts of water use on water resource | The weir will result in some alterations to streamflow patterns during flow periods; however these are not deemed to have a significant impact on downstream resources. |
| Summary of proposed impact on water use will have on other users | The road crossing will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Monitor erosion. Monitor water quality. |

**Table 66: Summary of the assessment undertaken at Site 31.**

<table>
<tr><td>Site number: 31</td><td>Coordinates:<br>25°38'41.89S 27°15'17.04"E</td></tr>
<tr><td colspan="2">Crossing Type: Railway crossing</td></tr>
<tr><td colspan="2">Site Photo:<br></td></tr>
<tr><td>Present Ecological State</td><td>D</td></tr>
<tr><td>Wetland type</td><td>River</td></tr>
<tr><td>Morphology</td><td>Wide, relatively shallow channel, high sediment load along the culvert</td></tr>
<tr><td>Riparian and in Stream Habitat</td><td>Acacia karroo dominate the bushveld vegetation.</td></tr>
<tr><td>Vegetation</td><td>Morus alba, Melia azedarach, Tagetes minuta, Rhus lancea</td></tr>
<tr><td>System Modifiers</td><td>Sediment and debris deposition causing streamflow diversion and aquatic migratory barrier. Erosion below the bridge and banks. Algae proliferation.</td></tr>
<tr><td>Potential impacts of water use on environment</td><td>The road crossing will not significantly negatively impact on the environment.</td></tr>
<tr><td>Socio-economic impacts of water use</td><td>The road crossing will not significantly negatively impact on any water users.</td></tr>
<tr><td>Socio–economic advantages of water use</td><td>The road crossing plays an important role in providing connectivity in the area, particularly to the local community, thereby allowing economic activity in the area.</td></tr>
<tr><td>Potential impacts of water use on water resource</td><td>The support structures within the channel will result in some alterations to streamflow patterns during flow periods; however these are not deemed to have a significant impact on downstream resources.</td></tr>
<tr><td>Summary of proposed impact on water use will have on other users</td><td>The road crossing will not impact significantly on other water users.</td></tr>
<tr><td>Mitigation and Rehabilitation plan</td><td>Remove debris within the stream. Control erosion by putting berms on the banks below bridge. Desilt the feature.</td></tr>
</table>

**Table 67: Summary of the assessment undertaken at Site 31a.**

| | |
|---|---|
| Site number: 31a | Coordinates:<br>25°37'55.64S 27°15'39.41"E |
| Crossing Type: Weir | |
| Site Photo:<br> | |
| Present Ecological State | C |
| Wetland type | River |
| Morphology | Exposed bedrock |
| Riparian and in Stream Habitat | Exposed bedrock |
| Vegetation | *Eichhornia crassipes, Typha capensis, Tagetes minuta* |
| System Modifiers | Sewage effluent. |
| Potential impacts of water use on environment | The weir crossing will not significantly negatively impact on the environment. |
| Socio-economic impacts of water use | The weir will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | N/A |
| Potential impacts of water use on water resource | The weir will result in some alterations to streamflow patterns during flow periods; however these are not deemed to have a significant impact on downstream resources. |
| Summary of proposed impact on water use will have on other users | The weir crossing will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Monitor water quality and implement measures to prevent sewage effluent from entering the system. |

**Table 68: Summary of the assessment undertaken at Site 32a and Site 32b.**

| | |
|---|---|
| Site number: **Site 32a and Site 32b** | Coordinates:<br>25°37'53.08"S 27°15'55.66"E |
| Crossing Type: Road crossing | |
| Site Photo:<br> | |
| Present Ecological State | D |
| Wetland type | River |
| Morphology | Wide, relatively shallow channel. |
| Riparian and in Stream Habitat | Water flow ceased due to construction. |
| Vegetation | *Xanthium stramonium, Flaveria bidentis, Erqagrostis gummiflua, Sporobolus africanus* |
| System Modifiers | Road bridge construction. Erosion. Stockpiling. |
| Potential impacts of water use on environment | The road crossing will not significantly negatively impact on the environment. |
| Socio-economic impacts of water use | The road crossing will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The road crossing plays an important role in providing connectivity in the area, particularly to the local community, thereby allowing economic activity in the area. |
| Potential impacts of water use on water resource | The support structures within the channel will result in some alterations to streamflow patterns during flow periods; however these are not deemed to have a significant impact on downstream resources. |
| Summary of proposed impact on water use will have on other users | The road crossing will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Control alien vegetation. Control runoff. Monitor erosion. |

**Table 69: Summary of the assessment undertaken at Site 32c.**

| Site number: 32c | Coordinates:<br>25°37'39.14"S 27°16'24.15"E |
|---|---|
| Crossing Type: Road crossing | |
|  | |
| Present Ecological State | C |
| Wetland type | River |
| Morphology | Wide, very shallow channel |
| Riparian and in Stream Habitat | *Acacia* spp. dominated bushveld vegetation. Instream ecology: Echhornia crassipes |
| Vegetation | *Tagetes minuta, Asclepias fruiticosa, Typha capensis, Conyza bonariensis, Cyperus sexangularis, Persicaria lapathifolia, Datura stramonium, Asclepias fruiticosa, Sesbania sesban, Sporobolus pyramidalis, Verbena bonariensis, Bidens pilosa* |
| System Modifiers | Waste dumping. Increased water input from the road. Livestock grazing. |
| Potential impacts of water use on environment | The road crossing will not significantly negatively impact on the environment. |
| Socio-economic impacts of water use | The road crossing will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The road crossing plays an important role in providing connectivity in the area, particularly to the local community, thereby allowing economic activity in the area. |
| Potential impacts of water use on water resource | The support structures within the channel will result in some alterations to streamflow patterns during flow periods; however these are not deemed to have a significant impact on downstream resources. |
| Summary of proposed impact on water use will have on other users | The road crossing will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Monitor water quality. Control alien vegetation. Clean up litter |

**Table 70: Summary of the assessment undertaken at Site 32d.**

| | |
|---|---|
| Site number: 32d | Coordinates: 25°36'28.67"S 27°13'12.66"E |
| Crossing Type: Pipeline | |
| Site Photo:  | |
| Present Ecological State | C |
| Wetland type | River |
| Morphology | Wide, relatively shallow, incised channel. |
| Riparian and in Stream Habitat | *Acacia karroo*. Dominated bushveld vegetation. Instream ecology: flowing water. |
| Vegetation | *Cynodon dactylon, Lantana camara, Asclepias fruiticosa, Phragmites australis, Senecio cinerascens* |
| System Modifiers | Sedimentation. Erosion. Encroachment |
| Potential impacts of water use on environment | The pipeline crossing will not significantly negatively impact on the receiving environment; provided it is adequately maintained. |
| Socio-economic impacts of water use | The pipeline crossing will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | N/A |
| Potential impacts of water use on water resource | The support structures within the channel will result in some alterations to streamflow patterns during flow periods; however these are not deemed to have a significant impact on downstream resources. |
| Summary of proposed impact on water use will have on other users | The pipeline crossing will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Monitor erosion. Control alien vegetation. |

**Table 71: Summary of the assessment undertaken at Site 32e.**

| | |
|---|---|
| Site number: 32e | Coordinates:<br>25°37'31.96"S 27°17'02.40"E |
| Crossing Type: Road crossing | |
| Site Photo:<br> | |
| Present Ecological State | C |
| Wetland type | River |
| Morphology | Wide, relatively shallow incised channel. |
| Riparian and in Stream Habitat | *Rhus lancea* dominated bushveld vegetation. Instream ecology: Flowing water with vegetation such as *Cyperus sexangularis* in stream |
| Vegetation | *Asclepias fruiticosa, Typha capensis, Conyza bonariensis, Cyperus sexangularis, Persicaria lapathifolia, Asclepias fruiticosa, Sporobolus pyramidalis, Eichhornia crassipes, Xanthium strumarium, Phragmites australis, Asparagus laricinus, Conyza bonariensis, Cynodon dactylon. Parthenium hysterophorus* |
| System Modifiers | Erosion. Broken informal small weir. |
| Potential impacts of water use on environment | The road crossing will not significantly will further increase erosion along the banks. |
| Socio-economic impacts of water use | The road crossing will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The road no longer serves its purpose of connectivity within the area. |
| Potential impacts of water use on water resource | The collapsed road will result in some alterations to streamflow patterns during flow periods; however these are not deemed to have a significant impact on downstream resources. |
| Summary of proposed impact on water use will have on other users | The road crossing will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | If the road is no longer required, remove collapsed structure. Insert berms to control erosion. |

**Table 72: Summary of the assessment undertaken at Site 32f.**

| | |
|---|---|
| Site number: 32f | Coordinates:<br>25°37'31.44"S 27°17'07.71"E |
| Crossing Type: Road crossing | |
| Site Photo:<br> | |
| Present Ecological State | C |
| Wetland type | River |
| Morphology | Wide, relatively shallow channel, exposed rocks along the banks due to erosion. |
| Riparian and in Stream Habitat | Instream ecology: flowing water |
| Vegetation | *Cyperus sexangularis, Sporobolus pyramidalis, Xanthium strumarium, Phragmites australis, Asparagus laricinus, Conyza bonariensis, Panicum ecklonii, Rhus lancea, Tagetes minuta, Hyparrhenia hirta.* |
| System Modifiers | Weir altering water flow. Erosion |
| Potential impacts of water use on environment | The road crossing will not significantly negatively impact on the environment. |
| Socio-economic impacts of water use | The road crossing will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The road is not efficiently providing connectivity due to the fact that it is very narrow and not well constructed. |
| Potential impacts of water use on water resource | The road will result in some alterations to streamflow patterns during flow periods; however these are not deemed to have a significant impact on downstream resources. |
| Summary of proposed impact on water use will have on other users | The road crossing will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Control erosion. Construct a proper bridge crossing or remove the collapsed structure if crossing is no longer needed. |

**Table 73: Summary of the assessment undertaken at Site 33.**

| | |
|---|---|
| Site number: 33 | Coordinates: 25°37'11.05"S 27°13'31.08"E |
| Crossing Type: Road crossing | |
| Site Photo:  | |
| Present Ecological State | D |
| Wetland type | Artificial channel |
| Morphology | Very narrow artificial channel |
| Riparian and in Stream Habitat | *Melia azedarach* dominated bushveld vegetation. |
| Vegetation | *Ipomoea purpurea, Asparagus laricinus, Datura stramonium, Typha capensis* |
| System Modifiers | Stockpiling which will result in sediment deposition within the wetland. Cemented channels. Site clearing adjacent feature. Altered water quality. Dense trees obstructing the view. Erosion. Encroachment |
| Potential impacts of water use on environment | The road crossing will not significantly negatively impact on the environment; |
| Socio-economic impacts of water use | The road crossing will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The road is not efficiently providing connectivity in the area. |
| Potential impacts of water use on water resource | The road will result in some alterations to streamflow patterns during flow periods; however these are not deemed to have a significant impact on downstream resources. |
| Summary of proposed impact on water use will have on other users | The sewer line crossing will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Clean culverts. Cut trees along the banks. |

**Table 74: Summary of the assessment undertaken at site 33a and 33b.**

| | |
|---|---|
| Site number: 33a and 33b | Coordinates:<br>25°37'33.76"S 27°13'44.07"E |
| Crossing Type: Road crossing | |
| Site Photo:<br> | |
| Present Ecological State | C |
| Wetland type | Artificial channel |
| Morphology | Relatively narrow artificial channel, no water present at the time of the assessment. |
| Riparian and in Stream Habitat | Dominated by bushveld grass; alien vegetation component moderate. Instream ecology: Artificial stream dry at the time of the study. |
| Vegetation | *Eragrostis gummiflua, Tagetes minuta, Melinis repens, Bidens pilosa, Asclepias fruiticosa, Acacia karroo, Datura stramonium, Persicaria lapathifolia.* |
| System Modifiers | Increased water input from the road. Alien vegetation. Cemented channel. |
| Potential impacts of water use on environment | Loss of natural instream habitat. |
| Socio-economic impacts of water use | The bridge will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The bridge plays an important role in providing connectivity in the area, particularly in the industrial sector, thereby allowing economic activity in the area. |
| Potential impacts of water use on water resource | The bridge has been well-constructed with little to no incision apparent at the bridge tie-ins. Moderate alteration to streamflow patterns as well as increased water input is anticipated as a result of the artificial nature of the channel, however since the system is ephemeral, no significant impact on downstream resources is anticipated as a result of this. |
| Summary of proposed impact on water use will have on other users | The bridge will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Monitor the area for structure failure and alien vegetation control. |

**Table 75: Summary of the assessment undertaken at site 34.**

| | |
|---|---|
| Site number: 34 | Coordinates:<br>24°37'04.04"S 27°13'40.26"E |
| Crossing Type: Railway line/bridge crossing | |
| Site Photo:<br> | |
| Present Ecological State | D |
| Wetland type | Artificial channel |
| Morphology | Relatively narrow artificial channel. Some water present during the study, unlikely to support any aquatic macro-invertebrates. Overgrown instream vegetation. |
| Riparian and in Stream Habitat | Dominated by bushveld grasses. Instream ecology: limited flow present at the time of the assessment. Overgrown instream vegetation. |
| Vegetation | *Xanthium strumarium, Acacia karroo, Datura stramonium, Asclepias fruiticosa, Themeda triandra, Persicaria lapathifolia, Ipomoea purpurea, Tagetes minuta, Rhus lancea, Tithonia rotundifolia* |
| System Modifiers | Sedimentation. Erosion. Encroachment. |
| Potential impacts of water use on environment | Loss of natural instream habitat. |
| Socio-economic impacts of water use | The railway crossing will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The railway crossing plays an important role in providing connectivity in the area, particularly in the industrial sector, thereby allowing economic activity in the area. |
| Potential impacts of water use on water resource | The railway crossing has been well-constructed with little to no incision evident. Moderate alteration to streamflow is anticipated as a result of the artificial nature of the channel, however since the system is ephemeral, no significant impact on downstream resources is anticipated as a result of this. |
| Summary of proposed impact on water use will have on other users | The railway crossing will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Monitoring of erosion. Alien vegetation removal and monitoring within the channel. |

**Table 76: Summary of the assessment undertaken at site 34a.**

| | |
|---|---|
| Site number: 34a | Coordinates: 25°37'29.34"S 27°13'54.70"E |
| Crossing Type: Pipeline | |
| Site Photo:  | |
| Present Ecological State | B |
| Wetland type | River |
| Morphology | Relatively narrow, shallow channel, mixture of alluvial sand and mud. Limited flow present at the time of the study. |
| Riparian and in Stream Habitat | *Cymbopogon* dominated bushveld vegetation; alien vegetation component moderate. Instream ecology: limited flow present at the time of the assessment, dominated by *Typha*. |
| Vegetation | *Tagetes minuta, Typha capensis, Cymbopogon validus, Flaveria bidentis* |
| System Modifiers | Invasive alien vegetation. |
| Potential impacts of water use on environment | Possible flow impedance during high flow periods. |
| Socio-economic impacts of water use | The pipeline will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The pipeline will not significantly negatively impact on any water users. |
| Potential impacts of water use on water resource | The support structures within the channel will result in some alterations to streamflow patterns during flow periods; however these are not deemed to have a significant impact on downstream resources. |
| Summary of proposed impact on water use will have on other users | The pipeline will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Implement alien vegetation control programme. Monitor the pipeline for leaks. |

**Table 77: Summary of the assessment undertaken at site 34b.**

| Site number: 34b | Coordinates:<br>25°37'29.82"S 27°13'54.76"E |
|---|---|
| Crossing Type: Road crossing/culvert | |
| Site Photo:<br> | |
| Present Ecological State | C |
| Wetland type | River |
| Morphology | Wide, relatively deep channel, mixture of alluvial sand and rocky substrate. Low flow present at the time of the study. |
| Riparian and in Stream Habitat | Dominated by bushveld grass, alien vegetation component moderate. Instream ecology: low flow present, no instream vegetation present at the time of the study. |
| Vegetation | *Verbena bonariensis, Tagetes minuta, Persicaria lapathifolia, Bidens pilosa, Cynodon dactylon, Datura stramonium,* |
| System Modifiers | Erosion. Construction. Waste dumping. |
| Potential impacts of water use on environment | Increased water input from the road. Further erosion and sedimentation of the system. |
| Socio-economic impacts of water use | The bridge will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The bridge plays an important role in providing connectivity in the area, thereby allowing economic activity in the area |
| Potential impacts of water use on water resource | Some erosion and incision apparent at the bridge tie-ins. Moderate alteration to streamflow patterns is anticipated as a result of the culvert. |
| Summary of proposed impact on water use will have on other users | The bridge will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Invasive vegetation control. Erosion monitoring. |

**Table 78: Summary of the assessment undertaken at site 34c.**

| | |
|---|---|
| Site number: 34c | Coordinates:<br>25°37'24.04"S 27°13'59.50"E |
| Crossing Type: Culvert/Road | |
| Site Photo:  | |
| Present Ecological State | C |
| Wetland type | River |
| Morphology | Narrow, relatively shallow channel, with a mixture of alluvial sand. Dry river bed at the time of the assessment. |
| Riparian and in Stream Habitat | Dominated by bushveld grass; alien vegetation component moderate. Instream ecology: riverbed dry at the time of the study. |
| Vegetation | *Leonotis dysophylla, Tagetes minuta, Asparagus laricinus, circium vulgare, Cyperus sexangularis, Bidens pilosa, Persicaria lapathifolia, Xanthium strumarium* |
| System Modifiers | Erosion. Rock dumping. Alien invasion. Encroachment |
| Potential impacts of water use on environment | The culvert will not significantly negatively impact on the environment due to the ephemeral nature of the stream. |
| Socio-economic impacts of water use | The culvert will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The culvert will not significantly negatively impact on any water users, but does not serve as an important socio-economic advantage due to its remote location. |
| Potential impacts of water use on water resource | The culvert has been well-constructed with little to no incision apparent at the tie-ins. Moderate alteration to streamflow patterns is anticipated as a result of the overgrown instream habitat; however since the system is ephemeral, no significant impact on downstream resources is anticipated as a result of this. |
| Summary of proposed impact on water use will have on other users | The culvert will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Invasive vegetation control especially within the river channel. Insert proper berms along the culvert, instead of rocks. Erosion monitoring. Remove rocks. |

**Table 79: Summary of the assessment undertaken at site 34d.**

| | |
|---|---|
| Site number: 34d | Coordinates: 25°37'25.30"S 27°13'58.66"E |
| Crossing Type: Railway crossing | |
| Site Photo:  | |
| Present Ecological State | C |
| Wetland type | River |
| Morphology | Wide, relatively shallow channel, mixture of alluvial sand and mud. Limited water present at the time of the assessment, unlikely to support any aquatic macro-invertebrates.. |
| Riparian and in Stream Habitat | Dominated by bushveld grass; alien vegetation component moderate. Instream ecology: limited water present at the time of the assessment. Instream habitat dominated by terrestrial species. |
| Vegetation | *Leonotis dysophylla, Tagetes minuta, Asparagus laricinus, circium vulgare, Cyperus sexangularis, Bidens pilosa, Persicaria lapathifolia* |
| System Modifiers | Sedimentation. Alien vegetation |
| Potential impacts of water use on environment | The railway crossing will not significantly negatively impact on the environment due to the ephemeral nature of the stream. |
| Socio-economic impacts of water use | The railway crossing will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The railway crossing plays an important role in providing connectivity in the area, particularly to the industrial sector, thereby allowing economic activity in the area |
| Potential impacts of water use on water resource | The railway crossing has been well-constructed with little to no incision apparent at the bridge tie-ins. Moderate alteration to streamflow patterns is anticipated as a result of the culverts; however since the system is ephemeral, no significant impact on downstream resources is anticipated as a result of this. |
| Summary of proposed impact on water use will have on other users | The railway crossing will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Control alien vegetation |

**Table 80: Summary of the assessment undertaken at site 34e.**

| | |
|---|---|
| Site number: 34e | Coordinates:<br>25°36'57.65"S 27°14'30.30"E |
| Crossing Type: Road crossing | |
| Site Photo:<br> | |
| Present Ecological State | D |
| Wetland type | River |
| Morphology | Wide, relatively shallow channel, mixture of alluvial sand. Dry river bed at the time of the study. |
| Riparian and in Stream Habitat | Dominated by bushveld vegetation; alien vegetation component moderate. Instream ecology: riverbed dry at the time of the study and dominated by *Typha capensis*. |
| Vegetation | *Typha capensis, Cyperus sexangularis, Cynodon dactylon* |
| System Modifiers | Increased water input from the road. Dumping of general waste. |
| Potential impacts of water use on environment | The bridge will not significantly negatively impact on the environment due to the ephemeral nature of the stream. |
| Socio-economic impacts of water use | The bridge will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The bridge plays an important role in providing connectivity in the area, particularly to the local community, thereby allowing economic activity in the area |
| Potential impacts of water use on water resource | The bridge has been well-constructed with little to no incision apparent at the bridge tie-ins. Moderate alteration to streamflow patterns is anticipated as a result of the culverts; however since the system is ephemeral, no significant impact on downstream resources is anticipated as a result of this. |
| Summary of proposed impact on water use will have on other users | The bridge will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Remove general waste from bridge crossing. |

**Table 81: Summary of the assessment undertaken at Site 34f.**

| | |
|---|---|
| Site number: 34f | Coordinates: 25°36'04.22"S 27°15'20.27"E |
| Crossing Type: Pipe crossing | |
| Site Photo:  | |
| Present Ecological State | D |
| Wetland type | River |
| Morphology | Wide, relatively shallow channel, mixture of alluvial sand. Slow flowing water present at the time of the assessment. |
| *Riparian and in Stream Habitat* | Instream ecology: dominated by *Typha capensis*. |
| Vegetation | *Conyza bonariensis, Cyperus sexangularis, Typha capensis, Bidens pilosa, Urochloa mosambicens, Tithonia rotundifolia* |
| System Modifiers | Sewage effluent altering water quality. Burst pipe traversing the road and the feature. Trampling. Erosion. |
| Potential impacts of water use on environment | At the moment sewage is entering the system due to the broken pipe at the time of the assessment. The pipeline crossing will not significantly negatively impact on the receiving environment; provided it is adequately maintained. |
| Socio-economic impacts of water use | At the moment sewage is entering the system due to the broken pipe at the site. The pipeline crossing will not significantly negatively impact on any water users, provided it is adequately maintained. |
| Socio–economic advantages of water use | The sewer line is necessary for the safe disposal of sewage. |
| Potential impacts of water use on water resource | The pipeline crossing has been poorly-constructed with some erosion present at the site. The pipeline present at the site has been damaged, this will alter the flow of the system with increased flow entering the system. |
| Summary of proposed impact on water use will have on other users | At the moment the pipeline crossing is having a negative impact due to the damaged pipe and sewage entering the system. The crossing will not impact significantly on other water users if it is properly maintained. |
| Mitigation and Rehabilitation plan | Monitor erosion. Construct a proper road crossing. Install proper sewage pipes. |

**Table 82: Summary of the assessment undertaken at Site 34g.**

| | |
|---|---|
| Site number: 34g | Coordinates:<br>25°56'44.93"S 27°15'41.10"E |
| Crossing Type: Road crossing | |
|  | |
| Present Ecological State | C |
| Wetland type | River |
| Morphology | Wide, relatively shallow channel. Slow flowing water present at the site. |
| Riparian and in Stream Habitat | Instream habitat dominated by *Cyperus sexangularis* and *Typha capensis*. |
| Vegetation | *Conyza bonariensis, Cyperus sexangularis, Typha capensis, Bidens pilosa, Urochloa mosambicens, Tithonia rotundifolia* |
| System Modifiers | Sewage effluent. Increased water input from the road. Waste dumping. |
| Potential impacts of water use on environment | The bridge crossing will not significantly negatively impact on the receiving environment. |
| Socio-economic impacts of water use | The bridge crossing will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The bridge plays an important role in providing connectivity in the area, particularly to the local community, thereby allowing economic activity in the area |
| Potential impacts of water use on water resource | The bridge has been well-constructed with little to no incision apparent at the bridge tie-ins. Moderate alteration to streamflow patterns is anticipated as a result of the culverts and overgrown instream vegetation. |
| Summary of proposed impact on water use will have on other users | The bridge will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Monitoring of erosion. |

**Table 83: Summary of the assessment undertaken at Site 34h.**

| | |
|---|---|
| Site number: 34h | Coordinates: 25°35'43.76"S 27°15'40.05"E |
| Crossing Type: Road crossing culvert | |
| Site Photo:  | |
| Present Ecological State | C |
| Wetland type | River |
| Morphology | Wide, relatively shallow channel, mixture of alluvial sand. Dry river bed at the time of the study. |
| Riparian and in Stream Habitat | Dominated by bushveld vegetation. Instream ecology: riverbed dry at the time of the study and dominated by terrestrial species. |
| Vegetation | *Typha capensis, Cyperus sexangularis, Bidens pilosa, Persicaria lapathifolia* |
| System Modifiers | Increased water input due to the road crossing. |
| Potential impacts of water use on environment | The bridge crossing will not significantly negatively impact on the receiving environment. |
| Socio-economic impacts of water use | The bridge crossing will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The bridge plays an important role in providing connectivity in the area, particularly to the local community, thereby allowing economic activity in the area |
| Potential impacts of water use on water resource | The bridge has been well-constructed with little to no incision apparent at the bridge tie-ins. Moderate alteration to streamflow patterns is anticipated as a result of the culverts and overgrown instream vegetation, however due to the ephemeral nature of the system, limited impact on the downstream users is expected. |
| Summary of proposed impact on water use will have on other users | The bridge will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Monitoring of erosion. |

**Table 84: Summary of the assessment undertaken at site 35.**

| | |
|---|---|
| Site number:<br>Site 35 | Coordinates:<br>25°36'35.39"S 27°13'07.44"E |
| Crossing Type: Culvert/Railway | |
| Site Photo:<br> | |
| Present Ecological State | C |
| Wetland type | Non-perennial drainage line |
| Morphology | Wide, relatively deep channel, mixture of alluvial sand and gravel. Shallow pool present at the time of the assessment, unlikely to support any aquatic macro-invertebrates. . |
| Riparian and in Stream Habitat | Dominated by bushveld vegetation; alien vegetation component moderate. Instream ecology: shallow pool present at the time of the study with no instream vegetation present. |
| Vegetation | *Setaria sphacelata, Bidens pilosa, Cynodon dactylon, Acacia karroo* |
| System Modifiers | Burst leaking pipes. Erosion. Grazing. Alien invasion. |
| Potential impacts of water use on environment | Aquatic migratory barrier- during low flow periods. |
| Socio-economic impacts of water use | The railway culvert will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The railway culvert plays an important role in providing connectivity in the area, particularly to the industrial sector, thereby allowing economic activity in the area |
| Potential impacts of water use on water resource | The railway culvert has been poorly-constructed with incision and erosion apparent at the bridge tie-ins. Moderate alteration to streamflow patterns is anticipated as a result of the culverts; scouring of the streambed evident. |
| Summary of proposed impact on water use will have on other users | The railway culvert will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Invasive vegetation control. Erosion monitoring. Monitor pipes for leaks. |

**Table 85: Summary of the assessment undertaken at site 35a.**

| | |
|---|---|
| Site number: Site 35a | Coordinates:<br>25°36'42.81"S 27°13'01.83"E |
| Crossing Type: Culvert | |
| Site Photo:<br> | |
| Present Ecological State | E |
| Wetland type | Non-perennial drainage line |
| Morphology | Wide, relatively shallow channel, mixture of alluvial sand. Dry stream bed at the time of the assessment. |
| Riparian and in Stream Habitat | Dominated by bushveld vegetation. Instream ecology: streambed dry at the time of the study. Excessive sedimentation of the system. |
| Vegetation | *Asclepias fruiticosa, Xanthium strumarium, Tagetes minuta, Melinis repens, Bidens pilosa, Cynodon dactylon* |
| System Modifiers | Clogged pipes. Erosion. Encroachment. Trampling by livestock, some alteration to streamflow patterns is anticipated due to the support structures placed in the channel. |
| Potential impacts of water use on environment | Unclog pipes to in order to restore instream flow patterns. The culvert will not significantly negatively impact on the environment, if the culvert is properly maintained. |
| Socio-economic impacts of water use | The culvert will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The culvert will not significantly negatively impact on any water users. |
| Potential impacts of water use on water resource | Some streamflow alteration is anticipated high flow periods, however, due to the ephemeral nature of the stream it is unlikely to have a significant impact on downstream resources. |
| Summary of proposed impact on water use will have on other users | The culvert will not significantly negatively impact on any water users. |
| Mitigation and Rehabilitation plan | Erosion monitoring, alien vegetation monitoring. Unclog pipes to in order to restore instream flow patterns. |

**Table 86: Summary of the assessment undertaken at Site 35b.**

| | |
|---|---|
| Site number: 35b | Coordinates: 25°36'28.32"S 27°13'13.8"E |
| Crossing Type: Road crossing/pipeline | |
| Site Photo:  | |
| Present Ecological State | D |
| Wetland type | Non-perennial drainage line |
| Morphology | Wide, relatively shallow channel, mixture of alluvial sand and bedrock. Dry riverbed at the time of the study. |
| Riparian and in Stream Habitat | Dominated by bushveld vegetation. Instream ecology: dry riverbed at the time of the assessment dominated by terrestrial species. |
| Vegetation | *Tagetes minuta, Melinis repens, Hyparrhenia hirta. Rhus lancea* |
| System Modifiers | Erosion. Encroachment |
| Potential impacts of water use on environment | The crossing will not significantly negatively impact on the environment. |
| Socio-economic impacts of water use | The culvert will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The culvert plays an important role in providing connectivity in the area, particularly to the industrial sector, thereby allowing economic activity in the area |
| Potential impacts of water use on water resource | Some streamflow alteration may occur during high flow periods, however due to the ephemeral nature of the stream it is unlikely to have a significant impact on downstream resources. |
| Summary of proposed impact on water use will have on other users | The culvert will not significantly negatively impact on any water users. |
| Mitigation and Rehabilitation plan | Erosion monitoring. Alien vegetation monitoring. Build a proper culvert. |

**Table 87: Summary of the assessment undertaken at Site 36.**

| | |
|---|---|
| Site number: 36 | Coordinates:<br>25°36'28.67"S 27°13'12.66"E |
| Crossing Type: Road crossing culvert | |
| Site Photo:<br> | |
| Present Ecological State | C |
| Wetland type | Non-perennial drainage line |
| Morphology | Wide, relatively shallow channel, mixture of alluvial sand. Dry river bed at the time of the assessment. |
| Riparian and in Stream Habitat | Dominated by bushveld vegetation. Instream ecology: riverbed dry at the time of the study. Excessive sedimentation of the system. |
| Vegetation | *Xanthium strumarium, Acacia karroo, Datura stramonium, Asclepias fruiticosa, Themeda triandra* |
| System Modifiers | Sedimentation. Erosion. Encroachment |
| Potential impacts of water use on environment | Unclog pipes to in order to restore instream flow patterns. The culvert will not significantly negatively impact on the environment, if the culvert is properly maintained. |
| Socio-economic impacts of water use | The culvert will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The culvert plays an important role in providing connectivity in the area, particularly to the industrial sector, thereby allowing economic activity in the area. |
| Potential impacts of water use on water resource | Some streamflow alteration is anticipated high flow periods, however, due to the ephemeral nature of the stream it is unlikely to have a significant impact on downstream resources. |
| Summary of proposed impact on water use will have on other users | The culvert will not significantly negatively impact on any water users. |
| Mitigation and Rehabilitation plan | Monitoring of erosion. Alien vegetation monitoring. Unclog sediment from the culvert. |

**Table 88: Summary of the assessment undertaken at Site 36a.**

| | |
|---|---|
| Site number: 36a | Coordinates:<br>25°37'30.69"S 27°13'48.20"E |
| Crossing Type: Road crossing | |
|  | |
| Present Ecological State | D |
| Wetland type | Non-perennial drainage line |
| Morphology | Narrow shallow channel |
| Riparian and in Stream Habitat | Instream ecology: channel vegetated. |
| Vegetation | *Ipomoea bolusiana, Persicaria lapathifolia, Asclepias fruiticosa, Bidens pilosa, Cynodon dactylon, Melinis repens, Tagetes minuta, Morus alba, Datura stramonium, Sesbania sesban, Typha capensis.* |
| System Modifiers | Construction, stockpiling, Erosion |
| Potential impacts of water use on environment | The road crossing will not significantly negatively impact on the environment. |
| Socio-economic impacts of water use | The road crossing will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The road is mainly used by mining vehicles. |
| Potential impacts of water use on water resource | The road will result in some alterations to streamflow patterns during flow periods; however these are not deemed to have a significant impact on downstream resources. |
| Summary of proposed impact on water use will have on other users | The road crossing will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Provide hessian curtains to minimise erosion and sediment deposition. |

**Table 89: Summary of the assessment undertaken at Site 37.**

| | |
|---|---|
| Site number: 37 | Coordinates:<br>25°42'01.90"S 27°24'42.46"E |
| Crossing Type: Road culvert | |
| Site Photo:  | |
| Present Ecological State | C |
| Wetland type | River |
| Morphology | Wide, shallow channel. Dry river bed. |
| Riparian and in Stream Habitat | Dry at the time of the assessment. |
| Vegetation | *Asclepias fruiticosa, Brachiaria brizantha, Cynodon dactylon, Melinis repens, Tagetes minuta, Acacia karroo. Setaria sphacelata, Hyparrhenia hirta, Helichrysum aureonitens, Cyperus sexangularis* |
| System Modifiers | Grazing and trampling. Erosion. Culvert |
| Potential impacts of water use on environment | The road culvert will not significantly negatively impact on the environment. |
| Socio-economic impacts of water use | The road will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The road will not significantly negatively impact on any water users. |
| Potential impacts of water use on water resource | The road culvert will result in some alterations to streamflow patterns during flow periods; however these are not deemed to have a significant impact on downstream resources. |
| Summary of proposed impact on water use will have on other users | The road will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Control erosion. |

**Table 90: Summary of the assessment undertaken at Site 38.**

| | |
|---|---|
| Site number: 38 | Coordinates: 25°42'16.31"S 27°24'46.74"E |
| Crossing Type: Road culvert | |
| Site Photo:  | |
| Present Ecological State | C |
| Wetland type | River |
| | Narrow, shallow channel, Dry river bed. |
| Riparian and in Stream Habitat | Dry at the time of the assessment. |
| Vegetation | *Typha capensis, Cyperus sexangularis, Asparagus ;laricinus, Tagetes minuta, Cirsium vulgare, Eragrostis curvula, Sesbania sesban, Verbena bonariensis* |
| System Modifiers | Erosion. Cattle trampling and grazing. |
| Potential impacts of water use on environment | The road crossing will not significantly negatively impact on the environment. |
| Socio-economic impacts of water use | The road crossing will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The road crossing plays an important role in providing connectivity in the area. |
| Potential impacts of water use on water resource | Alterations to streamflow patterns during flow periods. Due to erosion, there will be sediment deposition. |
| Summary of proposed impact on water use will have on other users | The road crossing will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Insert berms to control erosion along the culvert |

**Table 91: Summary of the assessment undertaken at Site 38a/38b.**

| | |
|---|---|
| Site number: 38a/38b | Coordinates:<br>25°42'01.47"S 27°25'02.04"E - 25°42'10.61"S 27°24'56.85"E |
| Crossing Type: River diversion | |
| Site Photo:<br> |  |
| Present Ecological State | C |
| Wetland type | River |
| Morphology | Wide, paved and shallow channel. Dry river bed. |
| Riparian and in Stream Habitat | Dry at the time of the assessment. |
| Vegetation | *Acacia karroo, Eragrostis curvula, Hyparrhenia hirta* |
| System Modifiers | Diversion, pavement, alien vegetation invasion, slight erosion on the diversion banks. |
| Potential impacts of water use on environment | The diversion will redirect the flow of water and cause drying up in areas where there used to be flowing water or water available to users. |
| Socio-economic impacts of water use | The diversion will result in lack of water in certain areas as a result of water not being able to flow to those areas. |
| Socio–economic advantages of water use | The diversion will not significantly negatively impact on any water users |
| Potential impacts of water use on water resource | Alterations to streamflow patterns during flow periods. |
| Summary of proposed impact on water use will have on other users | The diversion will impact water supply on other water users. |
| Mitigation and Rehabilitation plan | Control alien vegetation species. |

**Table 92: Summary of the assessment undertaken at Site 38c.**

| | |
|---|---|
| Site number: 38c | Coordinates: 25°42'14.56"S 27°24'50.81"E |
| Crossing Type: Road culvert/pipeline | |
| Site Photo:  | |
| Present Ecological State | C |
| Wetland type | River |
| Morphology | Wide, relatively shallow channel, Dry river bed. |
| Riparian and in Stream Habitat | *Acacia karroo* dominated the bushveld. Dry at the time of the assessment. |
| Vegetation | *Cyperus sexangularis, Conyza bonariensis, Melinis repens, Setaria sphacelata, Sesbania sesban, Verbena bonariensis, Themeda triandra, Acacia karroo* |
| System Modifiers | Road/pipeline increasing water input. Alien vegetation |
| Potential impacts of water use on environment | The road/pipeline crossing will not significantly negatively impact on the receiving environment. |
| Socio-economic impacts of water use | The road/pipeline will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The road crossing is necessary for connectivity. |
| Potential impacts of water use on water resource | Since the road/pipeline is locate adjacent a stream there will be no obstruction or impact on water flow. However, there might be increased water input coming through the pipes into the stream. |
| Summary of proposed impact on water use will have on other users | These structures will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Control alien vegetation species. |

**Table 93: Summary of the assessment undertaken at Site 39.**

| | |
|---|---|
| Site number: 39 | Coordinates: 25°41'41.51"S 27°25'54.36"E |
| Crossing Type: Road culvert | |
| Site Photo:  | |
| Present Ecological State | C |
| Wetland type | River |
| Morphology | Wide, and diffuse. Dry river bed. |
| Riparian and in Stream Habitat | Dry at the time of the assessment. |
| Vegetation | *Sesbania sesban, Sporobolus pyramidalis, Helichrysum spp, Persicaria lapathifolia, Tagetes minuta* |
| System Modifiers | Culvert. Livestock grazing and trampling. Erosion. |
| Potential impacts of water use on environment | The road crossing will not significantly negatively impact on the environment. |
| Socio-economic impacts of water use | The road crossing will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The road crossing plays an important role in providing connectivity in the area. |
| Potential impacts of water use on water resource | The road will result in increased runoff, the culvert will result in some alterations to streamflow patterns during flow periods; however these are not deemed to have a significant impact on downstream resources. |
| Summary of proposed impact on water use will have on other users | The road crossing will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Control erosion, remove litter. |

**Table 94: Summary of the assessment undertaken at Site 40a.**

| | |
|---|---|
| Site number: 40a | Coordinates:<br>25°40'52.00"S 27°24'20.43"E |
| Crossing Type: Railway culvert | |
| Site Photo:<br> | |
| Present Ecological State | C |
| Wetland type | River |
| Morphology | Very diffuse area. Dry river bed. |
| Riparian and in Stream Habitat | Mostly grass species dominating the area. Instream ecology: riverbed dry at the time of the study. |
| Vegetation | *Chloris virgata, Melinis repens, Setaria sphacelata, Asclepias fruiticosa* |
| System Modifiers | Erosion. |
| Potential impacts of water use on environment | The railway crossing will not significantly negatively impact the environment. |
| Socio-economic impacts of water use | The railway crossing will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The railway crossing will not significantly negatively impact on any water users. |
| Potential impacts of water use on water resource | Alterations to water flow patterns during flow periods; however these are not deemed to have a significant impact on downstream resources. |
| Summary of proposed impact on water use will have on other users | The railway crossing will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Monitor erosion. |

**Table 95: Summary of the assessment undertaken at Site 40c.**

| | |
|---|---|
| Site number: 40c | Coordinates:<br>25°42'11.92"S 27°24'24.54"E |
| Crossing Type: Pipeline | |
| Site Photo:<br> | |
| Present Ecological State | C |
| Wetland type | River |
| Morphology | Narrow, shallow channel. Dry river bed. |
| Riparian and in Stream Habitat | Dry at the time of the assessment. Alien vegetation within the stream channel. |
| Vegetation | *Flaveria bidentis, Conyza bonariensis, Hyparrhenia hirta, Asclepias fruiticosa* |
| System Modifiers | Pipes obstructing water flow |
| Potential impacts of water use on environment | The pipeline will not significantly negatively impact on the receiving environment; provided it is adequately maintained. |
| Socio-economic impacts of water use | The pipeline is very low/ close to the ground, therefore it will obstruct water flow during heavy rainfall events. |
| Socio–economic advantages of water use | The pipeline will not significantly negatively impact on water users. |
| Potential impacts of water use on water resource | The presence of the pipeline as well as rocks within the channel will alter water flow patterns during flow periods. |
| Summary of proposed impact on water use will have on other users | The pipeline will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | The pipes should in fact be underground so that it doesn't inhibit the flow of water. |

**Table 96: Summary of the assessment undertaken at Site 40d-40h.**

| | |
|---|---|
| Site number: 40d-40h | Coordinates: 25°40'52.00"S 27°24'20.43"E - 25°40'17.92"S 27°25'51.60"E |
| Crossing Type: Diversion | |
| Site Photo:  | |
| Present Ecological State | C |
| Wetland type | River |
| Morphology | Wide, shallow paved channel |
| Riparian and in Stream Habitat | Acacia spp dominated the bushveld. |
| Vegetation | *Heteropogon contortus, Bothriochloa insculpta, Andropogon eucomus, Themeda triandra, Setaria sphacelata, Conyza bonariensis, Asclepias fruiticosa,* |
| System Modifiers | Eroded banks where there's a culvert. Trampling and grazing. |
| Potential impacts of water use on environment | The diversion will redirect the flow of water and cause drying up in areas where there used to be flowing water or water available to users. |
| Socio-economic impacts of water use | The diversion will result in lack of water in certain areas as a result of water not being able to flow to those areas. |
| Socio–economic advantages of water use | The diversion will not significantly negatively impact on any water users |
| Potential impacts of water use on water resource | Alterations to streamflow patterns during flow periods. |
| Summary of proposed impact on water use will have on other users | The diversion will impact water supply on other water users. |
| Mitigation and Rehabilitation plan | Monitor erosion. |

**Table 97: Summary of the assessment undertaken at Site 40e.**

| | |
|---|---|
| Site number: 40e | Coordinates:<br>25°40'55.27"S 27°24'49.78E |
| Crossing Type: Road culvert | |
| Site Photo:<br> | |
| Present Ecological State | C |
| Wetland type | River |
| Morphology | Wide, shallow channel. Dry river bed. The channel has been artificially paved. |
| Riparian and in Stream Habitat | *Dichrostachys* dominated bushveld vegetation. Instream ecology: riverbed dry at the time of the study. |
| Vegetation | *Sesbania sesban, Flaveria bidentis, Setaria sphacelata, Asclapias fruiticosa, polygala hottentota, Themeda triandra, Melinis repens, Brachiaria brizantha* |
| System Modifiers | Erosion. Runoff from the adjacent development deposits sediment into the feature since the banks are unvegetated. |
| Potential impacts of water use on environment | The road crossing will not significantly negatively impact on any water users. |
| Socio-economic impacts of water use | The road crossing will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The road crossing is necessary for providing connectivity in the area. |
| Potential impacts of water use on water resource | The paved channel as well as the culvert have altered water flow patterns. |
| Summary of proposed impact on water use will have on other users | The road crossing will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Monitor erosion. |

**Table 98: Summary of the assessment undertaken at Site 41.**

| | |
|---|---|
| Site number: 41 | Coordinates: 25°39'54.60"S 27°19'51.80"E |
| Crossing Type: Road crossing | |
| Site Photo:  |  |
| Present Ecological State | C |
| Wetland type | River |
| Morphology | Narrow, shallow channel. Dry river bed. |
| Riparian and in Stream Habitat | Riverbed dry at the time of the study. |
| Vegetation | *Acacia karroo, Cynodon dactylon, Conyza bonariensis, Phragmites australis, Flaveria bidentis Bothriochloa insculpta* |
| System Modifiers | Partially collapsed culvert. Erosion. Stockpiling. |
| Potential impacts of water use on environment | The road crossing will not significantly negatively impact on any water users. |
| Socio-economic impacts of water use | The road crossing will not significantly negatively impact on any water users. |
| Socio–economic advantages of water use | The road crossing plays a role in in providing connectivity in the area thereby allowing economic activity in the area. |
| Potential impacts of water use on water resource | The culvert is very low and it might constrict water flow during heavy rainfall events. |
| Summary of proposed impact on water use will have on other users | The road crossing will not impact significantly on other water users. |
| Mitigation and Rehabilitation plan | Reconstruct the collapsed culvert. Insert erosion control berms. Control alien vegetation species. |

# 6 RESULTS: AQUATICS ASSESSMENT

Based on the results of the site selection effort, fifteen sites were visually assessed and eight out of the fifteen were subjected to further detailed aquatic assessment. The field assessment took place during the week of the $20^{th}$ to $24^{th}$ of April 2015.

## 6.1 Visual Assessment

A photographic record of each site was made in order to provide a visual record of the condition of each assessment site as observed during the field assessment. The photographs taken at each site are presented in the sections below. The tables in each section summarise the observations for the various criteria made during the visual assessment undertaken at each site.

**The Hex River**

**Figure 47: Upstream view of the SASS 22 site indicating the low flow at the time of the assessment.**

**Figure 48: Upstream view of the SASS 26 site indicating the turbid water present at the time of the assessment.**

**Figure 49: Downstream view of the SASS 27A site indicating the presence of turbid water at the time of the assessment.**

**Figure 50: Downstream view of the SASS 29 site indicating the presence of abundant aquatic vegetation at the time of the assessment.**

## The Dorpspruit

**Figure 51: Upstream view of the SASS 31 site indicating the low flow and discoloured water at the time of the assessment likely due to presence of untreated sewage effluent.**

**Figure 52: Upstream view of the SASS 32 site indicating the low flow present at the time of the assessment.**

## The Klipfonteinspruit

**Figure 53: Local view of the SASS 4 site indicating the lack of flow at the time of the assessment.**

**Figure 54: Downstream view of the SASS 9 site indicating the low flows and turbid water present at the time of the assessment.**

**The Paardekraalspruit**

**Figure 55: Local view of the SASS 19 site indicating the lack of flow at the time of the assessment.**

**Figure 56: Downstream view of the SASS 15 site indicating the lack of flow at the time of the assessment.**

**Figure 57: Upstream view of the SASS 21 site indicating the low flow at the time of the assessment.**

**Surrounding Tributaries**

**Figure 58: Upstream view of the SASS 35A site located on the Wildebeesfonteinspruit. The site was dry at the time of the assessment and culverts largely silted up.**

**Figure 59: Downstream view of the SASS 39 site located on the Brakspruit. The site was dry at the time of the assessment.**

**Figure 60: Upstream view of the SASS 40E located on the Hoedspruit. The site was dry at the time of the assessment.**

**Figure 61: Downstream view of the SASS 12A site located on the Klipgatspruit. The site was dry at the time of the assessment.**

**Table 99: Description of the eight assessed sites located in the vicinity of the RPM operations.**

| SITE | SASS 22 | SASS 26 | SASS 27A | SASS 29 | SASS 31 | SASS 32 | SASS 9 | SASS 21 |
|---|---|---|---|---|---|---|---|---|
| Existing biomonitoring site | HEX01 | None | HEX03 | None; downstream of Hex4B | None | None | None | None |
| Surface water monitoring point | K052 | K053 | K039 | K081 | K091 (upstream of SASS31) | K040 | K061 | K082 |
| Upstream features | This site is located on the Hex River and will serve as the upstream reference site for sites SASS 26, 27A and 29. | This site is located on the Hex River, west of the Waterval West Tailings Dam. | This site is located on the Hex River, west of the West of Paardekraal Tailings Dam PK4. | This point is located on the Hex River, downstream of the RPM operations and downstream of the Dorpspruit and Klipgatspruit confluences. | This site is located on the Dorpspruit. This site will be representative of the upstream conditions of the Dorpspruit at the time of the assessment. | This point is located on the Dorpspruit downstream of Prison Dam. This site is downstream of site SASS 31. | The site is located on the Klipfonteinspruit, downstream of site SASS 4 which was dry at the time of the assessment. This site will be representative of the system. | This site is located on the Paardekraalspruit and is located downstream of reference site SASS 19 and 15 which were dry at the time of the assessment. This site will be representative of the system. |
| Downstream significance | The site is located upstream from any RPM operations. | The site is located upstream of Paardekraal Angling dam, and upstream of a rural residential area. | The site is located downstream of the Boitekong settlement and upstream of the Dorpspruit confluence. | The site is located within the Kanana settlement and upstream of the Bospoort Dam. | The site is located upstream of Khuseleka 1. | The site is located upstream from the Hex River confluence. | The site is located south of the UG2 concentrator. | This site is located downstream of the Paardekraal Tailings Dam PK4. The site is located upstream of the Hex River confluence. |
| Riparian zone characteristics | The riparian zone is relatively wide. The riparian zone is dominated by grass, shrubs and trees. Some inundated bankside vegetation is present. | The riparian zone is relatively wide. The riparian zone is dominated by grass, shrubs and trees. Some inundated bankside vegetation is present. | The riparian zone is relatively wide. The riparian zone is dominated by grass, shrubs and trees. Some inundated bankside vegetation is present. | The riparian zone is relatively narrow due to the incised nature of the active-channel. The riparian zone is dominated by grass. Abundant inundated bankside vegetation is present. | The riparian zone is relatively narrow due to the incised nature of the active-channel. The riparian zone is dominated by grass. Abundant inundated bankside vegetation is present. | The riparian zone is relatively narrow due to the incised nature of the active-channel. The riparian zone is dominated by grass, trees and shrubs. Some bankside vegetation is present. | The riparian zone is relatively wide. The riparian zone is dominated by grass. Some inundated bankside vegetation is present. | The riparian zone is relatively wide. The riparian zone is dominated by grass. Some inundated bankside vegetation is present. |

| SITE | SASS 22 | SASS 26 | SASS 27A | SASS 29 | SASS 31 | SASS 32 | SASS 9 | SASS 21 |
|---|---|---|---|---|---|---|---|---|
| Algal presence | No algal proliferation was evident at the time of the assessment. | No algal proliferation was evident at the time of the assessment. | No algal proliferation was evident at the time of the assessment. | Duckweed and water hyacinth proliferation at the time of the assessment. | Algal proliferation was evident at the time of the assessment. | No algal proliferation was evident at the time of the assessment. | No algal proliferation was evident at the time of the assessment. | No algal proliferation was evident at the time of the assessment. |
| Visual indication of and impact on aquatic fauna | No visual indication of an impact on aquatic fauna, due to alterations in water quality was evident at the time of the assessment, but some erosion was present at the site along with alien vegetation. | No visual indication of an impact on aquatic fauna, due to alterations in water quality was evident at the time of the assessment, but high instream turbidity was present at the time of the assessment, likely due to the erosion evident in the system. | No visual indication of an impact on aquatic fauna, due to alterations in water quality was evident at the time of the assessment, but high instream turbidity was present at the site along with some alien vegetation. The turbidity is likely due to the proximity of the rural settlement. | No visual indication of an impact on aquatic fauna, due to alterations in water quality was evident at the time of the assessment. Some alien vegetation was present at the site. | No visual indication of an impact on aquatic fauna, due to alterations in the water quality was evident at the time of the assessment. Some loss of instream flow and high instream turbidity were present at the site. This is likely due to the proximity of the residential area and the construction activities related to the road and bridge upgrades of the R510. | Construction activities were taking place at the time of the assessment, impeding flow and altering water quality. Erosion was also evident at the site during the assessment. | No visual indication of an impact on aquatic fauna, due to alterations in water quality were evident at the time of the assessment. A general loss of instream flow and stream continuity was evident at the site. This is likely due to the location of the site within the RPM boundary area. | No visual indication of an impact on aquatic fauna, due to alterations in water quality were evident at the time of the assessment. A general loss of instream flow and stream continuity was evident at the site. This is likely due to the location of the site within the RPM boundary area, located downstream of the Paardekraal Tailings Dam. |
| Depth characteristics | The system at this point is dominated by shallow riffles and runs as well as deep pools at the time of the assessment. | The system at this point is dominated by moderately deep pools and faster riffles at the time of the assessment. | The system was dominated by moderately deep pools and runs at the time of the assessment. | The system at this point is dominated by moderately deep runs at the time of the assessment. | The system at this point is dominated by shallow riffles and runs as well as deep pools at the time of the assessment. | The system at this point is dominated by shallow riffles and runs as well as deep pools at the time of the assessment. | The system at this point is dominated by shallow pools at the time of the assessment. | The system at this point is dominated by shallow pools at the time of the assessment. |

| SITE | SASS 22 | SASS 26 | SASS 27A | SASS 29 | SASS 31 | SASS 32 | SASS 9 | SASS 21 |
|---|---|---|---|---|---|---|---|---|
| Flow condition | There is a low diversity of flow. Flow can be considered as slow at the time of the assessment. This will have some limit on the diversity and sensitivity of the aquatic community. | There is low diversity of flow; the water can be considered as moderately fast at the time of the assessment. This will have some limit on the diversity and sensitivity of the aquatic community. | There is a low diversity of flow. Flow can be considered as slow at the time of the assessment. This will have some limit on the diversity and sensitivity of the aquatic community. | There is a little diversity of flow; the water can be considered as slow. This will have some limit on the diversity and sensitivity of the aquatic community. | There is low diversity of flow; the water can be considered as moderately fast at the time of the assessment. This will have some limit on the diversity and sensitivity of the aquatic community. | There is a low diversity of flow. Flow can be considered as slow at the time of the assessment. This will have some limit on the diversity and sensitivity of the aquatic community. | There is a low diversity of flow. Flow can be considered as slow at the time of the assessment. This will have some limit on the diversity and sensitivity of the aquatic community. | There is a low diversity of flow. Flow can be considered as slow at the time of the assessment. This will have some limit on the diversity and sensitivity of the aquatic community. |
| Water clarity | Water is discoloured at the time of the assessment. | Water is discoloured at the time of the assessment. | The water is discoloured at the time of the assessment. | The water was clear at the time of the assessment. | The water is discoloured at the time of the assessment. | The water is slightly discoloured at the time of the assessment. | The water is slightly discoloured at the time of the assessment. | The water is clear at the time of the assessment. |
| Water odour | No odours were evident at the time of the assessment. | | | | | | | |
| Erosion potential | There is potential for erosion due to the presence of bare riverbanks. | There is potential for erosion due to the presence of bare riverbanks. | There is limited potential for erosion due to the adequately vegetated riverbanks. | There is limited potential for erosion due to the adequately vegetated riverbanks. | There is potential for erosion due to the bare riverbanks. | There is potential for erosion due to the presence of bare riverbanks. | There is limited potential for erosion due to the adequately vegetated riverbanks. | There is limited potential for erosion due to the adequately vegetated riverbanks. |

## 6.2 Biota Specific Water Quality

The table below summarises the biota specific water quality of the assessment sites.

**Table 100: Biota specific water quality variables**

| Site | Cond (mS/m) | pH (units) | DO (mg/L) | Temperature (°C) |
|---|---|---|---|---|
| SASS 22 | 62.0 | 7.98 | 6.28 | 23.5 |
| SASS 26 | 67.0 | 8.45 | 6.28 | 21.9 |
| SASS 27A | 100.0 | 8.39 | 8.69 | 24.1 |
| SASS 29 | 107.0 | 7.94 | 1.84 | 19.0 |
| SASS 31 | 65.0 | 7.60 | 3.70 | 21.6 |
| SASS 32 | 92.0 | 7.45 | 3.37 | 23.2 |
| SASS 9 | 274.0 | 6.20 | 7.92 | 21.5 |
| SASS 21 | 72.0 | 7.41 | 3.82 | 21.3 |

- The water quality data indicates that the electrical conductivity (EC) at all the sites is significantly elevated from expected natural conditions (EC < 40 mS/m);
- The EC values of the sites located on the Hex River increases significantly in a downstream direction. The EC increased by 8.1% between the SASS 22 and SASS 26 sites, by 49.3% between site SASS 26 and SASS 27A, and by 7.0% between site SASS 27A and SASS 29. Overall the EC increased by 72.6% between the upstream site SASS 22 and the downstream site SASS 29. This spatial change exceeds the target water quality requirements (TWQR) for aquatic ecosystems (DWAF, 1996), which advocate no change greater than 15% from the reference value;
- The increased EC indicates that dissolved salts are entering the system, and is likely due to activities associated with the RPM operations. However, the contribution from these sources are difficult to quantify as run-off from various diffuse and point sources from the surrounding areas most likely also contributes to the salt load;
- The EC values of sites located on the Dorpspruit increase significantly in a downstream direction by 41.5%. This spatial change exceeds the TWQR (DWAF, 1996). The elevated EC value at site SASS 32 is likely due to the construction activities taking place at the time of the assessment;
- The EC value at site SASS 9 is critically elevated from natural conditions and is the highest EC recorded at the time of the assessment. It is possible that the run-off from the UG2 Concentrator and surrounding RPM activities are reaching the Klipfonteinspruit;
- The EC recorded at site SASS 21 is elevated from natural conditions, indicating that dissolved salts are entering the system. Run-off and/or seepage from the

Paardekraal Tailings Dam PK4 is likely entering the system. However, the contribution from these sources are difficult to quantify as run-off from various diffuse and point sources from the surrounding areas possibly also contribute to the salt load;

- The pH values recorded at all the sites can be considered as largely natural, with the exception of site SASS 9 which is slightly acidic;
- Spatially, pH values of sites located on the Hex River increases by 5.9% between sites SASS 22 and SASS 26, decrease by 0.7% between sites SASS 26 and SASS 27A, and decreased by 5.4% between sites SASS 29 and SASS 27A. Overall the pH has decreased by 0.5% between the upstream site SASS 22 and the downstream site SASS 29. This change complies with the TWQR (DWAF, 1996) for aquatic ecosystems which advocate no change greater than 5% from spatial or temporal data. No impact on the aquatic community as a result of altered pH values are likely at the time of the assessment;
- The pH values of sites located on the Dorpspruit decreased slightly by 2.0% in a downstream direction. This change complies with the TWQR (DWAF, 1996) for aquatic ecosystems. No impact on the aquatic community as a result of altered pH values are likely at the time of the assessment;
- The pH recorded at site SASS 9 on the Klipfonteinspruit can be considered as slightly acidic at the time of the assessment. It is possible that the run-off from the UG2 Concentrator and surrounding RPM activities are reaching the Klipfonteinspruit;
- The pH recorded at site SASS 21 on the Paardekraalspruit can be considered as largely natural at the time of the assessment. No impact on the aquatic community as a result of altered pH values are likely at the time of the assessment;
- The water quality guideline for aquatic ecosystems (DWAF, 1996) states that dissolved oxygen concentrations should range between 80% and 120% of saturation.
- Saturation (i.e. maximum dissolved oxygen concentrations) shall in turn depend on the temperature of the water sampled (USA EPA website accessed May 2015). The current readings were expressed as a percentage of the potential maximum (Table 101).

**Table 101: Oxygen measured expressed as a percentage of maximum concentration at the temperature measured.**

| Site | Oxygen (mg/l) | Temperature when measured (°C) | Maximum oxygen at that temperature (mg/l) | Oxygen measured expressed as percentage of maximum |
|---|---|---|---|---|
| SASS 22 | 6.28 | 23.5 | 8.56 | 73.4 |
| SASS 26 | 6.28 | 21.9 | 8.9 | 70.6 |
| SASS 27A | 8.69 | 24.1 | 8.4 | 103.5 |
| SASS 29 | 1.84 | 19.0 | 9.26 | 19.9 |
| SASS 31 | 3.70 | 21.6 | 8.9 | 41.6 |
| SASS 32 | 3.37 | 23.2 | 8.56 | 39.4 |
| SASS 9 | 7.92 | 21.5 | 8.9 | 89.0 |
| SASS 21 | 3.82 | 21.3 | 8.9 | 42.9 |

- The DO concentrations at most of the sites do not comply with the TWQR (DWAF, 1996) for aquatic ecosystems, only sites SASS 27A and SASS 9 exceed the minimum guideline requirements of 80% saturation;
- DO concentrations of sites SASS 31 and SASS 32 on the Dorpspruit and site SASS 21 on the Paardekraalspruit are significantly lower than the TWQR (DWAF, 1996) for aquatic ecosystems. This is likely due to diffuse and point impacts from the surrounding settlements, from Prison Dam as well as the RPM operations. Some impact on the aquatic community is likely at the time of the assessment;
- The DO concentration recorded at site SASS 29 is critically low at the time of the assessment, thus some impact on the diversity and sensitivity of the aquatic community is likely at this point. The reduced DO at the downstream site SASS 29 is likely as a result of cumulative impacts from other diffuse and point impacts in the larger RPM operations area as this site is located downstream of the confluence with the Dorpspruit, Klipfonteinspruit and Paardekraalspruit;
- Temperatures can be regarded as normal for the time of year when sampling took place.

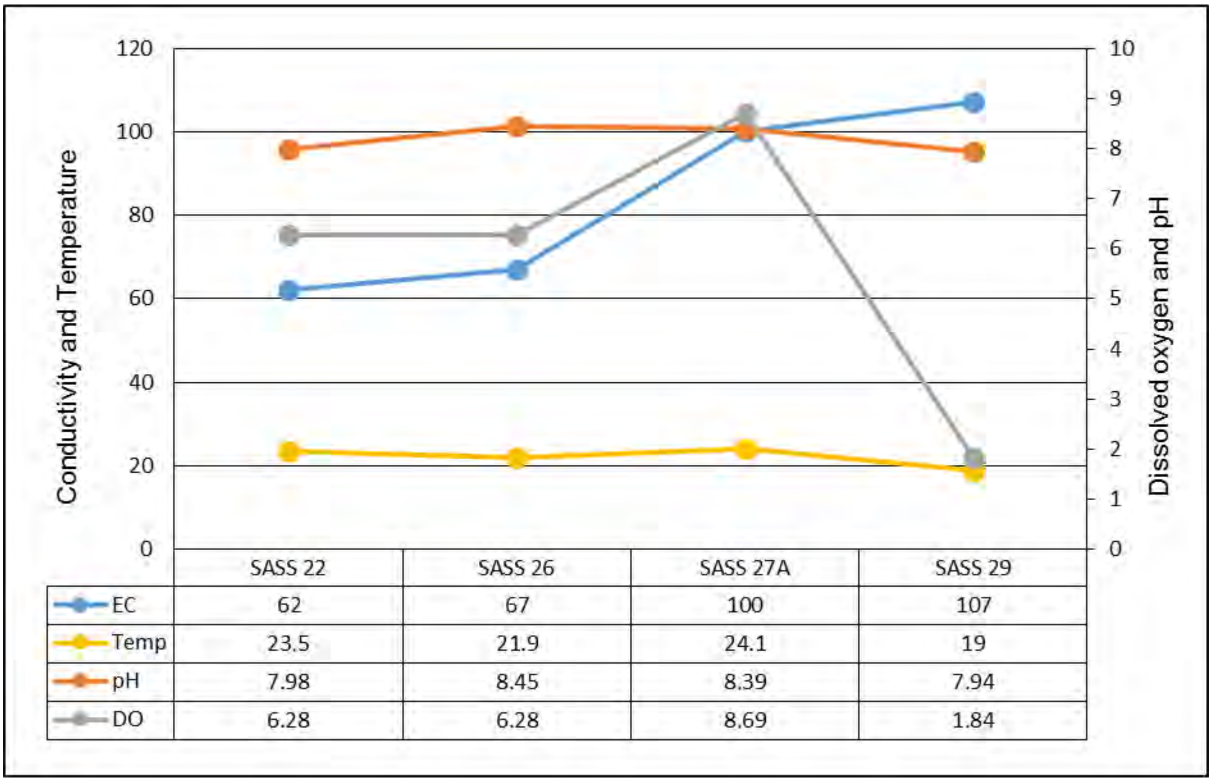



**Figure 62: Spatial variation of the biota-specific water quality of the Hex River monitoring sites.**

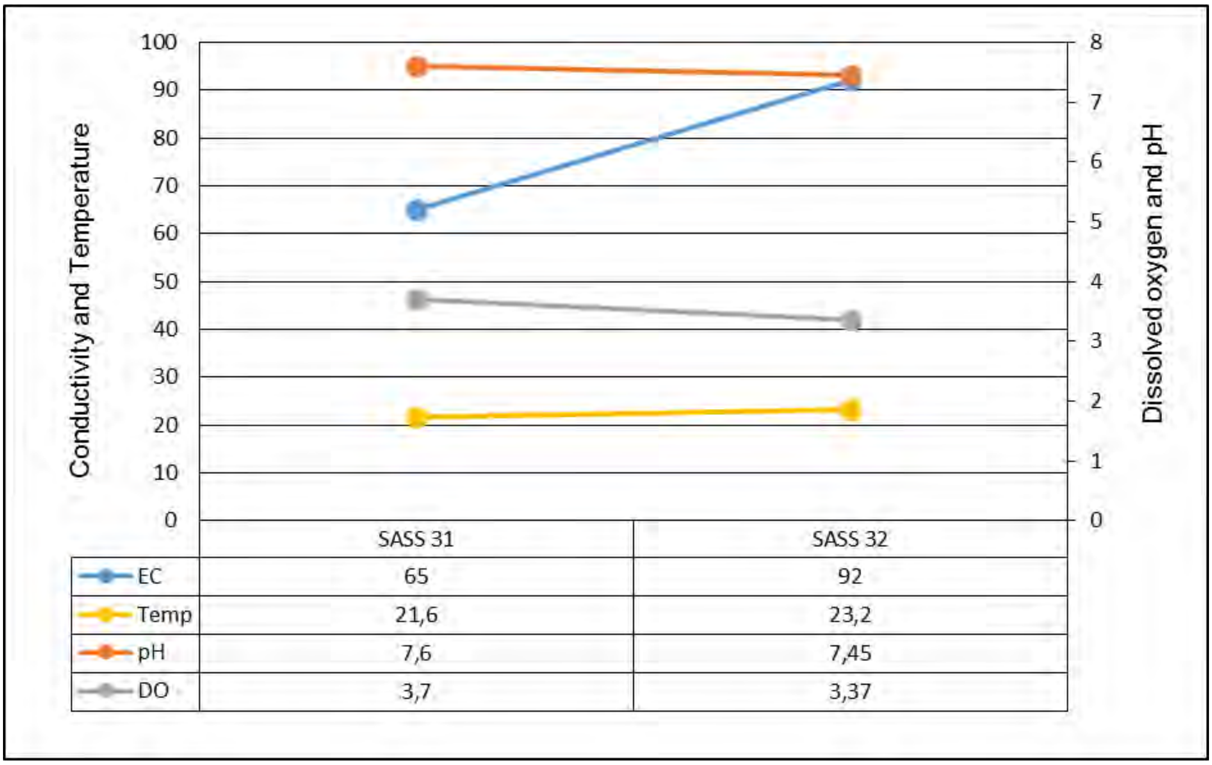



**Figure 63: Spatial variation of the biota-specific water quality of the Dorpspruit monitoring sites.**

## 6.3 Habitat Assessment

### 6.3.1 Invertebrate Habitat Integrity Assessment (IHIA)

An Invertebrate Habitat Integrity Assessment was applied to each of the aquatic systems (Hex River, Dorpspruit, Klipfonteinspruit and Paardekraalspruit). The Wildebeesfonteinspruit, Brakspruit and Hoedspruit systems were not assessed as no aquatic assessments were applied to these systems due to the lack of flowing water at the time of the assessment. Small, moderate, large and serious impacts were recorded for each system (Appendix H).

Small instream zone impacts included exotic aquatic fauna, exotic macrophytes and solid waste disposal within all four aquatic resources. Inundation was recorded as a small impact in the Dorpspruit and Paardekraalspruit but as a moderate impact in the Hex River and Klipfonteinspruit. Flow modification, bed modification and channel modification were considered as large impacts at all aquatic resources. Both water abstraction and water quality were considered serious impacts within the Hex River and Dorpspruit and as large impacts in the Klipfonteinspruit and Paardekraalspruit. No abstraction by RPM is currently taking place from the aquatic systems. The Hex River, Klipfonteinspruit and Paardekraalspruit all achieved a Class D (largely modified) classification for instream habitat integrity, while the Dorpspruit achieved a Class C (moderately modified) classification.

Small riparian zone impacts within the aquatic resources included inundation. Moderate impacts recorded at the sites included water abstraction and flow modification. Large riparian zone impacts included channel modification, indigenous vegetation removal, and exotic vegetation encroachment. Bank erosion was recorded as a serious impact within the Hex River, but as large impacts within the Dorpspruit, Klipfonteinspruit and Paardekraalspruit. Water quality modifications are considered as serious impacts at all sites. The Hex River, Klipfonteinspruit and Paardekraalspruit all achieved a Class D (largely modified) classification for riparian habitat integrity, while the Dorpspruit achieved a Class C (moderately modified) classification.

Overall, for habitat integrity the Hex River scored 57.1% (Class D), the Dorpspruit scored 67.8% (Class C), the Klipfonteinspruit scored 46.9% (Class D), and the Paardekraalspruit scored 59.0% (Class D).

### 6.3.2 Invertebrate Habitat Assessment (IHAS)

Table 102 provides a summary of the results obtained from the application of the IHAS Index to the eight assessment sites. This index determines habitat suitability with particular reference to the requirements of aquatic macro-invertebrates. The results obtained from this assessment will aid in interpreting the SASS data.

- The habitat structure and diversity of the Hex River sites are adequate (SASS 22) and highly suited (SASS 26, 27A and 29) for supporting a diverse and sensitive aquatic community. Spatially the IHAS increased in a downstream direction, as a result species diversity and sensitivity is expected to increase in a downstream direction;
- The habitat structure and diversity of the Dorpspruit can be regarded as adequate for supporting a diverse and sensitive aquatic community at both sites. Spatially the IHAS decreased between the two sites, as a result the species diversity and sensitivity is expected to decrease in a downstream direction;
- The habitat structure and diversity in both the Klipfonteinspruit (SASS 9) and Paardekraalspruit (SASS 21) can be regarded as inadequate for supporting a diverse and sensitive aquatic community.

**Table 102: A summary of the results obtained from the application of an IHAS index to the assessment sites**

| Type of Result | SASS 22 | SASS 26 | SASS 27A | SASS 29 | SASS 31 | SASS 32 | SASS 9 | SASS 21 |
|---|---|---|---|---|---|---|---|---|
| McMillan, 1998 IHAS description | Habitat structure and diversity was adequate for supporting a diverse aquatic macro-invertebrate community. | Habitat structure and diversity was highly suited for supporting a diverse aquatic macro-invertebrate community. | Habitat structure and diversity was highly suited for supporting a diverse aquatic macro-invertebrate community. | Habitat structure and diversity was highly suited for supporting a diverse aquatic macro-invertebrate community. | Habitat structure and diversity was adequate for supporting a diverse aquatic macro-invertebrate community. | Habitat structure and diversity was adequate for supporting a diverse aquatic macro-invertebrate community. | Habitat structure and diversity was inadequate for supporting a diverse aquatic macro-invertebrate community. | Habitat structure and diversity was inadequate for supporting a diverse aquatic macro-invertebrate community. |
| IHAS stones biotopes results | There was good rocky substrate available at this site. | There was good rocky substrate available at this site. | There was good rocky substrate available at this site. | There was limited rocky substrate available at this site. | There was good rocky substrate available at this site. | There was good rocky substrate available at this site. | There was no rocky substrate available at this site. | There was no rocky substrate available at this site. |
| IHAS vegetation biotopes results | Marginal vegetation was present to provide habitat for aquatic macro-invertebrates. | Marginal vegetation was present to provide habitat for aquatic macro-invertebrates. | Both fringing and aquatic vegetation were present to provide habitat for aquatic macro-invertebrates. | Both fringing and aquatic vegetation were present to provide habitat for aquatic macro-invertebrates. | Marginal vegetation was present to provide habitat for aquatic macro-invertebrates. | Marginal vegetation was present to provide habitat for aquatic macro-invertebrates. | Both fringing and aquatic vegetation were present to provide habitat for aquatic macro-invertebrates. | Both fringing and aquatic vegetation were present to provide habitat for aquatic macro-invertebrates. |
| IHAS other biotopes results | Gravel, sand and mud deposits were present at the site. | Gravel, sand and mud deposits were present at the site. | Gravel, sand and mud deposits were present at the site. | Gravel, sand and mud deposits were present at the site. | Gravel, sand and mud deposits were present at the site. | Gravel, sand and mud deposits were present at the site. | Gravel and mud deposits were present at the site. | Gravel and mud deposits were present at the site. |
| IHAS general stream characteristics | A relatively wide stream with low flow at the time of the assessment. The stream is discoloured and exhibited slow flow at this point. Limited bank cover with risk of erosion. | A relatively wide stream with moderate flow at the time of the assessment. The stream is discoloured and exhibited slow flow at this point. Good bank cover with little risk of erosion. | A relatively wide stream with moderate flow at the time of the assessment. The stream is discoloured and exhibited slow flow at this point. Good bank cover with little risk of erosion. | A relatively wide stream with moderate flow at the time of the assessment. The stream is discoloured and exhibited slow flow at this point. Good bank cover with little risk of erosion. | A relatively narrow stream with low flow at the time of the assessment. The stream is discoloured and exhibited slow flow at this point. Limited bank cover with risk of erosion. | A relatively wide stream with low flow at the time of the assessment. The stream is discoloured and exhibited slow flow at this point. Good bank cover with little risk of erosion. | A relatively wide stream with low flow at the time of the assessment. The stream is discoloured and exhibited slow flow at this point. Good bank cover with little risk of erosion. | A relatively narrow stream with low flow at the time of the assessment. The stream is discoloured and exhibited slow flow at this point. Good bank cover with little risk of erosion. |
| IHAS score | 71% | 77% | 75% | 78% | 73% | 67% | 57% | 54% |
| Current IHAS Adjustment score | +17 | +11 | +15 | +12 | +15 | +17 | +29 | +30 |

## 6.4 Aquatic macro-invertebrate community assessment

### 6.4.1 South African scoring system (SASS5)

Tables 103 to 106 provide a summary of the results obtained from the application of the SASS5 and IHAS indices to the sites.

**Table 103: Biotope specific summary of the results obtained from the application of the SASS5 index to the assessment sites of the Hex River**

| PARAMETER | Site | STONES | VEGETATION | GRAVEL, SAND AND MUD | TOTAL |
|---|---|---|---|---|---|
| SASS5 Score | SASS 22 | 30 | 44 | 19 | 47 |
| | SASS 26 | 34 | 61 | 31 | 70 |
| | SASS 27A | 43 | 69 | 24 | 95 |
| | SASS 29 | 14 | 33 | 5 | 40 |
| Taxa | SASS 22 | 7 | 10 | 6 | 11 |
| | SASS 26 | 9 | 14 | 9 | 17 |
| | SASS 27A | 11 | 14 | 8 | 20 |
| | SASS 29 | 5 | 6 | 2 | 9 |
| ASPT | SASS 22 | 4.28 | 4.40 | 3.16 | 4.27 |
| | SASS 26 | 3.78 | 4.36 | 3.44 | 4.12 |
| | SASS 27A | 3.91 | 4.93 | 3.0 | 4.75 |
| | SASS 29 | 2.80 | 5.50 | 2.50 | 4.44 |

**Table 104: A summary of the results obtained from the application of the SASS5 and IHAS indices to the assessment sites of the Hex River**

| Type of Result | SASS 22 | SASS 26 | SASS 27A | SASS 29 |
|---|---|---|---|---|
| Biotopes sampled | Stones, marginal vegetation, gravel, sand and mud. | Stones, marginal and instream vegetation, gravel, sand and mud. | Stones, marginal and instream vegetation, gravel, sand and mud. | Limited stones, marginal and instream vegetation, gravel, sand and mud. |
| Sensitive taxa present | *Aeshnidae* | *Aeshnidae; Naucoridae* | Hydracarina; Aeshnidae; *Ecnomidae;* | *Naucoridae* |
| Sensitive taxa absent | *Ancylidae; Atyidae; Caenidae; Ecnomidae; Gomphidae; Naucoridae* Hydracarina | *Ancylidae; Atyidae; Caenidae; Ecnomidae; Gomphidae;* Hydracarina; | *Ancylidae; Atyidae; Caenidae; Gomphidae; Naucoridae* | *Ancylidae; Atyidae; Caenidae; Ecnomidae; Gomphidae;* Hydracarina |
| SASS5 score | 47 | 70 | 95 | 40 |
| Adjusted SASS5 score | 64 | 81 | 110 | 52 |
| SASS5 % of theoretical reference score* | 39.2% | 58.3% | 79.2% | 33.3% |
| ASPT score | 4.3 | 4.8 | 4.4 | 4.4 |
| ASPT % of theoretical | 76.8% | 85.7% | 78.6% | 78.6% |

| Type of Result | SASS 22 | SASS 26 | SASS 27A | SASS 29 |
|---|---|---|---|---|
| reference score** | | | | |
| Dickens & Graham, 2001 SASS5 classification | Class E: Seriously Modified | Class C: Moderately Modified | Class B: Largely Natural | Class E: Seriously Modified |
| Dallas 2007 classification | Class E/F | Class D | Class C | Class E/F |

***SASS5 reference score = 120 **ASPT reference score = 5.6**

**Table 105: Biotope specific summary of the results obtained from the application of the SASS5 index to the assessment sites located on the Dorpspruit, Klipfonteinspruit and Paardekraalspruit**

| PARAMETER | Site | STONES | VEGETATION | GRAVEL, SAND AND MUD | TOTAL |
|---|---|---|---|---|---|
| SASS5 Score | SASS 31 | 28 | 24 | 22 | 35 |
| | SASS 32 | 15 | 22 | 19 | 36 |
| | SASS 9 | - | 60 | 37 | 60 |
| | SASS 21 | - | 50 | 26 | 50 |
| Taxa | SASS 31 | 6 | 4 | 4 | 8 |
| | SASS 32 | 4 | 7 | 7 | 11 |
| | SASS 9 | - | 12 | 7 | 12 |
| | SASS 21 | - | 11 | 6 | 11 |
| ASPT | SASS 31 | 4.66 | 6.0 | 5.5 | 4.37 |
| | SASS 32 | 3.75 | 3.12 | 2.71 | 3.25 |
| | SASS 9 | - | 5.0 | 5.28 | 5.0 |
| | SASS 21 | - | 4.54 | 4.33 | 4.54 |

**Table 106: A summary of the results obtained from the application of the SASS5 and IHAS indices to the assessment sites located on the Dorpspruit, Klipfonteinspruit and Paardekraalspruit**

| Type of Result | SASS 31 | SASS 32 | SASS 9 | SASS 21 |
|---|---|---|---|---|
| Biotopes sampled | Stones, marginal vegetation, gravel, sand and mud. | Stones, marginal and instream vegetation, gravel, sand and mud. | Marginal and instream vegetation and mud. | Marginal and instream vegetation and mud. |
| Sensitive taxa present | None | None | Aeshnidae; *Gomphidae* | Aeshnidae; *Gomphidae;* |
| Sensitive taxa absent | *Aeshnidae; Ancylidae; Atyidae; Caenidae; Ecnomidae; Gomphidae; Naucoridae*; Hydracarina; | *Ancylidae; Atyidae; Caenidae; Ecnomidae; Gomphidae; Naucoridae;* Hydracarina; | *Ancylidae; Atyidae; Caenidae; Ecnomidae; Naucoridae;* Hydracarina; | *Ancylidae; Atyidae; Caenidae; Ecnomidae; Naucoridae;* Hydracarina; |
| SASS5 score | 35 | 36 | 60 | 50 |
| Adjusted SASS5 | 50 | 53 | 89 | 86 |
| SASS5 % of | 29.2% | 30.0% | 50.0% | 41.7% |

| Type of Result | SASS 31 | SASS 32 | SASS 9 | SASS 21 |
|---|---|---|---|---|
| theoretical reference score* | | | | |
| ASPT score | 4.4 | 3.3 | 5.0 | 4.5 |
| ASPT % of theoretical reference score** | 78.6% | 58.9% | 89.3% | 80.4% |
| Dickens & Graham, 2001 SASS5 classification | Class E: Seriously Modified | Class E: Seriously Modified | Class C: Moderately Modified | Class D: Largely Modified |
| Dallas 2007 classification | Class E/F | Class E/F | Class C | Class D |

***SASS5 reference score = 120 **ASPT reference score = 5.6**

- The upstream (SASS 22) and downstream (SASS 29) sites of the Hex River may be considered to be in a Class E/F (severely impaired) condition according to the Dallas (2007) classification system. Both sites can be classified as a Class E (seriously impaired) conditions according to the Dickens & Graham (2001) classification system. Site SASS 26 can be considered as Class D (largely impaired) according to the Dallas (2007) classification, and as a Class C (moderately impaired) condition according to the Dickens & Graham (2001) classification system. Site SASS 27A can be considered as Class C (moderately impaired) according to the Dallas (2007) classification, and as a Class B (largely natural) condition according to the Dickens & Graham (2001) classification system;
- Spatially between the upstream and the downstream sites of the Hex River, the SASS5 score increased by 48.9% between the SASS 22 and SASS 26 sites, by 35.7% between the SASS 26 and SASS 27A sites, while decreasing by 57.9% between SASS 27A and SASS 29. Overall between the upstream SASS 22 site and the downstream SASS 29 site the SASS5 score decreased by 14.9%. It is clear that the macro-invertebrate diversity increases in a downstream direction on the Hex River, and decreases significantly once the Hex River confluences with the Dorpspruit, Klipfonteinspruit and Paardekraalspruit. This is likely as a result of the increased salt loading and possibly the addition of specific contaminants to the system;
- Spatially the ASPT score increased by 11.6% between sites SASS 22 and SASS 26, and decreased by 8.3% between sites SASS 26 and SASS 27A. The ASPT has remained unchanged between sites SASS 27A and SASS 29. Overall, between sites SASS 22 and SASS 29 the ASPT score has increased slightly by 2.3%, this is likely due to the increased habitat suitability at the downstream site;

- Both the upstream (SASS 31) and downstream (SASS 32) sites of the Dorpspruit may be considered to be in a Class E/F (severely impaired) condition according to the Dallas (2007) classification system. Both sites can be classified as a Class E (seriously impaired) conditions according to the Dickens & Graham (2001) classification system.
- Spatially between the upstream (SASS 31) and downstream (SASS 32) sites of the Dorpspruit, the SASS5 score has increased slightly by 2.9%, while the ASPT score has decreased by 25.0%. The decrease in macro-invertebrate sensitivity is likely due to the increased salt loading and possibly the addition of specific contaminants to the system. This is likely to be partially as a result of the bridge construction activities present at the time of the assessment;
- The SASS 9 site of the Klipfonteinspruit may be considered to be in a Class C (moderately impaired) condition according to the Dallas (2007) classification system. The site can be classified as a Class C (moderately impaired) conditions according to the Dickens & Graham (2001) classification system;
- The SASS 21 site of the Paardekraalspruit may be considered to be in a Class D (largely impaired) condition according to both the Dallas (2007) and Dickens & Graham (2001) classification systems.

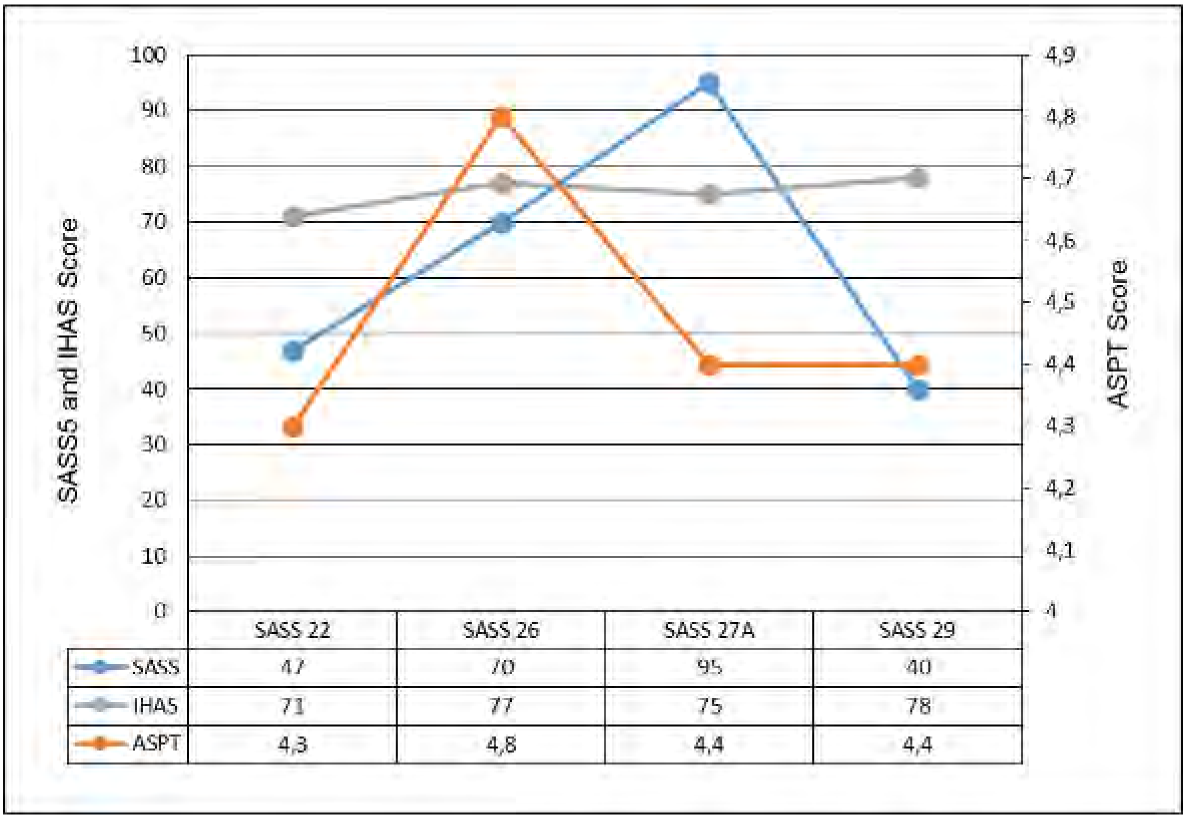



**Figure 64: Spatial variation of the macro-invertebrate community integrity of the Hex River monitoring sites.**

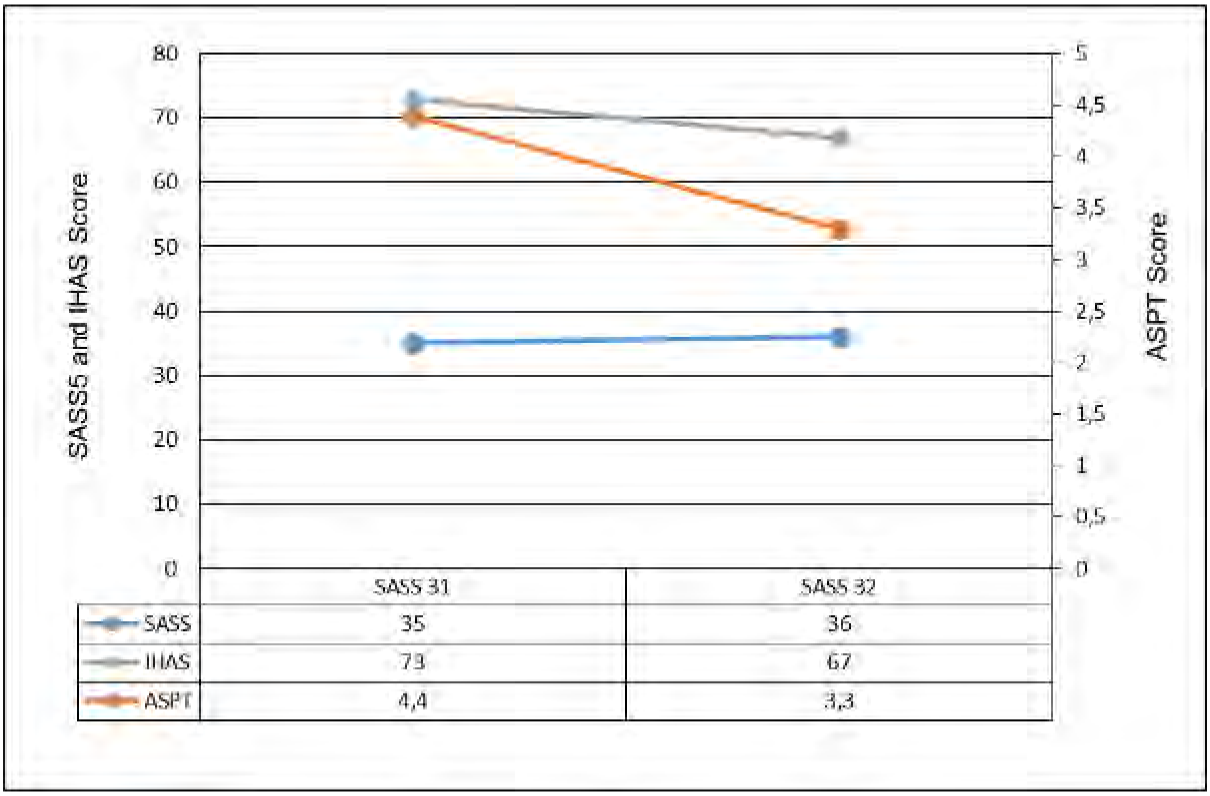



**Figure 65: Spatial variation of the macro-invertebrate community integrity of the Dorpspruit monitoring sites.**

## 6.5 Aquatic Macro-Invertebrates: MIRAI

The number of taxa actually present was expressed as a percentage of the number of taxa expected. The latter list was compiled using the Department of Water and Sanitation (DWS) Resource Quality Services (RQS) PES/EIS database and supplemented with taxa actually collected at the sites assessed. Percentage occurrence for each of the preference variables are tabulated (Table 107).

For the purposes of the MIRAI assessment itself, the percentage of taxa exhibiting flow, habitat and water quality preferences (Table 107) was taken into consideration. Results are tabulated on the next page (Table 108).

**Table 107: Percentage of taxa (actually present expressed as percentage of expected) showing flow, habitat and water quality preferences at each of the sites assessed.**

| Variable | Criteria | Percentage occurrence of taxa showing preferences at each of the sites | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | SASS 22 | SASS 26 | SASS 27A | SASS 29 | SASS 31 | SASS 32 | SASS 9 | SASS 21 |
| Flow | Very Fast (>0.6 m/s) | 66.67 | 66.67 | 100.00 | 100.00 | 66.67 | 66.67 | 0.00 | 33.33 |
| | Moderately Fast (0.3-0.6 m/s) | 25.00 | 75.00 | 50.00 | 50.00 | 25.00 | 25.00 | 75.00 | 75.00 |
| | Slow (0.1-0.3 m/s) | 50.00 | 75.00 | 100.00 | 100.00 | 25.00 | 50.00 | 50.00 | 50.00 |
| | Very Slow (<0.1 m/s) | 28.57 | 42.86 | 57.14 | 57.14 | 14.29 | 37.50 | 62.50 | 62.50 |
| Habitat | Bedrock | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Cobbles | 14.29 | 28.57 | 85.71 | 85.71 | 42.86 | 42.86 | 28.57 | 28.57 |
| | Vegetation | 33.33 | 66.67 | 66.67 | 66.67 | 16.67 | 57.14 | 50.00 | 50.00 |
| | Gravel, Sand, Mud | 25.00 | 25.00 | 50.00 | 50.00 | 25.00 | 25.00 | 25.00 | 25.00 |
| | Water | 60.00 | 80.00 | 60.00 | 60.00 | 40.00 | 20.00 | 66.67 | 66.67 |
| Water quality | High | 0.00 | 0.00 | 100.00 | 100.00 | 100.00 | 0.00 | 50.00 | 50.00 |
| | Moderate | 20.00 | 20.00 | 40.00 | 40.00 | 0.00 | 0.00 | 33.33 | 33.33 |
| | Low | 33.33 | 60.00 | 60.00 | 60.00 | 20.00 | 26.67 | 33.33 | 33.33 |
| | Very Low | 50.00 | 62.50 | 87.50 | 87.50 | 50.00 | 77.78 | 50.00 | 50.00 |

The results obtained after employing the MIRAI are summarised below. For ease of comparison the classifications obtained using SASS5 are also presented in this section.

**Table 108: Summary of the results (ecological categories) obtained from the application of the MIRAI to the assessment sites, compared to classes awarded using SASS5.**

| Variable / Index | SASS 22 | SASS 26 | SASS 27A | SASS 29 | SASS 31 | SASS 32 | SASS 9 | SASS 21 |
|---|---|---|---|---|---|---|---|---|
| Ecological category (MIRAI) | E | D | D | E | E | E | D | D |
| Dickens and Graham (SASS5) | E | C | B | E | E | E | C | D |
| Dallas (SASS5) | E/F | D | C | E/F | E/F | E/F | C | D |

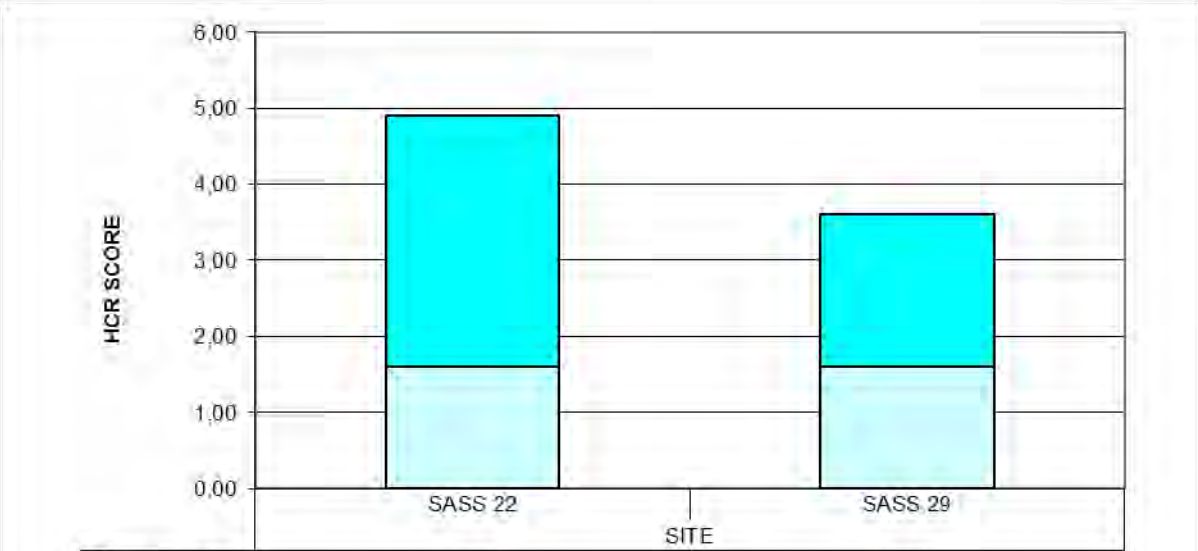
The MIRAI results are similar to those of the SASS5 indices employed, as measured by the Ecological Category classification. A trend of general deterioration from expected natural conditions in terms of macro-invertebrate community integrity is clearly evident. This is due to the modified flow conditions experienced at the time of the assessment, the decreased water quality with special mention of increased salt loading within all the systems and low dissolved oxygen concentrations especially within the Dorpspruit and the limited habitat availability at the Paardekraalspruit and Klipfonteinspruit biomonitoring sites. This general deterioration in integrity is evident at all sites assessed, indicating that the entire system suffers from negative impacts. The aaquatic assessment indicated severely modified conditions that correspond with the PES category median classification of E (DWS RQIS PES/EIS database).

## 6.6 Fish Community Integrity

Figure 66 and tables below serve as a summary of the results obtained at the sites.

### 6.6.1 Habitat Cover Rating (HCR) and Fish Habitat Assessment (FHA)

The Habitat Cover Rating (HCR) results for site SASS 22 and SASS 29 on the Hex River are provided below:




| | SASS 22 | SASS 29 |
|---|---|---|
| Fast – Shallow | 0,00 | 0,00 |
| Fast - Deep | 0,00 | 0,00 |
| Slow - Shallow | 3,30 | 2,00 |
| Slow - Deep | 1,60 | 1,60 |

**Figure 66: HCR scores for Sites SASS 22 and SASS 29.**

Results indicate that slow-shallow conditions dominate the system followed by slow-deep conditions. The fish expected at Sites SASS 22 and SASS 29 will therefore be limited to fish with high intolerance values for fast-flowing water and to a lesser degree, species with a high intolerance value for deep habitats. Based on the HCR ratings, very similar fish species are expected at both sites as a result of the same diversity in depth flow classes present at these points.

### 6.6.2 Fish Response Assessment Index (FRAI)

Table 109 below summarises the fish species sampled at site SASS 22 and SASS 29 with the associated abundance score (AS). Table 110 indicates a summary of the results obtained from the application of the FRAI index to Sites SW1 and SW2.

**Table 109: Fish species collected at site SASS 22 and SASS 29 indicating abundance with natural ranges included in the Hex River (Kleynhans, Louw and Moolman, 2007).**

| SPECIES NAME | NUMBERS OF FISH COLLECTED AT SITES SASS 22 and SASS 29 WITH ASSOCIATED ABUNDANCE SCORE (AS): | | | | | |
|---|---|---|---|---|---|---|
| | SASS 22 | | SASS 29 | | TOTAL | FROC SCORE |
| | No. fish | AS* | No. fish | AS* | | |
| *Barbus paludinosus* | 0 | 0 | 0 | 0 | 0 | 1 |
| *Barbus trimaculatus* | 0 | 0 | 0 | 0 | 0 | 1 |
| *Barbus unitaeniatus* | 0 | 0 | 0 | 0 | 0 | 1 |
| *Clarias gariepinus* | 0 | 0 | 0 | 0 | 0 | 1 |
| *Labeo molybdinus* | 0 | 0 | 0 | 0 | 0 | - |
| *Labeobarbus marequensis* | 0 | 0 | 0 | 0 | 0 | 1 |
| *Oreochromis mossambicus* | 0 | 0 | 0 | 0 | 0 | 1 |
| *Pseudocrenilabrus philander* | 0 | 0 | 0 | 0 | 0 | 1 |
| *Tilapia Sparrmanii* | 0 | 0 | 0 | 0 | 0 | 1 |

*1 to 5 fish = 1; 6 to 15 fish = 2; 16 to 30 fish = 3

The table below serves as a summary of the results obtained at each site.

**Table 110: A summary of the results obtained from the application of the FRAI index to the sites.**

| | SASS 22 | SASS 29 |
|---|---|---|
| Habitat and cover | The habitat available to fish at this site is inadequate. Cover is present in the form of slow shallow and to a lesser extent, slow deep muddy substrate. Very limited amounts of overhanging bankside vegetation are present and some undercut root wads are present due to bank incision. | Slightly better habitat for fish is available at this site in relation to the habitat at site SASS 22. Similarly, cover is present in slow shallow and slow deep muddy substrate, although slightly larger amounts of overhanging bankside vegetation, instream vegetation and undercut banks are present in the slow deep areas providing more cover for fish at this point. |
| Species present | *None* | *None* |
| Health and condition | N/A | N/A |
| FRAI Score | 11.3 | 11.3 |
| FRAI EC (Kleynhans and Louw 2007). | F (Critically Modified) | F (Critically Modified) |

**N/A=Non-Applicable; EC = Ecological Category.**

- Results indicate that the fish integrity at both the upstream and downstream sites are currently in a critically modified state (Class F);
- The absence of a fish community at both sites is likely due to poor water quality as a result of high dissolved salt concentrations observed at these points. The shallow

water and lack of cover in the muddy substrate observed in the system during the current assessment is also deemed likely to have had an impact on the presence and distribution of the fish at both sites;

- Some restriction on the fish community may be present due to these habitat and water quality limitations with species relying on cleaner, deeper water and vegetative cover being limited; and
- Upstream and downstream migration barriers on the Hex River may also affect the fish diversity along this section of the river, although the natural variation in distribution patterns, as well as seasonal variation in fish movement in the system may also be influencing the absence of fish in this section of the catchment.

# 7 IMPACT STATEMENT

Long linear ecosystems, rivers and streams are particularly vulnerable to fragmentation. A number of human activities can disrupt the continuity of river and stream ecosystems. There is growing concern about the role of road crossings, and especially culverts, in altering habitats and disrupting river and stream continuity.

Road crossings can affect river and stream ecosystems through the loss and degradation of habitats and by disrupting ecological processes that structure and maintain these systems over time. The movement of organisms within rivers and streams is an important ecological process that can be significantly affected by road crossings.

## *7.1 RIPARIAN ZONE: Current Impacts on River and Stream Crossings within the RPM Boundary*

**Habitat Loss and Degradation**

Construction related activities, such as vegetation clearing and excavations usually results in the disturbance of the soil profile and disturbance of vegetation communities. Currently, riparian habitat integrity has already undergone significant transformation and furthermore, continuous disturbance of vegetation and soils within the immediate vicinity of the road crossings will result in loss of habitat and ecological structure should mitigation measures not be implemented. Therefore, the area will be rendered incompatible to support species that inhabit the area.

**Impacts on stream diversions**

Vegetation clearing and canalisation for stream flow diversions might result in erosion along the banks especially at the inlet and outlet points. Furthermore, this alters the natural state as well as the flow pattern of the features. Disturbance of vegetation along these points will result in the proliferation of alien vegetation species and also change the vegetation composition along the river and the adjacent terrestrial areas. In addition, this activity will lower ecosystem service provision of the features. Due to the meandering design of the diversions, stormwater attenuation and stream flow capacities will be enhanced.

**Erosion and Sedimentation**

Impacts due to canalisation and trampling are significant and have the potential to affect the hydrological functioning and sediment balance of the systems. An important cause of impact can be increased water input within the riparian features leading to destabilization of river banks and resulting in sediment deposition within the systems. Sediment load can alter soil profile and channel character. In addition, waste dumping and deposition of fine sediment particles can alter water quality and also cause turbidity in the water, thus impacting on taxa requiring fast clear flowing water free of suspended solids.

**Stream Hydrology**

Structures such as weirs and culverts can alter and/constrict water flow within the stream. In addition, the presence of these structures increases the width and depth of the stream, thus modifying the geomorphology of the area. Construction can scour streambeds and also lead to susceptibility of the soils to erosion, which might lead to the collapse of supporting structures. Furthermore, these collapsed structures result in migration barriers and causes a change in drainage patterns. Specific examples of such structures altering flow patterns in the study are exposed pipes, waste rock, concrete slabs and other debris and deteriorating tar roads.

**Alteration of Ecological Processes**

Obstruction of water flow might lead to a significant impact on the functioning and the integrity of the systems. During low flow periods, there might be retention of water upstream of the crossing and less water being carried to downstream areas. As a result, this will affect the survival of faunal and floral species inhabiting the stream, and might lead to their extinction in the system. Disturbances in the vicinity of the crossings, leads to change in the provision of ecological services. Functions such as the toxicant assimilation and sediment trapping and biodiversity maintenance depend mainly on the vegetation cover. In cases where vegetation is disturbed or removed, the system's capacity to perform these functions will then be threatened.

**Water Quality**

Landuse activities within the catchment contribute to the alteration of water quality within watercourses. Waste dumping at crossings as well as leaking pipes and runoff and seepage from mining areas are the main activities that contaminates soils and water. Furthermore, other potential influences on water quality are sedimentation and runoff from the neighbouring communities. In addition, stockpiling of residues from the operations may lead to the deposition of contaminants within watercourses during rainfall events. Discharging effluent from mining areas increases water input within watercourses, and might result in excessive flooding of the areas in close proximity of these water courses.

## *7.2 Prioritization of intervention*

The following points summarise interventions that need to be prioritized during rehabilitation of the affected areas:

- Leaking pipelines can be divided into low priority and high priority in terms of the contents that they convey. Pipelines conveying portable and raw water can be regarded as low priority, whereas pipelines conveying process water and tailings should be regarded as high priority and requires immediate intervention. Damaged and leaking pipelines should be replaced as a matter of urgency;
- Collapsed culverts must be reconstructed immediately to enhance and maintain the flow of water as well as migration corridors;
- Implement effective waste removal measures below culverts and along streams to avoid further deterioration of water quality within streams;
- Clogged culverts that interrupts the flow of water due to high sediment load deposition and waste dumping must be desilted to enhance water flow; and
- Eroded areas along the structures should be revegetated and alien species eradicated.

## *7.3 Mitigation Measures*

- Sensitivity maps have been developed for the study area, indicating the drainage lines and riparian systems, and their relevant buffer zones as shown in Figures 42 to 46 of Section 4.9. It is recommended that this sensitivity map be considered during rehabilitation, to aid in the conservation of wetland and aquatic habitat and resources within the study area;

- A minimum buffer of 100m around all riparian systems should be maintained in line with the requirements of Regulation GN704 of the NWA wherever possible;
- Any areas where bank failure is observed, due to the effects of bridge crossings, should be immediately repaired by reducing the gradient of the banks to a 1:3 slope and where deemed necessary, installing support structures;
- Reconstruct collapsed roads and culverts and remove debris from the area;
- Regularly desilt all clogged culverts and clean up litter below bridges. Communities must be urged not to litter and only use municipal waste sites to dump waste;
- Edge effects of activities, particularly erosion and alien/weed control need to be strictly managed;
- To prevent further erosion of soils, management measures may include berms, soil traps, hessian curtains and stormwater diversion away from areas particularly susceptible to erosion;
- Clear out any overgrown or alien vegetation reducing the flow of water within the watercourses. During the removal of alien and weed species care should be taken with the choice of herbicide to ensure that no additional impact and loss of indigenous plant species occurs due to the herbicide used. The alien vegetation removal process must comply with existing legislation (amendments to the regulations under the Conservation of Agricultural Resources Act, 1983 and Section 28 of the National Environmental Management Act, 1998);
- Stabilisation of river banks in the vicinity of any bridge crossings over riparian or ephemeral drainage line resources by employing one of the individual techniques below or a combination thereof, is essential, given the inherent susceptibility of the soils to erosion. Such measures include:
  - Re-sloping of banks to a maximum of a 1:3 slope;
  - Revegetation of re-profiled slopes;
  - Temporary stabilisation of slopes using geotextiles; and
  - Installation of gabions and reno mattresses.
- Monitor all areas for erosion and incision, particularly any riparian/wetland crossings. Any areas where erosion is occurring excessively quickly should be rehabilitated as quickly as possible and in conjunction with other role players in the catchment;
- Rehabilitate all drainage line and riparian habitat areas to ensure that the ecology of these areas is re-instated during all phases;

- As far as possible, all rehabilitation activities should occur in the low flow season, during the drier winter months; and
- As much indigenous vegetation growth as possible should be promoted in the vicinity of the crossings in order to protect soils.

## 7.4 CONCLUSION

For a system to be able to function and provide ecological services appropriately, it has to be in a good ecological state. The presence of structures (e.g. weirs and culverts), as well as land use activities such as mining and grazing alters the integrity of the watercourses and affects service provision. Therefore, since these structures are permanent, monitoring and rehabilitation measures should be implemented to reduce and enhance the condition of the area in the vicinity of the structures. Currently, the watercourses within the study area have been moderately to largely modified, with only a few that have been seriously modified. However, most of them are still able to provide ecological services at moderately low levels.

## 7.5 AQUATICS: Current Impacts of River and Stream Crossings within the RPM Boundary

**Habitat Loss and Degradation**

Replacement of natural streambed and banks with an artificial crossing structure will usually result in the loss of some habitat value. Culvert crossings provide very little habitat within the culvert. Some habitat can be provided if the culvert is sufficiently embedded such that the substrate in the culvert resembles that in the natural streambed.

**Figure 67: Culvert Bridge indicating the artificial habitat within the structure.**

### Erosion and Sedimentation

Erosion and sedimentation are two significant impacts of road crossings. Some of this may occur during construction if best management practices (BMPs) are not used or during operation if the design and post construction rehabilitation are inadequate to minimise the erosion potential. Use of the system by people and livestock may also contribute to erosion and sedimentation. Sedimentation degrades river and stream habitats by increasing suspended solids in the water and altering downstream substrate and channel characteristics. Increased turbidity in the water can adversely affect visual predators and increase the amount of inorganic particles (relative to organic particles) available to filter feeders downstream.


**Figure 68: Erosion and Sedimentation evident at crossings within the RPM boundary.**

**Stream Hydrology**

Crossings may also have hydraulic effects on stream systems. Where crossings constrict the stream or river, water typically ponds upstream and may result in the accumulation of sediment above the crossings. At crossing outlets, increased velocities caused by the constriction can scour streambeds, creating scour pools and removing all but the coarsest substrate from channels. Scouring may undermine the culvert structure and is also likely to result in drops at culvert outlets that function as barriers to animal movement.

**Figure 69: Culvert Bridge indicating the scouring and undermining of the Culvert structure resulting in altered stream hydrology.**

**Alteration of Ecological Processes**

Depending on the degree to which road crossings constrict the river or stream channel, crossing structures can change the hydrology of the system by increasing the retention time of water upstream of the crossing. The more crossings on a particular river or stream the greater the potential impact on hydrology. With changes in hydrology may come changes in sediment transport (bed loading) and natural scouring of the channel during storm events or floods.

Large, woody debris is an important component of stream ecosystems. Where crossing structures restrict the ability of woody debris to pass downstream, crossings can inhibit or prevent the formation of natural debris dams and deflectors that are important habitat features for fish and wildlife, and play an important role in shaping channel characteristics.

**Figure 70: Blockages present at monitoring sites, restricting movement of debris downstream.**

**Migration Barriers**

The movement of organisms within rivers and streams is an important ecological process that can be significantly affected by road crossings. There are a variety of ways that crossing structures can impede or prevent the movement of animals:

- **Inlet or outlet drop.**

- Elevation drops at either the inlet or outlet of a crossing structure can represent physical barriers to many animal species. Piping (water flowing through the fill material rather than the culvert) and scouring can result in culverts that are perched above the stream channel making passage impossible for most aquatic species.

➢ **Physical barriers**.

- Animal movement can be blocked by clogged or collapsed culverts. Also, weirs or baffles associated with crossing structures can create barriers for some species.

➢ **Excessive turbulence.**

- Flow contraction at the inlet can create turbulence that inhibits or prevents animal passage.

➢ **Insufficient water depth.**

- Absence of a low-flow channel can result in water depths too shallow to allow passage for fish or other organisms.

➢ **Discontinuity of channel substrate.**

- Crossing structures that lack any natural substrate or contain substrates that contrast with the natural stream channel create discontinuities in streambed habitats. Many benthic (streambed-dwelling) organisms are confined to the streambed and can only move through appropriate substrates. Streambed discontinuities caused by crossing structures disrupt and fragment populations of these benthic organisms.

**Figure 71: Culvert Bridge indicating elevation drops at biomonitoring sites.**

**Figure 72: Discontinuity of natural stream substrate and physical migration barriers present at monitoring sites.**

**Water Quality**

Contamination of surface water may be due to inadequate handling, storage and disposal of process and mine water, hazardous waste, hydrocarbons and other substances. Excess mine water has the potential to contribute to dam overflows as the return water dams are not designed to cater for excess water. Surface water contamination in the RPM operations boundary can also be attributed to sources other than the RPM operations, for example various non-mining related non-point sources of pollution are suspected in contributing towards the organic and nutrient loads of the Hex River either directly or via the Paardekraalspruit, Klipgatspruit, Klipfonteinspruit and Dorpspruit. These include formal and informal settlements, livestock farming, agriculture, sewage treatment works, illegal dumping and industrial activities. Stormwater runoff from the road surface may contain contaminants that are toxic to aquatic organisms.

**Figure 73: Leaking pipes within the RPM operations boundary.**

**Figure 74: Leaking pipes within the RPM operations boundary and broken pipes within the rural residential area.**

## 7.6 Mitigation Measures

With mitigation the severity of the impacts can be significantly reduced leading to an overall improvement of the aquatic resources within the RPM operations boundary:

- Any areas where bank failure is observed, due to the effects of bridge crossings, should be immediately repaired by reducing the gradient of the banks to a 1:3 slope and where deemed necessary, installing support structures;
- Stabilisation of river banks in the vicinity of any bridge crossings over riparian or ephemeral drainage line resources by employing one of the individual techniques below or a combination thereof, is essential, given the inherent susceptibility of the soils to erosion. Such measures include:
  - Re-sloping of banks to a maximum of a 1:3 slope;
  - Revegetation of re-profiled slopes;
  - Temporary stabilisation of slopes using geotextiles; and
  - Installation of gabions and reno mattresses.
- To prevent the further erosion of soils, management measures may include berms, soil traps, hessian curtains and stormwater diversion away from areas particularly susceptible to erosion;
- Tend to bridge crossings that affect migration of aquatic fauna;
- Conduct regular inspections and implement follow up actions to clear out any silt build-up within culverts and bridge crossings before it blocks the flow of water;
- Conduct regular inspections to remove litter and illegally dumped waste from culverts and bridge crossings to insure that it does not reduce the flow of the watercourse;

- Clear out any overgrown or alien vegetation reducing the flow of water within the watercourse; and
- Conduct regular inspections to maintain the overall conditions of the crossing structures.

## 7.7 CONCLUSION

Based on the findings of this study, it can be concluded that the aquatic resources within the study area are moderately to seriously modified. The RPM operations may potentially impact on these resources with reference to dissolved salt concentration, sedimentation and possible introduction of specific contaminants. However, prior to impact from any RPM activities, the aquatic resources are already impacted upon by other diffuse and point sources within the larger study area, and potential impact from the RPM activities are difficult to quantify. The crossings within the RPM operations boundary have affected the river and stream ecosystems through the loss and degradation of habitats and by disrupting ecological processes that structure and maintain these systems over time.

# 8 RECOMMENDATIONS

The following recommendations were drawn upon completion of the aquatic assessment:

- Regular physico-chemical monitoring of aquatic resources in the vicinity of the RPM operations must be implemented in order to keep track of water quality. Close investigation and monitoring of the electrical conductivity (EC) levels, pH and oxygen levels of surface water bodies in the area is advised;
- No water from any RPM process activities should be allowed to enter into the receiving aquatic environment;
- Definitive testing on all four trophic levels is strongly recommended if discharge is expected to occur at any time. The definitive tests will allow the required dilution volumes to be determined to prevent an acute toxicological risk to the receiving aquatic environment. It is further recommended that the definitive toxicity testing be run according to the direct estimation of Ecological Effect Potential (DEEEP) as advocated by the Department of Water and Sanitation (DWS);
- It is recommended that ongoing aquatic ecological monitoring take place on a 6 monthly basis by an SA RHP Accredited assessor;
- Results should be compared spatially and temporally to the results of this document. If it is observed through biomonitoring information that significant negative changes

are taking place in ecological integrity (Change of Class), it should be taken as an indication that the system is suffering stress and mitigatory actions should be identified and where possible implemented;

- Conduct regular inspections at all crossings and diversions and implement follow up actions to clear out silt build-up, debris, litter and dumped waste within culverts and bridge crossings before these block the flow of water;
- Bridge crossings to insure that it does not reduce the flow of the watercourse;
- Clear out any overgrown or alien vegetation reducing the flow of water within the watercourse; and
- Conduct regular inspections and routine maintenance to maintain the overall conditions of the crossing structures.

# 9 REFERENCES

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# APPENDIX A: METHOD OF ASSESSMENT

The sections below describe the methodology used to assess the aquatic ecological integrity of the various sites based on water quality, instream and riparian habitat condition and biological impacts and integrity.

The ecological category (EC) classification for each aspect of ecology and habitat analyses will be employed using the eco-status A to F continuum approach (Kleynhans and Louw 2007) where applicable. This approach allows for boundary categories denoted as B/C, C/D etc., as illustrated in Figure 75.


**Figure 75: Ecological categories (EC) eco-status A to F continuum approach employed (Kleynhans and Louw 2007)**

## *A1 Literature Review*

A desktop study was compiled with all relevant information as presented by the South African National Biodiversity Institutes (SANBI's) Biodiversity Geographic Information Systems (BGIS) website (http://bgis.sanbi.org). Wetland specific information resources taken into consideration during the desktop assessment of the study area included:

- National Freshwater Ecosystem Priority Areas (NFEPAs, 2011)
- NFEPA water management area (WMA)
- FEPA (sub)WMA % area
- Sub water catchment area FEPAs
- Water management area FEPAs
- Fish sanctuaries
- Wetland ecosystem types
- Threatened Terrestrial Ecosystems for South Africa, 2009
- National Protected Area Expansion Strategy, 2011
- Mpumalanga Biodiversity Sector Plan, 2014
- Mining and Biodiversity Guidelines, 2013

### a National Freshwater Ecosystem Priority Areas (NFEPA; 2011)

The NFEPA project is a multi-partner project between the Council of Scientific and Industrial Research (CSIR), Water Research Commission (WRC), South African National Biodiversity Institute (SANBI), Department of Water Affairs (DWA), now DWS, South African Institute of Aquatic Biodiversity (SAIAB) and South African National Parks (SANParks). The project responds to the reported degradation of freshwater ecosystem condition and associated biodiversity, both globally and in South Africa. It uses systematic conservation planning to provide strategic spatial priorities of conserving South Africa's freshwater biodiversity, within the context of equitable social and economic development.

The NFEPA project aims to identify a national network of freshwater conservation areas and to explore institutional mechanisms for their implementation. Freshwater ecosystems provide a valuable, natural resource with economic, aesthetic, spiritual, cultural and recreational value. However, the integrity of freshwater ecosystems in South Africa is declining at an alarming rate, largely as a consequence of a variety of challenges that are practical (managing vast areas of land to maintain connectivity between freshwater ecosystems), socio-economic (competition between stakeholders for utilisation) and institutional (building appropriate governance and co-management mechanisms).

The NFEPA database was searched for information in terms of conservation status of rivers, wetland habitat and wetland features present within the study area.

## *A2 Riparian Assessment*

### a Classification System for Wetlands and other Aquatic Ecosystems in South Africa

All wetland or riparian features encountered within the study area were assessed using the Classification System for Wetlands and other Aquatic Ecosystems in South Africa. User Manual: Inland Systems, hereafter referred to as the "classification system" (Ollis *et al*., 2013). A summary of Levels 1 to 4 of the classification system are presented in Table 111 and 112, below.

**Table 111: Proposed classification structure for Inland Systems up to Level 3.**

| WETLAND / AQUATIC ECOSYSTEM CONTEXT | | |
|---|---|---|
| LEVEL 1:<br>SYSTEM | LEVEL 2:<br>REGIONAL SETTING | LEVEL 3:<br>LANDSCAPE UNIT |
| Inland Systems | DWA Level 1 Ecoregions<br>OR<br>NFEPA WetVeg Groups<br>OR<br>Other special framework | Valley Floor |
| | | Slope |
| | | Plain |
| | | Bench<br>(Hilltop / Saddle / Shelf) |

**Table 112: Hydrogeomorphic (HGM) Units for the Inland System showing the primary HGM Types at Level 4A and the subcategories at Level 4B to 4C.**

| FUNCTIONAL UNIT | | |
|---|---|---|
| LEVEL 4:<br>HYDROGEOMORPHIC (HGM) UNIT | | |
| *HGM type* | Longitudinal zonation/ Landform / Outflow drainage | Landform / Inflow drainage |
| A | B | C |
| River | Mountain headwater stream | Active channel |
| | | Riparian zone |
| | Mountain stream | Active channel |
| | | Riparian zone |
| | Transitional | Active channel |
| | | Riparian zone |
| | Upper foothills | Active channel |
| | | Riparian zone |
| | Lower foothills | Active channel |
| | | Riparian zone |
| | Lowland river | Active channel |
| | | Riparian zone |
| | Rejuvenated bedrock fall | Active channel |
| | | Riparian zone |
| | Rejuvenated foothills | Active channel |
| | | Riparian zone |
| | Upland floodplain | Active channel |
| | | Riparian zone |
| Channelled valley-bottom wetland | (not applicable) | (not applicable) |
| Unchannelled valley-bottom wetland | (not applicable) | (not applicable) |
| Floodplain wetland | Floodplain depression | (not applicable) |
| | Floodplain flat | (not applicable) |
| Depression | Exorheic | With channelled inflow |
| | | Without channelled inflow |
| | Endorheic | With channelled inflow |
| | | Without channelled inflow |
| | Dammed | With channelled inflow |
| | | Without channelled inflow |
| Seep | With channelled outflow | (not applicable) |
| | Without channelled outflow | (not applicable) |

| FUNCTIONAL UNIT | | |
|---|---|---|
| LEVEL 4:<br>HYDROGEOMORPHIC (HGM) UNIT | | |
| *HGM type* | Longitudinal zonation/ Landform / Outflow drainage | Landform / Inflow drainage |
| A | B | C |
| Wetland flat | (not applicable) | (not applicable) |

## b Level 1: Inland systems

From the classification system, Inland Systems are defined as aquatic ecosystems that have no existing connection to the ocean[2] (i.e. characterised by the complete absence of marine exchange and/or tidal influence) but which are inundated or saturated with water, either permanently or periodically. It is important to bear in mind, however, that certain Inland Systems may have had an historical connection to the ocean, which in some cases may have been relatively recent.

## c Level 2: Ecoregions

For Inland Systems, the regional spatial framework that has been included at Level 2 of the classification system is that of DWAF's Level 1 Ecoregions for aquatic ecosystems (Kleynhans *et al.,* 2005). There are a total of 31 Ecoregions across South Africa, including Lesotho and Swaziland (figure below). DWAF Ecoregions have most commonly been used to categorise the regional setting for national and regional water resource management applications, especially in relation to rivers.

## d Level 2: NFEPA Wet Veg Groups

The Vegetation Map of South Africa, Swaziland and Lesotho (Mucina & Rutherford, 2006) groups vegetation types across the country according to Biomes, which are then divided into Bioregions. To categorise the regional setting for the wetland component of the NFEPA project, wetland vegetation groups (referred to as WetVeg Groups) were derived by further splitting Bioregions into smaller groups through expert input (Nel *et al*., 2011). There are currently 133 NFEPA WetVeg Groups. It is envisaged that these groups could be used as a special framework for the classification of wetlands in national- and regional-scale conservation planning and wetland management initiatives.

[2] Most rivers are indirectly connected to the ocean via an estuary at the downstream end, but where marine exchange (i.e. the presence of seawater) or tidal fluctuations are detectable in a river channel that is permanently or periodically connected to the ocean, it is defined as part of the estuary.

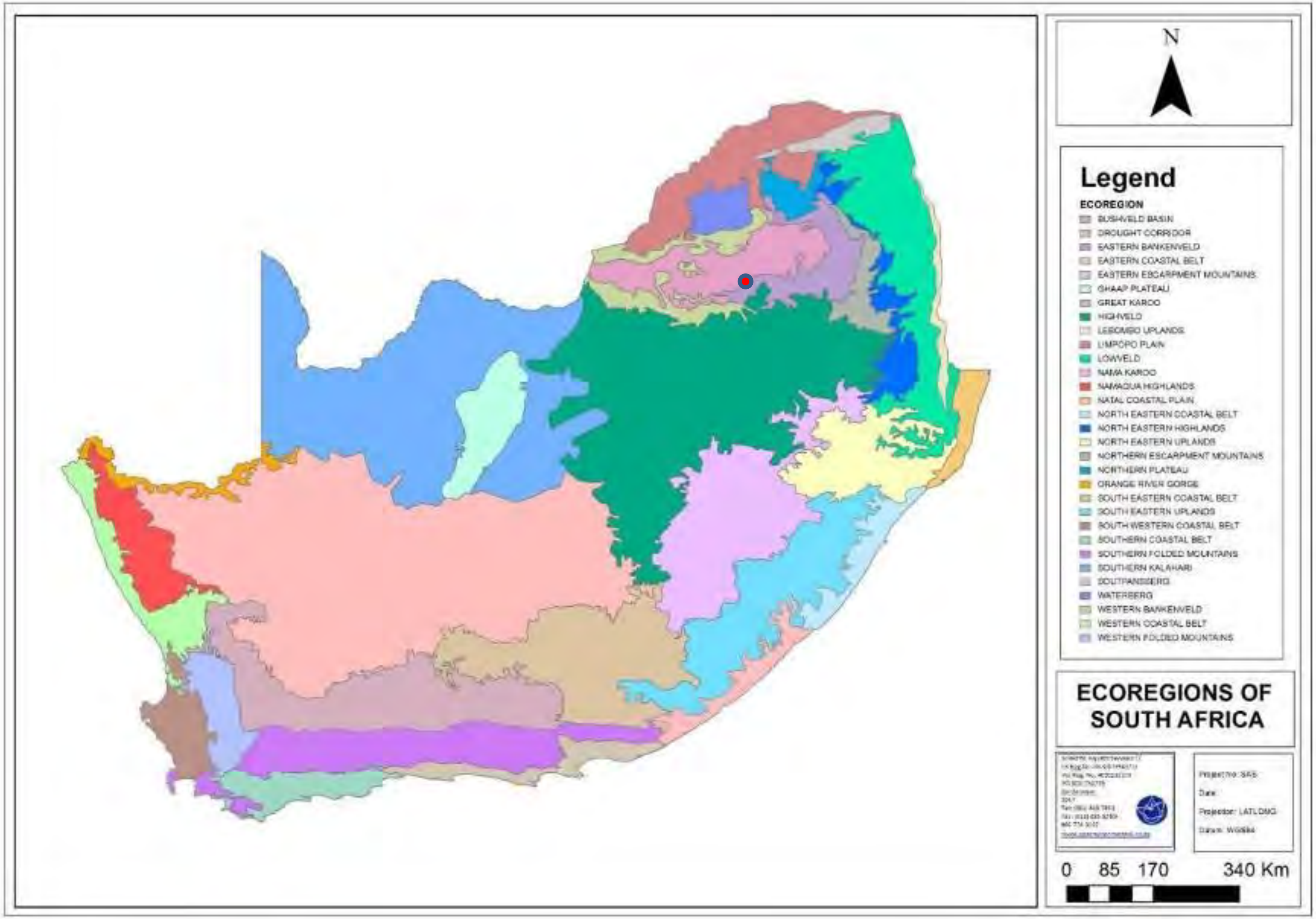


**Figure 76: Map of Level 1 Aquatic Ecoregions of South Africa, with the approximate position of the study area indicated in red.**

### e Level 3: Landscape Setting

At Level 3 of the proposed classification System, for Inland Systems, a distinction is made between four Landscape Units (Table 111) on the basis of the landscape setting (i.e. topographical position) within which an HGM Unit is situated, as follows (Ollis *et al.,* 2013):

- **Slope:** an included stretch of ground that is not part of a valley floor, which is typically located on the side of a mountain, hill or valley.
- **Valley floor:** The base of a valley, situated between two distinct valley side-slopes.
- **Plain:** an extensive area of low relief characterised by relatively level, gently undulating or uniformly sloping land.
- **Bench (hilltop/saddle/shelf):** an area of mostly level or nearly level high ground (relative to the broad surroundings), including hilltops/crests (areas at the top of a mountain or hill flanked by down-slopes in all directions), saddles (relatively high-lying areas flanked by down-slopes on two sides in one direction and up-slopes on two sides in an approximately perpendicular direction), and shelves/terraces/ledges (relatively high-lying, localised flat areas along a slope, representing a break in slope with an up-slope one side and a down-slope on the other side in the same direction).

### f Level 4: Hydrogeomorphic Units

Seven primary HGM Types are recognised for Inland Systems at Level 4A of the classification system (Table 112), on the basis of hydrology and geomorphology (Ollis *et al*., 2013), namely:

- **River:** a linear landform with clearly discernible bed and banks, which permanently or periodically carries a concentrated flow of water.
- **Channelled valley-bottom wetland:** a valley-bottom wetland with a river channel running through it.
- **Unchannelled valley-bottom wetland:** a valley-bottom wetland without a river channel running through it.
- **Floodplain wetland:** the mostly flat or gently sloping land adjacent to and formed by an alluvial river channel, under its present climate and sediment load, which is subject to periodic inundation by over-topping of the channel bank.
- **Depression:** a landform with closed elevation contours that increases in depth from the perimeter to a central area of greatest depth, and within which water typically accumulates.

- **Wetland Flat:** a level or near-level wetland area that is not fed by water from a river channel, and which is typically situated on a plain or a bench. Closed elevation contours are not evident around the edge of a wetland flat
- **Seep:** a wetland area located on (gently to steeply) sloping land, which is dominated by the colluvial (i.e. gravity-driven), unidirectional movement of material down-slope. Seeps are often located on the side-slopes of a valley but they do not, typically, extend into a valley floor.

The above terms have been used for the primary HGM Units in the classification system to try and ensure consistency with the wetland classification terms currently in common usage in South Africa. Similar terminology (but excluding categories for "channel", "flat" and "valleyhead seep") is used, for example, in the recently developed tools produced as part of the Wetland Management Series including WET-Health (Macfarlane *et al*., 2008), WET-IHI (DWAF, 2007) and WET-EcoServices (Kotze *et al*., 2009).

## A3. Riparian Vegetation Response Assessment Index (VEGRAI)

Riparian vegetation is described in the NWA (Act No 36 of 1998) as follows: 'riparian habitat' includes the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterised 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.

The Riparian Vegetation Response Assessment Index (VEGRAI) is designed for qualitative assessment of the response of riparian vegetation to impacts in such a way that qualitative ratings translate into quantitative and defensible results[3]. Results are defensible because their generation can be traced through an outlined process (a suite of rules that convert assessor estimates into ratings and convert multiple ratings into an Ecological Category (ECat)).

**Table 113: Descriptions of the A-F ecological categories.**

| Ecological category | Description | Score (% of total) |
|---|---|---|
| A | Unmodified, natural. | 90-100 |
| B | Largely natural with few modifications. A small change in natural habitat and biota may have taken place but the ecosystem functions are essentially unchanged. | 80-89 |
| C | Moderately modified. Loss and change of natural habitat have occurred, but the basic ecosystem functions are still predominately unchanged. | 60-79 |
| D | Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred. | 40-59 |

~~Kleynhans et al, 2007~~

| Ecological category | Description | Score (% of total) |
|---|---|---|
| E | Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive. | 20-39 |
| F | 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. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible | 0-19 |

## *A4 Index of Habitat Integrity (IHI)*

To assess the PES of the wetland and riparian features, the IHI for South African floodplain and channelled valley bottom wetland types (Department of Water Affairs and Forestry Resource Quality Services, 2007) was used.

The WETLAND-IHI is a tool developed for use in the National Aquatic Ecosystem Health Monitoring Programme (NAEHMP), formerly known as the River Health Programme (RHP). The WETLAND-IHI has been developed to allow the NAEHMP to include floodplain and channelled valley bottom wetland types to be assessed. The output scores from the WETLAND-IHI model are presented in A-F ecological categories (table below), and provide a score of the PES of the habitat integrity of the riparian system being examined.

**Table 114: Descriptions of the A-F ecological categories (after Kleynhans, 1996, 1999).**

| Ecological Category | PES % Score | Description |
|---|---|---|
| A | 90-100% | Unmodified, natural. |
| B | 80-90% | Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged. |
| C | 60-80% | Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged. |
| D | 40-60% | Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred. 20-40% Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive. |
| E | 20-40% | Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive. |
| F | 0-20% | Critically/Extremely modified. Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances, the basic ecosystem functions have been destroyed and the changes are irreversible. |

## A5 WET-Health Assessment

Healthy wetlands are known to provide important habitats for wildlife and to deliver a range of important goods and services to society. Management of these systems is therefore essential if these attributes are to be retained within an ever changing landscape. The primary purpose of this assessment is to evaluate the ecophysical health of wetlands, and in so doing promote their conservation and wise management.

### a Level of Evaluation

Two levels of assessment are provided by WET-Health:

- Level 1: Desktop evaluation, with limited field verification. This is generally applicable to situations where a large number of wetlands need to be assessed at a very low resolution; or
- Level 2: On-site evaluation. This involves structured sampling and data collection in a single wetland and its surrounding catchment.

### b Framework for the Assessment

A set of three modules has been synthesised from the set of processes, interactions and interventions that take place in wetland systems and their catchments: hydrology (water inputs, distribution and retention, and outputs), geomorphology (sediment inputs, retention and outputs) and vegetation (transformation and presence of introduced alien species).

### c Units of Assessment

Central to WET-Health is the characterisation of HGM Units, which have been defined based on geomorphic setting (e.g. hillslope or valley-bottom; whether drainage is open or closed), water source (surface water dominated or sub-surface water dominated) and pattern of water flow through the wetland unit (diffusely or channelled) as described under the Classification System for Wetlands and other Aquatic Ecosystems in Appendix A2.

### d Quantification of Present State of a Wetland

The overall approach is to quantify the impacts of human activity or clearly visible impacts on wetland health, and then to convert the impact scores to a Present State score. This takes the form of assessing the spatial *extent* of impact of individual activities and then separately assessing the *intensity* of impact of each activity in the affected area. The extent and intensity are then combined to determine an overall *magnitude* of impact. The impact scores and Present State categories are provided in Table 115.

**Table 115: Impact scores and categories of Present State used by WET-Health for describing the integrity of wetlands.**

| Impact category | Description | Impact score range | Present State category |
|---|---|---|---|
| None | Unmodified, natural | 0-0.9 | A |
| Small | Largely natural with few modifications. A slight change in ecosystem processes is discernible and a small loss of natural habitats and biota may have taken place. | 1-1.9 | B |
| Moderate | Moderately modified. A moderate change in ecosystem processes and loss of natural habitats has taken place but the natural habitat remains predominantly intact. | 2-3.9 | C |
| Large | Largely modified. A large change in ecosystem processes and loss of natural habitat and biota and has occurred. | 4-5.9 | D |
| Serious | The change in ecosystem processes and loss of natural habitat and biota is great but some remaining natural habitat features are still recognizable. | 6-7.9 | E |
| Critical | Modifications have reached a critical level and the ecosystem processes have been modified completely with an almost complete loss of natural habitat and biota. | 8-10 | F |

## e Assessing the Anticipated Trajectory of Change

As is the case with the Present State, future threats to the state of the wetland may arise from activities in the catchment upstream of the unit or within the wetland itself or from processes downstream of the wetland. In each of the individual sections for hydrology, geomorphology and vegetation, five potential situations exist depending upon the direction and likely extent of change (Table 116).

**Table 116: Trajectory of Change classes and scores used to evaluate likely future changes to the present state of the wetland.**

| Change Class | Description | HGM change score | Symbol |
|---|---|---|---|
| Substantial improvement | State is likely to improve substantially over the next 5 years | 2 | ↑↑ |
| Slight improvement | State is likely to improve slightly over the next 5 years | 1 | ↑ |
| Remain stable | State is likely to remain stable over the next 5 years | 0 | → |
| Slight deterioration | State is likely to deteriorate slightly over the next 5 years | -1 | ↓ |
| Substantial deterioration | State is expected to deteriorate substantially over the next 5 years | -2 | ↓↓ |

### f Overall Health of the Wetland

Once all HGM Units have been assessed, a summary of health for the wetland as a whole needs to be calculated. This is achieved by calculating a combined score for each component by area-weighting the scores calculated for each HGM Unit. Recording the health assessments for the hydrology, geomorphology and vegetation components provides a summary of impacts, Present State, Trajectory of Change and Health for individual HGM Units and for the entire wetland.

## *A6 Present Ecological State (PES) Assessment of Site Specific Wetland/Riparian Crossings*

In order to provide a brief assessment of the PES of site specific wetland/riparian crossings, a method was utilised which provides insights into the wetland EIS, PES, site specific impacts as well as site specific mitigation requirements. Information such as wetland classification and vegetation, as well as hydrology, hydraulic/geomorphic, biological criteria and water quality were used to assign a PES for the wetland/riparian features at each specific crossing point. It should be noted that this method was only applied to the specific crossing point, and was based on conditions relevant to that site; therefore, the site specific PES may differ from the PES ascertained for the larger system.

Table 117 below lists the attributes as well as criteria assessed during the PES assessment.

**Table 117: Criteria and attributes assessed during the determination of the PES (DWA, 1999).**

| Criteria and attributes | |
|---|---|
| Hydrological | Hydraulic/ Geomorphic |
| Flow modification | Canalisation |
| Permanent inundation | Topographic Alteration |
| Water Quality | Biota |
| Water Quality Modification | Terrestrial Encroachment |
| Sediment load modification | Indigenous Vegetation Removal |
| | Invasive plant encroachment |
| | Alien fauna |
| | Overutilisation of biota |

Each of the attributes were given a score according to ecological state observed during the site visit, as well as a confidence score to indicate areas of uncertainty (Table 118).

**Table 118: Scoring Guidelines.**

| Scoring Guidelines | | Relative confidence score | |
|---|---|---|---|
| Natural, unmodified | 5 | Very High | 4 |
| Largely natural | 4 | High | 3 |
| Moderately modified | 3 | Moderate | 2 |
| Largely modified | 2 | Low | 1 |
| Seriously modified | 1 | | |
| Critically modified | 0 | | |

A mean score for all attributes was then calculated and the final score was then used in the PES category determination as indicated in the table below:

**Table 119: PES Category descriptions**[4]

| Score | Class | Description |
|---|---|---|
| >4 | A | Unmodified, natural |
| >3 and <4 | B | Largely natural, with few modifications |
| >2 and <3 | C | Moderately modified |
| 2 | D | Largely modified |
| >0 and <2 | E | Extensively modified |
| 0 | F | Critically modified |

## *A7 Wetland Function Assessment*

"The importance of a water resource, in ecological social or economic terms, acts as a modifying or motivating determinant in the selection of the management class".[5] The assessment of the ecosystem services supplied by the identified wetlands was conducted according to the guidelines as described by Kotze *et al* (2009). An assessment was undertaken that examines and rates the following services according to their degree of importance and the degree to which the service is provided:

- Flood attenuation
- Stream flow regulation
- Sediment trapping
- Phosphate trapping

[4]Department of Water Affairs and Forestry, South Africa. *Version 1.0 of Resource Directed Measures for Protection of Water Resources, 1999 [Table G2].*

- Nitrate removal
- Toxicant removal
- Erosion control
- Carbon storage
- Maintenance of biodiversity
- Water supply for human use
- Natural resources
- Cultivated foods
- Cultural significance
- Tourism and recreation
- Education and research

The characteristics were used to quantitatively determine the value, and by extension sensitivity, of the wetlands. Each characteristic was scored to give the likelihood that the service is being provided. The scores for each service were then averaged to give an overall score to the wetland.

**Table 120: Classes for determining the likely extent to which a benefit is being supplied.**

| Score | Rating of the likely extent to which the benefit is being supplied |
|---|---|
| <0.5 | Low |
| 0.6-1.2 | Moderately low |
| 1.3-2 | Intermediate |
| 2.1-3 | Moderately high |
| >3 | High |

## *A8 Ecological Importance and Sensitivity (EIS)*

The method used for the EIS determination was adapted from the method as provided by DWA (1999) for floodplains. The method takes into consideration PES scores obtained for WET-Health as well as function and service provision to enable the assessor to determine the most representative EIS category for the wetland feature or group being assessed.

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. The mean of the determinants is used to assign the EIS category as listed in Table 121 below.

**Table 121: Descriptions of the EIS Categories.**

| Recommended Ecological Management Class | EIS Category | Range of Mean |
|---|---|---|
| A | Very high<br>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. | >3 and <=4 |
| B | High<br>Wetlands that are considered to be ecologically important and sensitive. The biodiversity of these wetlands may be sensitive to flow and habitat modifications. | >2 and <=3 |
| C | Moderate<br>Wetlands that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these wetlands is not usually sensitive to flow and habitat modifications. | >1 and <=2 |
| D | Low/marginal<br>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. | >0 and <=1 |

## *A9 Recommended Ecological Category*

"A high management class relates to the flow that will ensure a high degree of sustainability and a low risk of ecosystem failure. A low management class will ensure marginal maintenance of sustainability, but carries a higher risk of ecosystem failure."

The REC (Table 122) was determined based on the results obtained from the PES, reference conditions and EIS of the resource (sections above). Followed by realistic recommendations, mitigation, and rehabilitation measures to achieve the desired REC.

A wetland may receive the same class for the PES as the REC if the wetland is deemed in good condition, and therefore must stay in good condition.

Otherwise, an appropriate REC should be assigned in order to prevent any further degradation as well as enhance the PES of the wetland feature.

**Table 122: Description of REC classes.**

| Class | Description |
|---|---|
| A | Unmodified, natural |
| B | Largely natural with few modifications |
| C | Moderately modified |
| D | Largely modified |

## *A10 Wetland and Riparian Resource Delineation*

For the purposes of this investigation, a wetland and a riparian habitat are defined in the NWA (1998) as stated below:

- A wetland is a 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.
- Riparian habitat is defined as including 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 areas.

The wetland and riparian zone delineations took place according to the method presented in the final draft of “A practical field procedure for identification and delineation of wetlands and riparian areas” published by the DWAF in February 2008. The foundation of the method is based on the fact that wetlands and riparian zones have several distinguishing factors including the following:

- The presence of water at or near the ground surface;
- Distinctive hydromorphic soils;
- Vegetation adapted to saturated soils; and
- The presence of alluvial soils in stream systems.

By observing the evidence of these features in the form of indicators, wetlands and riparian zones can be delineated and identified. If the use of these indicators and the interpretation of the findings are applied correctly, then the resulting delineation can be considered accurate (DWA, 2008).

Riparian and wetland zones can be divided into three zones (DWA, 2008). The permanent zone of wetness is nearly always saturated. The seasonal zone is saturated for a significant part of the rainy season and the temporary zone surrounds the seasonal zone and is only saturated for a short period of the year, but is saturated for a sufficient period, under normal circumstances, to allow for the formation of hydromorphic soils and the growth of wetland vegetation. The object of this study was to identify the outer boundary of the temporary zone and then to identify a suitable buffer zone around the wetland area.

## *A11 Sensitivity Mapping*

All the ecological features of the study area were considered and sensitive areas were delineated with the use of a Global Positioning System (GPS) as well as delineation utlising digital satellite imagery. A Geographic Information System (GIS) was used to project these features onto aerial photographs and topographic maps. The sensitivity map should guide the rehabilitation processes within the study area.

## A12 AQUATIC ASSESSMENT

### a Method of Assessment

The sections below describe the methodology used to assess the aquatic ecological integrity of the various sites based on water quality, instream and riparian habitat condition and biological impacts and integrity.

The ecological category (EC) classification for each aspect of ecology and habitat analyses will be employed using the eco-status A to F continuum approach (Kleynhans and Louw 2007) where applicable. This approach allows for boundary categories denoted as B/C, C/D etc., as illustrated in Figure 77.


**Figure 77: Ecological categories (EC) eco-status A to F continuum approach employed (Kleynhans and Louw 2007)**

## A13 Aquatic Ecological Assessment sites and site selection

Potential aquatic biomonitoring points were selected on the various drainage features in the vicinity of the study area. Each site was investigated and visually assessed in order to determine whether the points were suitable for the application of aquatic ecological assessment indices. During the selection of aquatic ecological assessment points the following criteria were used to identify the most suitable points:

- Site location in relation to the existing infrastructure and activities in the area;
- Site location in relation to existing monitoring points;
- Identifying gaps in biomonitoring information and selecting sites to fill that information;
- Accessibility with a vehicle in order to allow for the transport of equipment;
- The sites were selected where there was suitable habitat conditions with the best level of diversity in relation to the condition of each stream assessed; and
- Position of sites in such a way to allow spatial variation and trends to be determined.

Based on the results of the site selection effort, fifteen sites were visually assessed and eight out of the fifteen were subjected to further detailed aquatic assessment, in order to define the Present Ecological State and Ecological Importance and Sensitivity in the vicinity of the RPM operations.

Table 123 below presents geographic information with regards to the monitoring points selected. Figure 78 visually presents the locations of the various points assessed.

**Table 123: Location of the biomonitoring points with co-ordinates**

| Key | Sites fully assessed during the site assessment. Assessments include visual assessment, biota specific water quality, habitat assessment, aquatic macro-invertebrate community integrity, and fish community integrity. | Sites were dry at the time of the assessment. | |
|---|---|---|---|
| Site | Site Description | GPS coordinates | |
| | | South | East |
| SASS 31 | Railway culvert located on the Dorpspruit. This site will serve as the upstream reference site for site SASS 32. | 25°38'41.93"S | 27°15'16.75"E |
| SASS 32 | Bridge crossing located on the Dorpspruit. This site is located downstream of site SASS 31. | 25°37'53.24"S | 27°15'55.30"E |
| SASS 22 | Bridge crossing located on the Hex River. This site will serve as the upstream reference for site SASS 26 and 27 A. | 25°40'36.62"S | 27°16'40.96"E |
| SASS 26 | Bridge crossing located on the Hex River. | 25°39'24.73"S | 27°17'13.88"E |
| SASS 27 A | Bridge crossing located on the Hex River. | 25°38'00.29"S | 27°17'26.83"E |
| SASS 4 | Bridge crossing located on the Klipfonteinspruit. This site will serve as the upstream reference for site SASS 9. The site was dry at the time of the assessment. | 25°41'26.57"S | 27°21'10.56"E |
| SASS 9 | Road culvert located on the Klipfonteinspruit. | 25°40'09.89"S | 27°17'54.13"E |
| SASS 19 | Road culvert located on the Paardekraalspruit. This site will serve as the upstream reference point for sites SASS 15 and 21. The site was dry at the time of the assessment. | 25°39'00.70"S | 27°22'40.20"E |
| SASS 15 | Road culvert located on the Paardekraalspruit. The site was dry at the time of the assessment. | 25°39'30.57"S | 27°22'18.45"E |
| SASS 21 | Road culvert located on the Paardekraalspruit. | 25°36'36.75"S | 27°18'21.18"E |
| SASS 35 A | Road culvert located on the Wildebeesfonteinspruit. This site is representative of the system. The site was dry at the time of the assessment. | 25°36'42.91"S | 27°13'00.96"E |
| SASS 39 | Road culvert located on the Brakspruit. This site is representative of the system. The site was dry at the time of the assessment. | 25°41'42.19"S | 27°25'50.05"E |
| SASS 40 E | Road culvert located on the Hoedspruit. This site is representative of the system. The site was dry at the time of the assessment. | 25°40'54.97"S | 27°24'50.89"E |
| SASS 12 A | Road culvert located on the Klipgatspruit. This site is representative of the system. The site was dry at the time of the assessment. | 25°39'56.60"S | 27°20'06.88"E |
| SASS 29 | Bridge crossing located on the Hex River downstream of all the tributary confluences and RPM operations. Any impact on the aquatic community will be evident at this site. | 25°35'06.43"S | 27°18'16.59"E |

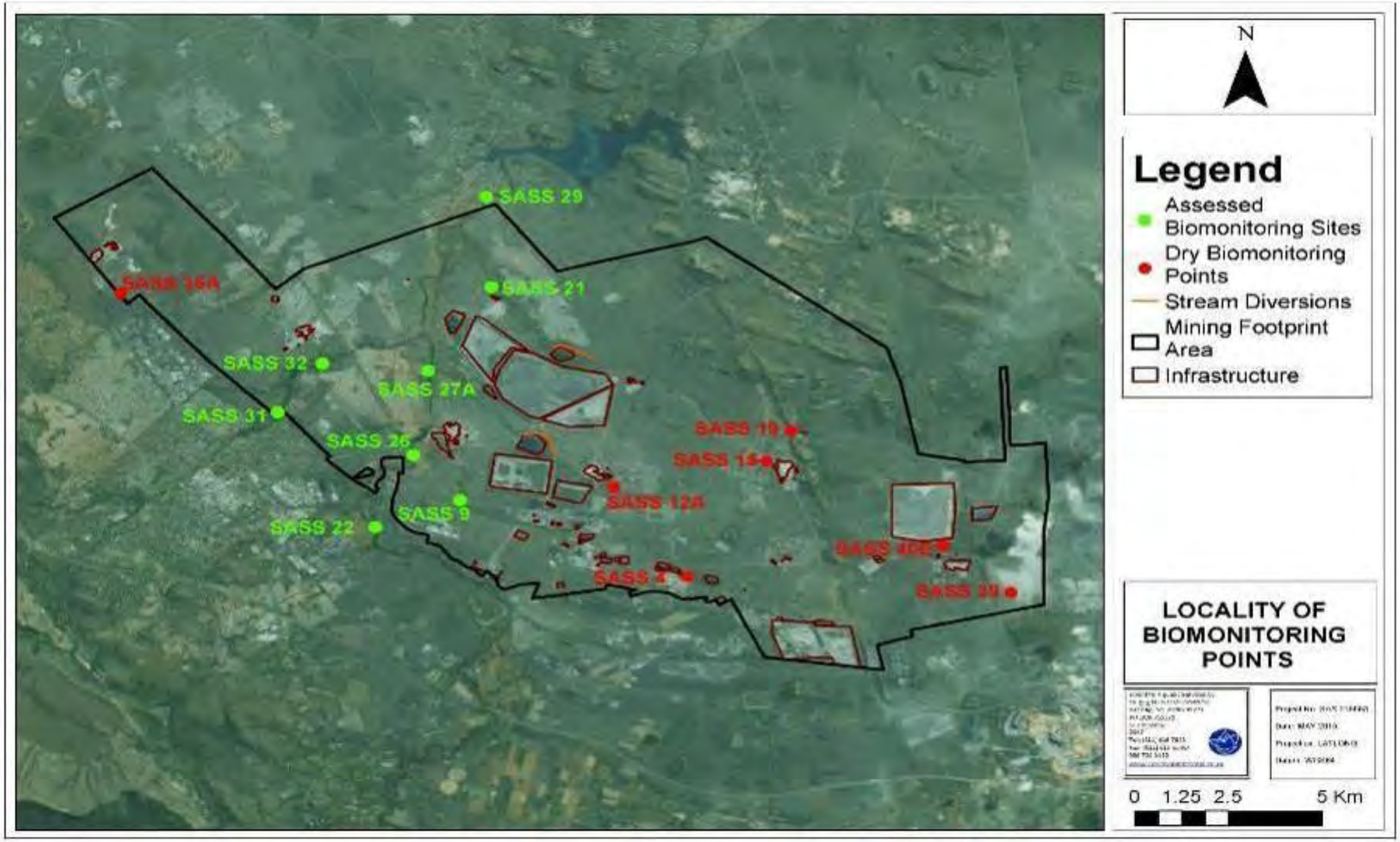


**Figure 78: Aerial view of the study area to show the location of the biomonitoring points.**

The sites selected for aquatic biomonitoring were all visually assessed. The Invertebrate Habitat Assessment System (IHAS), Intermediate Habitat Integrity Assessment (IHIA), the South African Scoring System version 5 (SASS5), Macro-Invertebrate Response Assessment Index (MIRAI) and Fish Response Assessment Index (FRAI) for the assessment of the aquatic community were employed on selected points within the RPM operations' boundary largely subject to availability of flow at the respective points. The protocols of applying the indices were strictly adhered to and all work was carried out by a South African River Health Program (SA RHP) accredited assessor.

## A14 Visual Assessment

Each site was investigated in order to identify visible impacts on the site with specific reference to impacts from the road crossings. Both natural constraints placed on ecosystem structure and function, as well as anthropogenic alterations to the system were assessed by observing conditions and relating them to professional experience. Photographs of each site were taken to provide visual indications of the conditions at the time of assessment. Factors which were noted in the site-specific visual assessments included the following:

- Stream morphology;
- Instream and riparian habitat diversity;
- Stream continuity;
- Erosion potential;
- Depth flow and substrate characteristics;
- Signs of physical disturbance of the area;
- Other life forms reliant on aquatic ecosystems and
- Signs of impact related to water quality.

## A15 Physico Chemical Water Quality Data

On site testing of biota specific water quality variables took place. Parameters measured include pH, electrical conductivity (EC), dissolved oxygen (DO) concentration and temperature. The results of on-site biota specific water quality analyses were used to aid in the interpretation of the data obtained by the biomonitoring. Results are discussed against the guideline water quality values for aquatic ecosystems (DWAF 1996 vol. 7). In addition the dissolved oxygen levels were measured to determine the percentage saturation level at the time of sampling and tabulated in accordance to the United States Environmental Protection Agency (USEPA) calculations (APHA, 1992).

## A16 Habitat Integrity

It is important to assess the habitat of each site, in order to aid in the interpretation of the results of the community integrity assessments by taking habitat conditions and impacts into consideration. The general habitat integrity of the site should be discussed based on the application of the Intermediate Habitat Integrity Assessment for (Kemper; 1999). The Intermediate Habitat Integrity Assessment (IHIA) protocol, as described by Kemper (1999), should be used for site specific assessments. This is a simplified procedure, which is based on the Habitat Integrity approach developed by Kleynhans (1996). The IHIA is conducted as a first level exercise, where a comprehensive exercise is not practical. The Habitat Integrity of each site should be scored according to 12 different criteria which represent the most important (and easily quantifiable) anthropogenically induced possible impacts on the system. The instream and riparian zones should be analysed separately, and the final assessment should be made separately for each, in accordance with Kleynhans' (1999) approach to Habitat Integrity Assessment. Data for the riparian zone are, however, primarily interpreted in terms of the potential impact on the instream component. The assessment of the severity of impact of modifications is based on six descriptive categories with ratings. Analysis of the data should be carried out by weighting each of the criteria according to Kemper (1999). By calculating the mean of the instream and riparian Habitat Integrity scores, an overall Habitat Integrity score can be obtained for each site. This method describes the Present Ecological State (PES) of both the in-stream and riparian habitats of the site. The method classifies Habitat Integrity into one of six classes, ranging from unmodified/natural (Class A), to critically modified (Class F).

**Table 124: Classification of Present State Classes in terms of Habitat Integrity [Based on Kemper 1999]**

| Class | Description | Score (% of total) |
|---|---|---|
| A | Unmodified, natural. | 90-100 |
| B | Largely natural, with few modifications. A small change in natural habitats and biota may have taken place but the basic ecosystem functions are essentially unchanged. | 80-90 |
| C | Moderately modified. A loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged. | 60-79 |
| D | Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred. | 40-59 |
| E | Extensively modified. The loss of natural habitat, biota and basic ecosystem functions is extensive. | 20-39 |
| F | 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. In the worst instances, basic ecosystem functions have been destroyed and the changes are irreversible. | <20 |

## A17 Habitat for Aquatic Macro-Invertebrates

The Invertebrate Habitat Assessment System (IHAS) was applied according to the protocol of McMillan (1998). This index was used to determine specific habitat suitability for aquatic macro-invertebrates as well as to aid in the interpretation of the results of the South African Scoring System version 5 (SASS5) scores. Scores for the IHAS index were interpreted according to the guidelines of McMillan (1998) as follows:

- <65% inadequate for supporting a diverse aquatic macro-invertebrate community;
- 65%-75% adequate for supporting a diverse aquatic macro-invertebrate community; and
- >75% highly suited for supporting a diverse aquatic macro-invertebrate community.

## A18 Aquatic Macro-Invertebrates

Aquatic macro-invertebrate communities of the selected sites were investigated according to the method, which is specifically designed to comply with international accreditation protocols. This method is based on the British Biological Monitoring Working Party (BMWP) method and has been adapted for South African conditions by Dr. F. M. Chutter (1998). The assessment was undertaken according to the protocol as defined by Dickens & Graham (2001). All work was undertaken by an accredited SASS5 practitioner.

Interpretation of the results of biological monitoring depends, to a certain extent, on interpretation of site-specific conditions (Thirion *et.al*, 1995). In the context of this investigation it would be best not to use SASS5 scores in isolation, but rather in comparison with relevant habitat scores. The reason for this is that some sites have a less desirable habitat or fewer biotopes than others do. In other words, a low SASS5 score is not necessarily regarded as poor in conjunction with a low habitat score. Also, a high SASS5 score in conjunction with a low habitat score can be regarded as better than a high SASS5 score in conjunction with a high habitat score. A low SASS5 score together with a high habitat score would be indicative of poor conditions. The IHAS Index is valuable in helping to interpret SASS5 scores and the effects of habitat variation on aquatic macro-invertebrate community integrity.

Classification of the system took place by comparing the present community status to reference conditions, which reflect the best conditions that can be expected in rivers and streams within a specific area and also reflect natural variation over time. The perceived reference state for the local streams was determined as a SASS5 score of 120 and an ASPT of 5.6 based on general conditions of streams in the Upper Bushveld Basin and Western

Bankenveld Ecoregions. Interpretation of the results, in relation to the reference scores, was made according to the classification by Dickens and Graham (2001).

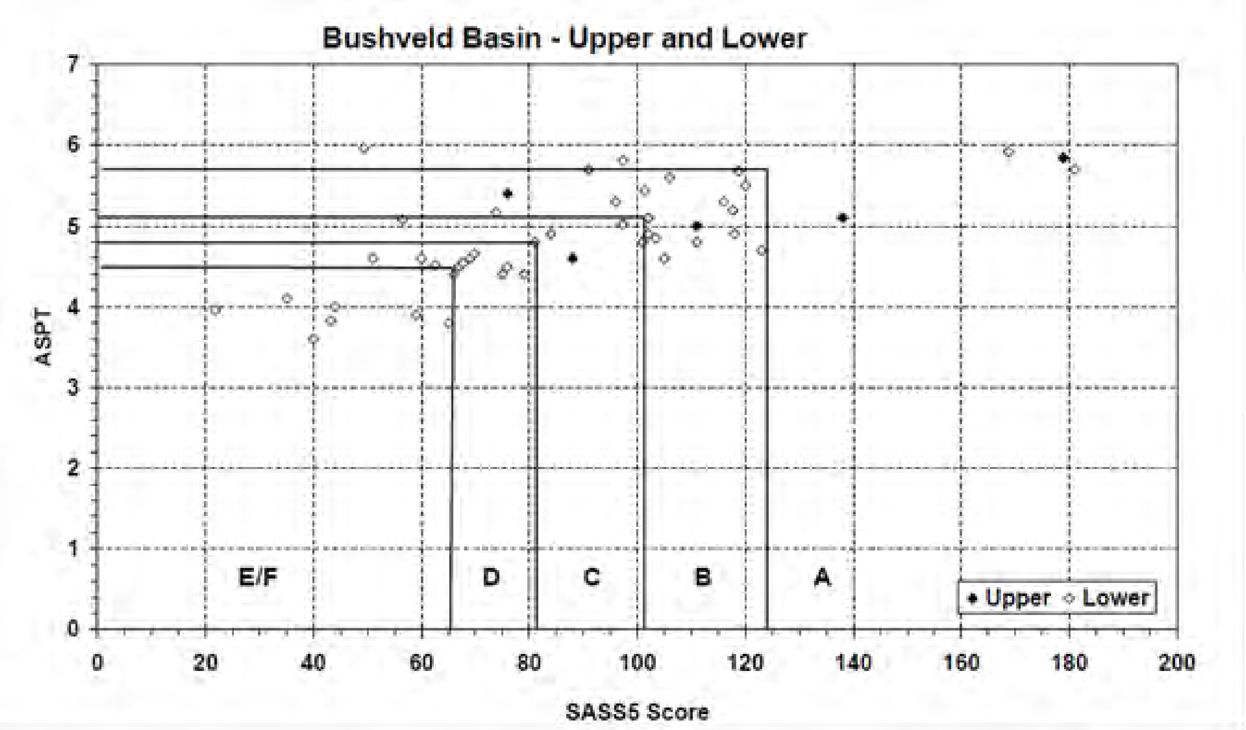


**Figure 79: Biological Bands for the Bushveld ecoregion, calculated using percentiles.**

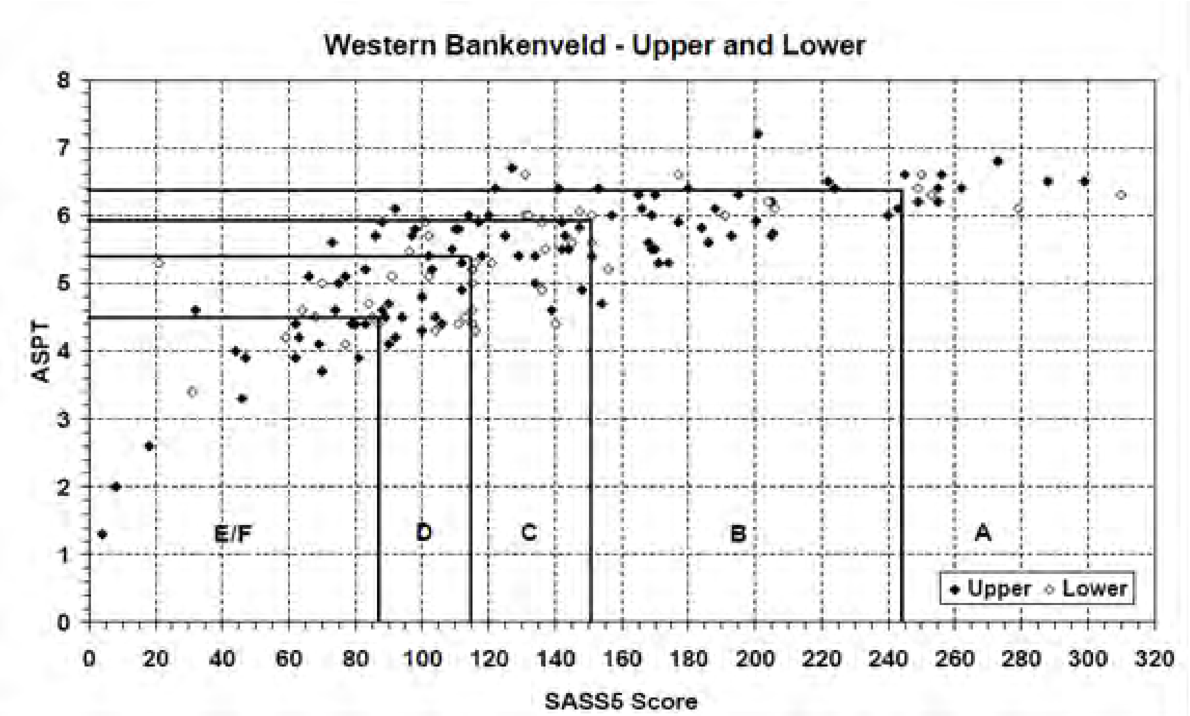


**Figure 80: Biological Bands for the Western Bankenveld ecoregion, calculated using percentiles.**

**Table 125: Definition of Present State Classes in terms of SASS scores as presented in Dickens & Graham (2001)**

| Class | Description | SASS5 Score% | ASPT |
|---|---|---|---|
| A | Unimpaired. High diversity of taxa with numerous sensitive taxa. | 90-100<br>80-89 | Variable<br>>90 |
| B | Slightly impaired. High diversity of taxa, but with fewer sensitive taxa. | 80-89<br>70-79<br>70-89 | <75<br>>90<br>76-90 |
| C | Moderately impaired. Moderate diversity of taxa. | 60-79<br>50-59<br>50-79 | <60<br>>75<br>60-75 |
| D | Largely impaired. Mostly tolerant taxa present. | 50 – 59<br>40-49 | <60<br>Variable |
| E | Severely impaired. Only tolerant taxa present. | 20-39 | Variable |
| F | Critically impaired. Very few tolerant taxa present. | 0-19 | Variable |

**Table 126: Description of the discussion points used for the discussion of data for each site**

| ASPECT | DEFINITION |
|---|---|
| Biotopes sampled | Refers to the various biotopes sampled for aquatic macro-invertebrates during the collection of the SASS5 samples. |
| Sensitive taxa present | A list of the taxa that were captured during SASS5 sampling regarded as being sensitive taxa relevant to the conditions in the area. |
| Sensitive taxa absent | A list of the taxa that were not captured during SASS5 sampling of the site but that were captured at other sites in the program and regarded as sensitive taxa. |
| Adjusted SASS5 score | The adjusted SASS5 value based on the adjustment figure in the IHAS index for variances in habitat conditions. |
| SASS5 % of reference score | The result compared to the reference SASS5 score of (120). |
| ASPT % of reference score | The result for the site compared to the reference ASPT score of (5.6) |
| Dallas; 2007 classification | This method utilizes natural variation in SASS5 Scores and ASPT at reference sites within a spatial group to determine the percentiles and band widths based on data from the Bushveld Basin and Western Bankenveld. Data within each spatial group have been plotted with ASPT as a function of SASS5 Score. |
| Dickens and Graham, 2001 SASS5 classification | The classification of each site into one of five classes, based on the degree of impairment observed in the aquatic macro-invertebrate community. |
| McMillan, 1998 IHAS description | Description of the adequacy of habitat according to the guidelines of McMillan 1998 |
| IHAS stones biotopes results | Discussion of the suitability of the stones biotopes of the site for supporting an aquatic macro-invertebrate community. |
| IHAS vegetation biotopes results | Discussion of the suitability of the vegetation biotopes of the site for supporting an aquatic macro-invertebrate community. |
| IHAS other biotopes results | Discussion of the suitability of the gravel, sand and mud biotopes of the site for supporting an aquatic macro-invertebrate community. |
| IHAS general stream characteristics | A summary of the notes made from the general stream characteristics section of the IHAS index. |
| Previous assessment IHAS score | The IHAS score obtained in the previous assessment. |
| Current IHAS score | The current score. |
| Current IHAS Adjustment score | The adjustment score from the IHAS index based on stream conditions. |

## A19 Aquatic Macro-Invertebrates: Macro-invertebrate Response Assessment Index (MIRAI)

The four major components of a stream system that determine productivity, with particular reference to aquatic organisms, are flow regime, physical habitat structure, water quality and energy inputs.

An interplay between these factors (particularly habitat and availability of food sources) result in the discontinuous, patchy distribution pattern of aquatic macro-invertebrate populations. As such aquatic invertebrates shall respond to habitat changes (i.e. changes in driver conditions).

To relate drivers to such changes in habitat and aquatic invertebrate condition, two key elements are required. Firstly habitat preferences and requirements for each taxa present should be obtained. As such reference conditions can be established against which any response to drivers can be measured. Secondly habitat features should be evaluated in terms of suitability and the requirements mentioned in the first point. As a result expected and actual patterns can be evaluated to achieve an Ecological Category (ECat) rating.

Based on the three key requirements, the MIRAI provides an approach to deriving and interpreting aquatic invertebrate response to driver changes. The index has been applied to the Klipgatspruit site following the methodology described by Thirion (2007). Aquatic macro-invertebrates expected at the site were derived both from previous studies of rivers near the area as well as habitat, flow and water parameters (Thirion, 2007).

## A20 Fish biota: Habitat Cover Rating (HCR) and Fish Habitat Assessment (FHA)

This approach was developed to assess habitats according to different attributes that are surmised to satisfy the habitat requirements of various fish species. At each site, the following depth-flow (df) classes are identified, namely:

- Slow (<0.3m/s), shallow (<0.5m) - Shallow pools and backwaters.
- Slow, deep (>0.5m) - Deep pools and backwaters.
- Fast (>0.3m/s), shallow - Riffles, rapids and runs.
- Fast, deep - Usually rapids and runs.

The relative contribution of each of the above mentioned classes at a site was estimated and indicated as:

0 = Absent

1 = Rare (<5%)

2 = Sparse (5-25%)

3 = Moderate (25-75%)

4 = Extensive (>75%)

For each depth-flow class, the following cover features (cf) -considered to provide fish with the necessary cover to utilise a particular flow and depth class- were investigated:

- Overhanging vegetation
- Undercut banks and root wads
- Stream substrate
- Aquatic macrophytes

The amount of cover present at each of these cover features (cf) was noted as:

0 = absent

1 = Rare/very poor (<5%)

2 = Sparse/poor (5-25%)

3 = Moderate/good (25-75%)

4 = Extensive/excellent (>75%)

The fish HCR was calculated as follows:

- The contribution of each depth-flow class at the site was calculated (df/Σdf).
- For each depth-flow class, the fish cover features (cf) were summed (Σcf).
  HCR = df/Σdf x Σcf.

The amount and diversity of cover available for the fish community at the selected site was graphically expressed as HCRs for different flow-depth classes as a stacked bar chart.

## A21 Fish biota: Fish Response Assessment Index (FRAI)

The FRAI (Kleynhans, 2008) is based on the premise that "drivers" (environmental conditions) may cause fish stress which shall then manifest as changes in fish species assemblage. The index employs preferences and intolerances of the reference fish assemblage, as well as the response of the actual (present) fish assemblage to particular drivers to indicate a change from reference conditions. Intolerances and preferences are divided into metric groups relating to preferences and requirements of individual species. This allows cause-effect relationships to be understood, i.e. between drivers and responses of the fish assemblage to changes in drivers. These metric groups are subsequently ranked, rated and finally integrated as a fish Ecological Category (EC) (Table 127).

Fish samples were collected by means of a fixed generator driven electro-fishing device. Fish species identified were compared to those expected to be present at the sites, which were compiled from a literature survey including Skelton (2001). Fish expected to occur in the system is summarised in Table 127. Comparisons between upstream and downstream points were made where applicable.

**Table 127: Intolerance ratings for naturally occurring fish species expected to occur in the area (Kleynhans *et al*., 2007).**

| SPECIES NAME | COMMON NAME | INTOLERANCE RATING | COMMENTS |
|---|---|---|---|
| *Barbus paludinosus* | Straightfin Barb | 1.8 | Widespread in east coastal rivers from East Africa south to the Vungu, KwaZulu-Natal, and from the southern Congo tributaries to the Orange River. |
| *Barbus trimaculatus* | Threespot barb | 2.2 | Common in many river systems of southern Africa |
| *Barbus unitaeniatus* | Longbeard barb | 1.7 | Widely distributed in southern Africa |
| *Clarias gariepinus* | Sharptooth Catfish | 1.0 | Widespread throughout southern Africa. |
| *Labeo molybdinus* | Leaden labeo | 3.2 | Middle and lower Zambezi down to Tugela system in KwaZulu-Natal |
| *Labeobarbus marequensis* | Largescale yellowfish | 2.6 | Widespread but unlikely to occur at the site |
| *Oreochromis mossambicus* | Blue Kurper | 1.3 | Widespread |
| *Pseudocrenilabrus philander* | Southern mouthbrooder | 1.3 | Widely distributed in southern Africa |
| *Tilapia Sparrmanii* | Banded tilapia | 1.3 | Widely distributed in southern Africa |

Tolerant: 1-2 Moderately tolerant :> 2-3 Moderately Intolerant: >3-4 Intolerant: >4

None of the above species are listed as being endangered, vulnerable or rare according to the 1996 IUCN Red List (Skelton, 2001). Most of the species observed have a relatively widespread distribution.

## *A22 Ecological Impact Statement*

The impacts that the crossings might have on the watercourses as well as their associated surroundings were discussed based on site visit observation. In addition, the mining activities as well as other land-use activities such as livestock grazing, hardened surfaces were also taken into consideration when assessing the impacts on the watercourses. Long linear ecosystems, rivers and streams are particularly vulnerable to fragmentation and loss of functionality. Most of the structures present within these rivers will operate in perpetuity, therefore rehabilitation measures must be implemented to enhance the feature and prevent further modification of the areas in which they are located. Mitigation measures to minimize impacts are explained in Section 5.3 and Section 5.6.

## A23 Ecological Impact Statement

The impacts that the crossings might have on the watercourses as well as their associated surroundings were discussed based on site visit observation. In addition, the mining activities as well as other land-use activities such as livestock grazing, hardened surfaces were also taken into consideration when assessing the impacts on the watercourses. Long linear ecosystems, rivers and streams are particularly vulnerable to fragmentation and loss of functionality. Most of the structures present within these rivers will operate in perpetuity, therefore rehabilitation measures must be implemented to enhance the feature and prevent further modification of the areas in which they are located. Mitigation measures to minimize impacts are explained below.

### a Mitigation measure development

According to the DMR, (2013) "Rich biodiversity underpins the diverse ecosystems that deliver ecosystem services that are of benefit to people, including the provision of basic services and goods such as clean air, water, food, medicine and fibre; as well as more complex services that regulate and mitigate our climate, protect people and other life forms from natural disaster and provide people with a rich heritage of nature-based cultural traditions. Intact ecological infrastructure contributes significant savings through, for example, the regulation of natural hazards such as storm surges and flooding by which is attenuated by wetlands".

According to the DMR, (2013) Ecosystem services can be divided into four main categories:

- Provisioning services are the harvestable goods or products obtained from ecosystems such as food, timber, fibre, medicine, and fresh water;
- Cultural services are the non-material benefits such as heritage landscapes and seascapes, recreation, ecotourism, spiritual values and aesthetic enjoyment;
- Regulating services are the benefits obtained from an ecosystem's control of natural processes, such as climate, disease, erosion, water flows, and pollination, as well as protection from natural hazards; and
- Supporting services are the natural processes such as nutrient cycling, soil formation and primary production that maintain the other services.

Loss of biodiversity puts aspects of the economy, wellbeing and quality of life at risk, and reduces socio-economic options for future generations. This is of particular concern for the poor in rural areas who have limited assets and are more dependent on common property resources for their livelihoods. The importance of maintaining biodiversity and intact ecosystems for ensuring on-going provision of ecosystem services, and the consequences of ecosystem change for human well-being, were detailed in a global assessment entitled the Millennium Ecosystem Assessment (MEA, 2005), which established a scientific basis for the need for action to enhance management and conservation of biodiversity.

Sustainable development is enshrined in South Africa's Constitution and laws. The need to sustain biodiversity is directly or indirectly referred to in a number of Acts, not least the National Environmental Management: Biodiversity Act (No. 10 of 2004) (hereafter referred to as the Biodiversity Act), and is fundamental to the notion of sustainable development. In addition International guidelines and commitments as well as national policies and strategies are important in creating a shared vision for sustainable development in South Africa (DMR, 2013).

The primary environmental objective of the Minerals and Petroleum Resource Development Act (MPRDA) is to give effect to the environmental right contained in the South African Constitution. Furthermore, Section 37(2) of the MPRDA states that "any prospecting or mining operation must be conducted in accordance with generally accepted principles of sustainable development by integrating social, economic and environmental factors into the planning and implementation of prospecting and mining projects in order to ensure that exploitation of mineral resources serves present and future generations".

Pressures on biodiversity are numerous and increasing. According to the DMR; (2013) Loss of natural habitat is the single biggest cause of biodiversity loss in South Africa and much of the world. The most severe transformation of habitat arises from the direct conversion of natural habitat for human requirements, including[6]:

- Cultivation and grazing activities;
- Rural and urban development;
- Industrial and mining activities, and
- Infrastructure development.

Given the limited resources available for biodiversity management and conservation, as well as the need for development, efforts to conserve biodiversity need to be strategic, focused and supportive of sustainable development. This is a fundamental principle underpinning South Africa's approach to the management and conservation of its biodiversity and has resulted the definition of a clear mitigation strategy for biodiversity impacts.

'Mitigation' is a broad term that covers all components of the 'mitigation hierarchy' defined hereunder. It involves selecting and implementing measures – amongst others – to conserve biodiversity and to protect, the users of biodiversity and other affected stakeholders from

[6] Limpopo Province Environment Outlook. A Report on the State of the Environment, 2002. Chapter 4.

potentially adverse impacts as a result of mining or any other land use. The aim is to prevent adverse impacts from occurring or, where this is unavoidable, to limit their significance to an acceptable level. Offsetting of impacts is considered to be the last option in the mitigation hierarchy for any project.

The mitigation hierarchy in general consists of the following in order of which impacts should be mitigated (DMR 2013):

- **Avoid/prevent impact:** can be done through utilising alternative sites, technology and scale of projects to prevent impacts. In some cases if impacts are expected to be too high the "no project" option should also be considered, especially where it is expected that the lower levels of mitigation will not be adequate to limit environmental damage and eco-service provision to suitable levels;
- **Minimise impact:** can be done through utilisation of alternatives that will ensure that impacts on biodiversity and ecoservices provision are reduced. Impact minimisation is considered an essential part of any development project;
- **Rehabilitate impact:** is applicable to areas where impact avoidance and minimisation are unavoidable where an attempt to re-instate impacted areas and return them to conditions which are ecologically similar to the pre-project condition or an agreed post project land use, for example arable land. Rehabilitation can however not be considered as the primary mitigation tool as even with significant resources and effort rehabilitation that usually does not lead to adequate replication of the diversity and complexity of the natural system. Rehabilitation often only restores ecological function to some degree to avoid ongoing negative impacts and to minimise aesthetic damage to the setting of a project. Practical rehabilitation should consist of the following phases in best practice:
  - **Structural rehabilitation** which includes physical rehabilitation of areas by means of earthworks, potential stabilisation of areas as well as any other activities required to develop a long terms sustainable ecological structure;
  - **Functional rehabilitation** which focuses on ensuring that the ecological functionality of the ecological resources on the study area supports the intended post closure land use. In this regard special mention is made of the need to ensure the continued functioning and integrity of wetland and riverine areas throughout and after the rehabilitation phase;
  - **Biodiversity reinstatement** which focuses on ensuring that a reasonable level of biodiversity is re-instated to a level that supports the local post closure land uses. In this regard special mention is made of re-instating vegetation to levels which

will allow the natural climax vegetation community of community suitable for supporting the intended post closure land use; and

- **Species reinstatement** which focuses on the re-introduction of any ecologically important species which may be important for socio-cultural reasons, ecosystem functioning reasons and for conservation reasons. Species re-instatement need only occur if deemed necessary.

➢ **Offset impact:** refers to compensating for latent or unavoidable negative impacts on biodiversity. Offsetting should take place to address any impacts deemed to be unacceptable which cannot be mitigated through the other mechanisms in the mitigation hierarchy. The objective of biodiversity offsets should be to ensure no net loss of biodiversity. Biodiversity offsets can be considered to be a last resort to compensate for residual negative impacts on biodiversity.

The significance of residual impacts should be identified on a regional as well as national scale when considering biodiversity conservation initiatives. If the residual impacts lead to irreversible loss or irreplaceable biodiversity the residual impacts should be considered to be of *very high significance* and when residual impacts are considered to be of *very high significance*, offset initiatives are not considered an appropriate way to deal with the magnitude and/or significance of the biodiversity loss. In the case of residual impacts determined to have *medium to high significance*, an offset initiative may be investigated. If the residual biodiversity impacts are considered of low significance no biodiversity offset is required.[7]

In light of the above discussion the following points present the key concepts considered in the development of mitigation measures for the study area.

➢ Mitigation and performance improvement measures and actions that address the risks and impacts[8] are identified and described in as much detail as possible.

➢ Measures and actions to address negative impacts will favour avoidance and prevention over minimisation, mitigation or compensation.

➢ Desired outcomes are defined, and have been developed in such a way as to be measurable events with performance indicators, targets and acceptable criteria that can be tracked over defined periods, with estimates of the resources (including human resource and training requirements) and responsibilities for implementation wherever possible.

### b Recommendations

[7] Provincial Guideline on Biodiversity Offsets, Western Cape, 2007.

[8] Mitigation measures should address both positive and negative impacts

Recommendations were developed to address and mitigate impacts associated with the landuse activities within the study area. These recommendations also include general management measures which apply to the study area as a whole. Mitigation measures have been developed to address issues encountered at various crossings.

# APPENDIX B: GENERAL IMPORTANCE OF THE STUDY AREA

## *B1 Ecoregions*

The majority of the study area falls within the Bushveld Basin Aquatic Ecoregion, with the remaining portion of the study area falling within the Western Bankenveld, the main attributes of these Ecoregions are summarised in Table 128.

The study area falls within the A22J, A22H and A21K quaternary catchments (Figure 81) and the ecological status of these quaternary catchments are summarised in Table 129 below.

**Table 128: Summary of the main attributes of the Bushveld Basin and Western Bankenveld Ecoregion.**

| MAIN ATTRIBUTES | BUSHVELD BASIN | WESTERN BANKENVELD |
|---|---|---|
| Terrain Morphology: Broad division (dominant types in bold) (Primary) | Plains; Low Relief; Plains; Moderate Relief; Lowlands; Hills and Mountains: Moderate and High Relief; Open Hills; Lowlands; Mountains: Moderate to High Relief; Closed Hills; Mountains: Moderate and High Relief (limited) | Plains; Low Relief; Plains; Moderate Relief; Lowlands; Hills and Mountains: Moderate and High Relief; Open Hills; Lowlands; Mountains: Moderate to High Relief; Closed Hills; Mountains: Moderate and High Relief |
| Vegetation types (dominant types in bold) (Primary) | Mixed Bushveld; Clay Thorn Bushveld; Waterberg Moist Mountain Bushveld (limited) | Waterberg Moist Mountain Bushveld; Mixed Bushveld Kalahari Plains Thorn Bushveld (limited); Clay Thorn Bushveld; (limited) Rocky Highveld Grassland; Dry Clay Highveld Grassland; (limited) |
| Altitude (m a.m.s.l) (modifying) | 700-1700 (1700-1900 very limited) | 900-1700 |
| MAP (mm) (Secondary) | 400 to 600 | 400 to 700 |
| Coefficient of Variation (% of annual precipitation) | 25 to 35 | 20 to 35 |
| Rainfall concentration index | 55 to >65 | 60 to >65 |
| Rainfall seasonality | Early to mid-summer | Early to mid-summer |
| Mean annual temp. (°C) | 14 to 22 | 14 to 22 |
| Mean daily max. temp. (°C): February | 22 to 32 | 24 to 32 |
| Mean daily max. temp. (°C): July | 14 to 24 | 14 to 24 |
| Mean daily min. temp. (°C): February | 12 to 20 | 12 to 20 |
| Mean daily min temp. (°C): July | 0 to 6 | 0 to 6 |
| Median annual simulated runoff (mm) for quaternary catchment | 20 to 100 | 20 to 80; 80 to 100 (limited) |

The PES/EIS database as developed by the DWS RQIS department was utilised to obtain background information on the project area. The PES/EIS database has been made available to consultants since mid-August 2014. The information from this database is based on information at a sub-quaternary catchment reach (subquat reach) level with the descriptions of the aquatic ecology based on the information collated by the DWS RQIS department from all reliable sources of reliable information such as SA RHP sites, Environmental Water Requirement Sites (EWRS) and Water Monitoring Sites (WMS). The results obtained serve to summarise this information as a background to the conditions within the study area.

**Table 129: Summary of the ecological status of quaternary catchments A22J, A22H and A21K.**

| SQ REACH | SQR NAME | PES ASSESSED BY EXPERTS? (IF TRUE="Y") | PES CATEGORY MEDIAN | MEAN EI CLASS | MEAN ES CLASS | STREAM ORDER | DEFAULT EC (BASED ON MEDIAN PES AND HIGHEST OF EI OR ES MEANS) |
|---|---|---|---|---|---|---|---|
| A22J-00878 | Hex | Y | E | Moderate | Moderate | 2.0 | C |
| A22H-01076 | Hex | Y | D | Moderate | Moderate | 2.0 | C |
| A22H-01077 | Sandspruit | Y | D | Moderate | Moderate | 1.0 | C |
| A21K-01023 | Sterkstroom | Y | D | High | High | 2.0 | B |

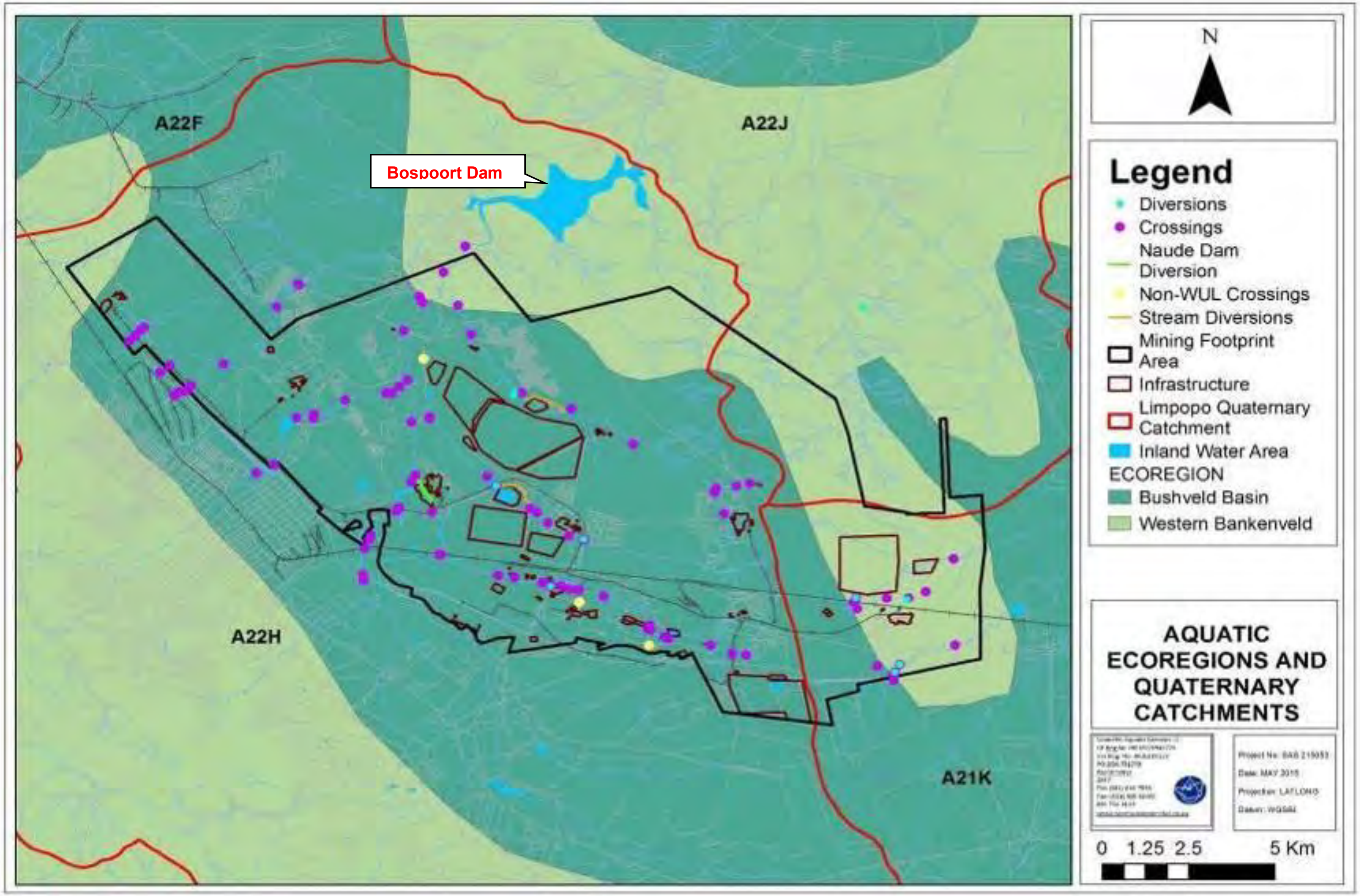


**Figure 81: The Aquatic Ecoregions and quaternary catchments associated with the study area.**

## B2 National Freshwater Priority Areas (NFEPA)

The FEPA database was consulted with regards to areas in close proximity to or traversed by the study area that may be of ecological importance. Aspects applicable to the study area are discussed below:

- The study area falls within Crocodile West and Marico water management area. The majority of the study area falls within the Elands Water Management Area (WMA),
- The subWMA is not regarded important in terms of fish sanctuaries, rehabilitation or corridors, translocation and relocation zones for fish;
- The subWMA is not listed as a fish FEPA;
- The NFEPA database indicates the presence of one river namely the Hex River; it is not classified as FEPA river, (Figure 82);
- The NFEPA database indicates the presence of several wetland features within the study area, with both natural and artificial features present. The artificial wetland features were identified during the site assessment and were found to be impoundments related to mining infrastructure (Figure 83 & Figure 84);
- The NFEPA database indicates no RAMSAR wetlands within the study area or within 500m of the study area; and
- The NFEPA database indicates that the wetland features within the study area are not within 500m of an IUCN threatened frog point locality, or within 500m of a threatened waterbird point locality.

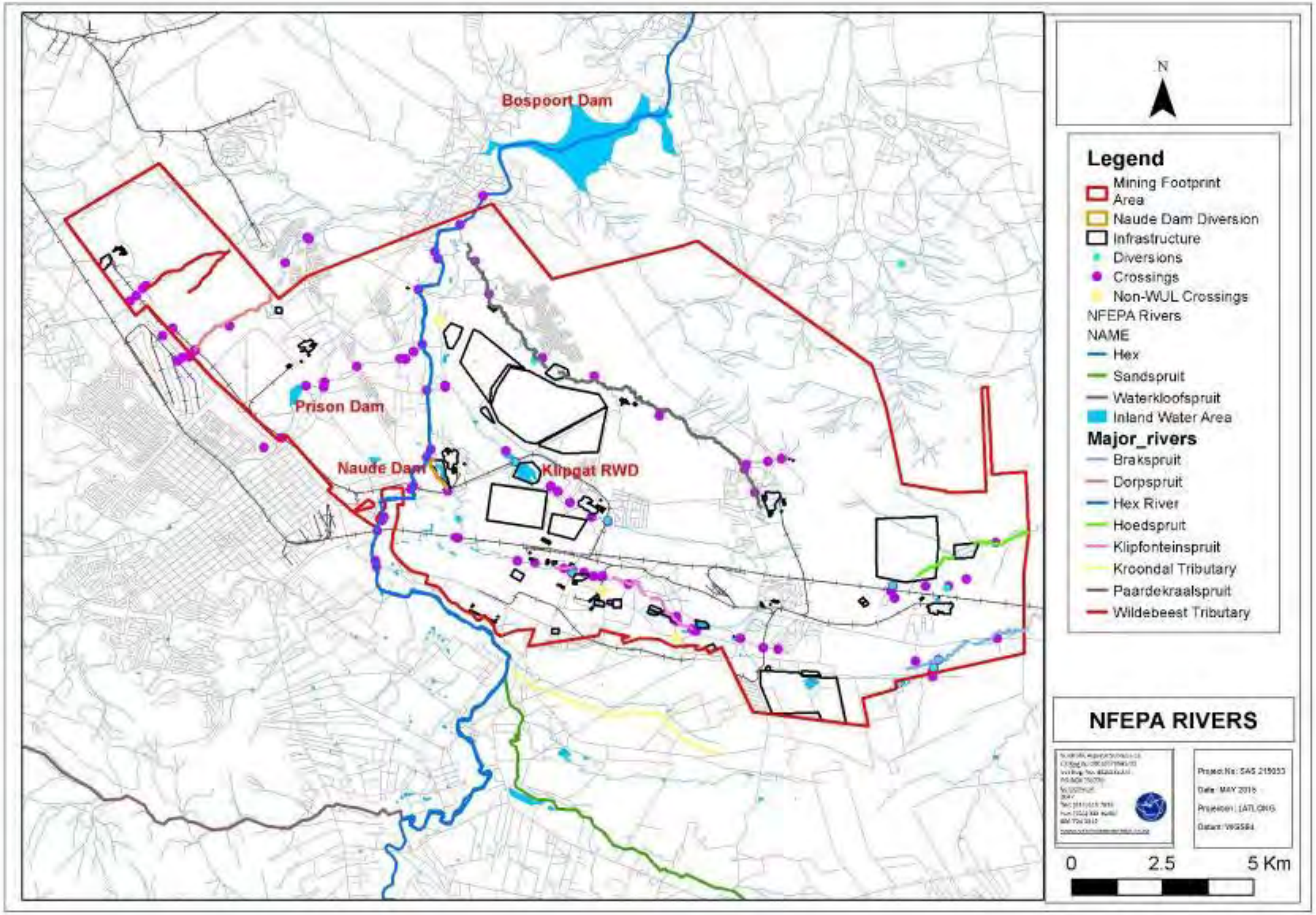


**Figure 82: The NFEPA database illustrating the presence of rivers within and adjacent to the study area.**

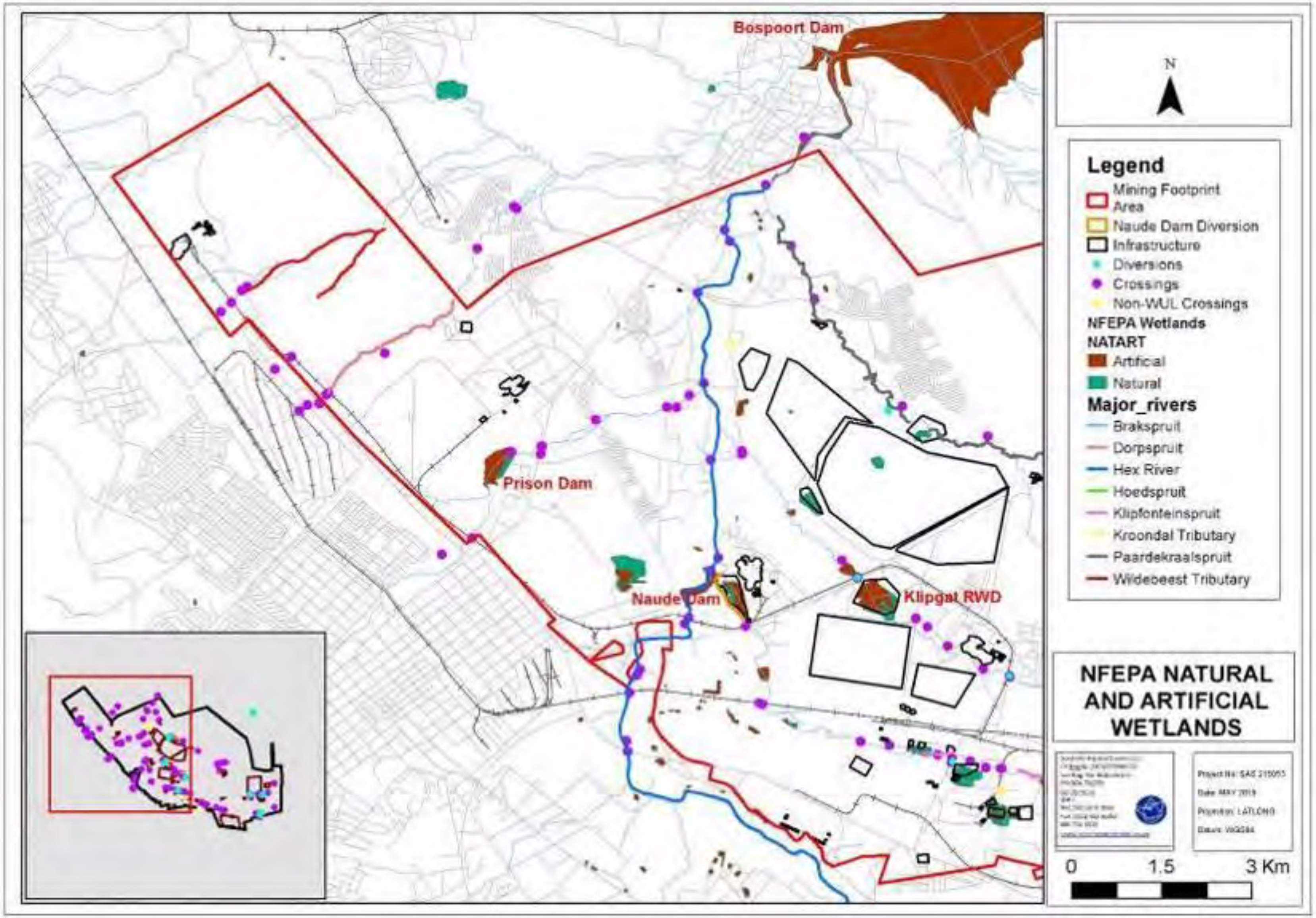


**Figure 83: Natural and artificial wetlands within the eastern portion of the study area according to the NFEPA database.**

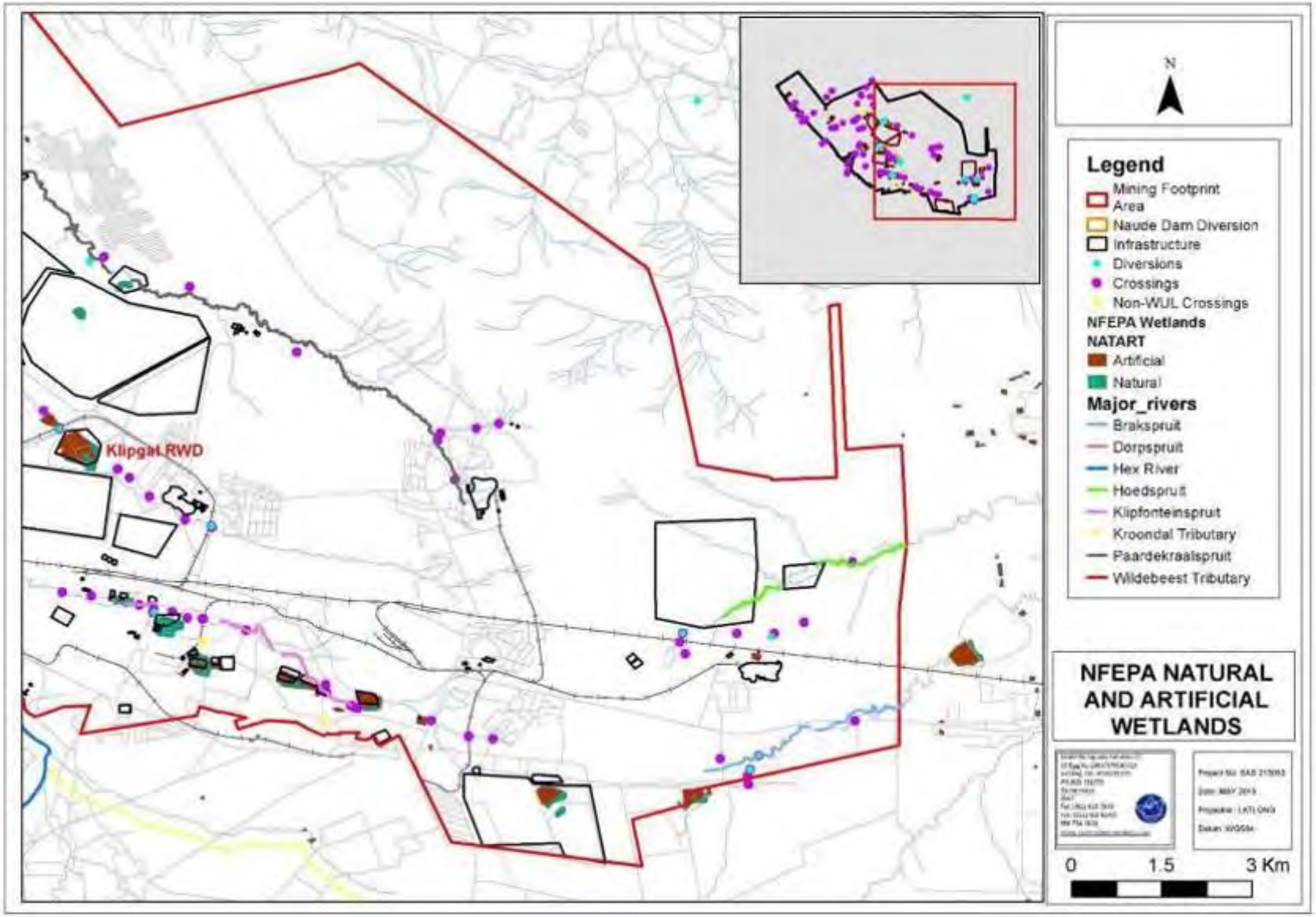


**Figure 84: Natural and artificial wetlands within the western portion of the study area according to the NFEPA database.**

## B3 National List of Threatened Terrestrial Ecosystems for South Africa (2011)

The National Environmental Management: Biodiversity Act (Act 10 of 2004) (NEMBA) provides for listing of threatened or protected ecosystems, in one of four categories: critically endangered, endangered, vulnerable or protected. Threatened ecosystems are listed in order to reduce the rate of ecosystem and species extinction by preventing further degradation and loss of structure, function and composition of threatened ecosystems. The purpose of listing protected ecosystems is primarily to conserve sites of exceptionally high conservation value (SANBI, BGIS).

According to the National List of Threatened Terrestrial Ecosystems (2011) the majority of the study area falls within the remaining extent of the vulnerable (VU) Marikana Thornveld ecosystem (Figure 85). Refer to Glossary for terms used in Figure 85.

## B4 Importance According to the Mining and Biodiversity Guidelines (2013)

The Mining Biodiversity Guidelines (2013) provides explicit direction in terms of where mining-related impacts are legally prohibited, where biodiversity priority areas may present high risks for mining projects, and where biodiversity may limit the potential for mining. The guidelines distinguish between four categories of biodiversity priority areas in relation to their importance from a biodiversity and ecosystem service point of view as well as the implications for mining. These categories include: Legally Protected Areas, Highest Biodiversity Importance, High Biodiversity Importance and Moderate Biodiversity Importance.

According to the Mining Biodiversity Guidelines (2013) the majority of the study area falls within a region considered to be of High Biodiversity Importance, portions falling within regions considered to be of Moderate Biodiversity Importance and the remainder of the study area is not classified (Figure 86).

High Biodiversity Importance areas include protected area buffer (including buffers around National Parks, World Heritage Sites and Nature Reserves), Transfrontier conservation Areas (remaining areas outside of formally proclaimed protected areas), other identified priorities from provincial spatial biodiversity plans and high water yield areas, amongst others. These areas are important for conserving biodiversity, for supporting or buffering other biodiversity priority areas, for maintaining important ecosystem services for particular communities or the country as a whole. An environmental impact assessment should include an assessment of optimum, sustainable land use for a particular area and will determine the significance of the impact on biodiversity. Mining options may be limited in these areas, and red flags for mining projects are possible. Authorisations may set limits and specify biodiversity offsets that would be written into licence agreements and/or authorisations.

Moderate Biodiversity Importance areas include Ecological Support Areas (ESAs), vulnerable ecosystems and focus areas for protected area expansion. Areas of Moderate Biodiversity Importance are considered of moderate risk for mining. (Environmental Assessment Practitioners) EAPs and their associated specialist studies should focus on confirming the presence and significance of these biodiversity features, identifying features (e.g. threatened species) not included in the existing datasets and on providing site-specific information to guide the application of the mitigation hierarchy. As for Moderate Biodiversity Importance areas, authorisations may set limits and specify biodiversity offsets that would be written into licence agreements and/or authorisations.

It must be noted that although areas of High and Moderate Biodiversity Importance are indicated within the study area, significant habitat transformation has occurred due to current and historical mining, agricultural and anthropogenic activities. Thus the site assessment focused on identifying areas within the study area which may still be considered representative of the above category.

## *B5 National Biodiversity Assessment (NBA, 2011)*

The National Biodiversity Assessment (NBA) (2011) provides an assessment of South Africa's biodiversity and ecosystems, including headline indicators such as ecosystem threat status and ecosystem protection level, and national maps for the terrestrial, freshwater, estuarine and marine environments.

According to the NBA (2011), the study area is not located within either a formal or an informal protected area, the formally protected area Kgaswane Nature Reserve is however approximately 6.5km south west of the study area (Figure 87). The study area is currently not protected. The land cover map (Figure 88) indicates large areas of natural vegetation within and adjacent to the study area as well as sections of urban built-up areas, cultivation and mines.

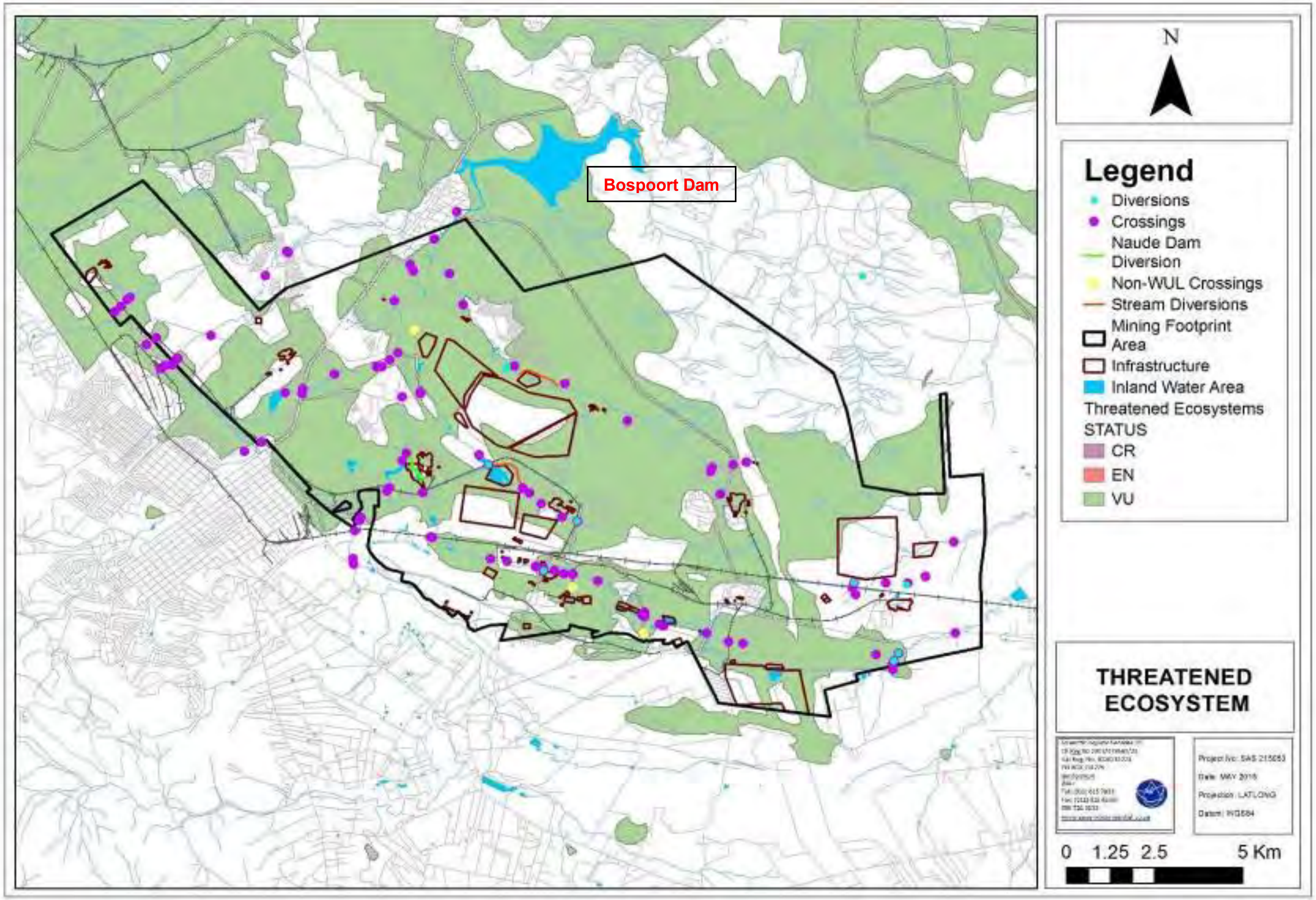


**Figure 85: Remaining extent of threatened ecosystems within the study area (National List of Threatened Terrestrial Ecosystems, 2011).**

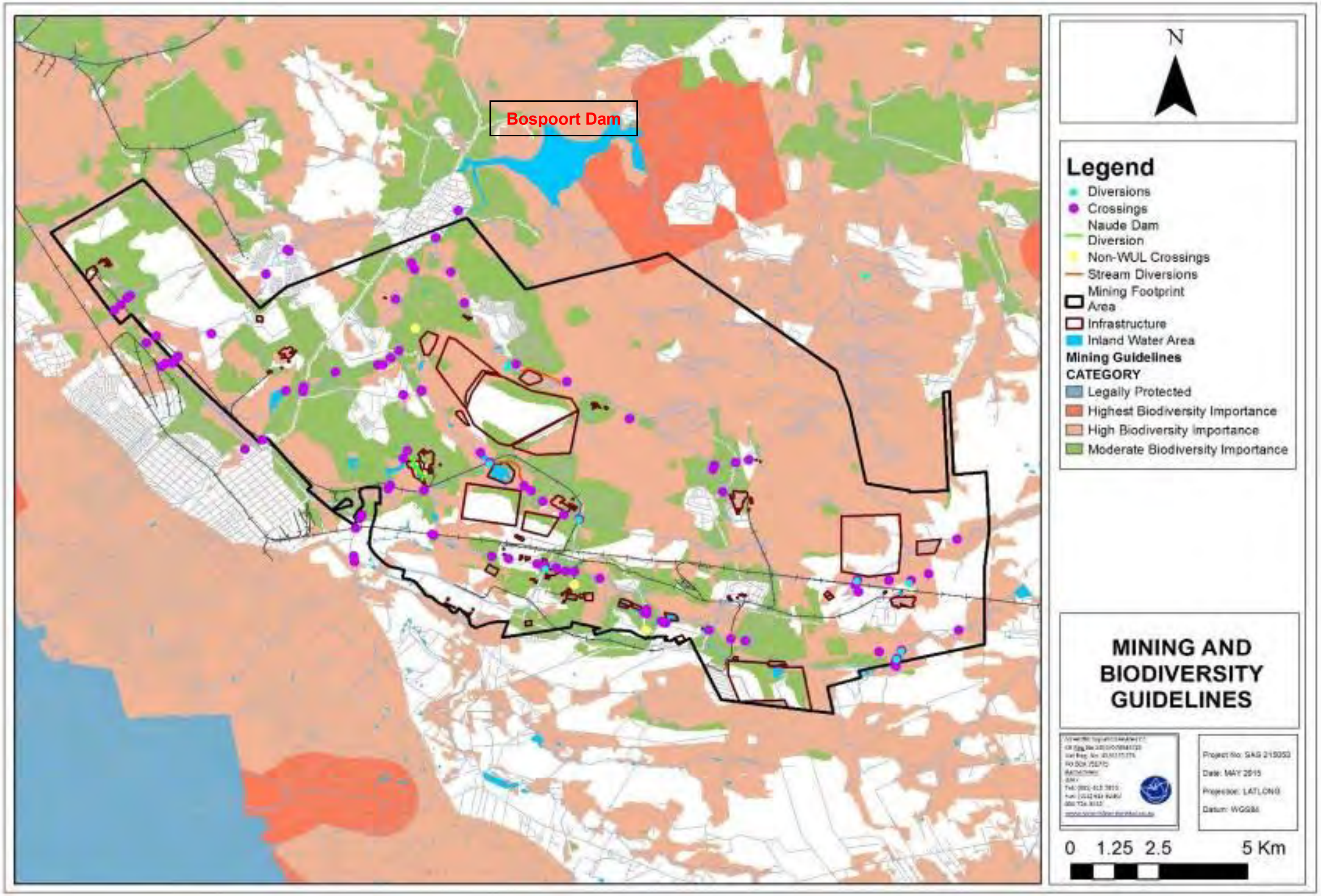


**Figure 86: Importance of the study area according to the Mining and Biodiversity Guidelines (2013).**

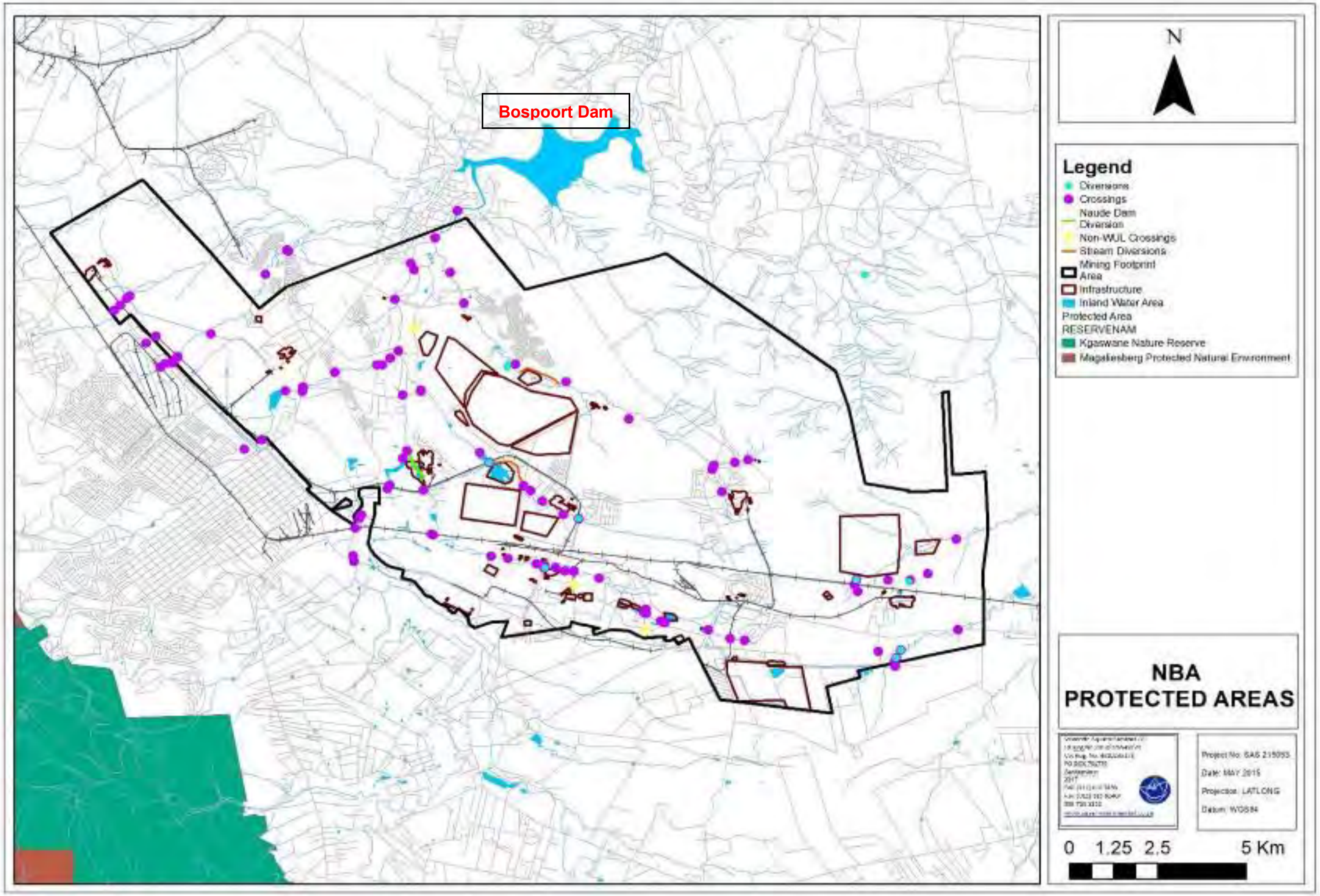


**Figure 87: Formal Protected areas in the vicinity of the study area according to the NBA (2011).**

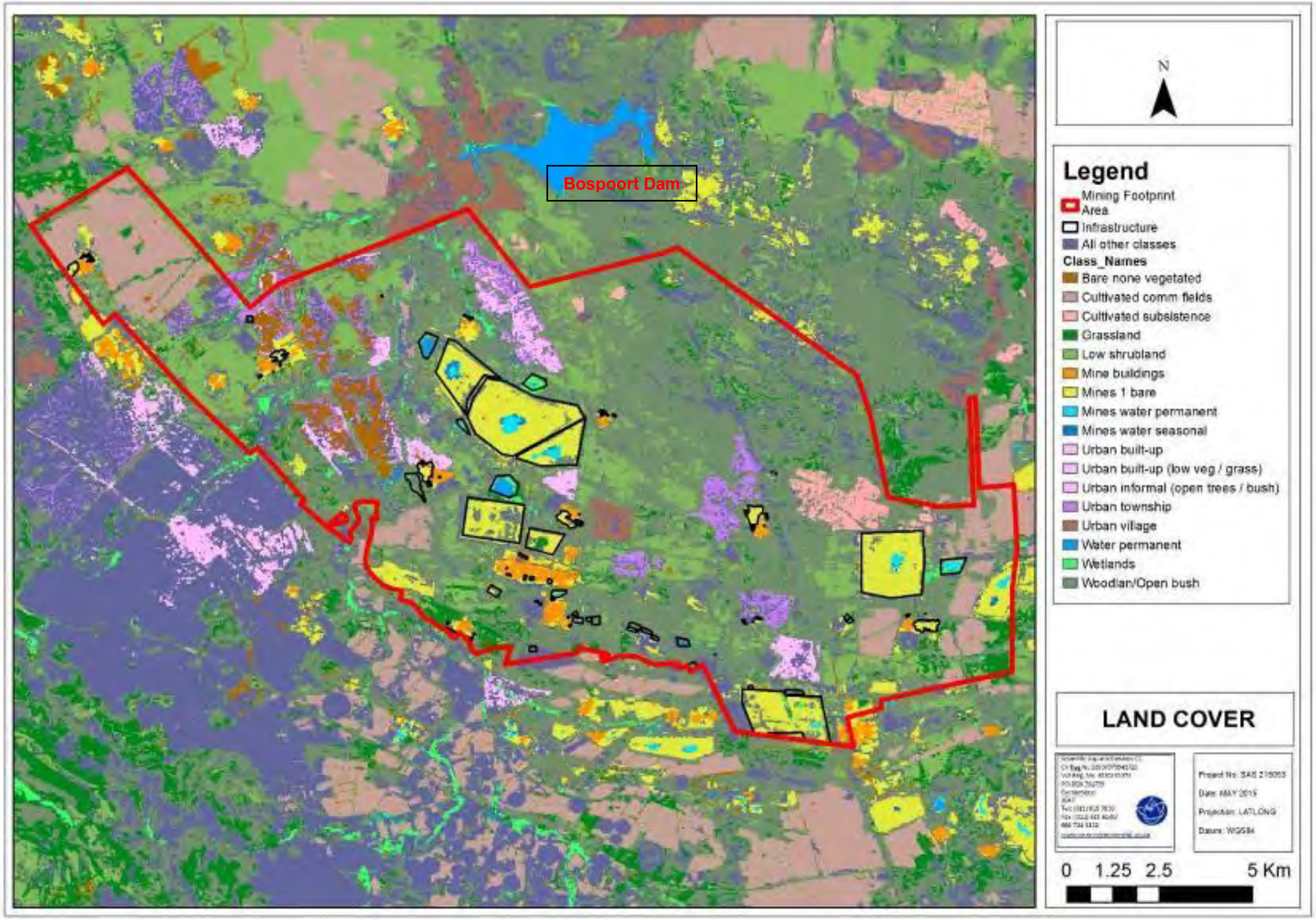


**Figure 88: Land cover uses associated with the study area.**

## *B6 North West Conservation Plan (NWCP, 2009)*

The NWPCP indicated that the study area occurs within an area that has high Critical Biodiversity Areas (CBAs). CBAs are areas of the landscape that need to be maintained in a natural or near-natural state in order to ensure the continued existence and functioning of species and ecosystems and the delivery of ecosystem services (Figure 89 to Figure 94).

The following are applicable to the study area according to the NWCP:

- Two Ecological Support Area (ESA) in the form of wetland buffers are indicated, namely around Prison Dam and the Klipgat Return Water Dam. The terrestrial habitats adjacent to these artificial wetlands are important ESA for the aquatic systems;
- The majority of the study area is classified as a CBA 2. According to the NWCP the following points describe CBA 2:
  - Ecosystems and species largely intact and undisturbed.
  - Areas with intermediate irreplaceability or some flexibility in terms of area required to meet biodiversity targets. There are options for loss of some components of biodiversity in these landscapes without compromising our ability to achieve targets.
  - These are landscapes that are approaching but have not passed their limits of acceptable change.
- CBA_Saveg 2: Remaining patches larger than 5ha of provincially endangered and vulnerable ecosystems (vegetation types), any further transformations of these vegetation types should be limited to existing transformed or heavily degraded areas;
- A north eastern portion of the study area falls within CBA Endemic: Remaining patches larger than 10ha of Endemic or Near-Endemic (>80% in province) vegetation types to the province with a global distribution of less than 50 000ha. These are vegetation types whose conservation target can only be achieved in the North-West Province;
- Isolated portions of the study area boundary fall within CBA Features: These are important natural features (habitats, springs, scenic landscapes) identified in the existing spatial development framework (SDF) data; and
- Isolated portions of CBA Hills are present: Hills and ridges identified as sensitive habitats in the existing provincial SDF dataset.

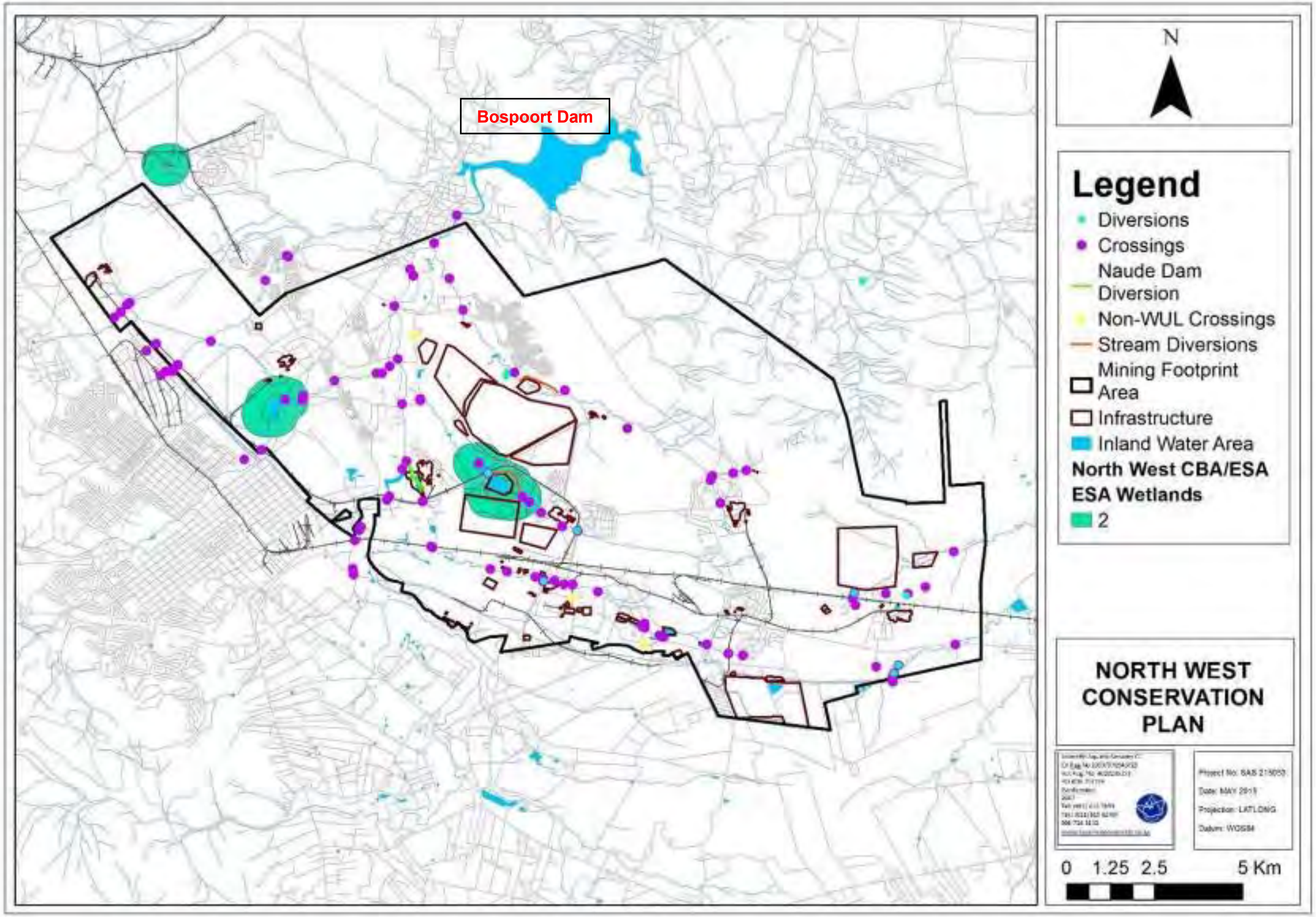


**Figure 89: North West Conservation Plan (2009) indicating the ESA wetland buffers for the study area.**

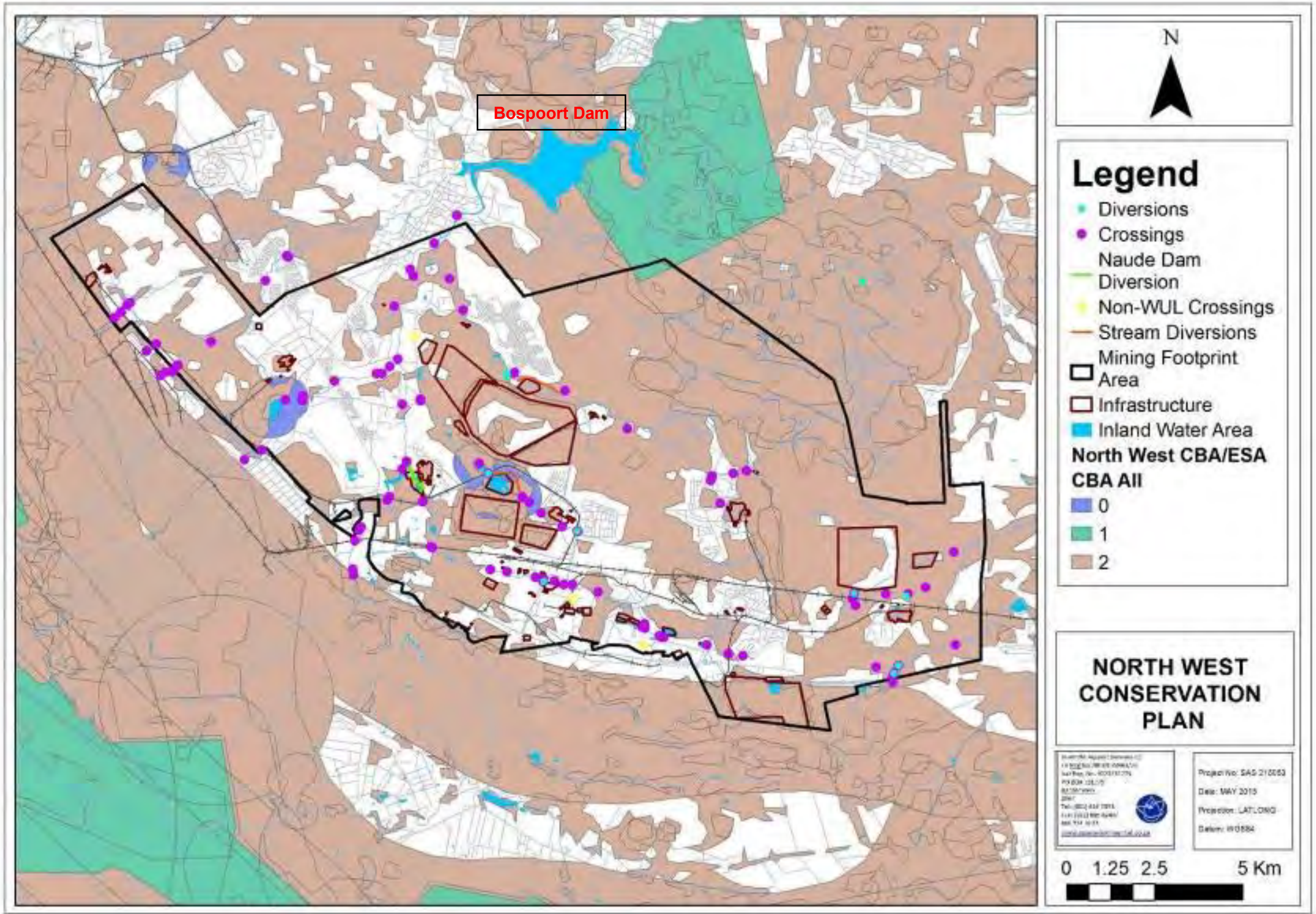


**Figure 90: North West Conservation Plan (2009) indicating the CBAs for the study area.**

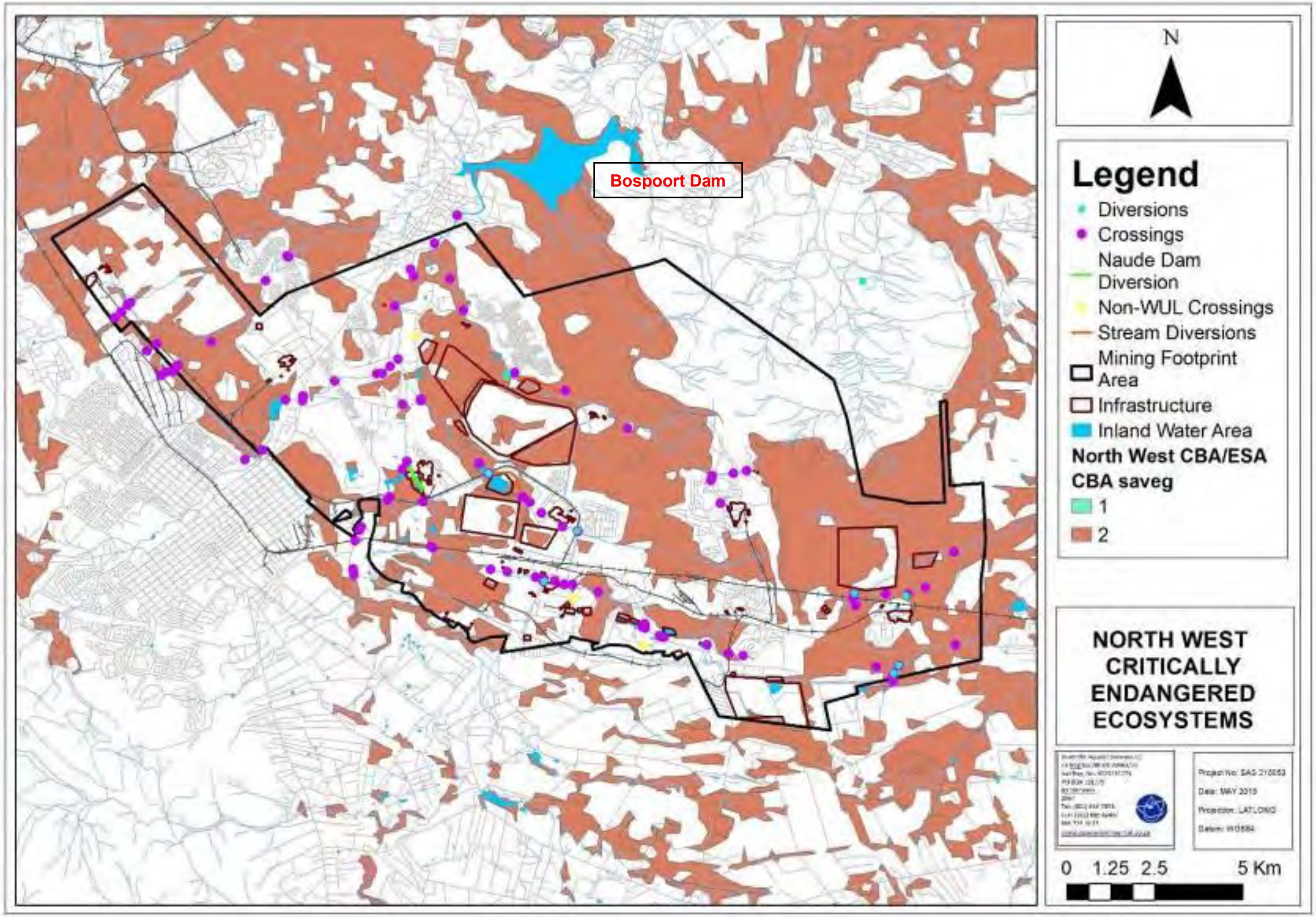


**Figure 91: North West Conservation Plan (2009) indicating the CBA save for the study area.**

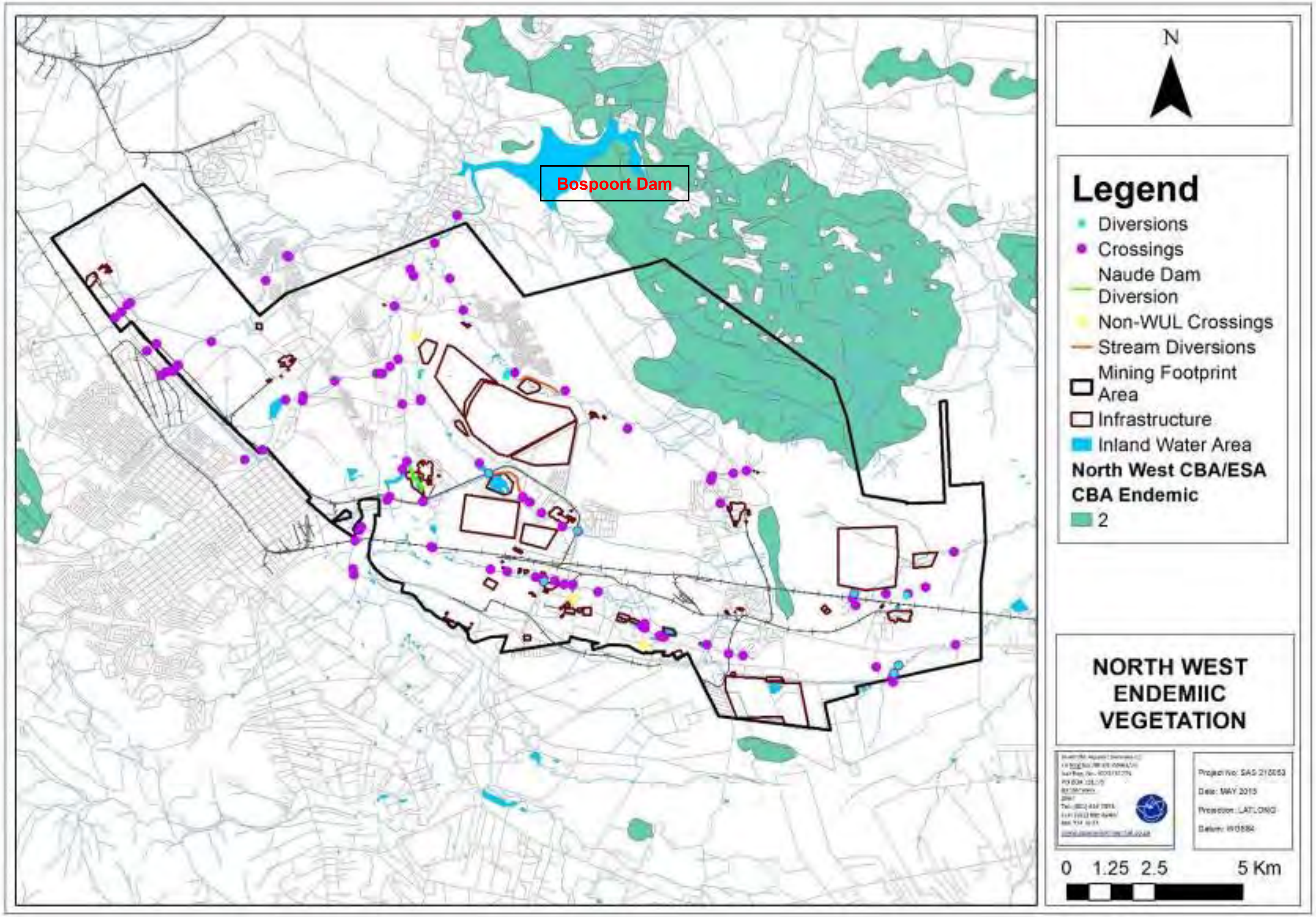


**Figure 92: North West Conservation Plan (2009) indicating the CBA Endemic Areas for the study area.**

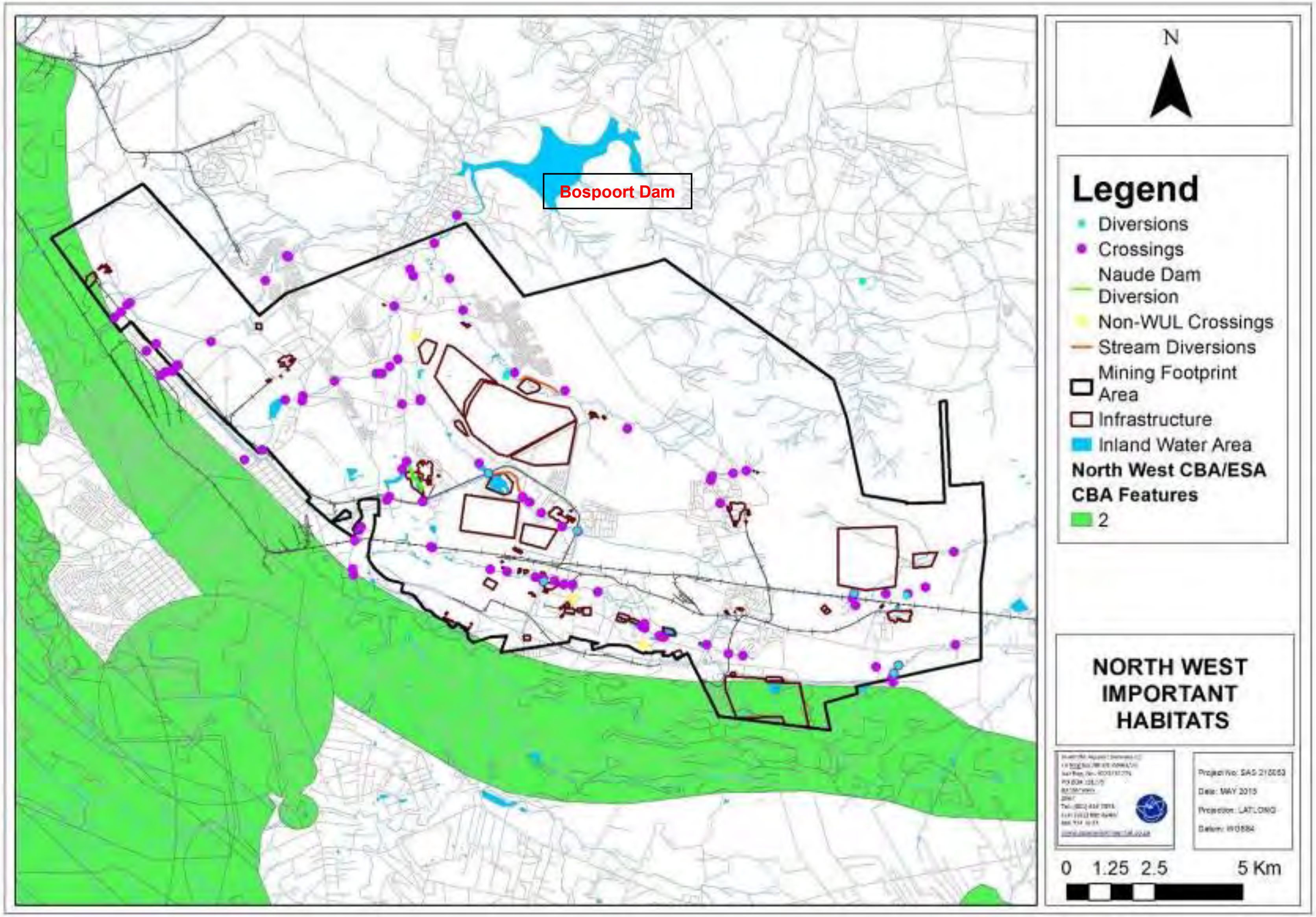


**Figure 93: North West Conservation Plan (2009) indicating the CBA features for the study area.**

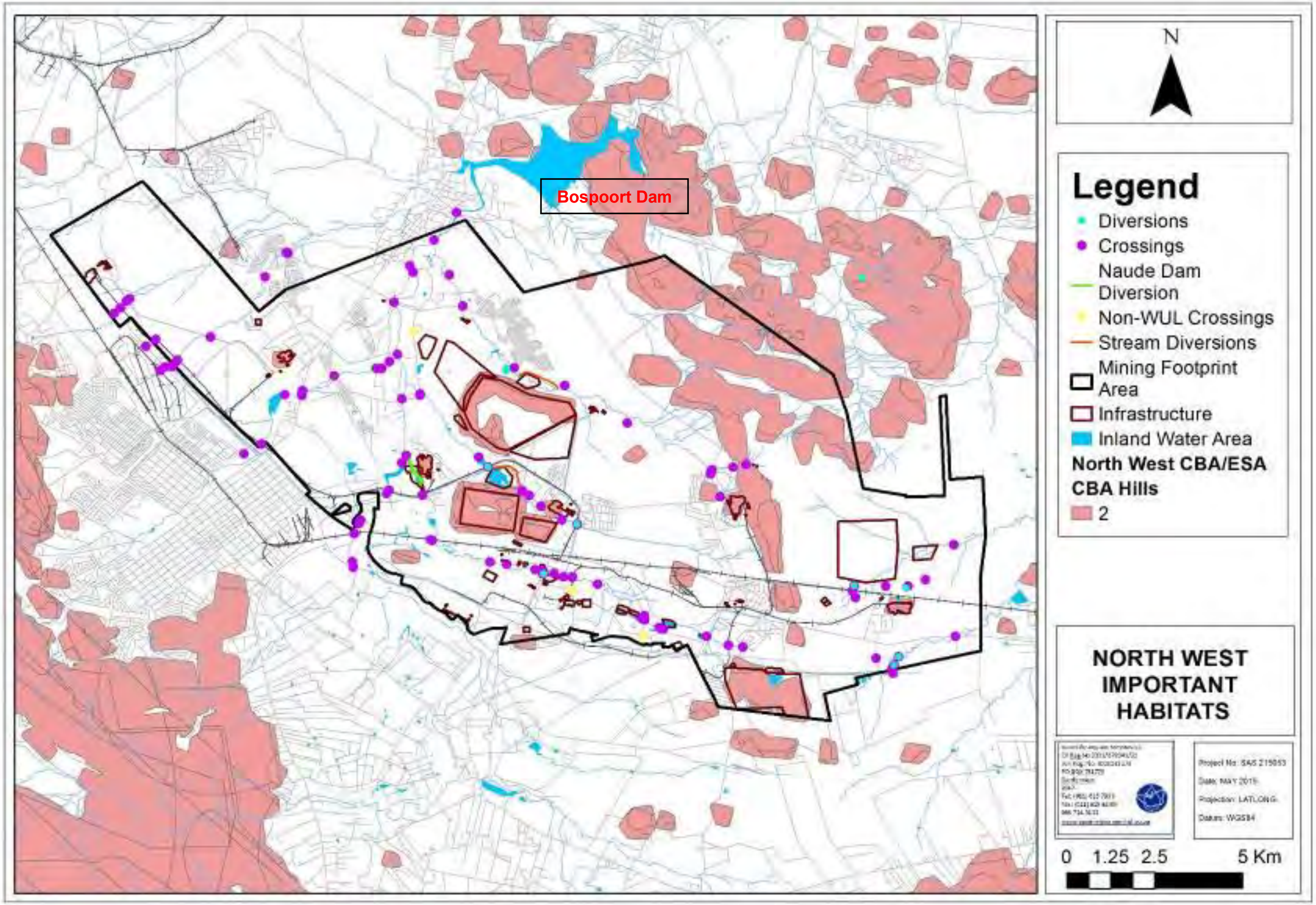


**Figure 94: North West Conservation Plan (2009) indicating the CBA Hills for the study area.**

# APPENDIX C: VEGRAI RESULTS

## RESULTS OF THE VEGRAI ASSESSMENT APPLIED TO THE RIPARIAN FEATURES

**Results of the VEGRAI assessment applied to Brakspruit**

| LEVEL 3 ASSESSMENT | | | | | |
|---|---|---|---|---|---|
| METRIC GROUP | CALCULATED RATING | WEIGHTED RATING | CONFIDENCE | RANK | % WEIGHT |
| MARGINAL | 57,4 | 21,5 | 3,3 | 2,0 | 60,0 |
| NON MARGINAL | 52,5 | 32,8 | 0,0 | 1,0 | 100,0 |
| | 2,0 | | | | 160,0 |
| LEVEL 3 VEGRAI (%) | | | | 54,3 | |
| VEGRAI EC | | | | D | |
| AVERAGE CONFIDENCE | | | | 1,7 | |

**Results of the VEGRAI assessment applied to Dorpspruit**

| LEVEL 3 ASSESSMENT | | | | | |
|---|---|---|---|---|---|
| METRIC GROUP | CALCULATED RATING | WEIGHTED RATING | CONFIDENCE | RANK | % WEIGHT |
| MARGINAL | 58,5 | 21,9 | 3,3 | 2,0 | 60,0 |
| NON MARGINAL | 35,8 | 22,4 | 0,0 | 1,0 | 100,0 |
| | 2,0 | | | | 160,0 |
| LEVEL 3 VEGRAI (%) | | | | 44,3 | |
| VEGRAI EC | | | | D | |
| AVERAGE CONFIDENCE | | | | 1,7 | |

**Results of the VEGRAI assessment applied to Hex River**

| LEVEL 3 ASSESSMENT | | | | | |
|---|---|---|---|---|---|
| METRIC GROUP | CALCULATED RATING | WEIGHTED RATING | CONFIDENCE | RANK | % WEIGHT |
| MARGINAL | 51,9 | 19,4 | 3,3 | 2,0 | 60,0 |
| NON MARGINAL | 59,2 | 37,0 | 0,0 | 1,0 | 100,0 |
| | 2,0 | | | | 160,0 |
| LEVEL 3 VEGRAI (%) | | | | 56,4 | |
| VEGRAI EC | | | | D | |
| AVERAGE CONFIDENCE | | | | 1,7 | |

**Results of the VEGRAI assessment applied to Hoedspruit**

| LEVEL 3 ASSESSMENT | | | | | |
|---|---|---|---|---|---|
| METRIC GROUP | CALCULATED RATING | WEIGHTED RATING | CONFIDENCE | RANK | % WEIGHT |
| MARGINAL | 51,9 | 19,4 | 3,3 | 2,0 | 60,0 |
| NON MARGINAL | 50,8 | 31,8 | 0,0 | 1,0 | 100,0 |
| | 2,0 | | | | 160,0 |
| LEVEL 3 VEGRAI (%) | | | | 51,2 | |
| VEGRAI EC | | | | D | |
| AVERAGE CONFIDENCE | | | | 1,7 | |

**Results of the VEGRAI assessment applied to Klipfonteinspruit**

| LEVEL 3 ASSESSMENT | | | | | |
|---|---|---|---|---|---|
| METRIC GROUP | CALCULATED RATING | WEIGHTED RATING | CONFIDENCE | RANK | % WEIGHT |
| MARGINAL | 61,5 | 23,1 | 3,3 | 2,0 | 60,0 |
| NON MARGINAL | 61,7 | 38,5 | 0,0 | 1,0 | 100,0 |
| | 2,0 | | | | 160,0 |
| LEVEL 3 VEGRAI (%) | | | | 61,6 | |
| VEGRAI EC | | | | C/D | |
| AVERAGE CONFIDENCE | | | | 1,7 | |

**Results of the VEGRAI assessment applied to Klipgatspruit**

| LEVEL 3 ASSESSMENT | | | | | |
|---|---|---|---|---|---|
| METRIC GROUP | CALCULATED RATING | WEIGHTED RATING | CONFIDENCE | RANK | % WEIGHT |
| MARGINAL | 37,8 | 14,2 | 3,3 | 2,0 | 60,0 |
| NON MARGINAL | 48,3 | 30,2 | 0,0 | 1,0 | 100,0 |
| | 2,0 | | | | 160,0 |
| LEVEL 3 VEGRAI (%) | | | | 44,4 | |
| VEGRAI EC | | | | D | |
| AVERAGE CONFIDENCE | | | | 1,7 | |

**Results of the VEGRAI assessment applied to Paardekraalspruit**

| LEVEL 3 ASSESSMENT | | | | | |
|---|---|---|---|---|---|
| METRIC GROUP | CALCULATED RATING | WEIGHTED RATING | CONFIDENCE | RANK | % WEIGHT |
| MARGINAL | 60,7 | 22,8 | 3,3 | 2,0 | 60,0 |
| NON MARGINAL | 64,2 | 40,1 | 0,0 | 1,0 | 100,0 |
| | 2,0 | | | | 160,0 |
| LEVEL 3 VEGRAI (%) | | | | 62,9 | |
| VEGRAI EC | | | | C | |
| AVERAGE CONFIDENCE | | | | 1,7 | |

**Results of the VEGRAI assessment applied to Wildebeesfonteinspruit**

| LEVEL 3 ASSESSMENT | | | | | |
|---|---|---|---|---|---|
| METRIC GROUP | CALCULATED RATING | WEIGHTED RATING | CONFIDENCE | RANK | % WEIGHT |
| MARGINAL | 37,0 | 13,9 | 3,3 | 2,0 | 60,0 |
| NON MARGINAL | 41,7 | 26,0 | 0,0 | 1,0 | 100,0 |
| | 2,0 | | | | 160,0 |
| LEVEL 3 VEGRAI (%) | | | | 39,9 | |
| VEGRAI EC | | | | D/E | |
| AVERAGE CONFIDENCE | | | | 1,7 | |

# APPENDIX D: IHI RESULTS

## RESULTS OF THE IHI ASSESSMENTS APPLIED TO THE WETLAND AND RIPARIAN FEATURES

### Results of the IHI assessment applied to Brakspruit

| OVERALL PRESENT ECOLOGICAL STATE (PES) SCORE | | | | | |
|---|---|---|---|---|---|
| | Ranking | Weighting | Score | | PES Category |
| DRIVING PROCESSES: | | 100 | 2,1 | *Confidence Rating* | |
| Hydrology | 1 | 100 | 2,3 | *2,9* | D |
| Geomorphology | 2 | 80 | 1,8 | *3,5* | C |
| Water Quality | 3 | 30 | 2,3 | *2,0* | D |
| WETLAND LANDUSE ACTIVITIES: | | 80 | 1,9 | *3,0* | |
| Vegetation Alteration Score | 1 | 100 | 1,9 | *3,0* | C |
| OVERALL SCORE: | | | 2,0 | | |
| | PES % | | 60,4 | *Confidence Rating* | |
| | PES Category: | | C/D | *1,3* | |

### Results of the IHI assessment applied to Dorpspruit

| OVERALL PRESENT ECOLOGICAL STATE (PES) SCORE | | | | | |
|---|---|---|---|---|---|
| | Ranking | Weighting | Score | | PES Category |
| DRIVING PROCESSES: | | 100 | 2,0 | *Confidence Rating* | |
| Hydrology | 1 | 100 | 1,8 | *2,7* | C |
| Geomorphology | 2 | 80 | 2,0 | *3,6* | C/D |
| Water Quality | 3 | 30 | 2,3 | *2,0* | D |
| WETLAND LANDUSE ACTIVITIES: | | 80 | 1,7 | *3,0* | |
| Vegetation Alteration Score | 1 | 100 | 1,7 | *3,0* | C |
| OVERALL SCORE: | | | 1,9 | | |
| | PES % | | 62,9 | *Confidence Rating* | |
| | PES Category: | | C | *1,3* | |

**Results of the IHI assessment applied to Hex River**

| OVERALL PRESENT ECOLOGICAL STATE (PES) SCORE | | | | | |
|---|---|---|---|---|---|
| | Ranking | Weighting | Score | | PES Category |
| DRIVING PROCESSES: | | 100 | 1,4 | *Confidence Rating* | |
| Hydrology | 1 | 100 | 1,2 | *2,8* | C |
| Geomorphology | 2 | 80 | 1,5 | *3,0* | C |
| Water Quality | 3 | 30 | 2,0 | *2,0* | C/D |
| WETLAND LANDUSE ACTIVITIES: | | 80 | 1,2 | *3,0* | |
| Vegetation Alteration Score | 1 | 100 | 1,2 | *3,0* | C |
| OVERALL SCORE: | | | 1,3 | | |
| | PES % | | 73,1 | *Confidence Rating* | |
| | PES Category: | | C | *1,3* | |

**Results of the IHI assessment applied to Hoedspruit**

| OVERALL PRESENT ECOLOGICAL STATE (PES) SCORE | | | | | |
|---|---|---|---|---|---|
| | Ranking | Weighting | Score | | PES Category |
| DRIVING PROCESSES: | | 100 | 2,1 | *Confidence Rating* | |
| Hydrology | 1 | 100 | 2,3 | *2,9* | D |
| Geomorphology | 2 | 80 | 1,8 | *3,5* | C |
| Water Quality | 3 | 30 | 2,3 | *2,0* | D |
| WETLAND LANDUSE ACTIVITIES: | | 80 | 2,2 | *3,0* | |
| Vegetation Alteration Score | 1 | 100 | 2,2 | *3,0* | D |
| OVERALL SCORE: | | | 2,1 | | |
| | PES % | | 57,0 | *Confidence Rating* | |
| | PES Category: | | D | *1,3* | |

**Results of the IHI assessment applied to Klipfontein**

| OVERALL PRESENT ECOLOGICAL STATE (PES) SCORE | | | | | |
|---|---|---|---|---|---|
| | Ranking | Weighting | Score | | PES Category |
| DRIVING PROCESSES: | | 100 | 1,6 | *Confidence Rating* | |
| Hydrology | 1 | 100 | 1,3 | *2,8* | C |
| Geomorphology | 2 | 80 | 1,6 | *3,5* | C |
| Water Quality | 3 | 30 | 2,3 | *2,0* | D |
| WETLAND LANDUSE ACTIVITIES: | | 80 | 1,2 | *3,0* | |
| Vegetation Alteration Score | 1 | 100 | 1,2 | *3,0* | C |
| OVERALL SCORE: | | | 1,4 | | |
| | PES % | | 71,8 | *Confidence Rating* | |
| | PES Category: | | C | *1,3* | |

**Results of the IHI assessment applied to Klipgatspruit South of Paardekraal Tailings Dam & North-west of Klipgat RWD**

| OVERALL PRESENT ECOLOGICAL STATE (PES) SCORE | | | | | |
|---|---|---|---|---|---|
| | Ranking | Weighting | Score | | PES Category |
| DRIVING PROCESSES: | | 100 | 2,6 | *Confidence Rating* | |
| Hydrology | 1 | 100 | 2,3 | *2,9* | D |
| Geomorphology | 2 | 80 | 3,1 | *3,0* | D/E |
| Water Quality | 3 | 30 | 2,3 | *2,0* | D |
| WETLAND LANDUSE ACTIVITIES: | | 80 | 2,0 | *3,0* | |
| Vegetation Alteration Score | 1 | 100 | 2,0 | *3,0* | C/D |
| OVERALL SCORE: | | | 2,3 | | |
| | PES % | | 53,7 | *Confidence Rating* | |
| | PES Category: | | D | *1,3* | |

**Results of the IHI assessment applied to Klipgatspruit East & South of Klipgat RWD**

| OVERALL PRESENT ECOLOGICAL STATE (PES) SCORE | | | | | |
|---|---|---|---|---|---|
| | Ranking | Weighting | Score | | PES Category |
| DRIVING PROCESSES: | | 100 | 1,5 | *Confidence Rating* | |
| Hydrology | 1 | 100 | 1,5 | *2,8* | C |
| Geomorphology | 2 | 80 | 1,3 | *3,5* | C |
| Water Quality | 3 | 30 | 2,3 | *2,0* | D |
| WETLAND LANDUSE ACTIVITIES: | | 80 | 1,3 | *3,0* | |
| Vegetation Alteration Score | 1 | 100 | 1,3 | *3,0* | C |
| OVERALL SCORE: | | | 1,4 | | |
| | PES % | | 71,3 | *Confidence Rating* | |

| | | | | |
|---|---|---|---|---|
| | PES Category: | C | *1,3* | |

**Results of the IHI assessment applied to Paardekraalspruit: North of Siphumelele 1 Waste Rock Dump**

| OVERALL PRESENT ECOLOGICAL STATE (PES) SCORE | | | | | |
|---|---|---|---|---|---|
| | Ranking | Weighting | Score | | PES Category |
| DRIVING PROCESSES: | | 100 | 1,8 | *Confidence Rating* | |
| Hydrology | 1 | 100 | 2,1 | *2,9* | C/D |
| Geomorphology | 2 | 80 | 1,3 | *3,5* | C |
| Water Quality | 3 | 30 | 2,3 | *2,0* | D |
| WETLAND LANDUSE ACTIVITIES: | | 80 | 1,2 | *3,0* | |
| Vegetation Alteration Score | 1 | 100 | 1,2 | *3,0* | C |
| OVERALL SCORE: | | | 1,6 | | |
| | PES % | | 68,7 | *Confidence Rating* | |
| | PES Category: | | C | *1,3* | |

**Results of the IHI assessment applied to Paardekraalspruit: North-west of Siphumelele 3 Waste Rock Dump**

| OVERALL PRESENT ECOLOGICAL STATE (PES) SCORE | | | | | |
|---|---|---|---|---|---|
| | Ranking | Weighting | Score | | PES Category |
| DRIVING PROCESSES: | | 100 | 2,1 | *Confidence Rating* | |
| Hydrology | 1 | 100 | 2,1 | *2,6* | D |
| Geomorphology | 2 | 80 | 2,0 | *3,0* | C/D |
| Water Quality | 3 | 30 | 2,3 | *2,0* | D |
| WETLAND LANDUSE ACTIVITIES: | | 80 | 2,0 | *3,0* | |
| Vegetation Alteration Score | 1 | 100 | 2,0 | *3,0* | C/D |
| OVERALL SCORE: | | | 2,1 | | |
| | PES % | | 58,7 | *Confidence Rating* | |
| | PES Category: | | C/D | *1,3* | |

**Results of the IHI assessment applied to Paardekraalspruit: North and South of Paardekraal Tailings Dam PK4**

| OVERALL PRESENT ECOLOGICAL STATE (PES) SCORE | | | | | |
|---|---|---|---|---|---|
| | Ranking | Weighting | Score | | PES Category |
| DRIVING PROCESSES: | | 100 | 2,6 | *Confidence Rating* | |
| Hydrology | 1 | 100 | 2,9 | *2,8* | D/E |
| Geomorphology | 2 | 80 | 2,2 | *3,0* | D |
| Water Quality | 3 | 30 | 2,3 | *2,0* | D |
| WETLAND LANDUSE ACTIVITIES: | | 80 | 2,0 | *3,0* | |
| Vegetation Alteration Score | 1 | 100 | 2,0 | *3,0* | C/D |
| OVERALL SCORE: | | | 2,3 | | |
| | PES % | | 54,1 | *Confidence Rating* | |
| | PES Category: | | D | *1,3* | |

**Results of the IHI assessment applied to Wildebeesfonteinspruit: South of Khuseleka 2**

| OVERALL PRESENT ECOLOGICAL STATE (PES) SCORE | | | | | |
|---|---|---|---|---|---|
| | Ranking | Weighting | Score | | PES Category |
| DRIVING PROCESSES: | | 100 | 1,9 | *Confidence Rating* | |
| Hydrology | 1 | 100 | 1,7 | *2,7* | C |
| Geomorphology | 2 | 80 | 2,1 | *3,0* | C/D |
| Water Quality | 3 | 30 | 2,3 | *2,0* | D |
| WETLAND LANDUSE ACTIVITIES: | | 80 | 1,2 | *3,0* | |
| Vegetation Alteration Score | 1 | 100 | 1,2 | *3,0* | C |
| OVERALL SCORE: | | | 1,6 | | |
| | PES % | | 67,8 | *Confidence Rating* | |
| | PES Category: | | C | *1,3* | |

**Results of the IHI assessment applied to Wildebeesfonteinspruit (34f, 34g, 34h)**

| OVERALL PRESENT ECOLOGICAL STATE (PES) SCORE | | | | | |
|---|---|---|---|---|---|
| | Ranking | Weighting | Score | | PES Category |
| DRIVING PROCESSES: | | 100 | 1,4 | *Confidence Rating* | |
| Hydrology | 1 | 100 | 1,5 | *2,9* | C |
| Geomorphology | 2 | 80 | 1,0 | *3,5* | B/C |
| Water Quality | 3 | 30 | 2,0 | *2,0* | C/D |
| WETLAND LANDUSE ACTIVITIES: | | 80 | 0,6 | *3,0* | |
| Vegetation Alteration Score | 1 | 100 | 0,6 | *3,0* | A/B |
| | PES % | | 79,8 | | |
| | PES Category: | | B/C | *1,3* | |

# APPENDIX E: EIS RESULTS

## RESULTS OF THE EIS ASSESSMENTS APPLIED TO THE WETLAND AND RIPARIAN FEATURES

**Results of the EIS assessments applied to the riparian features**

| Determinant | Brakspruit | Dorpspruit | Hex | Hoedspruit | Klipgatspruit | Confidence |
|---|---|---|---|---|---|---|
| PRIMARY DETERMINANTS | | | | | | |
| 1. Rare & Endangered Species | 0 | 0 | | 0 | 0 | 4 |
| 2. Populations of Unique Species | 0 | 0 | | 0 | 0 | 4 |
| 3. Species/taxon Richness | 3 | 2 | 2 | 3 | 2 | 3 |
| 4. Diversity of Habitat Types or Features | 3 | 2 | 3 | 3 | 2 | 3 |
| 5. Migration route/breeding and feeding site for wetland species | 2 | 2 | 2 | 2 | 2 | 3 |
| 6. PES as determined by IHI assessment | 2 | 2 | 2 | 1 | 1 | 4 |
| 7. Importance in terms of function and service provision | 1 | 1 | 1 | 1 | 1 | 4 |
| MODIFYING DETERMINANTS | | | | | | |
| 8. Protected Status according to NFEPA Wetveg | 1 | 1 | 1 | 1 | 1 | 4 |
| 9. Ecological Integrity | 1 | 2 | 1 | 2 | 1 | 4 |
| TOTAL | 13 | 12 | 12 | 13 | 10 | |
| MEAN | 1,4 | 1.3 | 1.3 | 1.4 | 1.1 | |
| OVERALL EIS | C | C | C | C | D | |

**Results of the EIS assessments applied to the riparian features**

| Determinant | Klipfonteinspruit | Paardekraalspruit | Wildebeesfonteinspruit | Confidence |
|---|---|---|---|---|
| PRIMARY DETERMINANTS | | | | |
| 1. Rare & Endangered Species | 0 | 0 | 0 | 4 |
| 2. Populations of Unique Species | 0 | 0 | 0 | 4 |
| 3. Species/taxon Richness | 1 | 2 | 1 | 3 |
| 4. Diversity of Habitat Types or Features | 1 | 2 | 1 | 3 |
| 5. Migration route/breeding and feeding site for wetland species | 1 | 2 | 1 | 3 |
| 6. PES as determined by IHI assessment | 2 | 2 | 2 | 4 |
| 7. Importance in terms of function and service provision | 2 | 2 | 2 | 4 |
| MODIFYING DETERMINANTS | | | | |
| 8. Protected Status according to NFEPA Wetveg | 1 | 1 | 1 | 4 |
| 9. Ecological Integrity | 1 | 1 | 1 | 4 |
| TOTAL | 9 | 12 | 9 | |
| MEAN | 1,0 | 1.3 | 1.0 | |
| OVERALL EIS | D | C | D | |

**Results of the EIS assessments applied to the drainage lines and dams**

| Determinant | Drainage Lines | Dams | Confidence |
|---|---|---|---|
| PRIMARY DETERMINANTS | | | |
| 1. Rare & Endangered Species | 0 | 0 | 4 |
| 2. Populations of Unique Species | 0 | 0 | 4 |
| 3. Species/taxon Richness | 1 | 0 | 3 |
| 4. Diversity of Habitat Types or Features | 1 | 1 | 3 |
| 5. Migration route/breeding and feeding site for wetland species | 1 | 1 | 3 |
| 6. PES as determined by WET-Health & IHI assessment | 2 | 3 | 4 |
| 7. Importance in terms of function and service provision | 1 | 1 | 4 |
| MODIFYING DETERMINANTS | | | |
| 8. Protected Status according to NFEPA Wetveg | 2 | 2 | 4 |
| 9. Ecological Integrity | 3 | 2 | 3 |
| TOTAL | 11 | 10 | |
| MEAN | 1.2 | 1.1 | |
| OVERALL EIS Category | C | C | |

# APPENDIX F: SASS5 Scoresheets

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET

| **DATE**: 22/04/2015 | **TAXON** | | **S** | **VG** | **GSM** | **TOT** | **TAXON** | | **S** | **VG** | **GSM** | **TOT** | **TAXON** | | **S** | **VG** | **GSM** | **TOT** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **GRID REFERENCE**: | **PORIFERA** | 5 | | | | | **HEMIPTERA:** | | | | | | **DIPTERA:** | | | | | |
| S:° | **COELENTERATA** | 1 | | | | | Belostomatidae* | 3 | | | | | Athericidae | 10 | | | | |
| E: ° | **TURBELLARIA** | 3 | **B** | | **1** | **B** | Corixidae* | 3 | | **A** | **A** | **B** | Blepharoceridae | 15 | | | | |
| SITE CODE: SASS 22/23 | **ANNELIDA:** | | | | | | Gerridae* | 5 | | | | | Ceratopogonidae | 5 | | | | |
| RIVER: | Oligochaeta | 1 | **A** | **1** | **A** | **A** | Hydrometridae* | 6 | | | | | Chironomidae | 2 | **A** | **A** | **A** | **B** |
| SITE DESCRIPTION: | Leeches | 3 | | | | | Naucoridae* | 7 | | | | | Culicidae* | 1 | | | | |
| WEATHER CONDITION: | **CRUSTACEA:** | | | | | | Nepidae* | 3 | | | | | Dixidae* | 10 | | | | |
| TEMP: 23.5 °C | Amphipoda | 13 | | | | | Notonectidae* | 3 | | | | | Empididae | 6 | | | | |
| Ph: 7.98 | Potamonautidae* | 3 | | | | | Pleidae* | 4 | | | | | Ephydridae | 3 | | | | |
| DO: 6.28 mg/l | Atyidae | 8 | | | | | Veliidae/M..veliidae* | 5 | | **A** | | **A** | Muscidae | 1 | | | | |
| Cond: 62.0 mS/m | Palaemonidae | 10 | | | | | **MEGALOPTERA:** | | | | | | Psychodidae | 1 | | | | |
| **BIOTOPES SAMPLED:** | **HYDRACARINA** | 8 | | | | | Cordalidae | 8 | | | | | Simuliidae | 5 | **A** | **A** | | **A** |
| SIC: TIME: minutes | **PLECOPTERA:** | | | | | | Sialidae | 6 | | | | | Syrphidae* | 1 | | | | |
| SOOC: | Notonemouridae | 14 | | | | | **TRICHOPTERA** | | | | | | Tabanidae | 5 | | | | |
| BEDROCK: | Perlidae | 12 | | | | | Dipseudopsidae | 10 | | | | | Tipulidae | 5 | | | | |
| AQUATIC VEG: DOM SP: | **EPHEMEROPTERA** | | | | | | Ecnomidae | 8 | | | | | **GASTROPODA** | | | | | |
| M VEG IC: DOM SP: | Baetidae 1sp | 4 | | | | | Hydropsychidae 1sp | 4 | | | | | Ancylidae | 6 | | | | |
| M VEG OOC: DOM SP: | Baetidae 2 sp | 6 | **B** | **B** | **B** | **B** | Hydropsychidae 2 sp | 6 | | | | | Bulininae* | 3 | | | | |
| GRAVEL: | Baetidae >2 sp | 12 | | | | | Hydropsychidae >2 sp | 12 | | | | | Hydrobiidae* | 3 | | | | |
| SAND: | Caenidae | 6 | | | | | Philopotamidae | 10 | | | | | Lymnaeidae* | 3 | | | | |
| MUD: | Ephemeridae | 15 | | | | | Polycentropodidae | 12 | | | | | Physidae* | 3 | | | | |
| HAND PICKING/VISUAL OBS: | Heptageniidae | 13 | | | | | Psychomyiidae/Xiphocen. | 8 | | | | | Planorbidae* | 3 | | | | |
| **FLOW**: | Leptophlebiidae | 9 | | | | | **CASED CADDIS:** | | | | | | Thiaridae* | 3 | | | | |
| **TURBIDITY**: | Oligoneuridae | 15 | | | | | Barbarochthonidae SWC | 13 | | | | | Viviparidae* ST | 5 | | | | |
| **RIPARIAN LAND USE:** | Polymitarcyidae | 10 | | | | | Calamoceratidae ST | 11 | | | | | **PELECYPODA** | | | | | |
| | Prosopistomatidae | 15 | | | | | Glossosomatidae SWC | 11 | | | | | Corbiculidae | 5 | | | | |
| | Telogonodidae SWC | 12 | | | | | Hydroptilidae | 6 | | | | | Sphaeriidae | 3 | | | | |
| | Tricorythidae | 9 | | | | | Hydrosalpingidae SWC | 15 | | | | | Unionidae | 6 | | | | |
| | **ODONATA:** | | | | | | Lepidostomatidae | 10 | | | | | **SASS SCORE:** | | 30 | 44 | 19 | 47 |
| **DISTURBANCE IN RIVER:** | Calopterygidae ST,T | 10 | | | | | Leptoceridae | 6 | | | | | **NO OF TAXA:** | | 7 | 10 | 6 | 11 |
| | Chlorocyphidae | 10 | | | | | Petrothrincidae SWC | 11 | | | | | **ASPT:** | | 4 | 4.4 | 3 | 4.3 |
| | Chlorolestidae | 8 | | | | | Pisuliidae | 10 | | | | | **IHAS**: | 71% | | | | |
| | Coenagrionidae | 4 | | **B** | **1** | **B** | Sericostomatidae SWC | 13 | | | | | **OTHER BIOTA**: | | | | | |
| | Lestidae | 8 | | | | | **COLEOPTERA:** | | | | | | | | | | | |
| **SIGNS OF POLLUTION:** | Platycnemidae | 10 | | | | | Dytiscidae* | 5 | | **A** | | **A** | **COMMENTS**: | | | | | |
| | Protoneuridae | 8 | | | | | Elmidae/Dryopidae* | 8 | | | | | | | | | | |
| | Zygoptera juvs. | 6 | | | | | Gyrinidae* | 5 | **A** | **1** | | **A** | | | | | | |
| | Aeshnidae | 8 | **1** | **1** | | **A** | Halipidae* | 5 | | | | | | | | | | |
| | Corduliidae | 8 | | | | | Helodidae | 12 | | | | | * = airbreathers | | | | | |
| **OTHER OBSERVATIONS:** | Gomphidae | 6 | | | | | Hydraenidae* | 8 | | | | | SWC = South Western Cape T = Tropical | | | | | |
| | Libellulidae | 4 | | | | | Hydrophilidae* | 5 | | | | | VG = all vegetation ST = Sub-tropical | | | | | |
| | **LEPIDOPTERA:** | | | | | | Limnichidae | 10 | | | | | GSM = gravel, sand & mud S = Stone & rock | | | | | |
| | Pyralidae | 12 | | | | | Psephenidae | 10 | | | | | 1=1, A=2-10, B=10-100, C=100-1000, D=>1000 | | | | | |

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **DATE**: 23/04/2015 | **TAXON** | | **S** | **VG** | **GSM** | **TOT** | **TAXON** | | **S** | **VG** | **GSM** | **TOT** | **TAXON** | | **S** | **VG** | **GSM** | **TOT** |
| **GRID REFERENCE**: | **PORIFERA** | 5 | | | | | **HEMIPTERA:** | | | | | | **DIPTERA:** | | | | | |
| S:° | **COELENTERATA** | 1 | | | | | Belostomatidae* | 3 | | **B** | **1** | **B** | Athericidae | 10 | | | | |
| E: ° | **TURBELLARIA** | 3 | | | | | Corixidae* | 3 | | **B** | **B** | **B** | Blepharoceridae | 15 | | | | |
| SITE CODE: SITE 9 | **ANNELIDA:** | | | | | | Gerridae* | 5 | | **A** | | **A** | Ceratopogonidae | 5 | | | | |
| RIVER: | Oligochaeta | 1 | | | | | Hydrometridae* | 6 | | | | | Chironomidae | 2 | | **B** | **B** | **B** |
| SITE DESCRIPTION: | Leeches | 3 | | | | | Naucoridae* | 7 | | | | | Culicidae* | 1 | | | | |
| WEATHER CONDITION: | **CRUSTACEA:** | | | | | | Nepidae* | 3 | | | | | Dixidae* | 10 | | | | |
| TEMP: 21.5 °C | Amphipoda | 13 | | | | | Notonectidae* | 3 | | **A** | | **A** | Empididae | 6 | | | | |
| Ph: 6.20 | Potamonautidae* | 3 | | | | | Pleidae* | 4 | | | | | Ephydridae | 3 | | | | |
| DO: 7.92 mg/l | Atyidae | 8 | | | | | Veliidae/M..veliidae* | 5 | | **A** | | **A** | Muscidae | 1 | | | | |
| Cond: 274.0 mS/m | Palaemonidae | 10 | | | | | **MEGALOPTERA:** | | | | | | Psychodidae | 1 | | | | |
| **BIOTOPES SAMPLED:** | **HYDRACARINA** | 8 | | | | | Cordalidae | 8 | | | | | Simuliidae | 5 | | | | |
| SIC: TIME: minutes | **PLECOPTERA:** | | | | | | Sialidae | 6 | | | | | Syrphidae* | 1 | | | | |
| SOOC: | Notonemouridae | 14 | | | | | **TRICHOPTERA** | | | | | | Tabanidae | 5 | | | | |
| BEDROCK: | Perlidae | 12 | | | | | Dipseudopsidae | 10 | | | | | Tipulidae | 5 | | | | |
| AQUATIC VEG: DOM SP: | **EPHEMEROPTERA** | | | | | | Ecnomidae | 8 | | | | | **GASTROPODA** | | | | | |
| M VEG IC: DOM SP: | Baetidae 1sp | 4 | | | | | Hydropsychidae 1sp | 4 | | | | | Ancylidae | 6 | | | | |
| M VEG OOC: DOM SP: | Baetidae 2 sp | 6 | | | | | Hydropsychidae 2 sp | 6 | | | | | Bulininae* | 3 | | | | |
| GRAVEL: | Baetidae >2 sp | 12 | | **B** | **A** | **B** | Hydropsychidae >2 sp | 12 | | | | | Hydrobiidae* | 3 | | | | |
| SAND: | Caenidae | 6 | | | | | Philopotamidae | 10 | | | | | Lymnaeidae* | 3 | | | | |
| MUD: | Ephemeridae | 15 | | | | | Polycentropodidae | 12 | | | | | Physidae* | 3 | | | | |
| HAND PICKING/VISUAL OBS: | Heptageniidae | 13 | | | | | Psychomyiidae/Xiphocen. | 8 | | | | | Planorbidae* | 3 | | | | |
| **FLOW**: | Leptophlebiidae | 9 | | | | | **CASED CADDIS:** | | | | | | Thiaridae* | 3 | | | | |
| **TURBIDITY**: | Oligoneuridae | 15 | | | | | Barbarochthonidae SWC | 13 | | | | | Viviparidae* ST | 5 | | | | |
| **RIPARIAN LAND USE:** | Polymitarcyidae | 10 | | | | | Calamoceratidae ST | 11 | | | | | **PELECYPODA** | | | | | |
| | Prosopistomatidae | 15 | | | | | Glossosomatidae SWC | 11 | | | | | Corbiculidae | 5 | | | | |
| | Teloganodidae SWC | 12 | | | | | Hydroptilidae | 6 | | | | | Sphaeriidae | 3 | | | | |
| | Tricorythidae | 9 | | | | | Hydrosalpingidae SWC | 15 | | | | | Unionidae | 6 | | | | |
| | **ODONATA:** | | | | | | Lepidostomatidae | 10 | | | | | **SASS SCORE:** | | 0 | 60 | 37 | 60 |
| **DISTURBANCE IN RIVER:** | Calopterygidae ST,T | 10 | | | | | Leptoceridae | 6 | | | | | **NO OF TAXA:** | | 0 | 12 | 7 | 12 |
| | Chlorocyphidae | 10 | | | | | Petrothrincidae SWC | 11 | | | | | **ASPT:** | | 0 | 5.0 | 5 | 5.0 |
| | Chlorolestidae | 8 | | | | | Pisuliidae | 10 | | | | | **IHAS**: | | 57% | | | |
| | Coenagrionidae | 4 | | **A** | | **A** | Sericostomatidae SWC | 13 | | | | | **OTHER BIOTA**: | | | | | |
| | Lestidae | 8 | | | | | **COLEOPTERA:** | | | | | | | | | | | |
| **SIGNS OF POLLUTION:** | Platycnemidae | 10 | | | | | Dytiscidae* | 5 | | **A** | **A** | **A** | **COMMENTS**: | | | | | |
| | Protoneuridae | 8 | | | | | Elmidae/Dryopidae* | 8 | | | | | VEG AND GSM ONLY | | | | | |
| | Zygoptera juvs. | 6 | | | | | Gyrinidae* | 5 | | | | | | | | | | |
| | Aeshnidae | 8 | | **A** | **1** | **A** | Halipidae* | 5 | | | | | | | | | | |
| | Corduliidae | 8 | | | | | Helodidae | 12 | | | | | * = airbreathers | | | | | |
| **OTHER OBSERVATIONS:** | Gomphidae | 6 | | **1** | | **1** | Hydraenidae* | 8 | | | | | SWC = South Western Cape T = Tropical | | | | | |
| | Libellulidae | 4 | | **1** | **1** | **A** | Hydrophilidae* | 5 | | | | | VG = all vegetation ST = Sub-tropical | | | | | |
| | **LEPIDOPTERA:** | | | | | | Limnichidae | 10 | | | | | GSM = gravel, sand & mud S = Stone & rock | | | | | |
| | Pyralidae | 12 | | | | | Psephenidae | 10 | | | | | 1=1, A=2-10, B=10-100, C=100-1000, D=>1000 | | | | | |

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET

| **DATE**: 23/04/2015 | **TAXON** | | **S** | **VG** | **GSM** | **TOT** | **TAXON** | | **S** | **VG** | **GSM** | **TOT** | **TAXON** | | **S** | **VG** | **GSM** | **TOT** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **GRID REFERENCE**: | **PORIFERA** | 5 | | | | | **HEMIPTERA:** | | | | | | **DIPTERA:** | | | | | |
| S:° | **COELENTERATA** | 1 | | | | | Belostomatidae* | 3 | | **B** | | **B** | Athericidae | 10 | | | | |
| E: ° | **TURBELLARIA** | 3 | | | | | Corixidae* | 3 | | **B** | **B** | **B** | Blepharoceridae | 15 | | | | |
| SITE CODE: SITE 21 | **ANNELIDA:** | | | | | | Gerridae* | 5 | | **A** | | **A** | Ceratopogonidae | 5 | | | | |
| RIVER: | Oligochaeta | 1 | | | | | Hydrometridae* | 6 | | | | | Chironomidae | 2 | | **B** | **B** | **B** |
| SITE DESCRIPTION: | Leeches | 3 | | | | | Naucoridae* | 7 | | | | | Culicidae* | 1 | | | | |
| WEATHER CONDITION: | **CRUSTACEA:** | | | | | | Nepidae* | 3 | | | | | Dixidae* | 10 | | | | |
| TEMP: 21.3 °C | Amphipoda | 13 | | | | | Notonectidae* | 3 | | | | | Empididae | 6 | | | | |
| Ph: 7.41 | Potamonautidae* | 3 | | | | | Pleidae* | 4 | | | | | Ephydridae | 3 | | | | |
| DO: 3.82 mg/l | Atyidae | 8 | | | | | Veliidae/M..veliidae* | 5 | | **1** | | **1** | Muscidae | 1 | | | | |
| Cond: 72.0 mS/m | Palaemonidae | 10 | | | | | **MEGALOPTERA:** | | | | | | Psychodidae | 1 | | | | |
| **BIOTOPES SAMPLED:** | **HYDRACARINA** | 8 | | | | | Cordalidae | 8 | | | | | Simuliidae | 5 | | **A** | | **A** |
| SIC: TIME: minutes | **PLECOPTERA:** | | | | | | Sialidae | 6 | | | | | Syrphidae* | 1 | | | | |
| SOOC: | Notonemouridae | 14 | | | | | **TRICHOPTERA** | | | | | | Tabanidae | 5 | | | | |
| BEDROCK: | Perlidae | 12 | | | | | Dipseudopsidae | 10 | | | | | Tipulidae | 5 | | | | |
| AQUATIC VEG: DOM SP: | **EPHEMEROPTERA** | | | | | | Ecnomidae | 8 | | | | | **GASTROPODA** | | | | | |
| M VEG IC: DOM SP: | Baetidae 1sp | 4 | | | | | Hydropsychidae 1sp | 4 | | | | | Ancylidae | 6 | | | | |
| M VEG OOC: DOM SP: | Baetidae 2 sp | 6 | | **B** | **A** | **B** | Hydropsychidae 2 sp | 6 | | | | | Bulininae* | 3 | | | | |
| GRAVEL: | Baetidae >2 sp | 12 | | | | | Hydropsychidae >2 sp | 12 | | | | | Hydrobiidae* | 3 | | | | |
| SAND: | Caenidae | 6 | | | | | Philopotamidae | 10 | | | | | Lymnaeidae* | 3 | | | | |
| MUD: | Ephemeridae | 15 | | | | | Polycentropodidae | 12 | | | | | Physidae* | 3 | | | | |
| HAND PICKING/VISUAL OBS: | Heptageniidae | 13 | | | | | Psychomyiidae/Xiphocen. | 8 | | | | | Planorbidae* | 3 | | | | |
| **FLOW**: | Leptophlebiidae | 9 | | | | | **CASED CADDIS:** | | | | | | Thiaridae* | 3 | | | | |
| **TURBIDITY**: | Oligoneuridae | 15 | | | | | Barbarochthonidae SWC | 13 | | | | | Viviparidae* ST | 5 | | | | |
| **RIPARIAN LAND USE:** | Polymitarcyidae | 10 | | | | | Calamoceratidae ST | 11 | | | | | **PELECYPODA** | | | | | |
| | Prosopistomatidae | 15 | | | | | Glossosomatidae SWC | 11 | | | | | Corbiculidae | 5 | | | | |
| | Teloganodidae SWC | 12 | | | | | Hydroptilidae | 6 | | | | | Sphaeriidae | 3 | | | | |
| | Tricorythidae | 9 | | | | | Hydrosalpingidae SWC | 15 | | | | | Unionidae | 6 | | | | |
| | **ODONATA:** | | | | | | Lepidostomatidae | 10 | | | | | **SASS SCORE:** | | 0 | 50 | 26 | 50 |
| **DISTURBANCE IN RIVER:** | Calopterygidae ST,T | 10 | | | | | Leptoceridae | 6 | | | | | **NO OF TAXA:** | | 0 | 11 | 6 | 11 |
| | Chlorocyphidae | 10 | | | | | Petrothrincidae SWC | 11 | | | | | **ASPT:** | | 0 | 4.5 | 4 | 4.5 |
| | Chlorolestidae | 8 | | | | | Pisuliidae | 10 | | | | | **IHAS**: | | 54% | | | |
| | Coenagrionidae | 4 | | **A** | | **A** | Sericostomatidae SWC | 13 | | | | | **OTHER BIOTA**: | | | | | |
| | Lestidae | 8 | | | | | **COLEOPTERA:** | | | | | | | | | | | |
| **SIGNS OF POLLUTION:** | Platycnemidae | 10 | | | | | Dytiscidae* | 5 | | **A** | **1** | **A** | **COMMENTS**: | | | | | |
| | Protoneuridae | 8 | | | | | Elmidae/Dryopidae* | 8 | | | | | VEG AND GSM ONLY | | | | | |
| | Zygoptera juvs. | 6 | | | | | Gyrinidae* | 5 | | | | | | | | | | |
| | Aeshnidae | 8 | | **1** | | **1** | Halipidae* | 5 | | | | | | | | | | |
| | Corduliidae | 8 | | | | | Helodidae | 12 | | | | | * = airbreathers | | | | | |
| **OTHER OBSERVATIONS:** | Gomphidae | 6 | | | **1** | | Hydraenidae* | 8 | | | | | SWC = South Western Cape T = Tropical | | | | | |
| | Libellulidae | 4 | | **A** | **1** | **A** | Hydrophilidae* | 5 | | | | | VG = all vegetation ST = Sub-tropical | | | | | |
| | **LEPIDOPTERA:** | | | | | | Limnichidae | 10 | | | | | GSM = gravel, sand & mud S = Stone & rock | | | | | |
| | Pyralidae | 12 | | | | | Psephenidae | 10 | | | | | 1=1, A=2-10, B=10-100, C=100-1000, D=>1000 | | | | | |

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **DATE**: 22/04/2015 | **TAXON** | | **S** | **VG** | **GSM** | **TOT** | **TAXON** | | **S** | **VG** | **GSM** | **TOT** | **TAXON** | | **S** | **VG** | **GSM** | **TOT** |
| **GRID REFERENCE**: | **PORIFERA** | 5 | | | | | **HEMIPTERA:** | | | | | | **DIPTERA:** | | | | | |
| S:° | **COELENTERATA** | 1 | | | | | Belostomatidae* | 3 | | | | | Athericidae | 10 | | | | |
| E: ° | **TURBELLARIA** | 3 | **B** | **A** | **A** | **B** | Corixidae* | 3 | | **1** | | **1** | Blepharoceridae | 15 | | | | |
| SITE CODE: SITE 26 | **ANNELIDA:** | | | | | | Gerridae* | 5 | | | | | Ceratopogonidae | 5 | | | | |
| RIVER: | Oligochaeta | 1 | **A** | **1** | **1** | **A** | Hydrometridae* | 6 | | | | | Chironomidae | 2 | **1** | **A** | **A** | **B** |
| SITE DESCRIPTION: | Leeches | 3 | | | | | Naucoridae* | 7 | | **A** | **1** | **A** | Culicidae* | 1 | | | | |
| WEATHER CONDITION: | **CRUSTACEA:** | | | | | | Nepidae* | 3 | | | | | Dixidae* | 10 | | | | |
| TEMP: 21.9 °C | Amphipoda | 13 | | | | | Notonectidae* | 3 | | | | | Empididae | 6 | | | | |
| Ph: 8.45 | Potamonautidae* | 3 | | | | | Pleidae* | 4 | | | | | Ephydridae | 3 | | | | |
| DO: 6.28 mg/l | Atyidae | 8 | | | | | Veliidae/M..veliidae* | 5 | | **A** | | **A** | Muscidae | 1 | | | | |
| Cond: 67.0 mS/m | Palaemonidae | 10 | | | | | **MEGALOPTERA:** | | | | | | Psychodidae | 1 | | | | |
| **BIOTOPES SAMPLED:** | **HYDRACARINA** | 8 | | | | | Cordalidae | 8 | | | | | Simuliidae | 5 | **A** | **B** | **A** | **B** |
| SIC: TIME: minutes | **PLECOPTERA:** | | | | | | Sialidae | 6 | | | | | Syrphidae* | 1 | | | | |
| SOOC: | Notonemouridae | 14 | | | | | **TRICHOPTERA** | | | | | | Tabanidae | 5 | | | | |
| BEDROCK: | Perlidae | 12 | | | | | Dipseudopsidae | 10 | | | | | Tipulidae | 5 | | | | |
| AQUATIC VEG: DOM SP: | **EPHEMEROPTERA** | | | | | | Ecnomidae | 8 | | | | | **GASTROPODA** | | | | | |
| M VEG IC: DOM SP: | Baetidae 1sp | 4 | | | | | Hydropsychidae 1sp | 4 | **B** | | | **B** | Ancylidae | 6 | | | | |
| M VEG OOC: DOM SP: | Baetidae 2 sp | 6 | **B** | **B** | **B** | **B** | Hydropsychidae 2 sp | 6 | | | | | Bulininae* | 3 | | | | |
| GRAVEL: | Baetidae >2 sp | 12 | | | | | Hydropsychidae >2 sp | 12 | | | | | Hydrobiidae* | 3 | | | | |
| SAND: | Caenidae | 6 | | | | | Philopotamidae | 10 | | | | | Lymnaeidae* | 3 | | | | |
| MUD: | Ephemeridae | 15 | | | | | Polycentropodidae | 12 | | | | | Physidae* | 3 | **A** | **A** | **A** | **B** |
| HAND PICKING/VISUAL OBS: | Heptageniidae | 13 | | | | | Psychomyiidae/Xiphocen. | 8 | | | | | Planorbidae* | 3 | | | | |
| **FLOW**: | Leptophlebiidae | 9 | | | | | **CASED CADDIS:** | | | | | | Thiaridae* | 3 | | | | |
| **TURBIDITY**: | Oligoneuridae | 15 | | | | | Barbarochthonidae SWC | 13 | | | | | Viviparidae* ST | 5 | | | | |
| **RIPARIAN LAND USE:** | Polymitarcyidae | 10 | | | | | Calamoceratidae ST | 11 | | | | | **PELECYPODA** | | | | | |
| | Prosopistomatidae | 15 | | | | | Glossosomatidae SWC | 11 | | | | | Corbiculidae | 5 | | | | |
| | Teloganodidae SWC | 12 | | | | | Hydroptilidae | 6 | | | | | Sphaeriidae | 3 | | | | |
| | Tricorythidae | 9 | | | | | Hydrosalpingidae SWC | 15 | | | | | Unionidae | 6 | | | | |
| | **ODONATA:** | | | | | | Lepidostomatidae | 10 | | | | | **SASS SCORE:** | | 34 | 61 | 31 | 70 |
| **DISTURBANCE IN RIVER:** | Calopterygidae ST,T | 10 | | | | | Leptoceridae | 6 | | | | | **NO OF TAXA:** | | 9 | 14 | 8 | 16 |
| | Chlorocyphidae | 10 | | | | | Petrothrincidae SWC | 11 | | | | | **ASPT:** | | 4 | 4.4 | 4 | 4.4 |
| | Chlorolestidae | 8 | | | | | Pisuliidae | 10 | | | | | **IHAS**: | 77% | | | | |
| | Coenagrionidae | 4 | | **B** | **A** | **B** | Sericostomatidae SWC | 13 | | | | | **OTHER BIOTA**: | | | | | |
| | Lestidae | 8 | | | | | **COLEOPTERA:** | | | | | | | | | | | |
| **SIGNS OF POLLUTION:** | Platycnemidae | 10 | | | | | Dytiscidae* | 5 | | **A** | | **A** | **COMMENTS**: | | | | | |
| | Protoneuridae | 8 | | | | | Elmidae/Dryopidae* | 8 | | | | | | | | | | |
| | Zygoptera juvs. | 6 | | | | | Gyrinidae* | 5 | **1** | **A** | | **A** | | | | | | |
| | Aeshnidae | 8 | | **1** | | **1** | Halipidae* | 5 | | | | | | | | | | |
| | Corduliidae | 8 | | | | | Helodidae | 12 | | | | | * = airbreathers | | | | | |
| **OTHER OBSERVATIONS:** | Gomphidae | 6 | | | | | Hydraenidae* | 8 | | | | | SWC = South Western Cape T = Tropical | | | | | |
| | Libellulidae | 4 | | **A** | | **A** | Hydrophilidae* | 5 | **1** | | | **1** | VG = all vegetation ST = Sub-tropical | | | | | |
| | **LEPIDOPTERA:** | | | | | | Limnichidae | 10 | | | | | GSM = gravel, sand & mud S = Stone & rock | | | | | |
| | Pyralidae | 12 | | | | | Psephenidae | 10 | | | | | 1=1, A=2-10, B=10-100, C=100-1000, D=>1000 | | | | | |

| RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **DATE**: 22/04/2015 | **TAXON** | | **S** | **VG** | **GSM** | **TOT** | **TAXON** | | **S** | **VG** | **GSM** | **TOT** | **TAXON** | | **S** | **VG** | **GSM** | **TOT** |
| **GRID REFERENCE**: | **PORIFERA** | 5 | | | | | **HEMIPTERA:** | | | | | | **DIPTERA:** | | | | | |
| S:° | **COELENTERATA** | 1 | | | | | Belostomatidae* | 3 | | **B** | | **B** | Athericidae | 10 | | | | |
| E: ° | **TURBELLARIA** | 3 | | | | | Corixidae* | 3 | **A** | **A** | **B** | **B** | Blepharoceridae | 15 | | | | |
| SITE CODE: SITE 27A | **ANNELIDA:** | | | | | | Gerridae* | 5 | | **1** | | **1** | Ceratopogonidae | 5 | **1** | **1** | | **A** |
| RIVER: | Oligochaeta | 1 | **1** | | **1** | **A** | Hydrometridae* | 6 | | | | | Chironomidae | 2 | **A** | **B** | **A** | **B** |
| SITE DESCRIPTION: | Leeches | 3 | | | **1** | **1** | Naucoridae* | 7 | | | | | Culicidae* | 1 | | | | |
| WEATHER CONDITION: | **CRUSTACEA:** | | | | | | Nepidae* | 3 | | | | | Dixidae* | 10 | | | | |
| TEMP: 24.1 °C | Amphipoda | 13 | | | | | Notonectidae* | 3 | **1** | **A** | **1** | **A** | Empididae | 6 | | | | |
| Ph: 8.39 | Potamonautidae* | 3 | | | | | Pleidae* | 4 | | **1** | | **1** | Ephydridae | 3 | | | | |
| DO: 8.69 mg/l | Atyidae | 8 | | | | | Veliidae/M..veliidae* | 5 | | | | | Muscidae | 1 | | | | |
| Cond: 100.0 mS/m | Palaemonidae | 10 | | | | | **MEGALOPTERA:** | | | | | | Psychodidae | 1 | | | | |
| **BIOTOPES SAMPLED:** | **HYDRACARINA** | 8 | | **A** | | **A** | Cordalidae | 8 | | | | | Simuliidae | 5 | **B** | | **A** | **B** |
| SIC: TIME: minutes | **PLECOPTERA:** | | | | | | Sialidae | 6 | | | | | Syrphidae* | 1 | | | | |
| SOOC: | Notonemouridae | 14 | | | | | **TRICHOPTERA** | | | | | | Tabanidae | 5 | | | | |
| BEDROCK: | Perlidae | 12 | | | | | Dipseudopsidae | 10 | | | | | Tipulidae | 5 | | | | |
| AQUATIC VEG: DOM SP: | **EPHEMEROPTERA** | | | | | | Ecnomidae | 8 | **A** | | | **A** | **GASTROPODA** | | | | | |
| M VEG IC: DOM SP: | Baetidae 1sp | 4 | **A** | | | | Hydropsychidae 1sp | 4 | **A** | | | **A** | Ancylidae | 6 | | | | |
| M VEG OOC: DOM SP: | Baetidae 2 sp | 6 | | | | | Hydropsychidae 2 sp | 6 | | | | | Bulininae* | 3 | | | | |
| GRAVEL: | Baetidae >2 sp | 12 | | **B** | | **B** | Hydropsychidae >2 sp | 12 | | | | | Hydrobiidae* | 3 | | | | |
| SAND: | Caenidae | 6 | | | | | Philopotamidae | 10 | | | | | Lymnaeidae* | 3 | | | | |
| MUD: | Ephemeridae | 15 | | | | | Polycentropodidae | 12 | | | | | Physidae* | 3 | **1** | **1** | **A** | **A** |
| HAND PICKING/VISUAL OBS: | Heptageniidae | 13 | | | | | Psychomyiidae/Xiphocen. | 8 | | | | | Planorbidae* | 3 | | | | |
| **FLOW**: | Leptophlebiidae | 9 | | | | | **CASED CADDIS:** | | | | | | Thiaridae* | 3 | | | | |
| **TURBIDITY**: | Oligoneuridae | 15 | | | | | Barbarochthonidae SWC | 13 | | | | | Viviparidae* ST | 5 | | | | |
| **RIPARIAN LAND USE:** | Polymitarcyidae | 10 | | | | | Calamoceratidae ST | 11 | | | | | **PELECYPODA** | | | | | |
| | Prosopistomatidae | 15 | | | | | Glossosomatidae SWC | 11 | | | | | Corbiculidae | 5 | | | | |
| | Teloganodidae SWC | 12 | | | | | Hydroptilidae | 6 | | | | | Sphaeriidae | 3 | | | | |
| | Tricorythidae | 9 | | | | | Hydrosalpingidae SWC | 15 | | | | | Unionidae | 6 | | | | |
| | **ODONATA:** | | | | | | Lepidostomatidae | 10 | | | | | **SASS SCORE:** | | 43 | 69 | 24 | 95 |
| **DISTURBANCE IN RIVER:** | Calopterygidae ST,T | 10 | | | | | Leptoceridae | 6 | | | | | **NO OF TAXA:** | | 11 | 14 | 8 | 20 |
| | Chlorocyphidae | 10 | | | | | Petrothrincidae SWC | 11 | | | | | **ASPT:** | | 4 | 4.9 | 3 | 4.8 |
| | Chlorolestidae | 8 | | | | | Pisuliidae | 10 | | | | | **IHAS**: | 75% | | | | |
| | Coenagrionidae | 4 | | **B** | **A** | **B** | Sericostomatidae SWC | 13 | | | | | **OTHER BIOTA**: | | | | | |
| | Lestidae | 8 | | | | | **COLEOPTERA:** | | | | | | | | | | | |
| **SIGNS OF POLLUTION:** | Platycnemidae | 10 | | | | | Dytiscidae* | 5 | | | | | **COMMENTS**: | | | | | |
| | Protoneuridae | 8 | | | | | Elmidae/Dryopidae* | 8 | | | | | | | | | | |
| | Zygoptera juvs. | 6 | | | | | Gyrinidae* | 5 | **1** | | | **1** | | | | | | |
| | Aeshnidae | 8 | | **B** | | **B** | Halipidae* | 5 | | | | | | | | | | |
| | Corduliidae | 8 | | | | | Helodidae | 12 | | | | | * = airbreathers | | | | | |
| **OTHER OBSERVATIONS:** | Gomphidae | 6 | | | | | Hydraenidae* | 8 | | | | | SWC = South Western Cape T = Tropical | | | | | |
| | Libellulidae | 4 | | **A** | | **A** | Hydrophilidae* | 5 | | **1** | | **1** | VG = all vegetation ST = Sub-tropical | | | | | |
| | **LEPIDOPTERA:** | | | | | | Limnichidae | 10 | | | | | GSM = gravel, sand & mud S = Stone & rock | | | | | |
| | Pyralidae | 12 | | | | | Psephenidae | 10 | | | | | 1=1, A=2-10, B=10-100, C=100-1000, D=>1000 | | | | | |

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET

| **DATE**: 21/04/2015 | **TAXON** | | **S** | **VG** | **GSM** | **TOT** | **TAXON** | | **S** | **VG** | **GSM** | **TOT** | **TAXON** | | **S** | **VG** | **GSM** | **TOT** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **GRID REFERENCE**: | **PORIFERA** | 5 | | | | | **HEMIPTERA:** | | | | | | **DIPTERA:** | | | | | |
| S:° | **COELENTERATA** | 1 | | | | | Belostomatidae* | 3 | | A | | A | Athericidae | 10 | | | | |
| E: ° | **TURBELLARIA** | 3 | | | | | Corixidae* | 3 | B | B | | C | Blepharoceridae | 15 | | | | |
| SITE CODE: SITE 29 / SASS 6 | **ANNELIDA:** | | | | | | Gerridae* | 5 | | | | | Ceratopogonidae | 5 | | | | |
| RIVER: | Oligochaeta | 1 | A | | | A | Hydrometridae* | 6 | | | | | Chironomidae | 2 | A | | A | A |
| SITE DESCRIPTION: | Leeches | 3 | | | | | Naucoridae* | 7 | | 1 | | 1 | Culicidae* | 1 | | | | |
| WEATHER CONDITION: COOL / CLEAR | **CRUSTACEA:** | | | | | | Nepidae* | 3 | | | | | Dixidae* | 10 | | | | |
| TEMP: 19 °C | Amphipoda | 13 | | | | | Notonectidae* | 3 | | A | 1 | A | Empididae | 6 | | | | |
| Ph: 7.49 | Potamonautidae* | 3 | | | | | Pleidae* | 4 | | | | | Ephydridae | 3 | | | | |
| DO: 1.84 mg/l | Atyidae | 8 | | | | | Veliidae/M..veliidae* | 5 | | A | | A | Muscidae | 1 | | | | |
| Cond: 107.0 mS/m | Palaemonidae | 10 | | | | | **MEGALOPTERA:** | | | | | | Psychodidae | 1 | | | | |
| **BIOTOPES SAMPLED:** | **HYDRACARINA** | 8 | | | | | Cordalidae | 8 | | | | | Simuliidae | 5 | | | | |
| SIC: TIME: minutes | **PLECOPTERA:** | | | | | | Sialidae | 6 | | | | | Syrphidae* | 1 | | | | |
| SOOC: | Notonemouridae | 14 | | | | | **TRICHOPTERA** | | | | | | Tabanidae | 5 | | | | |
| BEDROCK: | Perlidae | 12 | | | | | Dipseudopsidae | 10 | | | | | Tipulidae | 5 | | | | |
| AQUATIC VEG: DOM SP: | **EPHEMEROPTERA** | | | | | | Ecnomidae | 8 | | | | | **GASTROPODA** | | | | | |
| M VEG IC: DOM SP: | Baetidae 1sp | 4 | A | | | | Hydropsychidae 1sp | 4 | | | | | Ancylidae | 6 | | | | |
| M VEG OOC: DOM SP: | Baetidae 2 sp | 6 | | | | | Hydropsychidae 2 sp | 6 | | | | | Bulininae* | 3 | | | | |
| GRAVEL: | Baetidae >2 sp | 12 | | B | | B | Hydropsychidae >2 sp | 12 | | | | | Hydrobiidae* | 3 | | | | |
| SAND: | Caenidae | 6 | | | | | Philopotamidae | 10 | | | | | Lymnaeidae* | 3 | | | | |
| MUD: | Ephemeridae | 15 | | | | | Polycentropodidae | 12 | | | | | Physidae* | 3 | | | | |
| HAND PICKING/VISUAL OBS: | Heptageniidae | 13 | | | | | Psychomyiidae/Xiphocen. | 8 | | | | | Planorbidae* | 3 | | | | |
| **FLOW**: | Leptophlebiidae | 9 | | | | | **CASED CADDIS:** | | | | | | Thiaridae* | 3 | | | | |
| **TURBIDITY**: | Oligoneuridae | 15 | | | | | Barbarochthonidae SWC | 13 | | | | | Viviparidae* ST | 5 | | | | |
| **RIPARIAN LAND USE:** | Polymitarcyidae | 10 | | | | | Calamoceratidae ST | 11 | | | | | **PELECYPODA** | | | | | |
| | Prosopistomatidae | 15 | | | | | Glossosomatidae SWC | 11 | | | | | Corbiculidae | 5 | | | | |
| | Teloganodidae SWC | 12 | | | | | Hydroptilidae | 6 | | | | | Sphaeriidae | 3 | | | | |
| | Tricorythidae | 9 | | | | | Hydrosalpingidae SWC | 15 | | | | | Unionidae | 6 | | | | |
| | **ODONATA:** | | | | | | Lepidostomatidae | 10 | | | | | **SASS SCORE:** | | 14 | 33 | 5 | 40 |
| **DISTURBANCE IN RIVER:** | Calopterygidae ST,T | 10 | | | | | Leptoceridae | 6 | | | | | **NO OF TAXA:** | | 5 | 6 | 2 | 9 |
| | Chlorocyphidae | 10 | | | | | Petrothrincidae SWC | 11 | | | | | **ASPT:** | | 3 | 5.5 | 3 | 4.4 |
| | Chlorolestidae | 8 | | | | | Pisuliidae | 10 | | | | | **IHAS**: | 78% | | | | |
| | Coenagrionidae | 4 | | | | | Sericostomatidae SWC | 13 | | | | | **OTHER BIOTA**: | | | | | |
| | Lestidae | 8 | | | | | **COLEOPTERA:** | | | | | | DUCKWEED AND HYACINTH PROLIF | | | | | |
| **SIGNS OF POLLUTION:** | Platycnemidae | 10 | | | | | Dytiscidae* | 5 | | | | | **COMMENTS**: | | | | | |
| | Protoneuridae | 8 | | | | | Elmidae/Dryopidae* | 8 | | | | | LIMITED STONES | | | | | |
| | Zygoptera juvs. | 6 | | | | | Gyrinidae* | 5 | | | | | | | | | | |
| | Aeshnidae | 8 | | | | | Halipidae* | 5 | | | | | | | | | | |
| | Corduliidae | 8 | | | | | Helodidae | 12 | | | | | * = airbreathers | | | | | |
| **OTHER OBSERVATIONS:** | Gomphidae | 6 | | | | | Hydraenidae* | 8 | | | | | SWC = South Western Cape T = Tropical | | | | | |
| | Libellulidae | 4 | A | | | A | Hydrophilidae* | 5 | | | | | VG = all vegetation ST = Sub-tropical | | | | | |
| | **LEPIDOPTERA:** | | | | | | Limnichidae | 10 | | | | | GSM = gravel, sand & mud S = Stone & rock | | | | | |
| | Pyralidae | 12 | | | | | Psephenidae | 10 | | | | | 1=1, A=2-10, B=10-100, C=100-1000, D=>1000 | | | | | |

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **DATE**: 21/04/2015 | **TAXON** | | **S** | **VG** | **GSM** | **TOT** | **TAXON** | | **S** | **VG** | **GSM** | **TOT** | **TAXON** | | **S** | **VG** | **GSM** | **TOT** |
| **GRID REFERENCE**: | **PORIFERA** | 5 | | | | | **HEMIPTERA:** | | | | | | **DIPTERA:** | | | | | |
| S:° | **COELENTERATA** | 1 | | | | | Belostomatidae* | 3 | | | | | Athericidae | 10 | | | | |
| E:° | **TURBELLARIA** | 3 | | | | | Corixidae* | 3 | | | | | Blepharoceridae | 15 | | | | |
| SITE CODE: SITE 31/9 | **ANNELIDA:** | | | | | | Gerridae* | 5 | | | | | Ceratopogonidae | 5 | | | | |
| RIVER: | Oligochaeta | 1 | **A** | | | **A** | Hydrometridae* | 6 | | | | | Chironomidae | 2 | **B** | | **B** | **B** |
| SITE DESCRIPTION: | Leeches | 3 | **A** | | **A** | **A** | Naucoridae* | 7 | | | | | Culicidae* | 1 | | | | |
| WEATHER CONDITION: HOT / CLEAR | **CRUSTACEA:** | | | | | | Nepidae* | 3 | | | | | Dixidae* | 10 | | | | |
| TEMP: 21.6 °C | Amphipoda | 13 | | | | | Notonectidae* | 3 | | **1** | | **1** | Empididae | 6 | | | | |
| Ph: 7.60 | Potamonautidae* | 3 | | | | | Pleidae* | 4 | | | | | Ephydridae | 3 | | | | |
| DO: 3.70 mg/l | Atyidae | 8 | | | | | Veliidae/M..veliidae* | 5 | | | | | Muscidae | 1 | | | | |
| Cond: 65.0 mS/m | Palaemonidae | 10 | | | | | **MEGALOPTERA:** | | | | | | Psychodidae | 1 | | | | |
| **BIOTOPES SAMPLED:** | **HYDRACARINA** | 8 | | | | | Cordalidae | 8 | | | | | Simuliidae | 5 | **B** | **B** | **B** | **B** |
| SIC: TIME: minutes | **PLECOPTERA:** | | | | | | Sialidae | 6 | | | | | Syrphidae* | 1 | | | | |
| SOOC: | Notonemouridae | 14 | | | | | **TRICHOPTERA** | | | | | | Tabanidae | 5 | | | | |
| BEDROCK: | Perlidae | 12 | | | | | Dipseudopsidae | 10 | | | | | Tipulidae | 5 | | | | |
| AQUATIC VEG: DOM SP: | **EPHEMEROPTERA** | | | | | | Ecnomidae | 8 | | | | | **GASTROPODA** | | | | | |
| M VEG IC: DOM SP: | Baetidae 1sp | 4 | | | | | Hydropsychidae 1sp | 4 | | | | | Ancylidae | 6 | | | | |
| M VEG OOC: DOM SP: | Baetidae 2 sp | 6 | | | | | Hydropsychidae 2 sp | 6 | | | | | Bulininae* | 3 | | | | |
| GRAVEL: | Baetidae >2 sp | 12 | **B** | **B** | **B** | **B** | Hydropsychidae >2 sp | 12 | | | | | Hydrobiidae* | 3 | | | | |
| SAND: | Caenidae | 6 | | | | | Philopotamidae | 10 | | | | | Lymnaeidae* | 3 | | | | |
| MUD: | Ephemeridae | 15 | | | | | Polycentropodidae | 12 | | | | | Physidae* | 3 | | | | |
| HAND PICKING/VISUAL OBS: | Heptageniidae | 13 | | | | | Psychomyiidae/Xiphocen. | 8 | | | | | Planorbidae* | 3 | | | | |
| **FLOW**: | Leptophlebiidae | 9 | | | | | **CASED CADDIS:** | | | | | | Thiaridae* | 3 | | | | |
| **TURBIDITY**: | Oligoneuridae | 15 | | | | | Barbarochthonidae SWC | 13 | | | | | Viviparidae* ST | 5 | | | | |
| **RIPARIAN LAND USE:** | Polymitarcyidae | 10 | | | | | Calamoceratidae ST | 11 | | | | | **PELECYPODA** | | | | | |
| | Prosopistomatidae | 15 | | | | | Glossosomatidae SWC | 11 | | | | | Corbiculidae | 5 | | | | |
| | Teloganodidae SWC | 12 | | | | | Hydroptilidae | 6 | | | | | Sphaeriidae | 3 | | | | |
| | Tricorythidae | 9 | | | | | Hydrosalpingidae SWC | 15 | | | | | Unionidae | 6 | | | | |
| | **ODONATA:** | | | | | | Lepidostomatidae | 10 | | | | | **SASS SCORE:** | | 28 | 24 | 22 | 35 |
| **DISTURBANCE IN RIVER:** | Calopterygidae ST,T | 10 | | | | | Leptoceridae | 6 | | | | | **NO OF TAXA:** | | 6 | 4 | 4 | 8 |
| | Chlorocyphidae | 10 | | | | | Petrothrincidae SWC | 11 | | | | | **ASPT:** | | 5 | 6.0 | 6 | 4.4 |
| | Chlorolestidae | 8 | | | | | Pisuliidae | 10 | | | | | **IHAS**: | 73% | | | | |
| | Coenagrionidae | 4 | | **B** | | **B** | Sericostomatidae SWC | 13 | | | | | **OTHER BIOTA**: | | | | | |
| | Lestidae | 8 | | | | | **COLEOPTERA:** | | | | | | | | | | | |
| **SIGNS OF POLLUTION:** | Platycnemidae | 10 | | | | | Dytiscidae* | 5 | | | | | **COMMENTS**: | | | | | |
| | Protoneuridae | 8 | | | | | Elmidae/Dryopidae* | 8 | | | | | ALGAL PROLIF | | | | | |
| | Zygoptera juvs. | 6 | | | | | Gyrinidae* | 5 | **A** | | | **A** | | | | | | |
| | Aeshnidae | 8 | | | | | Halipidae* | 5 | | | | | | | | | | |
| | Corduliidae | 8 | | | | | Helodidae | 12 | | | | | * = airbreathers | | | | | |
| **OTHER OBSERVATIONS:** | Gomphidae | 6 | | | | | Hydraenidae* | 8 | | | | | SWC = South Western Cape T = Tropical | | | | | |
| | Libellulidae | 4 | | | | | Hydrophilidae* | 5 | | | | | VG = all vegetation ST = Sub-tropical | | | | | |
| | **LEPIDOPTERA:** | | | | | | Limnichidae | 10 | | | | | GSM = gravel, sand & mud S = Stone & rock | | | | | |
| | Pyralidae | 12 | | | | | Psephenidae | 10 | | | | | 1=1, A=2-10, B=10-100, C=100-1000, D=>1000 | | | | | |

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET

| DATE: 23/04/2015 | TAXON | | S | VG | GSM | TOT | TAXON | | S | VG | GSM | TOT | TAXON | | S | VG | GSM | TOT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GRID REFERENCE: | PORIFERA | 5 | | | | | HEMIPTERA: | | | | | | DIPTERA: | | | | | |
| S:° | COELENTERATA | 1 | | | | | Belostomatidae* | 3 | | B | 1 | B | Athericidae | 10 | | | | |
| E: ° | TURBELLARIA | 3 | | | | | Corixidae* | 3 | | A | | A | Blepharoceridae | 15 | | | | |
| SITE CODE: SITE 32 | ANNELIDA: | | | | | | Gerridae* | 5 | | | | | Ceratopogonidae | 5 | A | | | A |
| RIVER: | Oligochaeta | 1 | | | A | A | Hydrometridae* | 6 | | | | | Chironomidae | 2 | B | B | B | B |
| SITE DESCRIPTION: | Leeches | 3 | | | 1 | 1 | Naucoridae* | 7 | | | | | Culicidae* | 1 | | | | |
| WEATHER CONDITION: | CRUSTACEA: | | | | | | Nepidae* | 3 | | | | | Dixidae* | 10 | | | | |
| TEMP: 23.2 °C | Amphipoda | 13 | | | | | Notonectidae* | 3 | | | | | Empididae | 6 | | | | |
| Ph: 7.45 | Potamonautidae* | 3 | | | | | Pleidae* | 4 | | | | | Ephydridae | 3 | | | | |
| DO: 3.37 mg/l | Atyidae | 8 | | | | | Veliidae/M..veliidae* | 5 | | | | | Muscidae | 1 | | | | |
| Cond: 92.0 mS/m | Palaemonidae | 10 | | | | | MEGALOPTERA: | | | | | | Psychodidae | 1 | | | | |
| BIOTOPES SAMPLED: | HYDRACARINA | 8 | | | | | Cordalidae | 8 | | | | | Simuliidae | 5 | B | | | B |
| SIC: TIME: minutes | PLECOPTERA: | | | | | | Sialidae | 6 | | | | | Syrphidae* | 1 | | | | |
| SOOC: | Notonemouridae | 14 | | | | | TRICHOPTERA | | | | | | Tabanidae | 5 | | | | |
| BEDROCK: | Perlidae | 12 | | | | | Dipseudopsidae | 10 | | | | | Tipulidae | 5 | | | | |
| AQUATIC VEG: DOM SP: | EPHEMEROPTERA | | | | | | Ecnomidae | 8 | | | | | GASTROPODA | | | | | |
| M VEG IC: DOM SP: | Baetidae 1sp | 4 | | B | | B | Hydropsychidae 1sp | 4 | | | | | Ancylidae | 6 | | | | |
| M VEG OOC: DOM SP: | Baetidae 2 sp | 6 | | | | | Hydropsychidae 2 sp | 6 | | | | | Bulininae* | 3 | | | | |
| GRAVEL: | Baetidae >2 sp | 12 | | | | | Hydropsychidae >2 sp | 12 | | | | | Hydrobiidae* | 3 | | | | |
| SAND: | Caenidae | 6 | | | | | Philopotamidae | 10 | | | | | Lymnaeidae* | 3 | | A | B | B |
| MUD: | Ephemeridae | 15 | | | | | Polycentropodidae | 12 | | | | | Physidae* | 3 | A | A | B | B |
| HAND PICKING/VISUAL OBS: | Heptageniidae | 13 | | | | | Psychomyiidae/Xiphocen. | 8 | | | | | Planorbidae* | 3 | | | | |
| FLOW: | Leptophlebiidae | 9 | | | | | CASED CADDIS: | | | | | | Thiaridae* | 3 | | | | |
| TURBIDITY: | Oligoneuridae | 15 | | | | | Barbarochthonidae SWC | 13 | | | | | Viviparidae* ST | 5 | | | | |
| RIPARIAN LAND USE: | Polymitarcyidae | 10 | | | | | Calamoceratidae ST | 11 | | | | | PELECYPODA | | | | | |
| | Prosopistomatidae | 15 | | | | | Glossosomatidae SWC | 11 | | | | | Corbiculidae | 5 | | | | |
| | Teloganodidae SWC | 12 | | | | | Hydroptilidae | 6 | | | | | Sphaeriidae | 3 | | | | |
| | Tricorythidae | 9 | | | | | Hydrosalpingidae SWC | 15 | | | | | Unionidae | 6 | | | | |
| | ODONATA: | | | | | | Lepidostomatidae | 10 | | | | | SASS SCORE: | | 15 | 22 | 19 | 36 |
| DISTURBANCE IN RIVER: | Calopterygidae ST,T | 10 | | | | | Leptoceridae | 6 | | | | | NO OF TAXA: | | 4 | 7 | 7 | 11 |
| | Chlorocyphidae | 10 | | | | | Petrothrincidae SWC | 11 | | | | | ASPT: | | 4 | 3.1 | 3 | 3.3 |
| | Chlorolestidae | 8 | | | | | Pisuliidae | 10 | | | | | IHAS: | 67% | | | | |
| | Coenagrionidae | 4 | | B | 1 | B | Sericostomatidae SWC | 13 | | | | | OTHER BIOTA: | | | | | |
| | Lestidae | 8 | | | | | COLEOPTERA: | | | | | | | | | | | |
| SIGNS OF POLLUTION: | Platycnemidae | 10 | | | | | Dytiscidae* | 5 | | | | | COMMENTS: | | | | | |
| | Protoneuridae | 8 | | | | | Elmidae/Dryopidae* | 8 | | | | | | | | | | |
| | Zygoptera juvs. | 6 | | | | | Gyrinidae* | 5 | | | | | | | | | | |
| | Aeshnidae | 8 | | | | | Halipidae* | 5 | | | | | | | | | | |
| | Corduliidae | 8 | | | | | Helodidae | 12 | | | | | * = airbreathers | | | | | |
| OTHER OBSERVATIONS: | Gomphidae | 6 | | | | | Hydraenidae* | 8 | | | | | SWC = South Western Cape T = Tropical | | | | | |
| | Libellulidae | 4 | | | | | Hydrophilidae* | 5 | | | | | VG = all vegetation ST = Sub-tropical | | | | | |
| | LEPIDOPTERA: | | | | | | Limnichidae | 10 | | | | | GSM = gravel, sand & mud S = Stone & rock | | | | | |
| | Pyralidae | 12 | | | | | Psephenidae | 10 | | | | | 1=1, A=2-10, B=10-100, C=100-1000, D=>1000 | | | | | |

# APPENDIX G: IHAS Scoresheets

| INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS) | | | | | | |
|---|---|---|---|---|---|---|
| River Name: | | | | | | |
| Site Name: SASS 22/23 | Date: 22/04/2015 | | | | | |
| **SAMPLING HABITAT** | 0 | 1 | 2 | 3 | 4 | 5 |
| **STONES IN CURRENT (SIC)** | | | | | | |
| Total length of white water rapids (i.e.: bubbling water) (in meters) | none | 0-1 | >1-2 | >2-3 | >3-5 | >5 |
| Total length of submerged stones in current (run) (in meters) | none | 0-2 | >2-5 | >5-10 | >10 | |
| Number of separate SIC area's kicked (not individual stones) | 0 | 1 | 2-3 | 4-5 | 6+ | |
| Average stone size's kicked (cm's) (gravel is <2, bedrock is >20) | none | <2>20 | 2-10 | 11-20 | 2-20 | |
| Amount of stone surface clear (of algae, sediment, etc) (in %)* | n/a | 0-25 | 26-50 | 51-75 | >75 | |
| PROTOCOL: time spent actually kicking stones (in minutes) (gravel/bedrock = 0 min) | 0 | <1 | >1-2 | 2 | >2-3 | >3 |
| (* NOTE: up to 25% of stone is usually embedded in the stream bottom) | | | | | | |
| | SIC Score (max 20): | | | 15 | | |
| **VEGETATION** | 0 | 1 | 2 | 3 | 4 | 5 |
| Length of fringing vegetation sampled (river banks) (PROTOCOL - in meters) | none | 0-½ | >½-1 | >1-2 | 2 | >2 |
| Amount of aquatic vegetation sampled (underwater) (in square meters) | none | 0-½ | >½-1 | >1 | | |
| Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only) | none | | run | pool | | mix |
| Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%) | none | 0 | 1-25 | 26-50 | 51-75 | >75 |
| | Vegetation Score (max 15): | | | | 9 | |
| **OTHER HABITAT/GENERAL** | 0 | 1 | 2 | 3 | 4 | 5 |
| Stones out of current (SOOC) sampled: (PROTOCOL - in square meters) | none | 0-½ | >½-1 | 1 | >1 | |
| Sand sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones) | none | under | 0-½ | >½-1 | 1 | >1 |
| Mud sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones) | none | under | 0-½ | ½ | >½ | |
| Gravel sampled: (PROTOCOL - in minutes) (if all gravel, SIC stone size = <2)** | none | 0-½ | ½ | >½** | | |
| Bedrock sampled: ('all' = no SIC, sand, or gravel then SIC stone size = >20)** | none | some | | | all** | |
| Algae present: ('1-2m²' = algal bed; 'rocks' = on rocks; 'isol' = isolated clumps)*** | >2m² | rocks | 1-2m² | <1m² | isol | none |
| Tray identification: (PROTOCOL - using time: 'coor' = correct time) | | under | | corr | | over |
| (** NOTE: you must still fill in the SIC section) | | | | | | |
| | Other Habitat Score (max 20): | | | | 14 | |
| | HABITAT TOTAL (MAX 55): | | | | 38 | |
| **STREAM CONDITION** | 0 | 1 | 2 | 3 | 4 | 5 |
| **PHYSICAL** | | | | | | |
| River make up: ('pool' = pool/still/dam only; 'run' only; etc) | pool | | run | rapid | 2mix | 3mix |
| Average width of stream: (in meters) | | >10 | >5-10 | <1 | 1-2 | >2-5 |
| Average depth of stream: (in meters) | >2 | >1-2 | 1 | >½-1 | ½ | <½ |
| Approximate velocity of stream: ('slow' = <½m/s; 'fast' = >1m/s) (use twig to test) | still | slow | fast | med | | mix |
| Water colour: ('disc' = discoloured with visible colour but still transparent) | silty | opaque | | disc | | clear |
| Recent disturbance due to: ('const.' = construction; 'fl/dr' = flood or drought)*** | flood | fire | constr | other | | none |
| Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees) | none | | grass | shrubs | mix | |
| Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)*** | erosn | farm | trees | other | | open |
| Left bank cover: (rocks and vegetation) (in %) | 0-50 | 51-80 | 81-95 | >95 | | |
| Right bank cover: (rocks and vegetation) (in %) | 0-50 | 51-80 | 81-95 | >95 | | |
| (*** NOTE: if more than one option, choose the lowest) | | | | | | |
| | STREAM CONDITIONS TOTAL (MAX 4 | | | | 33 | |
| | TOTAL IHAS SCORE (%): | | | | 71 | |

| INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS) | | | | | | |
|---|---|---|---|---|---|---|
| **River Name**: | | | | | | |
| **Site Name**: SITE 9 | **Date**: 23/04/2015 | | | | | |
| ***SAMPLING HABITAT*** | **0** | **1** | **2** | **3** | **4** | **5** |
| **STONES IN CURRENT (SIC)** | | | | | | |
| Total length of white water rapids (i.e.: bubbling water) (in meters) | none | 0-1 | >1-2 | >2-3 | >3-5 | >5 |
| Total length of submerged stones in current (run) (in meters) | none | 0-2 | >2-5 | >5-10 | >10 | |
| Number of separate SIC area's kicked (not individual stones) | 0 | 1 | 2-3 | 4-5 | 6+ | |
| Average stone size's kicked (cm's) (gravel is <2, bedrock is >20) | none | <2>20 | 2-10 | 11-20 | 2-20 | |
| Amount of stone surface clear (of algae, sediment, etc) (in %)* | n/a | 0-25 | 26-50 | 51-75 | >75 | |
| PROTOCOL: time spent actually kicking stones (in minutes) (gravel/bedrock = 0 min) | 0 | <1 | >1-2 | 2 | >2-3 | >3 |
| (* NOTE: up to 25% of stone is usually embedded in the stream bottom) | | | | | | |
| | **SIC Score (max 20):** | | | 0 | | |
| **VEGETATION** | **0** | **1** | **2** | **3** | **4** | **5** |
| Length of fringing vegetation sampled (river banks) (PROTOCOL - in meters) | none | 0-½ | >½-1 | >1-2 | 2 | >2 |
| Amount of aquatic vegetation sampled (underwater) (in square meters) | none | 0-½ | >½-1 | >1 | | |
| Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only) | none | | run | pool | | mix |
| Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%) | none | 0 | 1-25 | 26-50 | 51-75 | >75 |
| | **Vegetation Score (max 15):** | | | | 12 | |
| **OTHER HABITAT/GENERAL** | **0** | **1** | **2** | **3** | **4** | **5** |
| Stones out of current (SOOC) sampled: (PROTOCOL - in square meters) | none | 0-½ | >½-1 | 1 | >1 | |
| Sand sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones) | none | under | 0-½ | >½-1 | 1 | >1 |
| Mud sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones) | none | under | 0-½ | ½ | >½ | |
| Gravel sampled: (PROTOCOL - in minutes) (if all gravel, SIC stone size = <2)** | none | 0-½ | ½ | >½** | | |
| Bedrock sampled: ('all' = no SIC, sand, or gravel then SIC stone size = >20)** | none | some | | | all** | |
| Algae present: ('1-2m² = algal bed; 'rocks' = on rocks; 'isol' = isolated clumps)*** | >2m² | rocks | 1-2m² | <1m² | isol | none |
| Tray identification: (PROTOCOL - using time: 'coor' = correct time) | | under | | corr | | over |
| (** NOTE: you must still fill in the SIC section) | | | | | | |
| | **Other Habitat Score (max 20):** | | | | 14 | |
| | **HABITAT TOTAL (MAX 55):** | | | | 26 | |
| ***STREAM CONDITION*** | **0** | **1** | **2** | **3** | **4** | **5** |
| **PHYSICAL** | | | | | | |
| River make up: ('pool' = pool/still/dam only; 'run' only; etc) | pool | | run | rapid | 2mix | 3mix |
| Average width of stream: (in meters) | | >10 | >5-10 | <1 | 1-2 | >2-5 |
| Average depth of stream: (in meters) | >2 | >1-2 | 1 | >½-1 | ½ | <½ |
| Approximate velocity of stream: ('slow' = <½m/s; 'fast' = >1m/s) (use twig to test) | still | slow | fast | med | | mix |
| Water colour: ('disc' = discoloured with visible colour but still transparent) | silty | opaque | | disc | | clear |
| Recent disturbance due to: ('const.' = construction; 'fl/dr' = flood or drought)*** | flood | fire | constr | other | | none |
| Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees) | none | | grass | shrubs | mix | |
| Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)*** | erosn | farm | trees | other | | open |
| Left bank cover: (rocks and vegetation) (in %) | 0-50 | 51-80 | 81-95 | >95 | | |
| Right bank cover: (rocks and vegetation) (in %) | 0-50 | 51-80 | 81-95 | >95 | | |
| (*** NOTE: if more than one option, choose the lowest) | | | | | | |
| | **STREAM CONDITIONS TOTAL (MAX** | | | | 31 | |
| | **TOTAL IHAS SCORE (%):** | | | | 57 | |

## INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)

**River Name**:
**Site Name**: SITE 21 **Date**: 23/04/2015

| SAMPLING HABITAT | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| **STONES IN CURRENT (SIC)** | | | | | | |
| Total length of white water rapids (i.e.: bubbling water) (in meters) | none | 0-1 | >1-2 | >2-3 | >3-5 | >5 |
| Total length of submerged stones in current (run) (in meters) | none | 0-2 | >2-5 | >5-10 | >10 | |
| Number of separate SIC area's kicked (not individual stones) | 0 | 1 | 2-3 | 4-5 | 6+ | |
| Average stone size's kicked (cm's) (gravel is <2, bedrock is >20) | none | <2>20 | 2-10 | 11-20 | 2-20 | |
| Amount of stone surface clear (of algae, sediment, etc) (in %)* | n/a | 0-25 | 26-50 | 51-75 | >75 | |
| PROTOCOL: time spent actually kicking stones (in minutes) (gravel/bedrock = 0 min) | 0 | <1 | >1-2 | 2 | >2-3 | >3 |
| (* NOTE: up to 25% of stone is usually embedded in the stream bottom) | | | | | | |
| | **SIC Score (max 20):** | | | 0 | | |
| **VEGETATION** | 0 | 1 | 2 | 3 | 4 | 5 |
| Length of fringing vegetation sampled (river banks) (PROTOCOL - in meters) | none | 0-½ | >½-1 | >1-2 | 2 | >2 |
| Amount of aquatic vegetation sampled (underwater) (in square meters) | none | 0-½ | >½-1 | >1 | | |
| Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only) | none | | run | pool | | mix |
| Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%) | none | 0 | 1-25 | 26-50 | 51-75 | >75 |
| | **Vegetation Score (max 15):** | | | | 12 | |
| **OTHER HABITAT/GENERAL** | 0 | 1 | 2 | 3 | 4 | 5 |
| Stones out of current (SOOC) sampled: (PROTOCOL - in square meters) | none | 0-½ | >½-1 | 1 | >1 | |
| Sand sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones) | none | under | 0-½ | >½-1 | 1 | >1 |
| Mud sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones) | none | under | 0-½ | ½ | >½ | |
| Gravel sampled: (PROTOCOL - in minutes) (if all gravel, SIC stone size = <2)** | none | 0-½ | ½ | >½** | | |
| Bedrock sampled: ('all' = no SIC, sand, or gravel then SIC stone size = >20)** | none | some | | | all** | |
| Algae present: ('1-2m² = algal bed; 'rocks' = on rocks; 'isol' = isolated clumps)*** | >2m² | rocks | 1-2m² | <1m² | isol | none |
| Tray identification: (PROTOCOL - using time: 'coor' = correct time) | | under | | corr | | over |
| (** NOTE: you must still fill in the SIC section) | | | | | | |
| | **Other Habitat Score (max 20):** | | | | 13 | |
| | **HABITAT TOTAL (MAX 55):** | | | | 25 | |

| STREAM CONDITION | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| **PHYSICAL** | | | | | | |
| River make up: ('pool' = pool/still/dam only; 'run' only; etc) | pool | | run | rapid | 2mix | 3mix |
| Average width of stream: (in meters) | | >10 | >5-10 | <1 | 1-2 | >2-5 |
| Average depth of stream: (in meters) | >2 | >1-2 | 1 | >½-1 | ½ | <½ |
| Approximate velocity of stream: ('slow' = <½m/s; 'fast' = >1m/s) (use twig to test) | still | slow | fast | med | | mix |
| Water colour: ('disc' = discoloured with visible colour but still transparent) | silty | opaque | | disc | | clear |
| Recent disturbance due to: ('const.' = construction; 'fl/dr' = flood or drought)*** | flood | fire | constr | other | | none |
| Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees) | none | | grass | shrubs | mix | |
| Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)*** | erosn | farm | trees | other | | open |
| Left bank cover: (rocks and vegetation) (in %) | 0-50 | 51-80 | 81-95 | >95 | | |
| Right bank cover: (rocks and vegetation) (in %) | 0-50 | 51-80 | 81-95 | >95 | | |
| (*** NOTE: if more than one option, choose the lowest) | | | | | | |
| | **STREAM CONDITIONS TOTAL (MAX** | | | | 29 | |
| | **TOTAL IHAS SCORE (%):** | | | | 54 | |

| INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS) | | | | | | |
|---|---|---|---|---|---|---|
| **River Name**: | | | | | | |
| **Site Name**: SITE 26 | **Date**: 22/04/2015 | | | | | |
| ***SAMPLING HABITAT*** | 0 | 1 | 2 | 3 | 4 | 5 |
| **STONES IN CURRENT (SIC)** | | | | | | |
| Total length of white water rapids (i.e.: bubbling water) (in meters) | none | 0-1 | >1-2 | >2-3 | >3-5 | >5 |
| Total length of submerged stones in current (run) (in meters) | none | 0-2 | >2-5 | >5-10 | >10 | |
| Number of separate SIC area's kicked (not individual stones) | 0 | 1 | 2-3 | 4-5 | 6+ | |
| Average stone size's kicked (cm's) (gravel is <2, bedrock is >20) | none | <2>20 | 2-10 | 11-20 | 2-20 | |
| Amount of stone surface clear (of algae, sediment, etc) (in %)* | n/a | 0-25 | 26-50 | 51-75 | >75 | |
| PROTOCOL: time spent actually kicking stones (in minutes) (gravel/bedrock = 0 min) | 0 | <1 | >1-2 | 2 | >2-3 | >3 |
| (* NOTE: up to 25% of stone is usually embedded in the stream bottom) | | | | | | |
| | **SIC Score (max 20):** | | | 18 | | |
| **VEGETATION** | 0 | 1 | 2 | 3 | 4 | 5 |
| Length of fringing vegetation sampled (river banks) (PROTOCOL - in meters) | none | 0-½ | >½-1 | >1-2 | 2 | >2 |
| Amount of aquatic vegetation sampled (underwater) (in square meters) | none | 0-½ | >½-1 | >1 | | |
| Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only) | none | | run | pool | | mix |
| Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%) | none | 0 | 1-25 | 26-50 | 51-75 | >75 |
| | **Vegetation Score (max 15):** | | | | 12 | |
| **OTHER HABITAT/GENERAL** | 0 | 1 | 2 | 3 | 4 | 5 |
| Stones out of current (SOOC) sampled: (PROTOCOL - in square meters) | none | 0-½ | >½-1 | 1 | >1 | |
| Sand sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones) | none | under | 0-½ | >½-1 | 1 | >1 |
| Mud sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones) | none | under | 0-½ | ½ | >½ | |
| Gravel sampled: (PROTOCOL - in minutes) (if all gravel, SIC stone size = <2)** | none | 0-½ | ½ | >½** | | |
| Bedrock sampled: ('all' = no SIC, sand, or gravel then SIC stone size = >20)** | none | some | | | all** | |
| Algae present: ('1-2m² = algal bed; 'rocks' = on rocks; 'isol' = isolated clumps)*** | >2m² | rocks | 1-2m² | <1m² | isol | none |
| Tray identification: (PROTOCOL - using time: 'coor' = correct time) | | under | | corr | | over |
| (** NOTE: you must still fill in the SIC section) | | | | | | |
| | **Other Habitat Score (max 20):** | | | | 14 | |
| | **HABITAT TOTAL (MAX 55):** | | | | 44 | |
| ***STREAM CONDITION*** | 0 | 1 | 2 | 3 | 4 | 5 |
| **PHYSICAL** | | | | | | |
| River make up: ('pool' = pool/still/dam only; 'run' only; etc) | pool | | run | rapid | 2mix | 3mix |
| Average width of stream: (in meters) | | >10 | >5-10 | <1 | 1-2 | >2-5 |
| Average depth of stream: (in meters) | >2 | >1-2 | 1 | >½-1 | ½ | <½ |
| Approximate velocity of stream: ('slow' = <½m/s; 'fast' = >1m/s) (use twig to test) | still | slow | fast | med | | mix |
| Water colour: ('disc' = discoloured with visible colour but still transparent) | silty | opaque | | disc | | clear |
| Recent disturbance due to: ('const.' = construction; 'fl/dr' = flood or drought)*** | flood | fire | constr | other | | none |
| Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees) | none | | grass | shrubs | mix | |
| Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)*** | erosn | farm | trees | other | | open |
| Left bank cover: (rocks and vegetation) (in %) | 0-50 | 51-80 | 81-95 | >95 | | |
| Right bank cover: (rocks and vegetation) (in %) | 0-50 | 51-80 | 81-95 | >95 | | |
| (*** NOTE: if more than one option, choose the lowest) | | | | | | |
| | **STREAM CONDITIONS TOTAL (MAX** | | | | | 33 |
| | **TOTAL IHAS SCORE (%):** | | | | 77 | |

## INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)

**River Name**:
**Site Name**: SITE 27A **Date**: 22/04/2015

| SAMPLING HABITAT | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| **STONES IN CURRENT (SIC)** | | | | | | |
| Total length of white water rapids (i.e.: bubbling water) (in meters) | none | 0-1 | >1-2 | >2-3 | >3-5 | >5 |
| Total length of submerged stones in current (run) (in meters) | none | 0-2 | >2-5 | >5-10 | >10 | |
| Number of separate SIC area's kicked (not individual stones) | 0 | 1 | 2-3 | 4-5 | 6+ | |
| Average stone size's kicked (cm's) (gravel is <2, bedrock is >20) | none | <2>20 | 2-10 | 11-20 | 2-20 | |
| Amount of stone surface clear (of algae, sediment, etc) (in %)* | n/a | 0-25 | 26-50 | 51-75 | >75 | |
| PROTOCOL: time spent actually kicking stones (in minutes) (gravel/bedrock = 0 min) | 0 | <1 | >1-2 | 2 | >2-3 | >3 |
| (* NOTE: up to 25% of stone is usually embedded in the stream bottom) | | | | | | |
| SIC Score (max 20): | | | | 15 | | |
| **VEGETATION** | 0 | 1 | 2 | 3 | 4 | 5 |
| Length of fringing vegetation sampled (river banks) (PROTOCOL - in meters) | none | 0-½ | >½-1 | >1-2 | 2 | >2 |
| Amount of aquatic vegetation sampled (underwater) (in square meters) | none | 0-½ | >½-1 | >1 | | |
| Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only) | none | | run | pool | | mix |
| Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%) | none | 0 | 1-25 | 26-50 | 51-75 | >75 |
| Vegetation Score (max 15): | | | | | 12 | |
| **OTHER HABITAT/GENERAL** | 0 | 1 | 2 | 3 | 4 | 5 |
| Stones out of current (SOOC) sampled: (PROTOCOL - in square meters) | none | 0-½ | >½-1 | 1 | >1 | |
| Sand sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones) | none | under | 0-½ | >½-1 | 1 | >1 |
| Mud sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones) | none | under | 0-½ | ½ | >½ | |
| Gravel sampled: (PROTOCOL - in minutes) (if all gravel, SIC stone size = <2)** | none | 0-½ | ½ | >½** | | |
| Bedrock sampled: ('all' = no SIC, sand, or gravel then SIC stone size = >20)** | none | some | | | all** | |
| Algae present: ('1-2m² = algal bed; 'rocks' = on rocks; 'isol' = isolated clumps)*** | >2m² | rocks | 1-2m² | <1m² | isol | none |
| Tray identification: (PROTOCOL - using time: 'coor' = correct time) | | under | | corr | | over |
| (** NOTE: you must still fill in the SIC section) | | | | | | |
| Other Habitat Score (max 20): | | | | | 13 | |
| HABITAT TOTAL (MAX 55): | | | | | 40 | |
| **STREAM CONDITION** | 0 | 1 | 2 | 3 | 4 | 5 |
| **PHYSICAL** | | | | | | |
| River make up: ('pool' = pool/still/dam only; 'run' only; etc) | pool | | run | rapid | 2mix | 3mix |
| Average width of stream: (in meters) | | >10 | >5-10 | <1 | 1-2 | >2-5 |
| Average depth of stream: (in meters) | >2 | >1-2 | 1 | >½-1 | ½ | <½ |
| Approximate velocity of stream: ('slow' = <½m/s; 'fast' = >1m/s) (use twig to test) | still | slow | fast | med | | mix |
| Water colour: ('disc' = discoloured with visible colour but still transparent) | silty | opaque | | disc | | clear |
| Recent disturbance due to: ('const.' = construction; 'fl/dr' = flood or drought)*** | flood | fire | constr | other | | none |
| Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees) | none | | grass | shrubs | mix | |
| Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)*** | erosn | farm | trees | other | | open |
| Left bank cover: (rocks and vegetation) (in %) | 0-50 | 51-80 | 81-95 | >95 | | |
| Right bank cover: (rocks and vegetation) (in %) | 0-50 | 51-80 | 81-95 | >95 | | |
| (*** NOTE: if more than one option, choose the lowest) | | | | | | |
| STREAM CONDITIONS TOTAL (MAX 35 | | | | | | 35 |
| TOTAL IHAS SCORE (%): | | | | | 75 | |

## INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)

**River Name:**
**Site Name:** SITE 29 / SASS 6
**Date:** 21/04/2015

| SAMPLING HABITAT | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| **STONES IN CURRENT (SIC)** | | | | | | |
| Total length of white water rapids (i.e.: bubbling water) (in meters) | none | 0-1 | >1-2 | >2-3 | >3-5 | >5 |
| Total length of submerged stones in current (run) (in meters) | none | 0-2 | >2-5 | >5-10 | >10 | |
| Number of separate SIC area's kicked (not individual stones) | 0 | 1 | 2-3 | 4-5 | 6+ | |
| Average stone size's kicked (cm's) (gravel is <2, bedrock is >20) | none | <2>20 | 2-10 | 11-20 | 2-20 | |
| Amount of stone surface clear (of algae, sediment, etc) (in %)* | n/a | 0-25 | 26-50 | 51-75 | >75 | |
| PROTOCOL: time spent actually kicking stones (in minutes) (gravel/bedrock = 0 min) | 0 | <1 | >1-2 | 2 | >2-3 | >3 |
| (* NOTE: up to 25% of stone is usually embedded in the stream bottom) | | | | | | |
| SIC Score (max 20): 14 | | | | | | |
| **VEGETATION** | 0 | 1 | 2 | 3 | 4 | 5 |
| Length of fringing vegetation sampled (river banks) (PROTOCOL - in meters) | none | 0-½ | >½-1 | >1-2 | 2 | >2 |
| Amount of aquatic vegetation sampled (underwater) (in square meters) | none | 0-½ | >½-1 | >1 | | |
| Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only) | none | | run | pool | | mix |
| Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%) | none | 0 | 1-25 | 26-50 | 51-75 | >75 |
| Vegetation Score (max 15): 13 | | | | | | |
| **OTHER HABITAT/GENERAL** | 0 | 1 | 2 | 3 | 4 | 5 |
| Stones out of current (SOOC) sampled: (PROTOCOL - in square meters) | none | 0-½ | >½-1 | 1 | >1 | |
| Sand sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones) | none | under | 0-½ | >½-1 | 1 | >1 |
| Mud sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones) | none | under | 0-½ | ½ | >½ | |
| Gravel sampled: (PROTOCOL - in minutes) (if all gravel, SIC stone size = <2)** | none | 0-½ | ½ | >½** | | |
| Bedrock sampled: ('all' = no SIC, sand, or gravel then SIC stone size = >20)** | none | some | | | all** | |
| Algae present: ('1-2m² = algal bed; 'rocks' = on rocks; 'isol' = isolated clumps)*** | >2m² | rocks | 1-2m² | <1m² | isol | none |
| Tray identification: (PROTOCOL - using time: 'coor' = correct time) | | under | | corr | | over |
| (** NOTE: you must still fill in the SIC section) | | | | | | |
| Other Habitat Score (max 20): 16 | | | | | | |
| HABITAT TOTAL (MAX 55): 43 | | | | | | |
| **STREAM CONDITION** | 0 | 1 | 2 | 3 | 4 | 5 |
| **PHYSICAL** | | | | | | |
| River make up: ('pool' = pool/still/dam only; 'run' only; etc) | pool | | run | rapid | 2mix | 3mix |
| Average width of stream: (in meters) | | >10 | >5-10 | <1 | 1-2 | >2-5 |
| Average depth of stream: (in meters) | >2 | >1-2 | 1 | >½-1 | ½ | <½ |
| Approximate velocity of stream: ('slow' = <½m/s; 'fast' = >1m/s) (use twig to test) | still | slow | fast | med | | mix |
| Water colour: ('disc' = discoloured with visible colour but still transparent) | silty | opaque | | disc | | clear |
| Recent disturbance due to: ('const.' = construction; 'fl/dr' = flood or drought)*** | flood | fire | constr | other | | none |
| Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees) | none | | grass | shrubs | mix | |
| Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)*** | erosn | farm | trees | other | | open |
| Left bank cover: (rocks and vegetation) (in %) | 0-50 | 51-80 | 81-95 | >95 | | |
| Right bank cover: (rocks and vegetation) (in %) | 0-50 | 51-80 | 81-95 | >95 | | |
| (*** NOTE: if more than one option, choose the lowest) | | | | | | |
| STREAM CONDITIONS TOTAL (MAX 35): 35 | | | | | | |
| TOTAL IHAS SCORE (%): 78 | | | | | | |

## INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)

**River Name**:
**Site Name**: SITE 319
**Date**: 21/04/2015

| SAMPLING HABITAT | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| **STONES IN CURRENT (SIC)** | | | | | | |
| Total length of white water rapids (i.e.: bubbling water) (in meters) | none | 0-1 | >1-2 | >2-3 | >3-5 | >5 |
| Total length of submerged stones in current (run) (in meters) | none | 0-2 | >2-5 | >5-10 | >10 | |
| Number of separate SIC area's kicked (not individual stones) | 0 | 1 | 2-3 | 4-5 | 6+ | |
| Average stone size's kicked (cm's) (gravel is <2, bedrock is >20) | none | <2>20 | 2-10 | 11-20 | 2-20 | |
| Amount of stone surface clear (of algae, sediment, etc) (in %)* | n/a | 0-25 | 26-50 | 51-75 | >75 | |
| PROTOCOL: time spent actually kicking stones (in minutes) (gravel/bedrock = 0 min) | 0 | <1 | >1-2 | 2 | >2-3 | >3 |
| (* NOTE: up to 25% of stone is usually embedded in the stream bottom) | | | | | | |
| | **SIC Score (max 20):** | | | 16 | | |
| **VEGETATION** | 0 | 1 | 2 | 3 | 4 | 5 |
| Length of fringing vegetation sampled (river banks) (PROTOCOL - in meters) | none | 0-½ | >½-1 | >1-2 | 2 | >2 |
| Amount of aquatic vegetation sampled (underwater) (in square meters) | none | 0-½ | >½-1 | >1 | | |
| Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only) | none | | run | pool | | mix |
| Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%) | none | 0 | 1-25 | 26-50 | 51-75 | >75 |
| | **Vegetation Score (max 15):** | | | | 10 | |
| **OTHER HABITAT/GENERAL** | 0 | 1 | 2 | 3 | 4 | 5 |
| Stones out of current (SOOC) sampled: (PROTOCOL - in square meters) | none | 0-½ | >½-1 | 1 | >1 | |
| Sand sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones) | none | under | 0-½ | >½-1 | 1 | >1 |
| Mud sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones) | none | under | 0-½ | ½ | >½ | |
| Gravel sampled: (PROTOCOL - in minutes) (if all gravel, SIC stone size = <2)** | none | 0-½ | ½ | >½** | | |
| Bedrock sampled: ('all' = no SIC, sand, or gravel then SIC stone size = >20)** | none | some | | | all** | |
| Algae present: ('1-2m² = algal bed; 'rocks' = on rocks; 'isol' = isolated clumps)*** | >2m² | rocks | 1-2m² | <1m² | isol | none |
| Tray identification: (PROTOCOL - using time: 'coor' = correct time) | | under | | corr | | over |
| (** NOTE: you must still fill in the SIC section) | | | | | | |
| | **Other Habitat Score (max 20):** | | | | 14 | |
| | **HABITAT TOTAL (MAX 55):** | | | | 40 | |

| STREAM CONDITION | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| **PHYSICAL** | | | | | | |
| River make up: ('pool' = pool/still/dam only; 'run' only; etc) | pool | | run | rapid | 2mix | 3mix |
| Average width of stream: (in meters) | | >10 | >5-10 | <1 | 1-2 | >2-5 |
| Average depth of stream: (in meters) | >2 | >1-2 | 1 | >½-1 | ½ | <½ |
| Approximate velocity of stream: ('slow' = <½m/s; 'fast' = >1m/s) (use twig to test) | still | slow | fast | med | | mix |
| Water colour: ('disc' = discoloured with visible colour but still transparent) | silty | opaque | | disc | | clear |
| Recent disturbance due to: ('const.' = construction; 'fl/dr' = flood or drought)*** | flood | fire | constr | other | | none |
| Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees) | none | | grass | shrubs | mix | |
| Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)*** | erosn | farm | trees | other | | open |
| Left bank cover: (rocks and vegetation) (in %) | 0-50 | 51-80 | 81-95 | >95 | | |
| Right bank cover: (rocks and vegetation) (in %) | 0-50 | 51-80 | 81-95 | >95 | | |
| (*** NOTE: if more than one option, choose the lowest) | | | | | | |
| | **STREAM CONDITIONS TOTAL (MAX** | | | | | 33 |
| | **TOTAL IHAS SCORE (%):** | | | | 73 | |

## INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)

**River Name**:

**Site Name**: SITE 32

**Date**: 23/04/2015

| SAMPLING HABITAT | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| **STONES IN CURRENT (SIC)** | | | | | | |
| Total length of white water rapids (i.e.: bubbling water) (in meters) | none | 0-1 | >1-2 | >2-3 | >3-5 | >5 |
| Total length of submerged stones in current (run) (in meters) | none | 0-2 | >2-5 | >5-10 | >10 | |
| Number of separate SIC area's kicked (not individual stones) | 0 | 1 | 2-3 | 4-5 | 6+ | |
| Average stone size's kicked (cm's) (gravel is <2, bedrock is >20) | none | <2>20 | 2-10 | 11-20 | 2-20 | |
| Amount of stone surface clear (of algae, sediment, etc) (in %)* | n/a | 0-25 | 26-50 | 51-75 | >75 | |
| PROTOCOL: time spent actually kicking stones (in minutes) (gravel/bedrock = 0 min) | 0 | <1 | >1-2 | 2 | >2-3 | >3 |
| (* NOTE: up to 25% of stone is usually embedded in the stream bottom) | | | | | | |
| | **SIC Score (max 20):** | | | 17 | | |
| **VEGETATION** | 0 | 1 | 2 | 3 | 4 | 5 |
| Length of fringing vegetation sampled (river banks) (PROTOCOL - in meters) | none | 0-½ | >½-1 | >1-2 | 2 | >2 |
| Amount of aquatic vegetation sampled (underwater) (in square meters) | none | 0-½ | >½-1 | >1 | | |
| Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only) | none | | run | pool | | mix |
| Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%) | none | 0 | 1-25 | 26-50 | 51-75 | >75 |
| | **Vegetation Score (max 15):** | | | | 11 | |
| **OTHER HABITAT/GENERAL** | 0 | 1 | 2 | 3 | 4 | 5 |
| Stones out of current (SOOC) sampled: (PROTOCOL - in square meters) | none | 0-½ | >½-1 | 1 | >1 | |
| Sand sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones) | none | under | 0-½ | >½-1 | 1 | >1 |
| Mud sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones) | none | under | 0-½ | ½ | >½ | |
| Gravel sampled: (PROTOCOL - in minutes) (if all gravel, SIC stone size = <2)** | none | 0-½ | ½ | >½** | | |
| Bedrock sampled: ('all' = no SIC, sand, or gravel then SIC stone size = >20)** | none | some | | | all** | |
| Algae present: ('1-2m² = algal bed; 'rocks' = on rocks; 'isol' = isolated clumps)*** | >2m² | rocks | 1-2m² | <1m² | isol | none |
| Tray identification: (PROTOCOL - using time: 'coor' = correct time) | | under | | corr | | over |
| (** NOTE: you must still fill in the SIC section) | | | | | | |
| | **Other Habitat Score (max 20):** | | | | 10 | |
| | **HABITAT TOTAL (MAX 55):** | | | | 38 | |
| **STREAM CONDITION** | 0 | 1 | 2 | 3 | 4 | 5 |
| **PHYSICAL** | | | | | | |
| River make up: ('pool' = pool/still/dam only; 'run' only; etc) | pool | | run | rapid | 2mix | 3mix |
| Average width of stream: (in meters) | | >10 | >5-10 | <1 | 1-2 | >2-5 |
| Average depth of stream: (in meters) | >2 | >1-2 | 1 | >½-1 | ½ | <½ |
| Approximate velocity of stream: ('slow' = <½m/s; 'fast' = >1m/s) (use twig to test) | still | slow | fast | med | | mix |
| Water colour: ('disc' = discoloured with visible colour but still transparent) | silty | opaque | | disc | | clear |
| Recent disturbance due to: ('const.' = construction; 'fl/dr' = flood or drought)*** | flood | fire | constr | other | | none |
| Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees) | none | | grass | shrubs | mix | |
| Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)*** | erosn | farm | trees | other | | open |
| Left bank cover: (rocks and vegetation) (in %) | 0-50 | 51-80 | 81-95 | >95 | | |
| Right bank cover: (rocks and vegetation) (in %) | 0-50 | 51-80 | 81-95 | >95 | | |
| (*** NOTE: if more than one option, choose the lowest) | | | | | | |
| | **STREAM CONDITIONS TOTAL (MAX** | | | | 29 | |
| | **TOTAL IHAS SCORE (%):** | | | | 67 | |

# APPENDIX H: IHIA Scoresheets

Instream Zone Habitat Integrity

| | Weights | 14 | 13 | 13 | 13 | 14 | 10 | 9 | 8 | 6 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Reach | ASSESSMENT DATE | Water abstraction | Flow modification | Bed modification | Channel modification | Water quality | Inundation | Exotic macrophytes | Exotic fauna | Solid waste disposal | Total Score (%) | Classification |
| Hex River | | 11 | 9 | 8 | 9 | 14 | 4 | 6 | 2 | 6 | 57.4 | D (Largely modified) |
| Dorpspruit | | 10 | 7 | 6 | 7 | 14 | 2 | 2 | 2 | 2 | 68.9 | C (Moderately modified) |
| Klipfonteinspruit | | 9 | 10 | 8 | 9 | 16 | 4 | 6 | 2 | 3 | 49.0 | D (Largely modified) |
| Raardekraalspruit | | 6 | 11 | 8 | 9 | 14 | 3 | 2 | 2 | 2 | 60.1 | C (Moderately modified) |

| | | | | | |
|---|---|---|---|---|---|
| *None* | *Small* | *Moderate* | *Large* | *Serious* | *Critical* |

Riparian Zone Habitat Integrity

| | Weights | 13 | 12 | 14 | 12 | 13 | 11 | 12 | 13 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Reach | ASSESSMENT DATE | Vegetation removal | Alien encroachment | Bank erosion | Water abstraction | Flow modification | Channel modification | Water quality | Inundation | Total Score (%) | Classification |
| Hex River | | 9 | 10 | 14 | 6 | 5 | 9 | 12 | 4 | 56.8 | D (largely modified) |
| Dorpspruit | | 9 | 5 | 9 | 6 | 7 | 9 | 12 | 2 | 66.6 | C (Moderately modified) |
| Klipfonteinspruit | | 9 | 9 | 9 | 6 | 5 | 9 | 14 | 4 | 44.8 | D (largely modified) |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Raardekraalspruit | | 9 | 8 | 8 | 6 | 7 | 9 | 12 | 2 | 58.0 | D (largely modified) |

| | | | | | |
|---|---|---|---|---|---|
| *None* | *Small* | *Moderate* | *Large* | *Serious* | *Critical* |

| REACH | ASSESSMENT DATE | INSTREAM HABITAT | RIPARIAN ZONE | IHI SCORE | CLASS |
|---|---|---|---|---|---|
| Hex River | | 57.4 | 56.8 | 57.1 | D (largely modified) |
| Dorpspruit | | 68.9 | 66.6 | 67.8 | C (Moderately modified) |
| Klipfonteinspruit | | 49.0 | 44.8 | 46.9 | D (largely modified) |
| Raardekraalspruit | | 60.1 | 58.0 | 59.0 | D (largely modified) |