AQUATIC BASELINE AND IMPACT STUDY AS PART OF THE ENVIRONMENTAL ASSESSMENT AND AUTHORISATION PROCESS FOR THE DOORNHOEK FLUORITE MINE, ZEERUST, NORTH-WEST PROVINCE

Prepared for

Exigo Pty Ltd

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BASELINE REPORT

Declaration of Independence

This report has been prepared according to the requirements of Section 32 (3b) of the Environmental Impact Assessments Regulations, 2014 (GNR 982). We (the undersigned) declare the findings of this report free from influence or prejudice.

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____________________ Date: 29 October 2016
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EXECUTIVE SUMMARY

Scientific Aquatic Services (SAS) was appointed to undertake a Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS) analysis of the aquatic resources as part of a risk assessment for the proposed Doornhoek mining project, between the towns of Zeerust and Groot Marico within the North-West Province, hereafter referred to as the 'study area'. A feasibility study was conducted in October 2014, where the Present Ecological State of the aquatic resources in the vicinity of the study area was assessed. A further study of the aquatic resources present was conducted in May 2016 as part of the baseline assessment for the proposed Doornhoek mining project.

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

According to the North West Biodiversity sector Plan (NW BSP 2015) the Marico River system, including its associated tributaries is a highly ecologically significant aquatic ecosystem as highlighted by them being designated as priority rivers (FEPA Rivers). The system is also defined as an aquatic Critical Biodiversity 2 (CBA2).CBA2 according to the 2008 CBA dataset areas are near natural landscape with the following attributes these classifications are due to the clean, free-flowing nature of the Marico River and the presence of the Vulnerable Marico barb (*Barbus motebensis*) and the Near Threatened Barbus sp. 'Waterberg barb' which is considered near threatened and occurs in the upper reaches of the Klein Marico River system as well as the Groot Marico and Koster River systems . The upper reaches the Marico river are in a natural or near-natural ecological state (ecological category A/B: largely natural) are important as they represent a representative sample of the diversity of freshwater ecosystem types in the province that should remain in a good ecological state.

According to the NW BSP (2015) Marico River Conservation Association has been established by the landowners whom are striving for Biosphere Reserve status The upper Groot Marico River and tributaries are also important for species evolutionary processes as the different catchments support three genetically distinct populations of the Vulnerable Marico barb (*Barbus motebensis*). Diversification of fish and other aquatic organisms is likely to be a phenomenon common to all upper catchments of rivers arising in the Swartruggens and Magaliesberg mountains. The rivers and associated catchments that support threatened fish species are Fish Sanctuary Areas, which are designated as Freshwater Ecosystem Priority Areas if in a good ecological condition (A or B ecological category) or Fish Support Areas (lower than A or B ecological category)

The Present Ecological State (PES) of the Klein-Marico River is categorised as a Class B: Largely Natural:

- The potential instream habitat continuity modification has no rating (no discernible impact);
- The potential riparian/wetland habitat continuity modification, the potential riparian/wetland zone modification, the potential instream habitat modification and the potential physico-chemical modification levels has a small impact rating (modification is limited to a few localities);
- The potential instream flow modification is moderately modified (modifications are only present at a small number of localities);

The Ecological Importance is considered moderately modified:

- The number of fish species estimated per sub quaternary reach is 5;
- The fish representivity is considered low;
- The fish rarity per secondary class (IRAR) is considered low;
- The Ecological Importance of the riparian-wetland-instream vertebrates (excluding fish) rating is low;
- The riparian-wetland natural vegetation importance, which is based on the percentage of natural vegetation within 500m is considered very high;
- The riparian-wetland natural vegetation importance based on expert rating is considered high;
- The number of invertebrate taxa per sub quaternary reach is 37;
- The invertebrate representivity per secondary class (IREP) is considered moderate;
- The invertebrate rarity per secondary class (IRAR) is considered high;
- The habitat diversity class is considered low;
- The habitat size (Length) class are considered very low;
- The instream migration link class is very high;
- The riparian-wetland zone mitigation link is very high;

- The riparian-wetland zone habitat integrity class is high;
- The instream habitat integrity class is very high.

The ecological sensitivity is considered moderate:

- The fish and invertebrate physio-chemical sensitivity description is high, meaning that the species require moderate unmodified physic-chemical conditions to survive and breed;
- The fish no-flow sensitivity description and the invertebrate velocity sensitivity is high, meaning that the species require flow during certain phases of the life cycle to breed in particular habitats (often fast flows). Generally, increased habitat suitability and availability resulting from increased flow can be expected to benefit such species, flow will stimulate breeding activities and stimulate migration;
- The riparian-wetland-instream vertebrates (excluding fish) intolerance water level/flow changes description is low, meaning that the taxa within the system have a low sensitivity to water levels and flow changes. Suitable level or flow will benefit taxa but they do not have a crucial dependence on this;
- The stream size sensitivity to modified flow/water level changes description is not assessed;
- The riparian-wetland vegetation intolerance to water level changes is low.

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

Please note that the following pertains to the results of a feasibility assessment performed in October 2014, as well as a baseline assessment performed in May 2016. All reference to temporal comparisons thus refer to comparison of changes in data between October 2014 and May 2016.

The Klein Marico River System
Key observations relating to water quality along this section of the Klein Marico River system:

- Concentration of dissolved salts remained fairly constant both spatially as well as temporally between each of the sites assessed;
- Spatially, in the October 2014 assessment, the conductivity decreased by 16.3% between sites DHK B3 and DHK B4 but increased by 16.1% between the former and site DHK B5. Conductivity increased by 38.8% between sites DHK B4 and DHK B5;
- In the May 2016 assessment, the conductivity decreases only slightly by 7.7% between sites DHK B3 and site DHK B4;
- Temporally, the conductivity increases by 14.8% at site DHK B3 and by 26.6% at site DHK B4. This spatial and temporal data indicates that during periods of low flows salts concentrate in the Klein Marico River system;
- Slow, shallow conditions predominated at all sites. Changes in conductivity may have been influenced by slight differences in evaporation rate and river make up, geological effects and agricultural activities in the form of abstraction and watering of cattle as well as agricultural return flows;
- The water quality guideline for aquatic ecosystems (DWA 1997) states that: 1) Total dissolved salts (TDS) concentrations (i.e. as indicated by the EC measurements) should not be changed by > 15 % from the normal cycles of the water body under unimpacted conditions at any time of the year; and 2) the amplitude and frequency of natural cycles in TDS concentrations should not be changed;
- The spatial and temporal changes in conductivity along this section of the Klein Marico River thus exceeds the above recommendation prior to any mining activities in the area. The data therefore indicates substantial variation in salt concentration in the system prior to any impact from the proposed mining operation;
- Data from future monitoring studies should be used to identify temporal trends and data from this report should be used as a temporal baseline to which future data can be compared;
- The water quality guideline for aquatic ecosystems (DWA 1997) states that pH values should not be allowed to vary from the range of the background pH values for a specific site by > 5 %;
- If the upstream site DHK B3 pH value observed in October 2014 is considered a spatial and temporal reference value. The observed changes in pH value exceed the recommended percentage change range. The data therefore indicates substantial variation in pH value in the system prior to any impact from the proposed mining operation;
- However, natural pH ranges fall between 6.5 and 8.5 as was observed at each of the sites in both the October 2014 as well as in the May 2016 assessments;

- Data from report should be used as a temporal baseline to which future data can be compared. As the pH appears somewhat variable in this system from both a spatial as well as a temporal perspective, it is deemed important that the absolute pH values be monitored and that any fluctuations outside of the natural pH ranges be regarded as a red flag for impact once mining activities in the area commence;
- The water quality guideline for aquatic ecosystems (DWA 1997) 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 18 May 2013);
- Dissolved oxygen concentrations at each of the sites assessed in May 2016 are below the recommended range indicating that the lack of dissolved oxygen in the system may limit the aquatic community to some degree;
- Data from future monitoring studies will be used to identify temporal trends;
- The temperatures observed at each of the points are deemed natural for the time of year and the nature of the systems. The observed variations can be attributed to diurnal variation between sampling times and the slight variation in the volume of water in the water bodies sampled.

Habitat integrity along this section of the Klein Marico River system:

- Based on the observations of both the October 2014 as well as the May 2016 habitat assessments, the habitat diversity and structure in terms of habitat provision for aquatic communities is deemed largely inadequate to support a diverse aquatic macro-invertebrate community under very low flow conditions. On comparison of the results of the October 2014 assessment to the results of the May 2016 assessment, it is evident that under higher flow conditions, habitat suitability is slightly improved;
- On application of the Intermediate Habitat Integrity Assessment (IHIA), for the Klein Marico River sites (DHK B3, DHK B4 and DHK B5 assessed in October 2014 and DHK B3, DHK B4 and DHKK 4 assessed in May 2016), mostly only small and moderate impacts were recorded for both instream and riparian zones habitat (Appendix 5). The DHK B5 site was not reassessed in the May 2016 assessment due to the absence of flow at this point and the results of the October 2014 assessment are thus retained;
- Large instream impacts in terms of flow and bed modifications were observed at site DHK B3 and site DHK B4. Other instream impacts at these two sites included small channel and water quality modifications and solid waste disposal. At site DHK B5, assessed only in the October 2014 assessment, a moderate instream impact in terms of water quality was noted, with smaller impacts related to water abstraction activities, flow, bed and channel modifications, exotic fauna and solid waste disposal also evident. At site DHKK 4, assessed only in the May 2016 assessment, only very small impacts in terms of flow, bed and water quality modifications were observed;
- For instream habitat zone integrity both sites DHK B3 and DHK B4 obtained a B (largely natural) classification in October 2014 and a C (moderately modified) classification in the May 2016 assessment. Site DHK B5 obtained a class B (largely natural) classification and the DHKK 4 site obtained an A (natural) classification in the May 2016 assessment;
- The variations observed are largely related to changes in flow condition at each site between the October 2014 and May 2016 assessments and are considered unrelated to any existing impacts as a result of activities in the vicinity of the proposed mining project which include but are not limited to game farming, livestock farming, agricultural activities, water abstraction and historical mining activities in the surrounding area;
- Riparian zone impacts included indigenous vegetation removal and exotic vegetation encroachment at sites DHK B3, DHK B4 and DHK B5, with some impacts as a result of erosion observed at site DHK B4. These impacts are likely related to agricultural activities, trampling by livestock and water abstraction activities. For riparian habitat zone integrity both sites DHK B3 and DHK B4 obtained B (largely natural) classifications in both the October 2014 and the May 2016 assessments. Site DHK B5 obtained a B (largely natural) classification in October 2014 and site DHKK 4 was assigned an A (natural) classification in May 2016.
- Overall scores of 73.68% (DHK B3), 78.95% (DHK B4), 84.84% (DHK B5) and 96.88% (DHKK 4) were calculated, placing sites DHK B3 and DHK B4 in a class C (moderately modified), site DHK B5 in a class B (largely natural) and site DHKK 4 in a class A (natural) condition.

Application of the Riparian Vegetation Response Assessment Index (VEGRAI) to the Klein Marico River:
The overall VEGRAI score calculated for the upper portion of the Klein Marico River falls within the EC Class E (Seriously modified) due to vegetation removal and alien vegetation encroachment. Vegetation associated with the downstream portion of the Klein Marico River falls within the EC Class C (Moderately modified) with less significant impacts encountered but water abstraction and impacts from livestock trampling and some alien vegetation encroachment were still evident.

The overall score calculated for the Klein Marico River, taking into consideration both the upper and lower portions of the river, falls within an EC Class D indicating largely modified conditions. Measures to control impacts on water loss from the system as well as vegetation removal will be important and measures to control alien vegetation encroachment will be critical.

Fish Community Assessment of the Klein Marico River:
Included in the list of expected species based on habitat availability and distribution range is the Marico barb (*Enteromius motebensis*).

The Marico barb has a very limited distribution range with very small area of occupancy. Because it is known from only approximately ten locations threatened by water abstraction for agriculture, seepage from mines via dolomitic groundwater or alien predatory fish species (*Micropterus* spp.), it has been classified as a vulnerable red data list species.

Whilst no specimens of this species were collected from assessed sites in the systems under investigation, such populations may exist on a regional scale. Various contributing factors are likely to play a role in the lack of field observations of *E. motebensis.* Very low flows observed in the May 2016 assessment as a result of severe nationwide drought conditions and the associated lack of flow connectivity are likely to have significantly affected natural migration routes and the absence is unlikely related to current impacts to water quality in the system. Should the Doornhoek mining project proceed, special effort should be made to ensure maintenance of habitat and ecological integrity of the stream to limit larger scale regional impacts on potential *E. motebensis* populations.

During the field assessments carried out in October 2014 and May 2016, the following fish species were observed:
- *Enteromius paludinosis*;
- *Pseudocriilabrus philander;* and
- *Tilapia sparrmanii*.

Thus, on application of the FRAI to the fish populations of the Klein Marico River, an Ecological Category E was assigned by the Automated FRAI, while an Ecological Category D was assigned according to the Refined FRAI.

Aquatic EIS determination of the Klein Marico River
Based on the findings of the assessment it is evident that aquatic features associated with the Klein Marico River have an EIS which can be considered moderate to high. The Klein Marico River system can therefore be defined as being unique on a local to national scale due to biodiversity (habitat diversity, species diversity, unique species, rare and endangered species).

The Unnamed Tributary of the Klein Marico River
Key observations relating to water quality along this section of the unnamed tributary of the Klein Marico River system:
- Conductivity values were similar to that recorded from the Klein Marico River assessment sites;
- Concentration of dissolved salts remained fairly constant but were slightly higher at the downstream (DHK B2) site;
- Conductivity increased by 20.8% between sites DHK B1 and DHK B2;
- Very slow and shallow conditions predominated at both sites. Changes in conductivity may have been influenced by slight differences in evaporation rate and river make up, geological effects and agricultural activities in the form of agricultural return flows, abstraction and watering of cattle;

- The water quality guideline for aquatic ecosystems (DWA 1997) states that: 1) Total dissolved salts (TDS) concentrations (i.e. as indicated by the EC measurements) should not be changed by > 15 % from the normal cycles of the water body under unimpacted conditions at any time of the year; and 2) the amplitude and frequency of natural cycles in TDS concentrations should not be changed;
- When viewing upstream site DHK B1 as a reference site, the spatial change in a downstream direction thus exceeds the guideline recommendation. This serves as an indication that before any impacts related to the proposed mining project, some salinisation of the system is deemed likely in the local area due to natural variations in the flow conditions and rates and the various agricultural activities taking place in the area;
- The pH at both points can be considered neutral and is unlikely to affect aquatic biota;
- Dissolved oxygen concentration at the upstream DHK B1 assessment site was in compliance with the recommended range and the system is therefore expected to support a diverse and sensitive aquatic community, unless habitat conditions constrain the ecology of the system;
- The temperatures observed at each of the points are deemed natural for the time of year and the nature of the systems. The observed variations can be attributed to diurnal variation between sampling times and the slight variation in the volume of water in the water bodies sampled.

Habitat integrity along this section of the Unnamed Tributary of the Klein Marico River system:

- In the May 2016 assessment, the habitat diversity and structure at the DHK B1 site may be regarded as adequate to support a diverse aquatic macro-invertebrate community under the current low flow conditions, while at site DHK B2, habitat conditions may be regarded as unsuitable for supporting a diverse and sensitive aquatic community due largely to constraints in the availability of adequate flow at this point;
- On application of the IHIA to the two sites on the unnamed tributary of the Klein Marico River, small to critical impacts were recorded for instream zone habitat whilst small to serious impacts were reported for riparian zones habitat (Appendix 5);
- For site DHK B1, the instream zone habitat integrity assessment revealed critical impacts on water abstraction and flow modification, while for site DHK B2, with reference to the same two variables, serious and moderate impacts were respectively recorded. In addition, at site DHK B1, a large impact as a result of channel modification was observed, while a moderate impact was reported for site DHK B2 for the same variable. Both sites DHK B1 and DHK B2 presented with moderate impacts on bed modification and small impacts on solid waste disposal. Other moderate impacts include exotic fauna at site DHK B2 and inundation at site DHK B1. For instream zone habitat integrity site DHK B1 achieved a score of 25.5% (Class E, extensive loss) whilst site DHK B2 achieved 40.9% (Class D, largely modified);
- In terms of impacts to the riparian zone, the most significant impact at site DHK B1 was alien vegetation encroachment, while at site DHK B2 only a moderate impact was recorded for the same variable. Both sites presented with large impacts related to vegetation removal and moderate impacts from water abstraction, flow modification and channel modification. Small impacts associated with inundation at site DHK B1 were noted. A moderate impact as a result of bank erosion was recorded for site DHK B2. In lieu of these observations, for riparian zone habitat integrity site DHK B1 achieved a score of 71.6% (Class C, moderately modified) whilst site DHK B2 achieved 45.9% (Class D, largely modified);
- An overall score of 48.5% was calculated for DHK B1 and 43.3% for DHK B2, resulting in both being classified as Class D (Largely modified) sites.

Application of the Riparian Vegetation Response Assessment Index (VEGRAI) to the Unnamed Tributary of the Klein Marico River:

The VEGRAI ecostatus tool for this unnamed tributary yielded a VEGRAI score of 68.7% indicating moderately modified Class B conditions. The levels of integrity of the marginal and non-marginal zones were largely similar. The most significant impacts on the system occur from alien vegetation encroachment and vegetation removal. Some stress on the marginal zone from water abstraction is however also evident.

Fish Community Assessment of the Unnamed Tributary of the Klein Marico River:

During the field assessments carried out in October 2014 and May 2016, only one fish species was observed, the *Tilapia sparrmanii*. Thus, on application of the FRAI to the fish populations of the unnamed tributary of Klein Marico River, an Ecological Category E/F was assigned by the Automated FRAI, while an Ecological Category D/E was assigned according to the Refined FRAI.

The EC calculated for the FRAI largely corresponds to that obtained for the MIRAI applied to this section of the unnamed tributary of the Klein Marico River. This could be expected as both fish populations as well as aquatic macro-invertebrate species are subject to and influenced by the same ecological drivers. Impacts on stream flow and stream connectivity are considered to be major contributors to the drivers of change in this system.

Aquatic EIS determination of the tributaries associated with the Klein Marico River

Based on the findings of the assessment it is evident that aquatic features associated with the unnamed tributary of the Klein Marico River have an EIS which can be considered moderate. As could be expected this is similar to the classification obtained for the Klein Marico River itself. The Klein Marico River system can therefore be defined as being unique on a provincial or local scale due to biodiversity (habitat diversity, species diversity, unique species, rare and endangered species).

Aquatic assessment results synopsis and conclusion

The aquatic EIS assessment performed is in agreement with literature cited. Aquatic features associated with the Klein Marico River system were found to have an EIS which can be considered “moderate”. The Klein Marico River system can therefore be defined as being unique on a provincial or local scale due to biodiversity and often have substantial capacity for use. Based on the aquatic communities present, it is evident that impacts on stream flow and stream connectivity are considered to be major contributors to the drivers of change in this system, with special mention of the fish communities expected.

Impact Assessment

In addition to the various localities earmarked for mining within the mining rights area, four possible infrastructure layout options are under consideration for the proposed Doornhoek mining project. Depending on the final layout chosen, the proposed Doornhoek mining project may result in a direct impact to the aquatic resources present in this area should mitigation not take place to avoid this and minimise the impacts, with special mention of Layout Option 2, which is located within a drainage line associated with the upper reaches of the Klein Marico River. These impacts are likely to, in turn, result in the loss of recharge to the downstream portions of the Klein Marico River and in turn to the Groot Marico River further along in the catchment. The Precautionary Principal was strictly applied in the assessment and the assessment of impacts is considered conservative. Furthermore in the light of precaution and based on the findings of this study, it is recommended that Layout Option 4 be investigated as the preferred option, with Layout Options 1 and 3 as alternatives. Careful management of edge effects resulting in loss of indigenous vegetation and alien vegetation encroachment, as well as careful management of the dirty water seepage related to any proposed infrastructure is deemed essential to maintaining habitat integrity and water quality integrity of the aquatic resources in the vicinity of the study area. Mitigation of seepage to the groundwater aquifers present is of specific concern as contamination of the groundwater resources is likely to affect habitat condition locally, as well as affect habitat and water quality integrity of the aquatic resources further downstream on a regional scale. In addition, the groundwater resources of these areas are valuable for water input to various aquifers and springs both locally and regionally.

Open cast mining activities are likely to result in an ever increasing cone of depression as a result of dewatering activities over the operational life of the proposed Doornhoek mining project, which is likely to negatively affect the groundwater resources present as well as affect surface water recharge. Furthermore, decant of dirty water in the open cast pits will need to be carefully controlled and dirty water appropriately managed and treated in all phases of the proposed mining project.

Prior to any potential impacts from mining, the systems present are already under considerable threat from the following:

- Reduced in-stream flow, stream connectivity and catchment yield;
- Impacts from cattle watering and agricultural return flows;
- Deteriorating water quality with specific reference to salinization and decreased oxygen levels resulting from the impacts mentioned above;
- Alien vegetation encroachment;
- Erosion; and

- Sedimentation.

It is deemed essential that all effort is made to ensure that impacts on the Klein Marico River and tributaries as a result of the proposed mining project are minimised. Specific mention is made of mining activities that will affect in-stream flow and stream connectivity, negative impacts on water quality, erosion and sedimentation. In addition, impacts from alien vegetation encroachment in the catchment may also occur.

The impact assessment was undertaken on all aspects of the aquatic ecology deemed likely to be affected by the proposed Doornhoek Mining Project.

This report, after consideration and description of the ecological integrity of the mining rights area and mining footprint area, must guide the Environmental Assessment Practitioner (EAP), authorities and potential developers, by means of recommendations, as to the viability of the proposed mining development from an ecological point of view.

The Doornhoek mining project is located within an area of increased ecological importance and sensitivity in terms of the groundwater resources present (DWA, 2012). The groundwater resources in this area play a significant role in the recharge of aquifers and of the surface water resources in the vicinity of the proposed project. Therefore, on this basis, should the project proceed it is considered likely that the project will have an ecological impact of the groundwater resources present, both within and potentially beyond the boundaries of the project. The potential for post-closure impacts on both water quality as well as water quantity, with special mention of the groundwater resources present, are of concern. Therefore, unless it is considered economically feasible to treat and/or contain all potential sources of contaminated water which may affect the receiving environment post-closure indefinitely to pre-mining water quality standards in such a way as to support the post closure land use and land capability, which supports the adjacent land uses, and to ensure rehabilitation back to natural or largely natural land capability, the project is regarded as posing a high long term impact on the regions' underground water resources in terms of fluoride contamination. In addition, should fluorides result in any precipitate, forming fluorite salts, these salts have the potential to significantly affect the surface water resources present in the form of impacts to water clarity and sedimentation. It is highly recommended that should it nonetheless be deemed appropriate to mine the resource from a cumulative sustainable development point of view, as much infrastructure as possible be moved to the areas where historical disturbance as a result of anthropogenic activity has occurred. In addition, the infrastructure required to access the resource must be kept to the absolute minimum. Furthermore, extensive mitigation must be applied during the construction and operational phases of the project to ensure that no impact takes place beyond the surface infrastructure footprint. In this regard particular mention is made of the management of the groundwater, surface water and the dirty water area of the mine footprint and the impact of mining related activities on the aquatic resources both in and further downstream of the mining rights area. Strict monitoring throughout the life of the mine and post-closure is required in order to ensure the health and functioning of the aquatic ecosystems is retained. The water resources will need to be rehabilitated in such a way as to support the larger drainage systems at the same level as those evident in the pre-mining condition and with particular mention of ensuring that no significant impact takes place on the groundwater, surface water quality and quantity both locally and in downstream river systems. It is deemed important that a desktop reserve model be run on the Klein Marico river at a point a short distance downstream of the proposed mining operations in order to define the Environmental Water requirements (EWR). This will allow site specific instream flow and water quality requirements to be determined which in turn will allow for improved planning and decision making to ensure that reserve requirements on a local scale can be met. In order to meet this objective, rehabilitation will need to be well planned and a suitably qualified ecologist must form part of the management team through the entire life cycle of the project and to guide the rehabilitation (including concurrent rehabilitation) and closure objectives of the mine.

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ACRONYMS

BGIS	Biodiversity Geographic Information Systems
°C	Degrees Celsius.
DEMC	Desired Ecological Management Class
DWA	Department of Water Affairs
EAP	Environmental Assessment Practitioner
EC	Ecological Class or Electrical Conductivity (use to be defined in relevant sections)
EIA	Environmental Impact Assessment
EIS	Ecological Importance and Sensitivity
EMC	Ecological Management Class
EMP	Environmental Management Program
EWR	*Environmental Water Requirements*
FRAI	Fish Response Assessment Index
GIS	Geographic Information System
GN	General Notice
HCR	Habitat Cover Ratings
HG	Hydrogeomorphic
HGM	Hydrogeomorphic Units
IHAS	Invertebrate Habitat assessment System
IHIA	Intermediate Habitat Integrity Assessment
IH	Index of Habitat Integrity
m	Meter
MC	Management Classes
MIRAI	Macro-invertebrate Response Assessment Index
MPRDA	Mineral and Petroleum Resources Development
NAEHMP	National Aquatic Ecosystem Health Monitoring Programme
NEMA	National Environmental Management Act
NBA	National Biodiversity Assessment
NFEPA	National Freshwater Ecosystem Priority Areas
NOMR	New Order Mining Rights
NSBA	National Spatial Biodiversity Assessment
NWA	National Water Act
NWCS	National Wetland Classification System
PEMC	Present Ecological Management Class
PPP	Public Participation Process
REC	Recommended Ecological Category
RHP	River Health Program
SACNASP	South African Council for Natural Scientific Professions
SANBI	South African National Biodiversity Institute
SAS	Scientific Aquatic Services
SASS5	South African Scoring System 5
VEGRAI-	Vegetation Response Assessment Index
WMA	Water Management Areas
subWMA	Sub-Water Management Area
WetVeg Groups	Wetland Vegetation Groups

1 INTRODUCTION

1.1 Background

Scientific Aquatic Services (SAS) was appointed to undertake an assessment of the aquatic resources as part of the Environmental Impact Assessment Process for the proposed Doornhoek Mining Project (hereafter also referred to as the 'study area') (depicted in Figure 1 and Figure 2).

The site for the project is located in the Ramotshere Moiloa and the Ditsobotla Local Municipalities. The project area is located between Zeerust and Mahikeng within the Ngaka Modiri Molema District Municipality. The land-use in the area is dominated by game, livestock farming and chicken farming, although some crop cultivation occurs in isolated parts of the area. The most prominent mining operation in the area is the Fluorspar Mine (Witkop Mine) that occurs to the west of the project area. Small-scale mining activities and prospecting also occur in isolated parts of the project area at present.

The proposed Doornhoek Mining Project is located within the Crocodile (West) Marico Water Management Area (WMA) and in particular the upper reaches of the Klein Marico river and its associated tributaries. It is notable that the water resources in this area are fed by springs which ensure the perennial surface flow of these systems. The diverse geology in this WMA has some of the richest mineral deposits in the world (River Health Programme, 2005).

Additional background information on the WMA and greater study area is presented in the literature research result section. Please refer to the literature search results section.

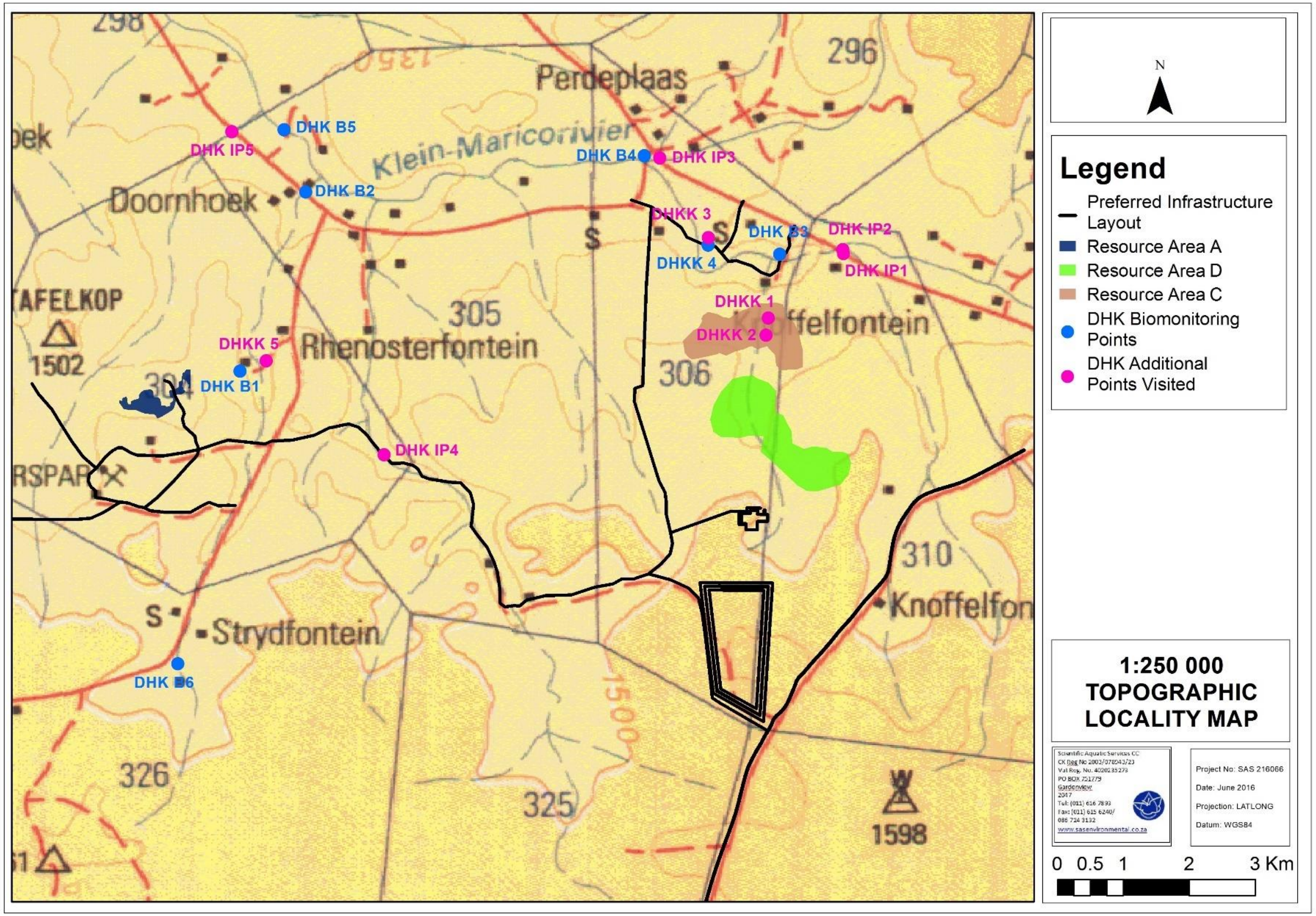


Figure 1: Riverine aquatic ecological assessment points and the study area presented on a 1:250 000 topographical map[1].

[1] For the purposes of this report, the preferred Layout Option 4 has been used for mapping purposes throughout this report, however, Options 1 and 3 may also be regarded as mining options. See Section 5 of this report.

During the feasibility study conducted in October 2014, five (DHK B1, DHK B2, DHK B3, DHK B4 and DHK B5) of the eleven sites visually assessed 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 proposed mining project. During the May 2016 baseline assessment, a further sites assessed in the feasibility study in order to obtain a comprehensive understanding of the aquatic ecology of the systems in the vicinity of the proposed Doornhoek mining project. Once again, 5 sites were subjected to further detailed aquatic assessment (DHK B1, DHK B2, DHK B3, DHK B4 and DHKK 4).

Table 1 below presents geographic information with regards to the monitoring points on the Klein Marico River as well as points on the tributaries of this system which had sufficient flow to support an aquatic community. In addition, sites visually assessed are also presented in the table and figures below which were considered for aquatic ecological assessment purposes. Figure 2 visually presents the locations of the various points along the various river systems, assessed.

Table 1: Location of the biomonitoring points with co-ordinates

Site	Detailed Site Description	GPS coordinates	
		South	East
DHK B1	A spring forming the source of a major unnamed tributary of the Klein Marico river	25°43'15.63"	26° 8'7.98"
DHK B2	A point further downstream on the unnamed tributary of the Klein Marico River and downstream of all possible mining activities	25°41'47.50"	26° 8'40.29"
DHK B3	The most upstream point on the Klein Marico river, a short distance downstream of one of the main springs feeding the system	25°42'18.05"	26°12'33.33"
DHK B4	A point located in the middle of the segment of interest of the Klein Marico River	25°41'29.66"	26°11'26.75"
DHK B5	A point located on the downstream edge of the segment of interest of the Klein Marico River and downstream of all potential mining activities	25°41'16.85"	26° 8'29.55"
DHK B6	A spring forming the source of an unnamed tributary of the Klein Marico River	25°45'39.40"	26° 7'37.38"
DHK IP1	The Spring on the Klein Marico River located to the east of the proposed mining area	25°42'17.71"	26°13'4.67"
DHK IP2	Upstream of the Spring on the Klein Marico River located to the east of the proposed mining area	25°42'15.87"	26°13'4.44"
DHK IP3	A small drainage line feeding into the Klein Marico river in the vicinity of point DHK B4	25°41'30.76"	26°11'34.39"
DHK IP4	A Major drainage feature feeding into the Klein Marico River and indicated as the Klein Marico river on some maps	25°43'56.65	26° 9'18.81"
DHK IP5	An unnamed tributary of the Klein Marico River on the western edge of the study area and located downstream of an existing mining operation	25°41'17.81"	26° 8'4.00"
DHKK 1	A small drainage line feeding into the Klein Marico river upstream of point DHK B3	25°42'82.5"	26° 12'4.63"
DHKK 2	A small drainage line feeding into the Klein Marico river upstream of point DHK B3 and DHKK 1.	25°42'96.4"	26° 12'4.44"
DHKK 3	A point located in the middle of the segment of interest on the Klein Marico River between sites DHK B3 and DHK B4.	25°42'16.6"	26° 11'9.71"
DHKK 4	A point located in the middle of the segment of interest on the Klein Marico River between sites DHK B3 and DHK B4 and upstream of site DHKK 3.	25°42'22.7"	26° 11'9.70"
DHKK 5	A small drainage line feeding into an unnamed tributary of the Klein Marico river in the vicinity of site DHK B1.	25°42'17.3"	26° 8'3.47"

The sites selected for aquatic biomonitoring were all visually assessed along with the other potential assessment points visited. The Invertebrate Habitat Assessment System (IHAS), Intermediate Habitat Integrity Assessment (IHIA), fish Habitat Cover Ratings (HCR), the South African Scoring System version 5 (SASS5) and Macro-Invertebrate Risk Assessment Index (MIRAI) for the assessment of the macro-invertebrate community and the Fish Risk Assessment Index (FRAI) in order to assess the risks to the fish community were employed on selected points on the Klein Marico River as well as the one major unnamed tributary of the Klein Marico River. 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.

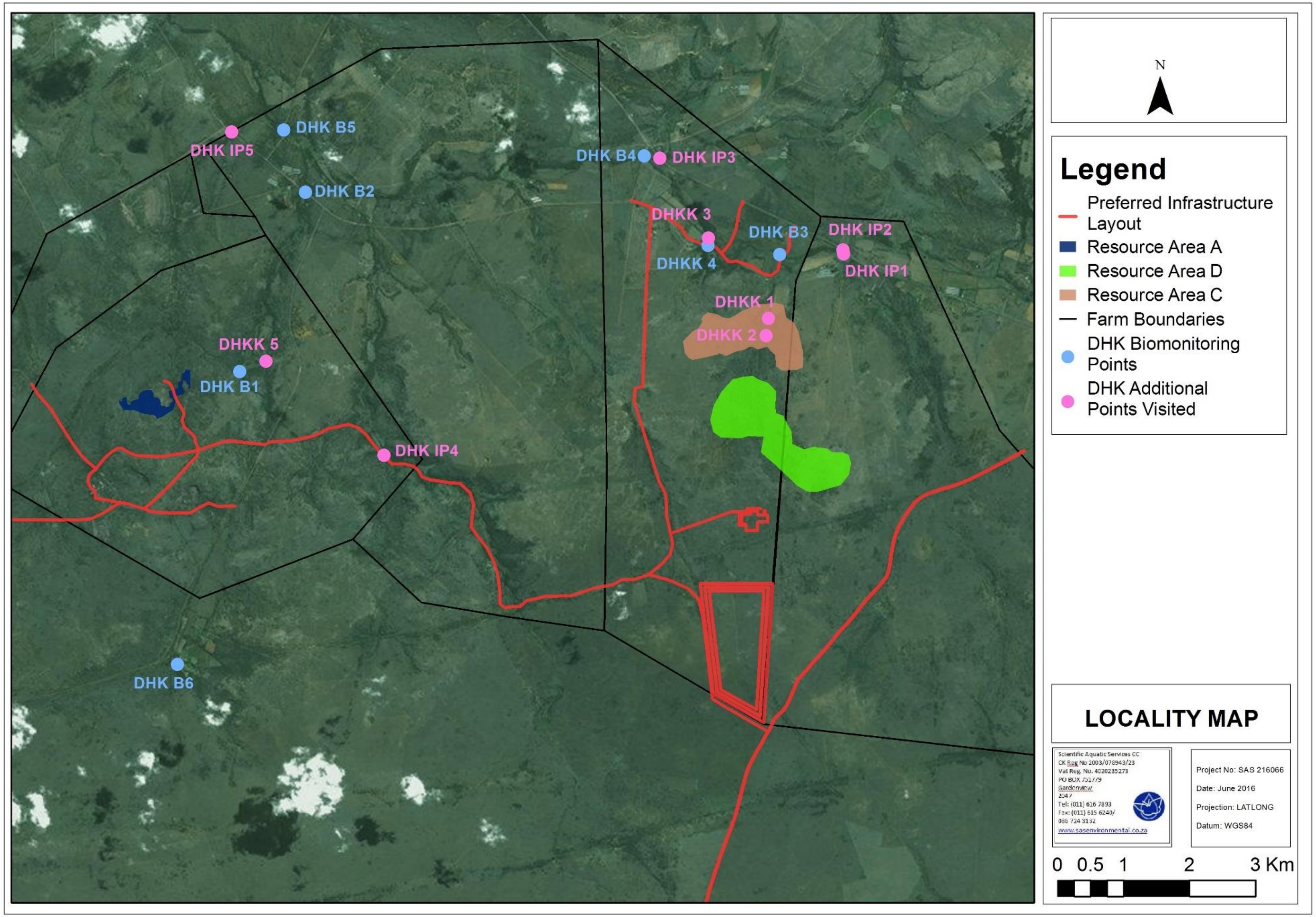


Figure 2: Aquatic ecological assessment points and study area presented on a digital satellite image.

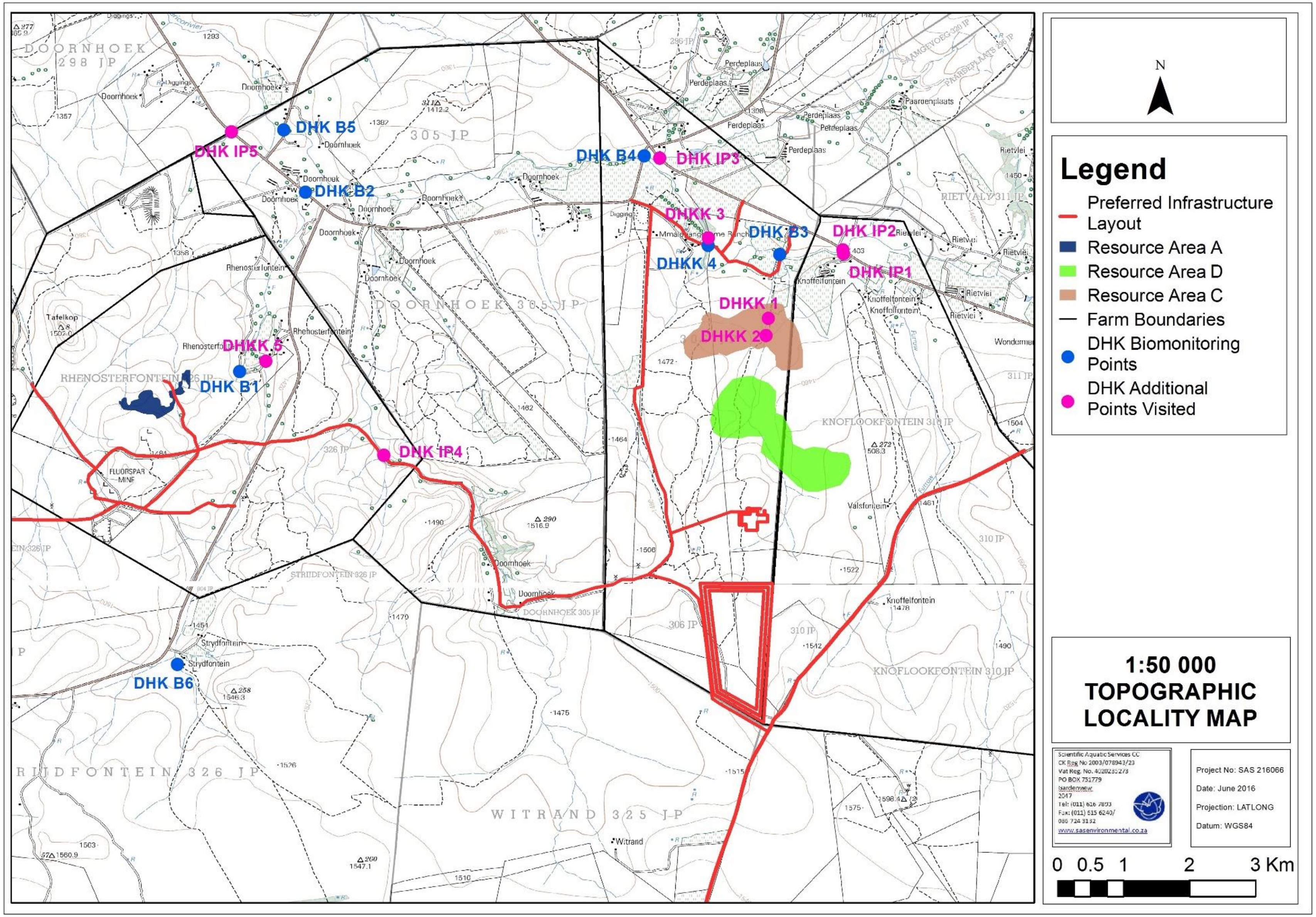


Figure 3: Riverine aquatic ecological assessment points and study area presented on a 1:50 000 topographical map.

1.2 Legislative Requirements

The following legislative requirements are triggered by the proposed Doornhoek Mining Project and are expanded on in more detail in Appendix 3:

- *Minerals and petroleum Resource Development Act (MPRDA) (Act 28 of 2002);*
- *National Environmental Management Act (Act 107 of 1998) with special mention of the Precautionary Principle as defined in Section 2(4)(a)(vii);*
- *National Water Act (NWA; Act 36 of 1998); and*
- *GN 704 – Regulations on use of water for mining and related activities aimed at the protection of water resources, 1999.*

1.3 Assumptions and Limitations

The following points serve to indicate the assumptions and limitations with regard to the aquatic assessment:

- ***Reference conditions are unknown:*** The composition of aquatic biota in aquatic resources associated with the mining rights area, prior to major disturbance, is limited and based only on a risk assessment performed in the late low flow season of 2014 and the current baseline assessment performed in the low flow winter season 2016, following severe nation-wide drought conditions in the months preceding the assessment. For this reason, reference conditions are largely hypothetical, as based on professional judgment and/or inferred from limited data available. Based on the reference data available and based on the observations on site, the information available is, however, deemed adequate to provide a reasonable level of understanding of the systems for the study. However, an assessment of the system under summer/high flow conditions is deemed best-practice to inform the environmental assessment and authorization process for the project;
- ***Temporal variability:*** The data presented in this report are based on two assessments. One performed in October 2014 and a second assessment performed in May 2016, both of which were performed under very low flow conditions. Only limited analyses of temporal trends are therefore currently possible. As a result, the effects of natural seasonal and long-term variation in the ecological conditions and aquatic biota found in the streams are largely unknown. Based on the reference data available and based on the observations on site, the information available is, however, deemed adequate to provide a reasonable level of understanding of the systems for the study. However, an assessment of the system under high flow conditions is deemed essential to inform the environmental assessment and authorization process for the project;

- ***Ecological assessment timing:*** Aquatic and terrestrial ecosystems are dynamic and complex. It is likely that aspects, some of which may be important, could have been overlooked. A more reliable assessment of the biota would require routine seasonal sampling, with sampling being undertaken on a quarterly basis to cover seasonal variability. Based on the reference data available and based on the observations on site the information available is, however, deemed adequate to provide an understanding of the systems for the study. However, an assessment of the system under summer/high flow conditions is deemed best practice to inform the environmental assessment and authorization process for the project;
- ***Accessibility:*** The area is relatively remote within the study area and as such access to sampling sites was limited to a small degree. Due to the limitations some aspects of the aquatic ecology of the area, some which may be important may have been overlooked. Based on the reference data available and based on the observations on site the information available is, however, deemed adequate to provide the required level of understanding of the systems for the study.

2 METHOD OF ASSESSMENT

The baseline assessment is comprised of both a desktop literature review as well as field verification of the conditions of the aquatic resources in the vicinity of the study area.

Best practice methodologies (detailed information pertaining to the methodologies used can be found in Appendix 4) were used during the field assessment to assess the aquatic ecological integrity of the various sites based on water quality, instream and riparian habitat condition and biological impacts and integrity. All work was undertaken by a South African River Health Program (SA RHP) accredited assessor. The field assessment included the following:

- Potential aquatic biomonitoring points were selected on the various drainage features in the vicinity of the study area and further investigated on a site drive-through.
- Each site was investigated and visually assessed in order to determine whether the points were suitable for the application of aquatic ecological assessment indices. Where conditions were inadequate for the application of the various aquatic biomonitoring indices, only location was noted and a visual assessment was conducted.
- At suitable biomonitoring sites, the following factors were investigated:
  - Visual conditions of the site, including an assessment of impacts on the stream, at each point;
  - On-site testing of biota specific water quality parameters including pH, electrical conductivity (EC), dissolved oxygen concentration (DO) and temperature. The results aid in the interpretation of the data obtained by the biomonitoring. Results are discussed against the guideline water quality values for aquatic ecosystems as defined by the Department of Water and Sanitation (DWS), formerly the Department of Water Affairs and Forestry (DWAF 1996 vol. 7).
  - Habitat suitability for aquatic macro-invertebrates was determined using the IHAS (Invertebrate Habitat Assessment System) method and was applied according to the protocol of McMillan (1998);
  - Riparian Vegetation Response Assessment Index (VEGRAI) was used as a qualitative assessment to assess the integrity of the riparian vegetation of the aquatic resources present and its response to current impacts in the area;
  - The integrity of the aquatic macro-invertebrate community was assessed using the SASS5 (South African Scoring System version 5) as defined by Dickens & Graham (2001);

- Interpretation of the results, in relation to reference scores, was made according to the classification of SASS5 scores presented in the SASS5 methodology, published by Dickens & Graham (2001) as well as according to the SASS5 data interpretation guidelines (Dallas 2007);
- Macro-invertebrate Response Assessment Index (MIRAI) was applied to provide an approach to deriving and interpreting aquatic invertebrate response to driver changes. Aquatic macro-invertebrates expected within the system were derived from the DWS Resource Quality Information Services (RQIS) PES/EIS database;
- Fish community integrity was assessed using the Habitat Cover Rating (HCR) and Fish Habitat Assessment (FHA) as well as the Fish Response Assessment Index (FRAI).

Based on the desktop and field assessments the Ecological Importance and Sensitivity (EIS) of the aquatic resources in the area is derived and an EIS category can be assigned.

On completion of the baseline assessment, a detailed impact assessment (detailed methodology provided in Appendix 3) based on the Plomp Method (Plomp, 2004) was undertaken to assess the magnitude and severity of any potential impacts associated with the proposed Doornhoek mining project. Impacts are discussed and suitable mitigation measures provided where possible.

3 RESULTS OF LITERATURE REVIEW

3.1 Conservation Importance of the Study Area

3.1.1 North West Biodiversity sector Plan 2015

According to the North West Biodiversity sector Plan (NW BSP 2015) the Marico River system, including its associated tributaries is a highly ecologically significant aquatic ecosystem as highlighted by them being designated as priority rivers (FEPA Rivers). The system is also defined as an aquatic Critical Biodiversity 2 (CBA2) according to the 2008 dataset (2015 dataset is not currently available for download).CBA2 areas are near natural landscape with the following attributes:

- 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 the ability to achieve targets, although loss of these sites would require alternative sites to be added to the portfolio of CBAs.
- These are landscapes that are approaching but have not passed their limits of acceptable change (READ, 2015).

The classification as a FEPA and CBA 2 is due to the clean, free-flowing nature of the Marico River and the presence of the Vulnerable Marico barb (*Barbus motebensis*) and the Near Threatened Barbus sp. 'Waterberg barb' which is considered near threatened and occurs in the upper reaches of the Klein Marico River system as well as the Groot Marico and Koster River systems. The upper reaches the Marico river are in a natural or near-natural ecological state (ecological category A/B: largely natural) are important as they represent a representative sample of the diversity of freshwater ecosystem types in the province that should remain in a good ecological state.

According to the NW BSP (2015) Marico River Conservation Association has been established by the landowners whom are striving for Biosphere Reserve status The upper Groot Marico River and tributaries are also important for species evolutionary processes as the different catchments support three genetically distinct populations of the Vulnerable Marico barb (*Barbus motebensis*). Diversification of fish and other aquatic organisms is likely to be a phenomenon common to all upper catchments of rivers arising in the Swartruggens and Magaliesberg mountains. The rivers and associated catchments that support threatened fish species are Fish Sanctuary Areas, which are designated as Freshwater Ecosystem Priority Areas if in a good ecological condition (A or B ecological category) or Fish Support Areas (lower than A or B ecological category)

3.1.2 Ecoregion and water management area

When assessing the ecology of any area (aquatic or terrestrial), it is important to know which ecoregion the area is located within. This knowledge allows for improved interpretation of data to be made, since reference information and representative species lists are often available on this level of assessment, which aids in guiding the assessment.

The Doornhoek Project Area falls within the Western Bankenveld ecoregion and is located within the A31D quaternary catchment. The south-eastern tip of the mining rights area also occurs within the Highveld ecoregion. However, the area within the Highveld ecoregion is very limited and did not contain any major drainage lines that were assessed.

The project area falls within the Crocodile (West) Marico Water Management Area (WMA) which lies primarily within the North West Province. The following information on this WMA has been gleaned from the State-of-Rivers Report Number 9 (River Health Programme, 2005).

The Crocodile and Marico Rivers are the two main rivers in this WMA. After their confluence, they form the Limpopo River. More than 50% of the total water use in the WMA comprises urban, industrial and mining use. Approximately one third is used by irrigation and the remainder for rural water supplies and power generation. Because the requirements exceed available supply, much of the water in the WMA is being imported mainly from the Vaal River system for domestic and industrial use purposes.

Climatic conditions in the Crocodile (West) Marico WMA are temperate and vary from east (semi-arid) to west (dry). Rainfall is strongly seasonal, with most rainfall occurring as thunderstorms during the summer period (October to April). Mean annual rainfall ranges from 400 to 800 mm and decreases from the eastern to the western side of the WMA. Mean annual temperature range is 18 °C to 20 °C.

The fairly uniform terrain has a diverse geology and some of the richest mineral deposits in the world. North of the Magaliesberg Mountains, the geology is dominated by the Bushveld Igneous Complex. In the Upper Crocodile sub-catchment dolomitic rock is found whilst the rest of the catchment consists of sedimentary rock. Soil types are broadly classified as either moderate to deep sandy loam (southern and far eastern regions) as well as moderate to deep clayey loam (rest of catchment).

Vegetation types are characterised by Mixed Bushveld vegetation type that varies from dense, short bushveld to more open tree savannah.

3.1.3 Ecostatus Classification

Water resources are generally classified according to the degree of modification or level of impairment. The classes, used by the South African River Health Program (RHP), are presented in the table below and will be used as the basis of classification of the systems in future field studies.

Table 2: Classification of river health assessment classes in line with the RHP

Class	Description
A	Unmodified, natural.
B	Largely natural, with few modifications.
C	Moderately modified.
D	Largely modified.
E	Extensively modified.
F	Critically modified.

In addition, the ecological category (EC) classification will be employed using the eco-status A to F continuum approach (Kleynhans and Louw 2007). This approach allows for boundary categories denoted as B/C, C/D etc., as illustrated in Figure 4.

Figure 4: Ecological categories (EC) eco-status A to F continuum approach employed (Kleynhans and Louw 2007)

Department of Water and Sanitation (DWS) Resource Quality Information Services (RQIS) PES/EIS database

The PES/EIS database, as developed by the DWS RQIS department, was utilised to obtain additional 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, EWR sites and Hydro WMS sites.

In this regard, information for sub-quaternary catchment reach (SQR) A31D-01019 (Klein-Marico River) is applicable. Key information on background conditions within the study area, as contained in this database and pertaining to the Present Ecological State (PES), ecological importance and ecological sensitivity for the Klein Marico River, is tabulated in Table 3.
From the assessment of the PES/EIS data, the following points are highlighted which summarise the data:

The system has low to moderate levels of aquatic biodiversity with reference to fish and invertebrates. The following fish species have been previously reported and are expected in the system based on information from this point:

Barbus paludinosus Peters, 1852
Pseudocrenilabrus philander (Weber, 1897)

The following macro-invertebrate families have been previously recorded and are expected in the system based on information from this point:

Oligochaeta	Gerridae	Haliplidae
Baetidae 2 spp.	Naucoridae	Hydraenidae
Caenidae	Notonectidae	Hydrophilidae
Coenagrionidae	Pleidae	Ceratopogonidae
Gomphidae	Veliidae/Mesoveliidae	Chironomidae
Belostomatidae	Dytiscidae	Culicidae
Corixidae	Gyrinidae	Simuliidae

Table 3: Summary of the ecological status of the sub-quaternary catchment (SQ) reach A31D 01019 (Klein Marico) based on the DWS RQS PES/EIS database

<table>
<tr><th colspan="6">Synopsis (SQ reach A31D-01019 Klein Marico River)</th></tr>
<tr><th>PES[1] category median</th><th>Mean EI[2] class</th><th>Mean ES[3] class</th><th>Length</th><th>Stream order</th><th>Default EC[4]</th></tr>
<tr><td>B
(largely natural)</td><td>Moderate</td><td>Moderate</td><td>11.9 km</td><td>2.0</td><td>C</td></tr>
<tr><th colspan="6">PES details</th></tr>
<tr><td colspan="2">Instream habitat continuity MOD</td><td>None</td><td colspan="2">Riparian/wetland zone MOD</td><td>Small</td></tr>
<tr><td colspan="2">RIP/wetland zone continuity MOD</td><td>Small</td><td colspan="2">Potential flow MOD activities</td><td>Moderate</td></tr>
<tr><td colspan="2">Potential instream habitat MOD activities</td><td>Small</td><td colspan="2">Potential physico-chemical MOD activities</td><td>Small</td></tr>
<tr><th colspan="6">EI details</th></tr>
<tr><td colspan="2">Fish spp/SQ</td><td>5.00</td><td colspan="2">Fish average confidence</td><td>2.60</td></tr>
<tr><td colspan="2">Fish representivity per secondary class</td><td>Low</td><td colspan="2">Fish rarity per secondary class</td><td>Low</td></tr>
<tr><td colspan="2">Invertebrate taxa/SQ</td><td>37.00</td><td colspan="2">Invertebrate average confidence</td><td>3.86</td></tr>
<tr><td colspan="2">Invertebrate representivity per secondary class</td><td>Moderate</td><td colspan="2">Invertebrate rarity per secondary class</td><td>High</td></tr>
<tr><td colspan="2">EI importance: riparian-wetland-instream vertebrates (excluding fish) rating</td><td>Low</td><td colspan="2">Habitat diversity class</td><td>Low</td></tr>
<tr><td colspan="2">Habitat size (length) class</td><td>Very low</td><td colspan="2">Instream migration link class</td><td>Very high</td></tr>
<tr><td colspan="2">Riparian-wetland zone migration link</td><td>Very high</td><td colspan="2">Riparian-wetland zone habitat integrity class</td><td>High</td></tr>
<tr><td colspan="2">Instream habitat integrity class</td><td>Very high</td><td colspan="2">Riparian-wetland natural vegetation rating based on percentage natural vegetation in 500m</td><td>Very high</td></tr>
<tr><td colspan="5">Riparian-wetland natural vegetation rating based on expert rating</td><td>High</td></tr>
<tr><th colspan="6">ES details</th></tr>
<tr><td colspan="2">Fish physical-chemical sensitivity description</td><td>High</td><td colspan="2">Fish no-flow sensitivity</td><td>High</td></tr>
<tr><td colspan="2">Invertebrates physical-chemical sensitivity description</td><td>High</td><td colspan="2">Invertebrates velocity sensitivity</td><td>Very high</td></tr>
<tr><td colspan="5">Riparian-wetland-instream vertebrates (excluding fish) intolerance water level/flow changes description</td><td>Low</td></tr>
<tr><td colspan="5">Stream size sensitivity to modified flow/water level changes description</td><td>Not stated</td></tr>
<tr><td colspan="5">Riparian-wetland vegetation intolerance to water level changes description</td><td>Low</td></tr>
</table>

[1] PES = Present Ecological State; confirmed in database that assessments were performed by expert assessors;
[2] EI = Ecological Importance;
[3] ES = Ecological Sensitivity
[4] EC = Ecological Category; default based on median PES and highest of EI or ES means.

The Present Ecological State (PES) of the Klein-Marico River is categorised as a Class B (Largely Natural):

- The potential instream habitat continuity modification has no rating, which means that there is no discernible impact, or the modification is located in such a way that it has no impact on the habitat quality, diversity, size and variability;
- The potential riparian/wetland habitat continuity modification, the potential riparian/wetland zone modification, the potential instream habitat modification and the potential physico-chemical modification levels has a small impact rating, meaning that the modification is limited to a few localities and the impact on habitat quality, diversity, size and variability are also limited; and
- The potential instream flow modification is moderately modified, meaning that the modifications are only present at a small number of localities and the impact on the habitat quality, diversity, size and variability are limited.

The Ecological Importance is considered moderately modified:

- The number of fish species estimated per sub quaternary reach is 5;
- The fish representivity per secondary class (FREP) is considered low;
- The fish rarity per secondary class (IRAR) is considered low;
- The Ecological Importance of the riparian-wetland-instream vertebrates (excluding fish) rating is low;
- The riparian-wetland natural vegetation importance, which is based on the percentage of natural vegetation within 500m is considered very high;
- The riparian-wetland natural vegetation importance based on expert rating is considered high;
- The number of invertebrate taxa per sub quaternary reach is 37;
- The invertebrate representivity per secondary class (IREP) is considered moderate;
- The invertebrate rarity per secondary class (IRAR) is considered high;
- The habitat diversity class is considered low;
- The habitat size (Length) class are considered very low;
- The instream migration link class is very high;
- The riparian-wetland zone mitigation link is very high;
- The riparian-wetland zone habitat integrity class is high; and
- The instream habitat integrity class is very high.

The ecological sensitivity is considered moderate:

- The fish and invertebrate physio-chemical sensitivity description is high, meaning that the species require moderate unmodified physic-chemical conditions to survive and breed;
- The fish no-flow sensitivity description and the invertebrate velocity sensitivity is high, meaning that the species require flow during certain phases of the life cycle to breed in particular habitats (often fast flows) for instance. Generally, increased habitat suitability and availability resulting from increased flow can be expected to benefit such species, flow will stimulate breeding activities and stimulate migration;
- The riparian-wetland-instream vertebrates (excluding fish) intolerance water level/flow changes description is low, meaning that the taxa within the system have a low sensitivity to water levels and flow changes. Suitable level or flow will benefit taxa but they do not have a crucial dependence on this;
- The stream size sensitivity to modified flow/water level changes description is not assessed; and
- The riparian-wetland vegetation intolerance to water level changes is low.

National Freshwater Ecosystem Priority Areas

The National Freshwater Ecosystem Priority Areas (NFEPA) (2011), database was consulted to define the aquatic ecology of the river systems in the vicinity of the proposed expansion project that may be of ecological importance. Aspects applicable to the study area and surroundings are indicated in the table below.

Table 4: NFEPA Rivers in the vicinity of the study area.

Area	WMA	SubWMA	FEPACODE	NFEPA Rivers	RIVCON
Study area	Crocodile (West) & Marico	Marico	Fish Support Area and Fish Sanctuary	Klein-Marico Rhenosterfontein	CDEFZ

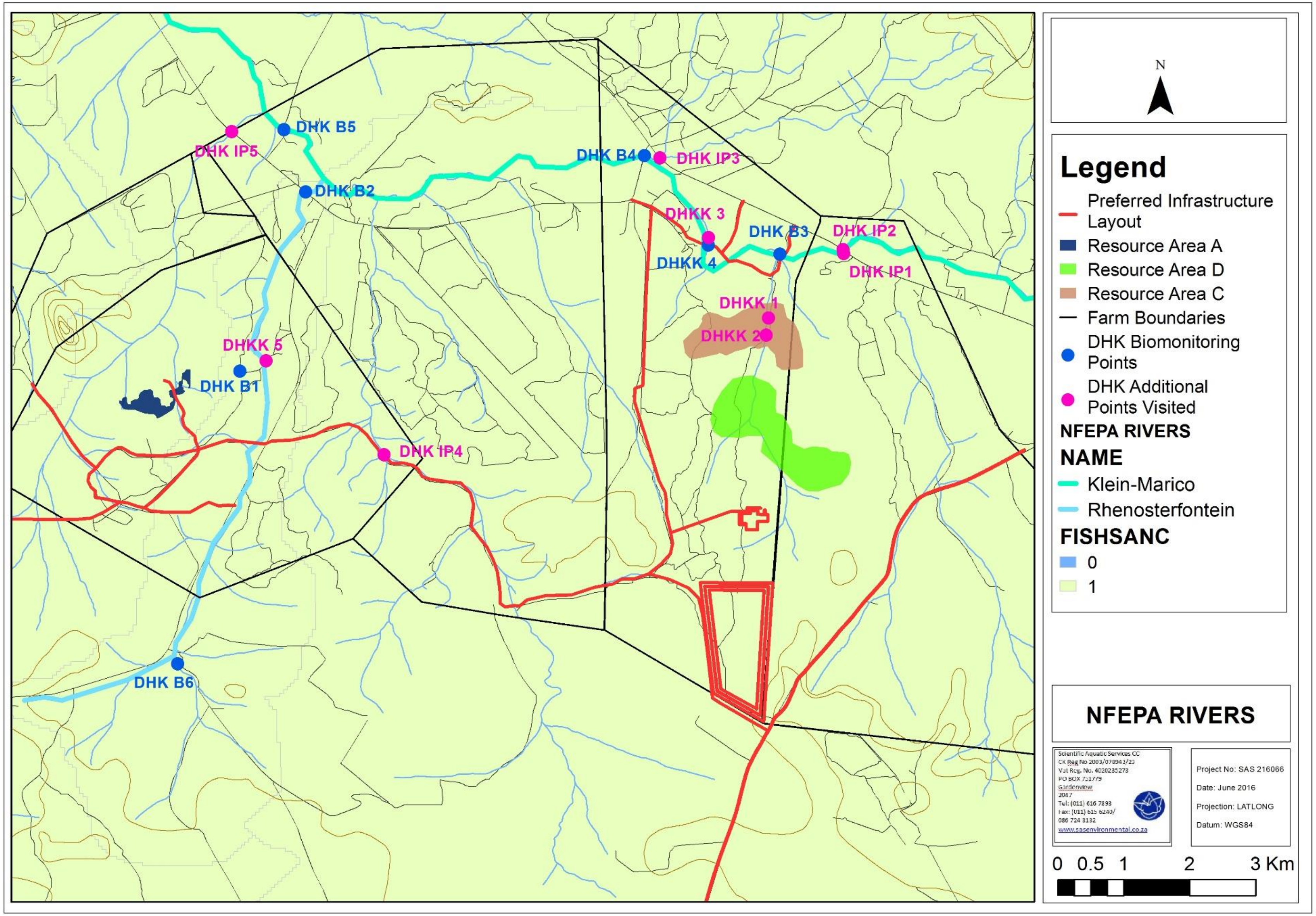


Figure 5: NFEPA Rivers in relation to the proposed Doornhoek mining area.

State-of-Rivers Report Number 9: Ecological state of rivers in the Crocodile (West) Marico Water Management Area (River Health Programme, 2005)

The following table summarises the ecological status of the Klein Marico River system as reported on during March 2005.

Table 5: Ecostatus of the Klein Marico River system as provided in the River Health Programme State-of Rivers report number 9 (March, 2005)

Variable/Index	Ecostatus	Variable/Index	Ecostatus
Overall Ecostatus	Fair	**Instream Habitat Integrity**	Fair (impacts from the Klein Maricopoort and Kromellenboog Dams)
Riparian Zone Habitat Integrity	Good (low levels of development yet at Oopgenoeg and Nahoek water abstraction has resulted in wetlands drying up)	**Riparian Vegetation Integrity**	Fair (presence of alien vegetation and removal of some vegetation for agriculture)
Fish Assemblage Integrity	Poor (reduced flow and localized poor water quality)	**Macro-invertebrate Integrity**	Poor (primarily reduced water quality but also impact of dams on flow)
Ecological Importance and Sensitivity	Marginal/Low (overall diversity of habitat types is low but there are some locally unique areas)	**Drivers of Change**	a. Water abstraction; b. Return flows from urban runoff (Zeerust area); c. Impoundment of river altering natural flow regimes; d. Sedimentation of Kromellenboog Dam; e. Alien fish (bass) in upper reaches of the Molemaneloop
Management Responses	a. Identify sources of run-off that impacts on water quality; b. Clear alien vegetation from riparian zone; c. Ensure that the ecological reserve is determined and maintained; d. Map and monitor wetlands to ensure future ecological functioning; e. Control alien fish.		

Department of Water Affairs Report Number RDM/WMA 1,3/00/CON/CLA/0312: Classification of significant water resources in the Crocodile (West) and Marico Water Management Area (Stassen, 2011)

Water quality of the Klein Marico River catchment is good in the upper reaches, but deteriorates to fair in the middle and lower reaches. Impacts pertain to urban development and the dams in the catchment where flows are largely managed on demand for irrigation purposes. High agricultural return flows are the major impacting activity in the lower catchment. Water quality has also deteriorated as a result of erosion and sedimentation. The Klein Marico River shows elevated levels of nutrients resulting from agricultural activity impacts in the catchment. There are also increased levels of toxicants in the middle reaches of the river. The following was tabulated for the Klein Marico River in quaternary catchment A31D:

Table 6: Ecostatus of the Klein Marico River system as provided in the Department of Water Affairs Report Number RDM/WMA 1,3/00/CON/CLA/0312 (September 2011)

Quaternary catchment	Nodes	EI	ES	PES
A31D	Malmanieloop to confluence with Klein Marico	High	High	C
	Kareespruit at confluence with Klein Marico	Low	Low	C
	Klein Marico to Klein Maricopoort Dam	Low	Low	C

Reserve Determination of the Groot Marico River

As the water resources in the Crocodile West & Marico Water Management Area are becoming more stressed due to an accelerated rate of development and changing weather patterns resulting in the scarcity of water resources, there is an urgency to ensure that water resources are able to sustain their level of use and be maintained at their desired states. The determination of the Management Classes (MC) of the significant water resources in the study area will ensure that the desired condition of the water resources, and conversely, the degree to which they can be utilised is maintained and adequately managed within the economic, social and ecological goals of the water users. The MC of the water resource will therefore set the boundaries for the volume, distribution and quality of the Reserve and Resource Quality Objectives (RQOs), and thus the potential allocable portion of a water resource for use (DWA, 2012).

The National Water Act (Act No. 36 of 1998) (NWA) is founded on the principle that National Government has overall responsibility for, and authority over, water resource management for the benefit of the public without, seriously affecting the functioning of the water resource systems. In order to achieve this objective, Chapter 3 of the NWA provides for the protection of water resources through the implementation of resource directed measures (RDM). As part of the RDM, a Management Class (MC) has to be determined for a significant water resource, as the means to ensure a desired level of protection. The purpose of the MC is to establish clear goals relating to the quantity and quality of the relevant water resource. The classification system, the Reserve and RQOs together are intended to ensure comprehensive protection of all water resources. An important consideration in the determination of RDM is that they should be technically sound, scientifically credible, practical and affordable (DWA, 2012).

The tables below show the PES, EIS and REC associated with identified Ecological Water Requirements (EWR) sites within the Marico Catchment Area, as well as the EIS ratings for Priority Wetlands identified and the present status categories of Groundwater Resource Units.

Table 7: Summary of the PES, EIS and REC per resource unit of the Groot Marico River system as provided in the Department of Water Affairs Report Number RDM/WMA 1,3/00/CON/CLA/0112A (March 2012)

EWR site number	EWR site Name	River	RU	Quaternary catchment	PES	REC	EIS
EWR1	Site below the gorge area (before confluence with Marico)	Kaaloog se loop	Kaaloog se loop	A31A	B	B	Very high
EWR2	Upstream confluence of the Sterkstroom	Groot Marico	Groot Marico 1	A31B	B	B	Very high
EWR3	Downstream of Marico Bosveld Dam	Groot Marico	Groot Marico 3	A31F	C/D	C/D	High
EWR4	Downstream of the Twasa Weir, in the Madikwe Game Reserve	Groot Marico	Groot Marico 6	A32D	C	C	High
Rapid EWR	Downstream Klein Maricopoort Dam	Klein Marico	Klein Marico 3	A31E			

Table 8: Summary of the EWR site information for the Groot Marico River catchment area as provided in the Department of Water Affairs Report Number RDM/WMA 1,3/00/CON/CLA/0112A (March 2012)

Catchment Area	Priority Wetlands	EIS Category	Eco Class
Groot Marico	Marico Dolomitic Eye	High	B
	Molemane Dolomitic Eye	High	B
	Malmane's Loop	Moderate	C
	Bokkraal Wetland (Upstream of tufa)	Moderate	C
	Rietspruit Eye	Moderate	C
	Ngotwane River Dinokana Eye	High	B

Table 9: Categorisation of Groundwater Resource Units (2010) in the Marico Catchment Area as provided in the Department of Water Affairs Report Number RDM/WMA 1,3/00/CON/CLA/0112A (March 2012)

Catchment area	Resource Unit: Quaternary Catchments	Present Status Category	Water Resource Category
Marico	A31A	C	Good
	A31B	B	Good
	A31C	C	Good
	A31D	B	Good
	A31E	A	Good
	A31F	B	Natural
	A31H	A	Natural
	A31J	A	Natural
	A32A	A	Natural
	A32B	A	Natural
	A32C	A	Natural
	A32D	A	Natural
	A32E	A	Good

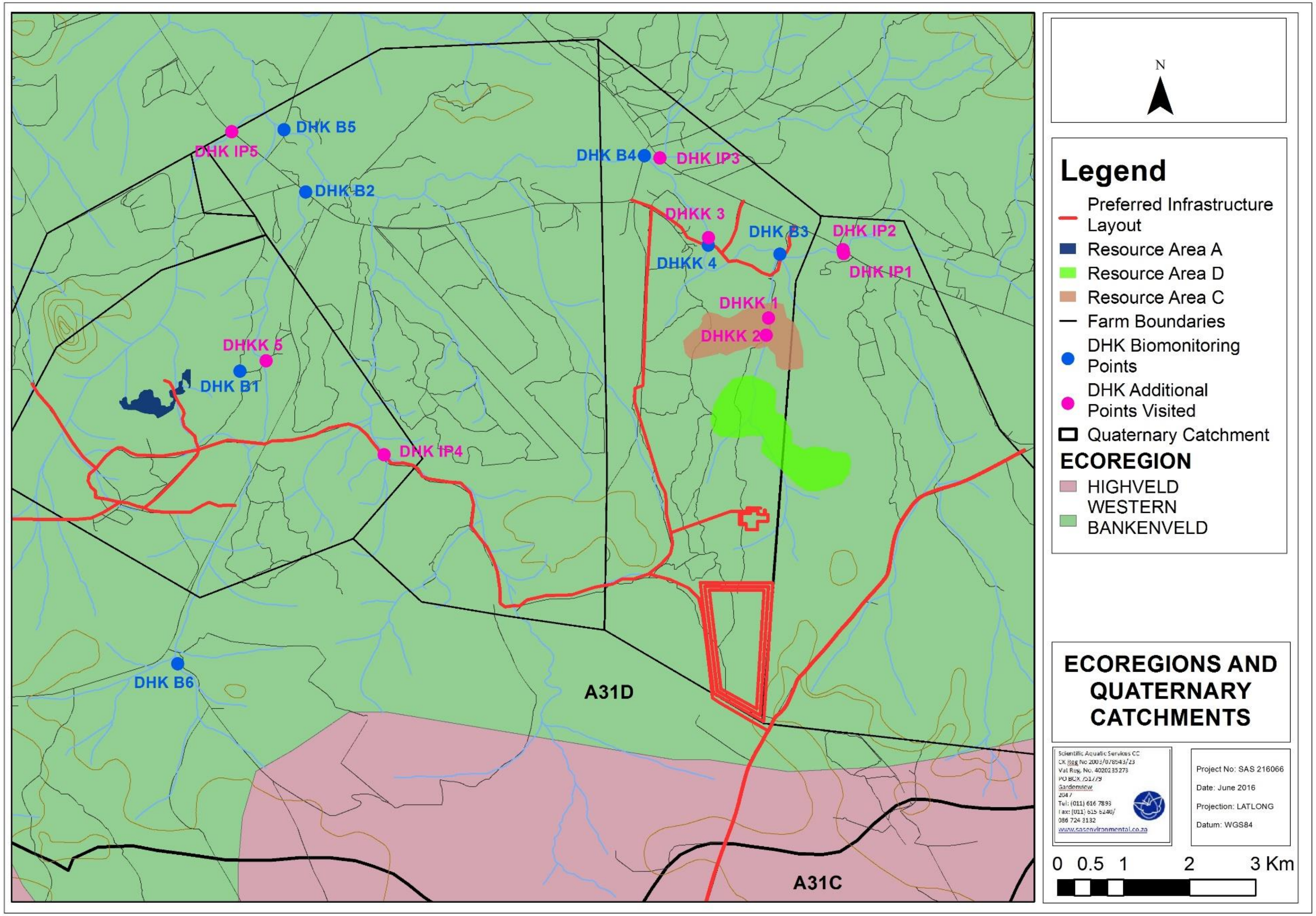


Figure 6: Map depicting the assessment points in relation to the quaternary catchments and aquatic ecoregions of the region.

4 AQUATIC ECOLOGICAL ASSESSMENT RESULTS

4.1 Interest Points visited but not assessed

The sections below present the results of the visual assessment of the sites visited during both the feasibility study (October 2014) as well as the baseline assessment (May 2016) for the aquatic ecological assessment. These points, although not assessed in detail, were used to inform the reach based assessments undertaken as part of the detailed site assessments. In this regard, specific mention is made of the application of the VEGRAI Ecostatus tool and the IHIA habitat assessment.

Table 10: Visual description of site DHK IP1 visited during the October 2014 and the May 2016 site assessments.

Figure 7: Interest Point 1 on the upper Klein Marico River at the spring (DHK IP1). Note the severe invasion by *Populus x canescens* during both the October 2014 (left) and the May 2016 (right) assessments.

Significance of the point	Surrounding features	Riparian zone characteristics	Depth and flow characteristics	Water clarity	Impacts and signs of pollution
The site is located on the tarred road bridge. Upstream of this area the system originates in an area dominated by agricultural activities	This site serves to indicate the condition on the upper Klein Marico River system at the spring. The point is upstream of the proposed mining area. The site potentially serves as a reference point for areas further downstream in the system.	The riparian zone along the length of this section of the Klein Marico River is narrow due to the lack of flow in the system. The riparian zone has been severely affected by alien vegetation encroachment	The site was dry at the time of the assessment.	The site was dry at the time of the assessment.	At the time of assessment impacts from upstream agricultural activities is likely. The impact from alien vegetation encroachment is severe.

Table 11: Visual description of site DHK IP2 visited during the October 2014 and the May 2016 site assessments.

Figure 8: Downstream view of Interest Point 2 on the upper Klein Marico River (DHK IP2). Note the severe invasion by alien vegetation (left) observed in the October 2014 assessment and the complete lack of flow at this point in the May 2016 assessment (right).

Significance of the point	Surrounding features	Riparian zone characteristics	Depth and flow characteristics	Water clarity	Impacts and signs of pollution
This site serves to indicate the condition on the upper Klein Marico River system downstream of the spring. The point is upstream of the proposed mining area. The site potentially serves as a reference point for areas further downstream in the system	The site is located on the eastern boundary of the study area near to the tarred road	The riparian zone along the length of this section of the Klein Marico River is narrow due to the lack of flow in the system. The riparian zone has been severely affected by alien vegetation encroachment	The site was dry at the time of the assessment.	The site was dry at the time of the assessment.	Impacts from upstream agricultural activities are likely. The impact from alien vegetation encroachment is severe.

Table 12: Visual description of site DHK IP3 visited during the October 2014 and the May 2016 site assessments.

Figure 9: A general view of a small tributary of the Klein Marico River at Interest point 3 (DHK IP3) during the October 2014 assessment (left). Note the dry bed and the effects from a veld fire. Downstream view of the DHK IP3 site during the May 2016 assessment presented on the right.

Significance of the point	Surrounding features	Riparian zone characteristics	Depth and flow characteristics	Water clarity	Impacts and signs of pollution
Photographs are representative of a small non-perennial tributary of the Klein Marico river near to the DHK B4 point. The point may be of significance during times of flow, potentially affecting water quality in the Klein Marico River system.	The site is located to the north of the Klein Marico River and north of the proposed mining area.	The riparian zone of the system is weakly formed due to a lack of perennial flow in the system.	The site was dry at the time of the assessment.	The site was dry at the time of the assessment.	Impacts from upstream agricultural activities are likely. The impact from fires in the area is considered significant.

Table 13: Visual description of site DHK IP4 visited during the October 2014 and the May 2016 site assessments.

Figure 10: Upstream view (left) and downstream view (right) of the upper section of a drainage line referred to as the Klein Marico river on some maps (DHK IP4) showing the very dry ephemeral nature of the system during the May 2016 assessment.

Significance of the point	Surrounding features	Riparian zone characteristics	Depth and flow characteristics	Water clarity	Impacts and signs of pollution
Photographs are representative of the upper reaches of a drainage feature referred to as the Klein Marico River on some maps and upstream of the proposed mining area. The site could potentially contribute to some degree to understanding the conditions further downstream.	The site is located in a remote area dominated by grazing activities.	The riparian zone of the system is weakly formed due to a lack of perennial flow in the system. The areas were seen to be significantly affected by livestock grazing	The system was completely dry at the time of assessment.	The site was dry at the time of the assessment.	Impacts from upstream agricultural activities are likely. The impact from livestock grazing is deemed significant.

Table 14: Visual description of site DHK IP5 visited during the October 2014 and the May 2016 site assessments.

Figure 11: Upstream view (left) of Interest Point 5 site on an unnamed tributary of the Klein Marico river (DHK IP5) during the October 2014 assessment. Downstream view at this point during the May 2016 assessment provided on the right. Note the dry bed of the system.

Significance of the point	Surrounding features	Riparian zone characteristics	Depth and flow characteristics	Water clarity	Impacts and signs of pollution
The site is situated on a small unnamed tributary of the Klein Marico River to the west of the proposed mining area and downstream of an existing operation. The site is important as a spatial reference and also as a temporal reference prior to the proposed mining of the Doornhoek deposit.	The site is located directly adjacent to the tarred road in the north eastern corner of the study area.	The riparian zone along the length of this well wooded with a fairly limited exotic vegetation component.	The system was completely dry at the time of assessment	The site was dry at the time of the assessment.	Some impact from upstream mining activities may be occurring. Some impacts from livestock grazing may be occurring

Table 15: Visual description of site DHKK 1 visited during the May 2016 site assessment.

Figure 12: Downstream view (left) of site DHKK 1 visited in the May 2016 assessment on a drainage line in the vicinity of the upper reaches of the Klein Marico river. Upstream view at this point (right) Note the dry bed of the system and the unsuitability of this site for the application of the various biomonitoring indices.

Significance of the point	Surrounding features	Riparian zone characteristics	Depth and flow characteristics	Water clarity	Impacts and signs of pollution
The site is situated on a small drainage line in the vicinity of the upper reaches of the Klein Marico River. The site aids in providing a holistic view of the state of the aquatic resources in the study area and the associated drainage lines.	The site is located within the proposed 20 year mining area and downstream of the proposed 10 – 20 year mining area. It is situated in an open area and can be accessed via a gravel road.	The riparian zone along the length of this drainage line is well wooded with a grassy understory and a fairly limited exotic vegetation component.	The system was completely dry at the time of assessment.	The site was dry at the time of the assessment.	Some impact from upstream mining activities may be occurring. It is evident that when water is present, the site is used as a watering hole for game.

Table 16: Visual description of site DHKK 2 visited during the May 2016 site assessment.

Figure 13: Downstream view of site DHKK 2 visited in the May 2016 assessment on a drainage line in the vicinity of the upper reaches of the Klein Marico river. Note the dry bed of the system and the unsuitability of this site for the application of the various biomonitoring indices.

Significance of the point	Surrounding features	Riparian zone characteristics	Depth and flow characteristics	Water clarity	Impacts and signs of pollution
The site is situated on a small drainage line in the vicinity of the upper reaches of the Klein Marico River. The site is situated upstream of site DHKK 1 and aids in providing a holistic view of the state of the aquatic resources in the study area and the associated drainage lines.	The site is located within the proposed 20 year mining area and downstream of the proposed 10 – 20 year mining area. It is situated in an open area and can be accessed via a gravel road.	The riparian zone along the length of this drainage line is dominated by grasses and a fairly limited exotic vegetation component.	The system was completely dry at the time of assessment.	The site was dry at the time of the assessment.	None evident.

Table 17: Visual description of site DHKK 3 visited during the May 2016 site assessment.

Figure 14: Downstream view (left) of site DHKK 3 visited in the May 2016 assessment on the Klein Marico river. Upstream view at this point (right).

Significance of the point	Surrounding features	Riparian zone characteristics	Depth and flow characteristics	Water clarity	Impacts and signs of pollution
The site is situated on the Klein Marico River itself and while suitable for the application of the various biomonitoring indices was considered near enough to site DHKK 4 for a visual assessment only to be sufficient. The site aids in providing a holistic view of the state of the aquatic resources in the study area.	The site is located downstream of the proposed 20 year mining area and downstream of the proposed 10 – 20 year mining area. It is situated in an open area on a game farm and can be accessed via a gravel road.	The riparian zone along the length of this drainage line is well wooded with a fairly limited understory. There is very little to no impact at this point as a result of exotic vegetation encroachment.	The system was relatively shallow and comprised of pools and runs <½ m deep.	Water was clear.	None evident.

Table 18: Visual description of site DHKK 5 visited during the May 2016 site assessment.

Figure 15: Upstream view (left) of site DHKK 5 visited in the May 2016 assessment on a drainage line in the vicinity of site DHK B1. Downstream view at this point (right).

Significance of the point	Surrounding features	Riparian zone characteristics	Depth and flow characteristics	Water clarity	Impacts and signs of pollution
The site is situated on a drainage line in the vicinity of the unnamed tributary of the Klein Marico River. The site aids in providing a holistic view of the state of the aquatic resources in the study area and the associated drainage lines.	The site is located downstream of the proposed 20 year mining area and downstream of the proposed 10 – 20 year mining area. It is situated in an open area on a game farm and can be accessed via a gravel road.	The riparian zone along the length of this drainage line is well wooded with a fairly limited understory. There is very little to no impact at this point as a result of exotic vegetation encroachment.	This point was dry at the time of the assessment.	Site was dry at the time of the assessment.	None evident.

4.2 The Klein Marico River

The sections below present the results of the various indices applied to the sites visited during both the feasibility study (October 2014) as well as the baseline assessment (May 2016) for the aquatic ecological assessment and which were deemed suitable for biomonitoring.

Table 19: Results of the assessment at site DHK B3 (The most upstream point on the Klein Marico River, a short distance downstream of one of the main springs feeding the system).

Site DHK B3

Figure 16: Upstream view of the DHK B3 site during the May 2016 assessment.

Algal proliferation	Significant algal proliferation was noted on the rocks at this point. Both marginal and aquatic vegetation were also significantly affected as a result of algal proliferation.
Depth profiles	The river consisted mostly of shallow riffles and deep sections in the larger pools.
Flow condition	The Klein Marico River was flowing very slowly at this point. No fast flowing water was present.
Riparian zone characteristics	The riparian zone along the length of this section of the Klein Marico River is steep due to topography of the area. Some vegetation removal has occurred in the vicinity of the bridge. The riparian zone at this point is affected by alien vegetation encroachment to a small degree.
Water clarity and odour	Water was clear at the time of the assessment. No odours were evident.
Significance	This site serves as a future spatial reference point for all sites further downstream in the catchment. The point also serves to indicate the condition of the Klein Marico River prior to any effects as a result of the activities of the proposed Doornhoek mining project.

SITE ECOSTATUS CATEGORY	October 2014	May 2016
Dickens & Graham (2001)	Category D	Category D
Dallas (2007)	Category D	Category D
MIRAI	Category C	Category D

In situ physico-chemical water quality

Parameter	October 2014	May 2016
pH	6.96	7.73
EC (mS/m)	45.3	52.0
DO (mg/L)	6.23	6.12
DO (% sat)	78.79	71.72
Temp (℃)	19.4	15.7

Site specific temporal water quality variations (% var)

Parameter	% Var compared to feasibility assessment (October 2014)
pH	+11.1
EC (mS/m)	+14.8
DO (% sat)	-0.9

Sensitive macro-invertebrate species observed at this point:
Atyidae, Hydracarina, Lestidae
Fish species observed:
None
Additional species observed:
Daphnia sp.

Impacts and Essential Mitigation
Significant algal proliferation was observed at this point and is indicative of some nutrient enrichment at this point.
In addition, flow is affected at this point as a result of the road crossing just upstream of this point.

Aquatic macro-invertebrate community integrity

Invertebrate community assessment (SASS5 and IHAS)

Parameter	October 2014	May 2016
SASS5 score	70	64
Number of taxa	14	12
ASPT score	5.0	5.3
IHAS score	65 (Adequate)	55 (Inadequate)
MIRAI score	62.1	54.4

Site specific aquatic invertebrate community variations

Parameter	% of ref ecoregion data October 2014	% of ref ecoregion data May 2016	% Var May 2016 compared to October 2014
SASS5	46.7	42.7	-8.6
ASPT	84.7	89.8	+6.0
IHAS	NA	NA	-15.4

Key Drivers of System Change

- Flow is severely affected at this point as a result of the road crossing;
- Lack of significant flow variation and diversity will largely shape the structure of the aquatic macro-invertebrate community at this point and taxa dependent on faster flow conditions are likely to be largely absent;
- The presence of relatively sensitive species, which are adapted to slow flowing pool like habitat, serve as an indication that the water quality at this point is currently unlikely to limit the aquatic community present.
- The low flows and water abstraction from the system of the Klein Marico River in the vicinity of the proposed project reduces the Ecological Importance and Sensitivity of the system in this area significantly;
- The Klein Marico River system is expected to exhibit broad variability in aquatic community integrity on a temporal scale due to variations in flow and habitat availability in the system. As more data on the system is collected, better inferences on the ecological condition of the community will be possible;
- Due to the degree of sensitivity of the system to habitat changes and loss of instream flow, careful design and operational procedures will be required to limit the impact on the Klein Marico River.

NA = Not Applicable, SASS reference score = 150, ASPT reference score = 5.9

Table 20: Results of the assessment at Site DHKK 4 (A point located in the middle of the segment of interest on the Klein Marico River between sites DHK B3 and DHK B4 and upstream of site DHKK 3. Only assessed in May 2016).

Site DHKK 4

Figure 17: Downstream view of the DHKK 4 site during the May 2016 assessment.

Algal proliferation	None noted.
Depth profiles	The river was generally <½ m at this point at the time of the assessment.
Flow condition	The Klein Marico River was flowing slowly at this point. No fast flowing water was present.
Riparian zone characteristics	The riparian vegetation is relatively sparse and consists of a mix of sedges, grasses, shrubs and riparian trees.
Water clarity and odour	Water was clear at the time of the assessment. No odours were evident.
Significance	The point also serves to indicate the condition of the Klein Marico River prior to any effects as a result of the activities of the proposed Doornhoek mining project.
SITE ECOSTATUS CATEGORY	May 2016
Dickens & Graham (2001)	Category B
Dallas (2007)	Category C/D
MIRAI	Category B

In situ physico-chemical water quality

Parameter	May 2016
pH	8.04
EC (mS/m)	48.0
DO (mg/L)	6.45
DO (% sat)	75.58
Temp (℃)	15.7

Sensitive macro-invertebrate species observed at this point:
Atyidae, Hydracarina, Caenidae, Gomphidae Pyralidae, Philopotamidae
Fish species observed:
None
Additional species observed:
Daphnia sp.
Tadpoles

Impacts and Essential Mitigation
No impacts were observed.

Aquatic macro-invertebrate community integrity

Invertebrate community assessment (SASS5 and IHAS)

Parameter	May 2016
SASS5 score	114
Number of taxa	21
ASPT score	5.4
IHAS score	60 (Inadequate)
MIRAI score	79.6

Site specific aquatic invertebrate community variations from reference data

Parameter	% of ref ecoregion data May 2016
SASS5	76.0
ASPT	91.5
IHAS	NA

Key Drivers of System Change

- Lack of significant flow variation and diversity will largely shape the structure of the aquatic macro-invertebrate community at this point and taxa dependent on faster flow conditions are likely to be largely absent;
- The presence of very sensitive species, with special mention of the *Pyralidae*, which are adapted to slow flowing pool habitat, serve as an indication that the water quality at this point is currently unlikely to limit the aquatic community present.
- The Klein Marico River system is expected to exhibit broad variability in aquatic community integrity on a temporal scale due to variations in flow and habitat availability in the system. As more data on the system is collected, better inferences on the ecological condition of the community will be possible;
- Due to the degree of sensitivity of the system to habitat changes and loss of instream flow, careful design and operational procedures will be required to limit the impact on the Klein Marico River.

NA = Not Applicable, SASS reference score = 150, ASPT reference score = 5.9

Table 21: Results of the assessment at Site DHK B4 (A point located in the middle of the segment of interest of the Klein Marico River).

Site DHK B4

Figure 18: Upstream view of the DHK B4 site during the May 2016 assessment.

Algal proliferation	None observed.
Depth profiles	The river consisted mostly of shallow glides and deep sections in the larger pools.
Flow condition	The Klein Marico River was flowing very slowly at this point. No fast flowing water was present.
Riparian zone characteristics	The riparian zone along the length of this section of the Klein Marico River is narrow and incised with a weakly developed riparian zone. Trees dominate the area and the banks are categorised with a sparse understory.
Water clarity and odour	Water was very discoloured at the time of the assessment. No odours were evident.
Significance	The point serves as a spatial reference for the system to which data from the downstream DHK B5 point can be compared to. The point also serves to indicate the condition of the Klein Marico River prior to any effects as a result of the activities of the proposed Doornhoek mining project.

SITE ECOSTATUS CATEGORY	October 2014	May 2016
Dickens & Graham (2001)	Category D	Category D
Dallas (2007)	Category C	Category D
MIRAI	Category C	Category C

***In situ* physico-chemical water quality**

Parameter	October 2014	May 2016
pH	7.82	7.91
EC (mS/m)	37.9	48.0
DO (mg/L)	6.86	6.36
DO (% sat)	85.2	71.4
Temp (℃)	18.5	13.7

Site specific temporal water quality variations (% var)

Parameter	% Var compared to feasibility assessment (October 2014)
pH	+1.2
EC (mS/m)	+26.6
DO (% sat)	-16.2

Sensitive macro-invertebrate species observed at this point:
Hydracarina, Caenidae, Lestidae
Fish species observed:
Tilapia sparrmani x 5
Additional species observed:
Frogs and tadpoles.

Impacts and Essential Mitigation
Flow is affected at this point as a result of the road crossing just upstream of this point. Some debris and old tyres were observed at this point and should be cleared from the system.

Aquatic macro-invertebrate community integrity

Invertebrate community assessment (SASS5 and IHAS)

Parameter	October 2014	May 2016
SASS5 score	67	70
Number of taxa	12	15
ASPT score	5.6	4.7
IHAS score	57 (Inadequate)	44 (Inadequate)
MIRAI score	62.1	64.0

Site specific aquatic invertebrate community variations

Parameter	% of ref ecoregion data October 2014	% of ref ecoregion data May 2016	% Var May 2016 compared to October 2014
SASS5	44.7	46.7	+4.5
ASPT	94.9	79.7	-16.1
IHAS	NA	NA	-22.8

Key Drivers of System Change

- Flow is severely affected at this point as a result of the road crossing;
- Lack of significant flow variation and diversity will largely shape the structure of the aquatic macro-invertebrate community at this point and taxa dependent on faster flow conditions are likely to be largely absent;
- The Klein Marico River system is expected to exhibit broad variability in aquatic community integrity on a temporal scale due to variations in flow and habitat availability in the system;
- This point is largely affected by removal of indigenous vegetation, some encroachment of exotic vegetation species, instream sedimentation and debris observed, which affects the stream substrate to some degree;
- Due to the degree of sensitivity of the system to habitat changes and loss of instream flow, careful design and operational procedures will be required to limit the impact on the Klein Marico River.

NA = Not Applicable, SASS reference score = 150, ASPT reference score = 5.9

Table 22: Results of the assessment at Site DHK B5 (A point located on the downstream edge of the segment of interest of the Klein Marico River and downstream of all potential mining activities Biomonitoring indices only applied in October 2014 as the site was dry during the May 2016 assessment).

Site DHK B5

Figure 19: Downstream view of the DHK B5 site during the May 2016 assessment.

Algal proliferation	Some algal proliferation was observed in the October 2014 assessment.
Depth profiles	Water was absent at this point during the May 2016 assessment.
Flow condition	According to the assessment in October 2014, when water is present, the Klein Marico River is characterised by slow flows at this point. However, water was absent in the current May 2016 assessment.
Riparian zone characteristics	The riparian vegetation is relatively sparse and consists of a mix of sedges, grasses, shrubs and riparian trees.
Water clarity and odour	Water was clear during the October 2014 assessment, while water was absent in the May 2016 assessment. No odours were evident.
Significance	The riparian zone along the length of this section of the Klein Marico River is relatively narrow due to the limited development of the system. The riparian vegetation is relatively sparse and consists of a mix of grasses, sedges, shrubs and trees.
SITE ECOSTATUS CATEGORY	October 2014
Dickens & Graham (2001)	Category D
Dallas (2007)	Category D
MIRAI	Category C

***In situ* physico-chemical water quality**

Parameter	October 2014
pH	7.59
EC (mS/m)	52.6
DO (mg/L)	7.39
DO (% sat)	89.75
Temp (℃)	17.4

Sensitive macro-invertebrate species observed at this point:
Caenidae
Fish species observed:
None
Additional species observed:
None

Impacts and Essential Mitigation
During the October 2014 assessment, limited impacts on the instream ecology were visually evident, although some impact due to water abstraction from the system leading to reduced instream flow and loss of refuge pools was considered likely to be occurring. Some impact on water quality was also deemed possible due to the algal growth observed in the system and some impact from livestock watering was observed. The lack of water at this point during the May 2016 assessment may be related to water abstraction activities taking place upstream of this point, however, nation-wide drought conditions in the months preceding the May 2016 assessment are likely to have exacerbated this impact.

Aquatic macro-invertebrate community integrity

Invertebrate community assessment (SASS5 and IHAS)

Parameter	October 2014
SASS5 score	70
Number of taxa	14
ASPT score	5.0
IHAS score	54 (Inadequate)
MIRAI score	62.1

Site specific aquatic invertebrate community variations from reference data

Parameter	% of ref ecoregion data October 2014
SASS5	46.7
ASPT	84.7
IHAS	NA

Key Drivers of System Change

- The Klein Marico River system is expected to exhibit broad variability in aquatic community integrity on a temporal scale due to variations in flow and habitat availability in the system. The lack of flow at this point is likely seasonal and possibly related to drought conditions experienced at the time of the May 2016 assessment. However, this is likely to severely limit the diversity and sensitivity of the aquatic macro-invertebrate community expected to occur at this point;
- In addition, the results of the water quality analysis during the October 2014 assessment suggests that some impact to water quality at this point may limit the sensitivity of the aquatic community present;
- When water is present, the aquatic community likely to occur at this point will be limited to those species adapted specifically to slow flows and still water environments;
- Due to the degree of sensitivity of the system to habitat changes and loss of instream flow, careful design and operational procedures will be required to limit the impact on the Klein Marico River.

NA = Not Applicable, SASS reference score = 150, ASPT reference score = 5.9

Key observations relating to water quality along this section of the Klein Marico River system:

(Please note that temporal comparisons in the discussion that follows refers to comparisons between the October 2014 and May 2016 assessments).

- Concentration of dissolved salts remained fairly constant both spatially as well as temporally between each of the sites assessed;
- Spatially, in the October 2014 assessment, the conductivity decreased by 16.3% between sites DHK B3 and DHK B4 but increased by 16.1% between the former and site DHK B5. Conductivity increased by 38.8% between sites DHK B4 and DHK B5;
- In the May 2016 assessment, the conductivity decreases only slightly by 7.7% between sites DHK B3 and site DHK B4;
- Temporally, the conductivity increases by 14.8% at site DHK B3 and by 26.6% at site DHK B4. This spatial and temporal data indicates that during periods of low flows salts concentrate in the Klein Marico River system;
- Slow, shallow conditions predominated at all sites. Changes in conductivity may have been influenced by slight differences in evaporation rate and river make up, geological effects and agricultural activities in the form of abstraction and watering of cattle as well as agricultural return flows;
- The water quality guideline for aquatic ecosystems (DWA 1997) states that: 1) Total dissolved salts (TDS) concentrations (i.e. as indicated by the EC measurements) should not be changed by > 15 % from the normal cycles of the water body under unimpacted conditions at any time of the year; and 2) the amplitude and frequency of natural cycles in TDS concentrations should not be changed;
- The spatial and temporal changes in conductivity along this section of the Klein Marico River thus exceeds the above recommendation prior to any mining activities in the area;
- The data therefore shows significant natural variation in the system prior to mining in the area;
- Data from future monitoring studies should be used to identify temporal trends and data from this report should be used as a temporal baseline to which future data can be compared;
- The water quality guideline for aquatic ecosystems (DWA 1997) states that pH values should not be allowed to vary from the range of the background pH values for a specific site by > 5 %;
- If the upstream site DHK B3 pH value observed in October 2014 is considered a spatial and temporal reference value. The observed changes in pH value exceed the recommended percentage change range;

- However, natural pH ranges fall between 6.5 and 8.5 as was observed at each of the sites in both the October 2014 as well as in the May 2016 assessments;
- Data from report should be used as a temporal baseline to which future data can be compared. As the pH appears somewhat variable in this system from both a spatial as well as a temporal perspective under pre-mining conditions, it is deemed important that the absolute pH values be monitored and that any fluctuations outside of the natural pH ranges be regarded as a red flag for impact once mining activities in the area commence;
- The water quality guideline for aquatic ecosystems (DWA 1997) 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 18 May 2013);
- Dissolved oxygen concentrations at each of the sites assessed in May 2016 are below the recommended range indicating that the lack of dissolved oxygen in the system may limit the aquatic community to some degree;
- Data from future monitoring studies will be used to identify temporal trends;
- The temperatures observed at each of the points are deemed natural for the time of year and the nature of the systems. The observed variations can be attributed to diurnal variation between sampling times and the slight variation in the volume of water in the water bodies sampled.

Habitat integrity along this section of the Klein Marico River system:

- Based on the observations of both the October 2014 as well as the May 2016 habitat assessments, the habitat diversity and structure in terms of habitat provision for aquatic communities is deemed largely inadequate to support a diverse aquatic macro-invertebrate community under very low flow conditions. On comparison of the results of the October 2014 assessment to the results of the May 2016 assessment, it is evident that under higher flow conditions, habitat suitability is slightly improved;
- On application of the Intermediate Habitat Integrity Assessment (IHIA), for the Klein Marico River sites (DHK B3, DHK B4 and DHK B5 assessed in October 2014 and DHK B3, DHK B4 and DHKK 4 assessed in May 2016), mostly only small and moderate impacts were recorded for both instream and riparian zones habitat (Appendix 5). The DHK B5 site was not reassessed in the May 2016 assessment due to the absence of flow at this point and the results of the October 2014 assessment are thus retained;
- Large instream impacts in terms of flow and bed modifications were observed at site DHK B3 and site DHK B4. Other instream impacts at these two sites included small channel and water quality modifications and solid waste disposal. At site DHK B5,

assessed only in the October 2014 assessment, a moderate instream impact in terms of water quality was noted, with smaller impacts related to water abstraction activities, flow, bed and channel modifications, exotic fauna and solid waste disposal also evident. At site DHKK 4, assessed only in the May 2016 assessment, only very small impacts in terms of flow, bed and water quality modifications were observed;

- For instream habitat zone integrity both sites DHK B3 and DHK B4 obtained a B (largely natural) classification in October 2014 and a C (moderately modified) classification in the May 2016 assessment. Site DHK B5 obtained a class B (largely natural) classification and the DHKK 4 site obtained an A (natural) classification in the May 2016 assessment;
- The variations observed are largely related to changes in flow condition at each site between the October 2014 and May 2016 assessments and are considered unrelated to any existing impacts as a result of activities in the vicinity of the proposed mining project which include but are not limited to game farming, livestock farming, agricultural activities, water abstraction and historical mining activities in the surrounding area;
- Riparian zone impacts included indigenous vegetation removal and exotic vegetation encroachment at sites DHK B3, DHK B4 and DHK B5, with some impacts as a result of erosion observed at site DHK B4. These impacts are likely related to agricultural activities, trampling by livestock and water abstraction activities. For riparian habitat zone integrity both sites DHK B3 and DHK B4 obtained B (largely natural) classifications in both the October 2014 and the May 2016 assessments. Site DHK B5 obtained a B (largely natural) classification in October 2014 and site DHKK 4 was assigned an A (natural) classification in May 2016.
- Overall scores of 73.68% (DHK B3), 78.95% (DHK B4), 84.84% (DHK B5) and 96.88% (DHKK 4) were calculated, placing sites DHK B3 and DHK B4 in a class C (moderately modified), site DHK B5 in a class B (largely natural) and site DHKK 4 in a class A (natural) condition.

Application of the Riparian Vegetation Response Assessment Index (VEGRAI) to the Klein Marico River:

The 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. Results are defensible because their generation can be traced through an outlined process (a suite of rules that convert assessor estimates into ratings and converts multiple ratings into an Ecological category). The degree of vegetation related impacts differed substantially between the upper areas of the Klein Marico river segment and lower areas of the Klein Marico river segment. Vegetation associated with the lower portion of the Klein Marico River is less impacted when compared to that associated with more upstream portions. VEGRAI scores were therefore calculated for each of these portions separately and a mean score was then calculated for the system as a whole.

Table 23: VEGRAI Ecological ecostatus output for the upper Klein Marico River.

LEVEL 3 ASSESSMENT					
METRIC GROUP	**CALCULATED RATING**	**WEIGHTED RATING**	**CONFIDENCE**	**RANK**	**% WEIGHT**
MARGINAL	31.7	18.6	1.8	1.0	100.0
NON MARGINAL	35.8	14.8	0.0	2.0	70.0
	2.0				170.0
LEVEL 3 VEGRAI (%)				33.4	
VEGRAI EC				**E**	
AVERAGE CONFIDENCE				0.9	

Table 24: VEGRAI Ecological ecostatus output for the lower Klein Marico River.

LEVEL 3 ASSESSMENT					
METRIC GROUP	**CALCULATED RATING**	**WEIGHTED RATING**	**CONFIDENCE**	**RANK**	**% WEIGHT**
MARGINAL	61.7	36.3	1.8	1.0	100.0
NON MARGINAL	65.0	26.8	0.0	2.0	70.0
	2.0				170.0
LEVEL 3 VEGRAI (%)				63.0	
VEGRAI EC				**C**	
AVERAGE CONFIDENCE				0.9	

Table 25: VEGRAI Ecological Category Description Scores for the Klein Marico River.

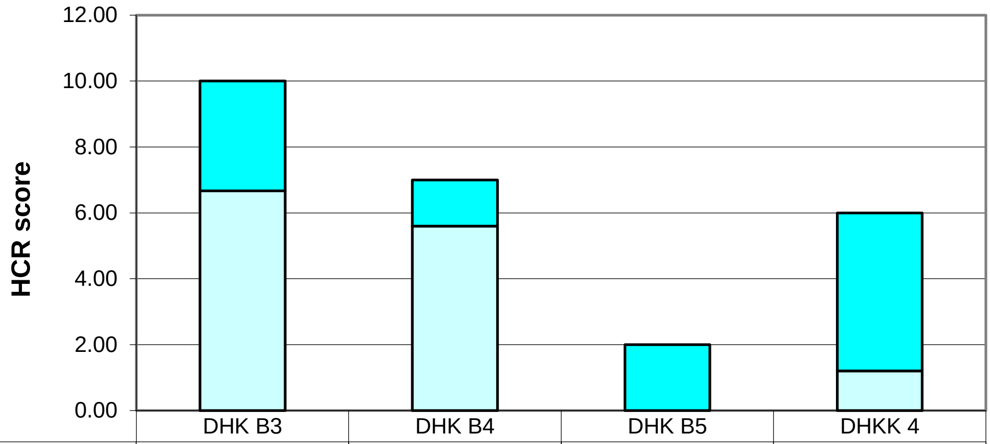
Portion	VEGRAI %	EC	Definition
Upper portion	33.4%	E	Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive
Lower portion	63%	C	Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.
Mean	**48.2%**	**D**	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.

The overall VEGRAI score calculated for the upstream portion of the Klein Marico River falls within the EC Class E (Seriously modified) due to vegetation removal and alien vegetation encroachment. Vegetation associated with the downstream portion of the Klein Marico River falls within the EC Class C (Moderately modified) with less significant impacts encountered but water abstraction and impacts from livestock trampling and some alien vegetation encroachment were still evident.

The overall score calculated for the Klein Marico River, taking into consideration both the upper and lower portions of the river, falls within an EC Class D indicating largely modified conditions. Measures to control impacts on water loss from the system as well as vegetation removal will be important and measures to control alien vegetation encroachment will be critical.

Fish Community Assessment of the Klein Marico River:

The HCR (Habitat Cover Rating) results for the Klein Marico River sites assessed in October 2014 and the May 2016 (DHK B3, DHK B4, DHK B5 and DHKK 4) are provided below.



	DHK B3	DHK B4	DHK B5	DHKK 4
Fast – Shallow	0.00	0.00	0.00	0.00
Fast - Deep	0.00	0.00	0.00	0.00
Slow - Shallow	3.33	1.40	2.00	4.80
Slow - Deep	6.67	5.60	0.00	1.20

Klein Marico River

Figure 20: HCR scores for the sites assessed on the Klein Marico River considered to be representative of conditions during both the October 2014 and May 2016 site visits.

The list of fish species expected to occur has been tabulated in the materials and methods section (Appendix 4). Included in the list of expected species based on habitat availability and distribution range is the Marico barb (*Enteromius motebensis*).

The Marico barb has a very limited distribution range with very small area of occupancy. Because it is known from only approximately ten locations threatened by water abstraction for agriculture, seepage from mines via dolomitic groundwater or alien predatory fish species (*Micropterus* spp.), it has been classified as a vulnerable red data list species.

Whilst no specimens of this species were collected from assessed sites in the systems under investigation, such populations may exist on a regional scale. Various contributing factors are likely to play a role in the lack of field observations of *E. motebensis.* Very low flows observed in the May 2016 assessment as a result of severe nationwide drought conditions and the associated lack of flow connectivity are likely to have significantly affected natural migration routes and the absence is unlikely related to current impacts to water quality in the system. Both natural and manmade migratory barriers are likely to impact significantly on this species, especially in extended periods of drought. Should the Doornhoek mining project proceed, special effort should be made to ensure maintenance of habitat and ecological integrity of the stream to limit larger scale regional impacts on potential *E. motebensis* populations. Furthermore, it is considered essential that a detailed understanding of the loss of baseflow in the Groot Marico River is obtained and that it is determined whether the proposed mining activity will allow the Ecological Reserve and environmental Water Requirements of the Klein Marico River to be met.

Fish actually collected in October 2014 and May 2016 and Frequency of Occurrence (FROC) scores employed are tabulated below along with the EC obtained using the FRAI.

Table 26: Summary of the results (ecological categories) obtained from the application of the FRAI to the Klein Marico River.

Variable / Index	Klein Marico River
Species observed	*Enteromius paludinosis* *Pseudocrenilabrus philander* *Tilapia sparrmanii*
FROC score	*Enteromius paludinosis (3)* *Pseudocrenilabrus philander (3)* *Tilapia sparrmanii (3)*
Automated FRAI (%)	33.4
Automated EC (FRAI)	E
Refined FRAI (%)	45.9
Refined EC (FRAI)	D

EC = Ecological category

4.2.1 Aquatic Ecostatus: Summary for the Klein Marico River

The results of the various assessment indices applied during the aquatic assessment at each site were used for the determination of the overall ecostatus classification at each site. The ecostatus classification obtained at each site is indicated in the table below. Results of the May 2016 assessment were utilised for the calculations at each site, with the exception of site BHK B5, which was dry during the May 2016 assessment period and the October 2014 results were used.

Table 27: Summary of the results of the Integrated Ecological Category for each site.

Site	Integrated Ecological Category (%)	Integrated Ecostatus Category
DHK B3	**45.65**	**D**
DHKK 4	**65.78**	**C**
DHK B4	**60.09**	**C/D**
DHK B5	**59.41**	**C/D**

4.2.2 Aquatic EIS determination of the Klein Marico River

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 median of the determinants is used to assign the EIS Category as listed in the table below.

Table 28: Aquatic EIS determination for the Klein Marico River

Biotic Determinants	**Klein Marico River**
Rare and endangered biota	3
Unique biota	2
Intolerant biota	1
Species/taxon richness	2
Aquatic Habitat Determinants	
Diversity of aquatic habitat types or features	2
Refuge value of habitat type	2
Sensitivity of habitat to flow changes	2
Sensitivity of flow-related water quality changes	3
Migration route/corridor for instream and riparian biota	2
Nature Reserves, Natural Heritage sites, Natural areas, PNEs	1
RATING AVERAGE	**2.0**
EIS CATEGORY	**Moderate/High**

Based on the findings of the assessment it is evident that aquatic features associated with the Klein Marico River have an EIS which can be considered moderate to high. The Klein Marico River system can therefore be defined as being unique on a local to national scale due to biodiversity (habitat diversity, species diversity, unique species, rare and endangered species).

4.3 The Unnamed Tributary of the Klein Marico River

The sections below present the results of the various indices applied to the sites visited during both the feasibility study (October 2014) as well as the baseline assessment (May 2016) for the aquatic ecological assessment, which were deemed suitable for biomonitoring.

Table 29: Results of the assessment at Site DHK B1 (A hot spring forming the source of a major unnamed tributary of the Klein Marico River).

Site DHK B1

Figure 21: Upstream view of the DHK B1 site during the May 2016 assessment.

Algal proliferation	None.
Depth profiles	The river consisted mostly of a shallow pool and isolated shallow runs in some areas.
Flow condition	The unnamed tributary of the Klein Marico River was flowing very slowly at this point. No fast flowing water was present.
Riparian zone characteristics	The riparian zone at the spring is intact but a short distance downstream grazing and other disturbances along with water abstraction have severely affected the site. The riparian zone at this point is affected by alien vegetation encroachment to a small degree and some impacts as a result of erosion at this point are evident.
Water clarity and odour	Water was very clear at the time of the assessment. No odours were evident.
Significance	This site serves as a future spatial reference point for the DHK B2 site further downstream in the catchment. The point also serves to indicate the condition of the unnamed tributary of the Klein Marico River prior to any effects as a result of the activities of the proposed Doornhoek mining project.

SITE ECOSTATUS CATEGORY	October 2014	May 2016
Dickens & Graham (2001)	Category E	Category C
Dallas (2007)	Category D	Category D
MIRAI	Category D	Category C

***In situ* physico-chemical water quality**

Parameter	October 2014	May 2016
pH	7.53	7.98
EC (mS/m)	45.3	53.0
DO (mg/L)	7.45	7.26
DO (% sat)	85.44	91.99
Temp (℃)	21.7	19.5

Site specific temporal water quality variations (% var)

Parameter	% Var compared to feasibility assessment (October 2014)
pH	+5.98
EC (mS/m)	+17.0
DO (% sat)	+7.7

Sensitive macro-invertebrate species observed at this point:
Atyidae, Hydracarina, Caenidae, Gomphidae
Fish species observed:
None
Additional species observed:
None.

Impacts and Essential Mitigation
At the time of assessment no significant impacts on the instream ecology were visually evident. Small impacts related to erosion in some areas as a result of poor vegetation cover, limited impacts associated with alien vegetation encroachment and the build-up of detritus in the system were observed.

Aquatic macro-invertebrate community integrity

Invertebrate community assessment (SASS5 and IHAS)

Parameter	October 2014	May 2016
SASS5 score	32	91
Number of taxa	7	18
ASPT score	4.6	5.1
IHAS score	52 (Inadequate)	72 (Adequate)
MIRAI score	50.5	78.7

Site specific aquatic invertebrate community variations

Parameter	% of ref ecoregion data October 2014	% of ref ecoregion data May 2016	% Var May 2016 compared to October 2014
SASS5	21.3	60.7	+184.4
ASPT	78.0	86.4	+10.9
IHAS	NA	NA	+38.5

Key Drivers of System Change

- Lack of significant flow variation and diversity will largely shape the structure of the aquatic macro-invertebrate community at this point and taxa dependent on faster flow conditions are likely to be largely absent;
- The presence of relatively sensitive species, which are adapted to slow flowing pool like habitats, serve as an indication that the water quality at this point is currently unlikely to limit the aquatic community present.
- The low flows and water abstraction from this system reduces the Ecological Importance and Sensitivity significantly;
- The river systems in the vicinity of the proposed mining project are expected to exhibit broad variability in aquatic community integrity on a temporal scale due to variations in flow and habitat availability. As more data is collected, better inferences on the ecological condition of the community will be possible;
- Due to the degree of sensitivity of the systems to habitat changes and loss of instream flow, careful design and operational procedures will be required to limit the impact on this tributary of the Klein Marico River, with special mention of the need to mitigate any losses to catchment yield as a result of the activities of the proposed Doornhoek mining project.

NA = Not Applicable, SASS reference score = 150, ASPT reference score = 5.9

Table 30: Results of the assessment at Site DHK B2 (A point further downstream on the unnamed tributary of the Klein Marico River and downstream of all possible mining activities).

Site DHK B2

Figure 22: Upstream view of the DHK B2 site during the May 2016 assessment.

Algal proliferation	Algal proliferation was observed in isolated areas at this point.
Depth profiles	The river consisted mostly of a shallow pool and very shallow runs in some areas.
Flow condition	The unnamed tributary of the Klein Marico River was flowing very slowly at this point. No fast flowing water was present.
Riparian zone characteristics	The riparian zone along the length of this section of the unnamed tributary of the Klein Marico River is relatively narrow due to the limited development of the system. The riparian vegetation is relatively dense and is dominated by woody species.
Water clarity and odour	Water was very clear at the time of the assessment. No odours were evident.
Significance	The site is situated on the lower reaches of the unnamed tributary of the Klein Marico River prior to the confluence with the Klein Marico River. Future data for this point can be spatially compared to the results obtained at site DHK B1 in order to identify any impacts on the aquatic ecology of the system occurring between these points.

SITE ECOSTATUS CATEGORY	October 2014	May 2016
Dickens & Graham (2001)	Category D	Category E
Dallas (2007)	Category A	Category E/F
MIRAI	Category D	Category D

***In situ* physico-chemical water quality**

Parameter	October 2014	May 2016
pH	7.92	7.80
EC (mS/m)	51.5	64.0
DO (mg/L)	8.29	6.43
DO (% sat)	87.72	71.65
Temp (℃)	17.5	13.4

Site specific temporal water quality variations (% var)

Parameter	% Var compared to feasibility assessment (October 2014)
pH	-1.5
EC (mS/m)	+24.3
DO (% sat)	-18.3

Sensitive macro-invertebrate species observed at this point:
Atyidae, Hydracarina
Fish species observed:
None
Additional species observed:
Tadpoles

Impacts and Essential Mitigation
At the time of assessment limited impacts on the instream ecology were visually evident. Some impact due to water abstraction from the system, leading to reduced instream flow and loss of refuge pools, is considered likely to be occurring. Some impact on water quality was also deemed possible due to the algal growth observed in the system and some impact from livestock watering was observed.

Aquatic macro-invertebrate community integrity

Invertebrate community assessment (SASS5 and IHAS)

Parameter	October 2014	May 2016
SASS5 score	61	47
Number of taxa	9	12
ASPT score	6.8	3.9
IHAS score	59 (Inadequate)	46 (Inadequate)
MIRAI score	50.5	58.8

Site specific aquatic invertebrate community variations

Parameter	% of ref ecoregion data October 2014	% of ref ecoregion data May 2016	% Var May 2016 compared to October 2014
SASS5	40.7	31.3	-23.0
ASPT	115.3	66.1	-42.6
IHAS	NA	NA	-22.0

Key Drivers of System Change

- Lack of significant flow variation and diversity at this point largely shapes the structure of the aquatic macro-invertebrate community present with taxa dependent on faster flow conditions absent;
- The severely reduced flow at this site in relation to the upstream DHK B1 site (resulting from the weir constructed at the latter site further reducing flow) plays a significant role in the spatial variation of the SASS5 and ASPT scores obtained in the current assessment, with the SASS5 score decreasing by 48.4% and the ASPT score decreasing by 23.5% in a downstream direction;
- The river systems in the vicinity of the proposed mining project are expected to exhibit broad variability in aquatic community integrity on a temporal scale due to variations in flow and habitat availability. As more data is collected, better inferences on the ecological condition of the community will be possible;
- Due to the degree of sensitivity of the systems to habitat changes and loss of instream flow, careful design and operational procedures will be required to limit the impact on this tributary of the Klein Marico River, with special mention of the need to mitigate any losses to catchment yield as a result of the activities of the proposed Doornhoek mining project.

NA = Not Applicable, SASS reference score = 150, ASPT reference score = 5.9

Key observations relating to water quality along this section of the unnamed tributary of the Klein Marico River system:

(Please note that temporal comparisons in the discussion that follows refers to comparisons between the October 2014 and May 2016 assessments).

- Conductivity values were similar to that recorded from the Klein Marico River assessment sites;
- Concentration of dissolved salts remained fairly constant but were slightly higher at the downstream (DHK B2) site;
- Conductivity increased by 20.8% between sites DHK B1 and DHK B2;
- Very slow and shallow conditions predominated at both sites. Changes in conductivity may have been influenced by slight differences in evaporation rate and river make up, geological effects and agricultural activities in the form of agricultural return flows, abstraction and watering of cattle;
- The water quality guideline for aquatic ecosystems (DWA 1997) states that: 1) Total dissolved salts (TDS) concentrations (i.e. as indicated by the EC measurements) should not be changed by > 15 % from the normal cycles of the water body under unimpacted conditions at any time of the year; and 2) the amplitude and frequency of natural cycles in TDS concentrations should not be changed;
- When viewing upstream site DHK B1 as a reference site, the spatial change in a downstream direction thus exceeds the guideline recommendation. This serves as an indication that before any impacts related to the proposed mining project, some salinisation of the system is deemed likely in the local area due to natural variations in the flow conditions and rates and the various agricultural activities taking place in the area;
- The pH at both points can be considered neutral and is unlikely to affect aquatic biota;
- Dissolved oxygen concentration at the upstream DHK B1 assessment site was in compliance with the recommended range and the system is therefore expected to support a diverse and sensitive aquatic community, unless habitat conditions constrain the ecology of the system;
- The temperatures observed at each of the points are deemed natural for the time of year and the nature of the systems. The observed variations can be attributed to diurnal variation between sampling times and the slight variation in the volume of water in the water bodies sampled.

Habitat integrity along this section of the Unnamed Tributary of the Klein Marico River system:

- In the May 2016 assessment, the habitat diversity and structure at the DHK B1 site may be regarded as adequate to support a diverse aquatic macro-invertebrate community under the current low flow conditions, while at site DHK B2, habitat conditions may be regarded as unsuitable for supporting a diverse and sensitive aquatic community due largely to constraints in the availability of adequate flow at this point;
- On application of the IHIA to the two sites on the unnamed tributary of the Klein Marico River, small to critical impacts were recorded for instream zone habitat whilst small to serious impacts were reported for riparian zones habitat (Appendix 5);
- For site DHK B1, the instream zone habitat integrity assessment revealed critical impacts on water abstraction and flow modification, while for site DHK B2, with reference to the same two variables, serious and moderate impacts were respectively recorded. In addition, at site DHK B1, a large impact as a result of channel modification was observed, while a moderate impact was reported for site DHK B2 for the same variable. Both sites DHK B1 and DHK B2 presented with moderate impacts on bed modification and small impacts on solid waste disposal. Other moderate impacts include exotic fauna at site DHK B2 and inundation at site DHK B1. For instream zone habitat integrity site DHK B1 achieved a score of 25.5% (Class E, extensive loss) whilst site DHK B2 achieved 40.9% (Class D, largely modified);
- In terms of impacts to the riparian zone, the most significant impact at site DHK B1 was alien encroachment, while at site DHK B2 only a moderate impact was recorded for the same variable. Both sites presented with large impacts related to vegetation removal and moderate impacts from water abstraction, flow modification and channel modification. Small impacts associated with inundation at site DHK B1 were noted. A moderate impact as a result of bank erosion was recorded for site DHK B2. In lieu of these observations, for riparian zone habitat integrity site DHK B1 achieved a score of 71.6% (Class C, moderately modified) whilst site DHK B2 achieved 45.9% (Class D, largely modified);
- An overall score of 48.5% was calculated for DHK B1 and 43.3% for DHK B2, resulting in both being classified as Class D (Largely modified) sites.

Application of the Riparian Vegetation Response Assessment Index (VEGRAI) to the Unnamed Tributary of the Klein Marico River:

The VEGRAI ecostatus tool for this unnamed tributary yielded a VEGRAI score of 68.7% indicating moderately modified Class B conditions. The levels of integrity of the marginal and non-marginal zones were largely similar. The most significant impacts on the system occur from alien vegetation encroachment and vegetation removal. Some stress on the marginal zone from water abstraction is, however, also evident.

Table 31: VEGRAI Ecostatus tool output for the unnamed tributary of the Klein Marico River.

LEVEL 3 ASSESSMENT					
METRIC GROUP	**CALCULATED RATING**	**WEIGHTED RATING**	**CONFIDENCE**	**RANK**	**% WEIGHT**
MARGINAL	68.3	40.2	1.8	1.0	100.0
NON MARGINAL	69.2	28.5	0.0	2.0	70.0
	2.0				170.0
LEVEL 3 VEGRAI (%)				68.7	
VEGRAI EC				**C**	
AVERAGE CONFIDENCE				0.9	

Fish Community Assessment of the Klein Marico River:

The HCR (Habitat Cover Rating) results for the sites on the unnamed tributary of the Klein Marico River assessed in October 2014 and the May 2016 (DHK B1 and DHK B2) are provided below

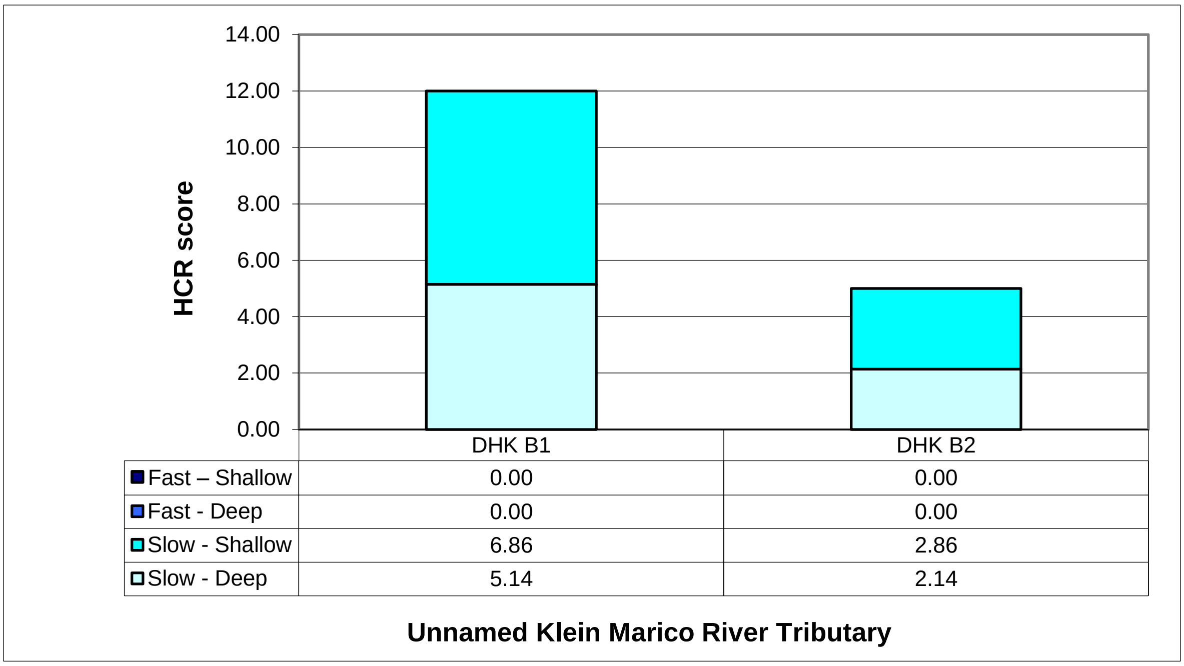


Figure 23: HCR scores for the two sites assessed on the unnamed tributary of the Klein Marico River in October 2014 and May 2016.

The list of fish species expected to occur has been tabulated in the materials and methods section. Fish actually collected in October 2014 and May 2016 and Frequency of Occurrence (FROC) scores employed are tabulated below. In addition, the table summarises the EC obtained using the FRAI.

Table 32: Summary of the results (ecological categories) obtained from the application of the FRAI to the unnamed tributary of the Klein Marico River.

River assessed	Unnamed tributary of the Klein Marico
Species observed	*Tilapia sparrmanii*
FROC score	3
Automated FRAI (%)	18.3
Automated EC (FRAI)	E/F
Refined FRAI (%)	39.8
Refined EC (FRAI)	D/E

EC = Ecological category

From the table above it is clear that the EC calculated for the FRAI largely corresponds to that obtained for the MIRAI applied to this section of the unnamed tributary of the Klein Marico River. This could be expected as both fish populations as well as aquatic macro-invertebrate species are subject to and influenced by the same ecological drivers. Impacts on stream flow and stream connectivity are considered to be major contributors to the drivers of change in this system.

4.3.1 Aquatic Ecostatus: Summary for the Klein Marico River

The results of the various assessment indices applied during the aquatic assessment at each site were used for the determination of the overall ecostatus classification at each site. The ecostatus classification obtained at each site is indicated in the table below. Results of the May 2016 assessment were applied for the calculations at each site, with the exception of site BHK B5, which was dry during the May 2016 assessment period and the October 2014 results were used.

Table 33: Summary of the results of the Integrated Ecological Category for each site.

Site	Integrated Ecological Category (%)	Integrated Ecostatus Category
DHK B1	**66.76**	**C**
DHK B2	**59.64**	**C/D**

4.3.2 Aquatic EIS determination

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 median of the determinants is used to assign the EIS Category as listed in the table below.

Table 34: Aquatic EIS determination for the unnamed tributary Klein Marico River

Biotic Determinants	**Unnamed tributary of the Klein Marico River**
Rare and endangered biota	3
Unique biota	2
Intolerant biota	1
Species/taxon richness	2
Aquatic Habitat Determinants	
Diversity of aquatic habitat types or features	2
Refuge value of habitat type	2
Sensitivity of habitat to flow changes	2
Sensitivity of flow-related water quality changes	3
Migration route/corridor for instream and riparian biota	1
Nature Reserves, Natural Heritage sites, Natural areas, PNEs	1
RATING AVERAGE	**1.9**
EIS CATEGORY	**Moderate**

Based on the findings of the assessment it is evident that aquatic features associated with the unnamed tributary of the Klein Marico River have an EIS which can be considered moderate. As could be expected this is similar to the classification obtained for the Klein Marico River itself. The Klein Marico River system can therefore be defined as being unique on a provincial or local scale due to biodiversity (habitat diversity, species diversity, unique species, rare and endangered species).

4.4 *Aquatic assessment results synopsis and conclusion*

4.4.1 Literature search and comparison with aquatic EIS determination

The table below summarises the EC, PES, EI and ES results reported in cited literature

Table 35: Summary of ecological status of the study area as gleaned from literature

Source	Default EC	PES	EI	ES
DWS RQIS PES/EIS	C	B	Moderate	Moderate
DWA report 1,3/00/CON/CLA/0312	Not stated	C	Low	Low
State of rivers report 9	Overall ecostatus stated as "Fair"			

The aquatic EIS assessment performed is in agreement with literature cited. Aquatic features associated with the Klein Marico River system were found to have an EIS which can be considered "moderate" to "low".

Based on the DWS RQIS database desktop result and current EIS assessments, the Klein Marico River system can therefore be defined as being unique on a provincial or local scale due to biodiversity and often has substantial capacity for use.

4.4.2 Sites of interest only visually assessed

Sites on the Klein Marico River that were only visually assessed were affected by the following impacts: Upstream mining and agricultural activities, with specific reference to abstraction and livestock grazing and alien vegetation encroachment.

4.4.3 Aquatic assessment results for the Klein Marico River and the unnamed tributary

Table 36 on the next page summarizes the results obtained for the respective sites assessed.

Based on the findings of the aquatic study, both the unnamed tributary and Klein Marico River can be considered water stressed systems with moderate ecological importance and sensitivity.

Although not collected from the sites assessed, Marico barbs (*E. motebensis*) may potentially occur within the larger regional area based on known distribution. This species is a vulnerable red data list species and care should be taken to avoid larger scale impacts within the system.

Table 36: Summary of aquatic assessment results

Index		Unnamed tributary of the Klein Marico River		Klein Marico River			
		DHK B1	DHK B2	DHK B3	DHK B4	DHK B5	DHKK 4
IHIA	October 2014	D	D	B	B	C	NA*
	May 2016	D	D	C	C	NA*	A
IHAS	October 2014	Inadequate	Inadequate	Borderline adequate	Inadequate	Inadequate	NA*
	May 2016	Adequate	Inadequate	Inadequate	Inadequate	NA*	Inadequate
VEGRAI	October 2014	B		E			
	May 2016	B		E			
SASS5 Dickens and Graham (2001)	October 2014	E	D	D	D	D	NA*
	May 2016	C	E	D	D	NA*	D
SASS5 Dallas (2007)	October 2014	D	A	D	C	D	NA*
	May 2016	D	E/F	D	D	NA*	D
MIRAI	October 2014	D	D	C	C	C	NA*
	May 2016	C	D	D	C	NA*	C
FRAI automated	October 2014	F		F			
	May 2016	E/F		E			
FRAI refined	October 2014	D/E		D/E			
	May 2016	D/E		D			
Integrated Ecological Category		C	C/D	D	C/D	C/D	C

*Not Assessed

The overall PES for the Klein Marico River, which occurs in the vicinity of the proposed Doornhoek mining project, appears to improve in a downstream direction and fall into largely to moderately modified conditions (Class D to Class C). The overall PES of the unnamed tributary of the Klein Marico Tributary decreases slightly in a downstream direction, but may also be classified as largely to moderately modified from natural conditions (Class D to Class C). The overall Integrated Ecological Category for these two systems thus fall within the Desired Ecological Management Class (according to the DWS RQS PES/EIS database) for a stream of this nature in the Klein Marico River Catchment.

5 IMPACT ASSESSMENT

In addition to the various localities earmarked for mining within the mining rights area, four possible infrastructure layout options (Figures 24 – 27) are under consideration for the proposed Doornhoek mining project. Table 37 provides a summary of the footprint structures envisioned for the proposed Doornhoek mining project.

Table 37: Summary of the footprint structures associated with the proposed Doornhoek mining project

Description	Footprint (m)		
	Length	Width	Height
Water Services	53,7	26,2	6
Primary Crushing Area	21	16	20
Security Gate House	20	16	4
Secondary Crushing	10	9	16
Site Establishment	62,3	11,3	3,5
Sub Station	26,1	7,2	6,6
Laboratory	20,45	37,75	7,15
Fuel Storage	9,22	4,5	3,5
Conditioning Plant	66	27,5	3,4
Change House Plan	25	25	4,6
Air Plant	20	16	4
Blower Plant	18,5	6,5	6,7
Tailing Dam			
Mill Building	46,7	52,5	28
Plant Ablution	8,3	3,4	3,9
Re-agent Plant	13,8	5,8	6
Tertiary Crushing Plant	22,1	11.5	27
Sewer Treatment Plant	46,3	25,7	3,5
Water Treatment Plant	33,5	11,9	5

Depending on the final layout chosen, the proposed Doornhoek mining project may result in a direct impact to the aquatic resources present in this area should mitigation not take place to avoid this and minimise the impacts, with special mention of Layout Option 2, which is located within a drainage line associated with the upper reaches of the Klein Marico River.

These impacts are likely to, in turn, result in the loss of recharge to the downstream portions of the Klein Marico River and in turn to the Groot Marico River further along in the catchment. Assessments indicate that flow variability is a major ecological driver in the system and loss of recharge will have a significant effect on aquatic community ecological integrity. Smaller systems are often less robust and affected to a greater degree by flow variability, compared to larger, more resilient systems. As such the Klein Marico River and to an even greater extent the related tributaries may be greatly affected by changes in flow, as also reflected in the EIS assessments.

Careful management of edge effects as well as careful management of the dirty water seepage related to any proposed infrastructure is thus deemed essential to maintaining habitat integrity and water quality integrity of the aquatic resources in the vicinity of the study area.

Mitigation of seepage to the groundwater aquifers present is of specific concern as contamination of the groundwater resources is likely to affect habitat condition locally, as well as affect habitat and water quality integrity of the aquatic resources further downstream on a regional scale. In addition, the groundwater resources of these areas are valuable for water input to various aquifers and springs both locally and regionally.

Open cast mining activities are likely to result in an ever increasing cone of depression as a result of dewatering activities over the life of the proposed Doornhoek mining project, which is likely to negatively affect the groundwater resources present as well as affect surface water recharge. It is deemed essential that a clear understanding be obtained of the degree of loss of base flow that will occur as a result of the proposed mining activity and in turn how this will impact on the EWR of the Klein Marico River. Furthermore, decant of dirty water in the open cast pits will need to be carefully controlled and dirty water appropriately managed and treated in all phases of the proposed mining project.

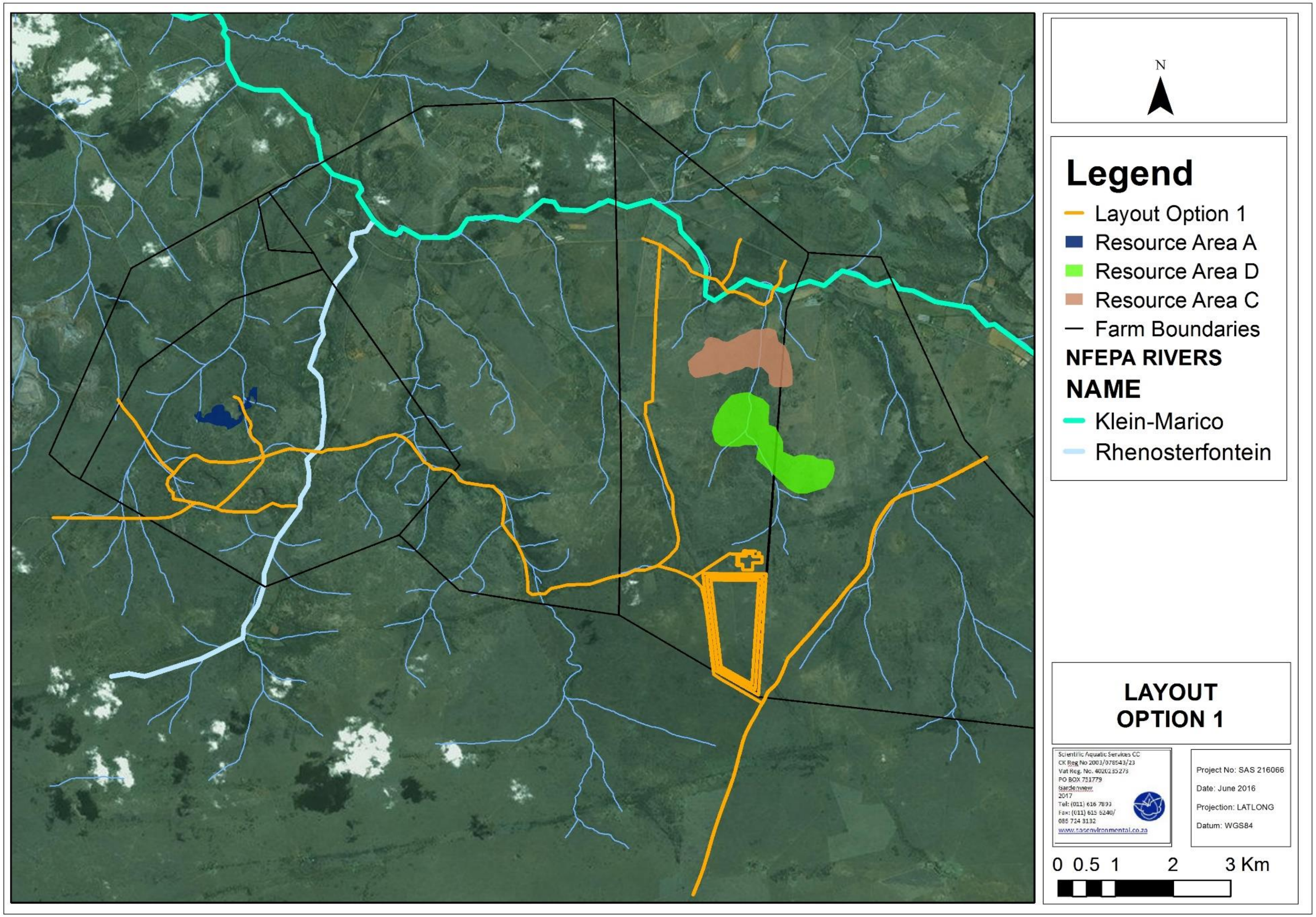


Figure 24: Footprint layout, Option 1.

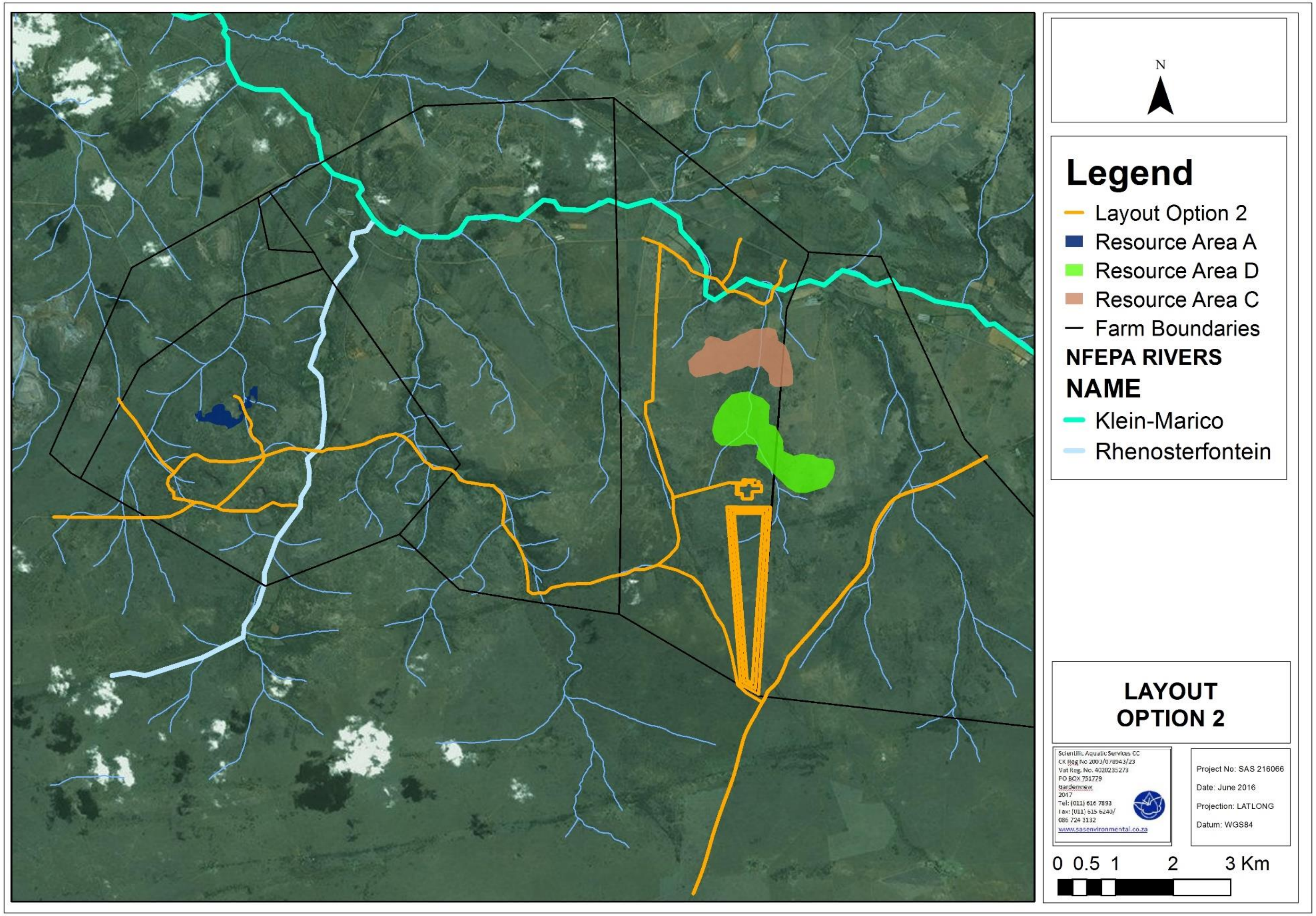


Figure 25: Footprint layout, Option 2.

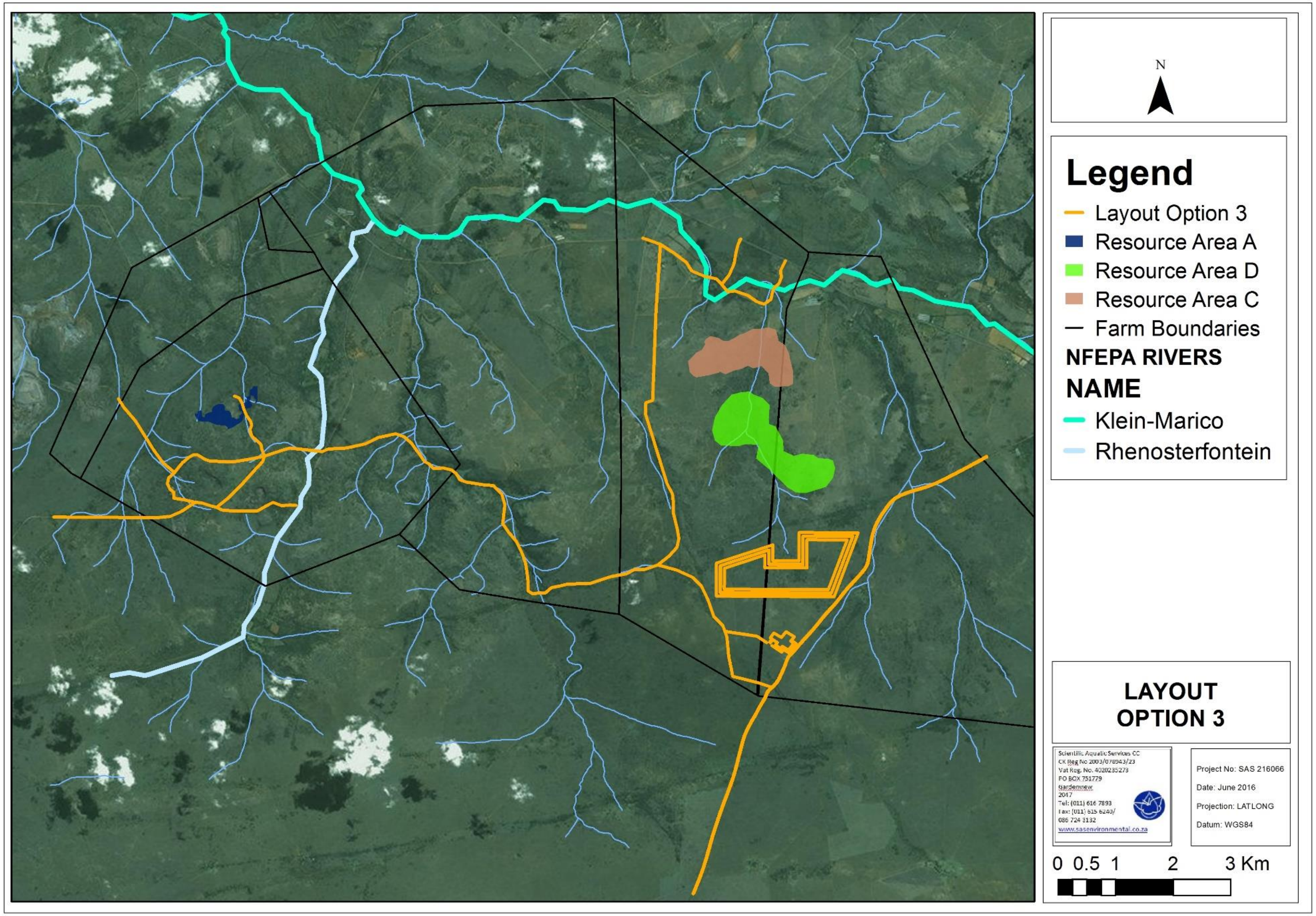


Figure 26: Footprint layout, Option 3.

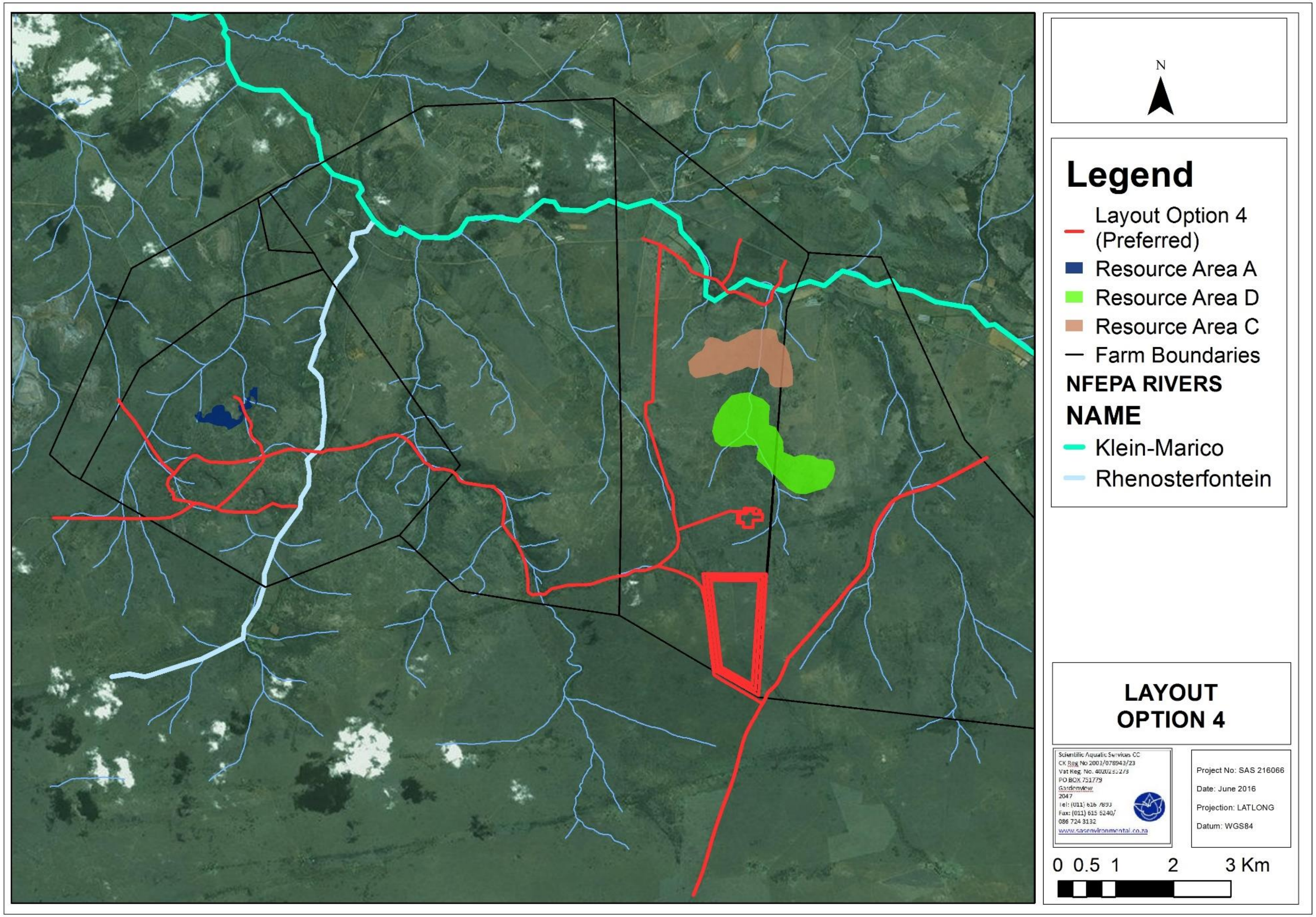


Figure 27: Footprint layout, Option 4.

5.1 Impact Analysis

Prior to any potential impacts from mining, the systems present are already under considerable threat from the following:

- Reduced in-stream flow, loss of base, stream connectivity and catchment yield which in turn will affect the EWR and the Ecostatus of the system;
- Impacts from cattle watering and agricultural return flows;
- Deteriorating water quality with specific reference to salinization and decreased oxygen levels resulting from the impacts mentioned above;
- Alien vegetation encroachment;
- Erosion; and
- Sedimentation.

It is deemed essential that all effort is made to ensure that impacts on the Klein Marico River and tributaries as a result of the proposed mining project are minimised. Specific mention is made of mining activities that will affect in-stream flow and stream connectivity, negative impacts on water quality, erosion and sedimentation. In addition, impacts from alien vegetation encroachment in the catchment may also occur.

The impact assessment was undertaken on all aspects of the aquatic ecology deemed likely to be affected by the proposed Doornhoek Mining Project. The sections below present the results of the findings per identified risk/ impact for the instream and riparian zones of the mining rights area.

Below potential impacts and recommendations for impact mitigation are discussed. Note that the estimation of the severity of impacts are included in Appendix 8.

IMPACT 1: LOSS OF INSTREAM FLOW

Impacts on reduced instream flow in terms of loss of instream surface and base flow will in turn affect aquatic refugia and loss of flow dependant taxa, along with a deterioration in water quality. These changes may mean that the Ecological reserve and the Environmental Water Requirements (EWR) for the Klein Marco River may not be achieved

Factors which may play a role include:

- Change in surface coverage. Development of the mining rights area will change the surface coverage in some areas from vegetated soil to buildings, hardened gravel roads, paved areas (parking) and compacted earth. Furthermore, the operational area of the mine will be defined as a “dirty water area” which will be separated from the clean water area. This dirty water area will then be lost to the environment reducing the catchment yield of the Klein Marico River.

- Inadequate separation and management of clean and dirty water may lead to unnatural instream flow changes, which may affect the flow characteristics and ultimately lead to loss of catchment yield;
- Capture of run-off and capture of rainfall (inundation) in the ‘dirty’/impacted areas would lower instream flow in the receiving environment;
- Closely related to inundation is the canalisation of run-off in other areas. Intercepting run-off around mining activities and infrastructure could reduce the amount of time that water would take to reach the Klein Marico River and its associated tributaries and may lead to “flash flood” events on varying scales. This is likely to occur due to:
  - the decreased friction on the water associated with concentrated flow in a concrete-lined canal, as opposed to sheet flow on hill slopes;
  - the consequently lower flow velocities;
- Disturbance of soils due to the construction, operational and decommissioning activities of the proposed Doornhoek mining project may result in erosion and sedimentation of the aquatic resources present, which in turn will result in a loss of instream flow.

The above factors are likely to lead to altered riverine recharge flood peaks and a general loss of runoff volumes successfully reaching the Klein Marico River system and its associated tributaries. This in turn may lead to the loss of aquatic biota such as fish and aquatic macro-invertebrates which rely on the presence of surface water. Loss of aquatic habitats and refugia for aquatic macro-invertebrates and fish, as well as increased moisture stress on riparian vegetation is considered possible as a result of the proposed mining project. Fish such as the Marico barb (*E. motebensis*), which are a red data species with a known distribution in the greater area may be negatively affected should adequate surface water recharge of these rivers be negatively affected as a result of the activities of the proposed Doornhoek mining project. The proposed activities may result in a loss of streamflow regulation and the proposed Doornhoek mining project may negatively affect existing flow rates and result in unnatural peak flows further downstream of the mining rights area.

Specific Mitigatory measures for loss of instream flow include the following:

- It is deemed important that a desktop reserve model be run on the Klein Marico river at a point a short distance downstream of the proposed mining operations in order to define the EWR. This will allow site specific instream flow and water quality requirements to be determined which in turn will allow for improved planning and decision making to ensure that reserve requirements on a local scale can be met.

- Ensure that as far as possible all infrastructures are placed outside of drainage and river areas. In particular, mention is made of the need to not encroach on the riparian systems near the Klein Marico River and its associated tributaries with a minimum buffer of 100m around all riparian systems maintained in line with the requirements of regulation GN704 of the National Water Act. Layout option 2 (Figure 25) is thus strongly discouraged from an aquatic health perspective;
- Ensure that sound environmental management is in place during the planning phase;
- Dirty water dams should be off stream and tributary structures and not within the natural drainage system of the area, thereby minimising impacts loss of instream flow and downstream recharge, as well as minimising impacts from inundation and siltation;
- Minimise loss of aquatic features where possible through planning and suitable layouts;
- Limit the footprint area of the construction activity to what is absolutely essential in order to minimise the loss of clean water runoff areas and the concomitant recharge of streams in the area;
- If it is absolutely unavoidable that either the Klein Marico River or its associated tributaries will be affected, disturbance must be minimised and suitably rehabilitated;
- Ensure that no incision and canalisation of the aquatic resources present takes place as a result of site clearing and construction or operational activities as well as decommissioning activities;
- All erosion noted within the study area should be remedied immediately and included as part of the ongoing rehabilitation plan;
- During the construction and operational phases of the proposed Doornhoek mining project, erosion berms should be installed on roadways to prevent gully formation and siltation of the aquatic resources. The following points should serve to guide the placement of erosion berms:
  - Where the track has slope of less than 2%, berms every 50m should be installed;
  - Where the track slopes between 2% and 10%, berms every 25m should be installed;
  - Where the track slopes between 10%-15%, berms every 20m should be installed;
  - Where the track has slope greater than 15%, berms every 10m should be installed.
- Ensure that all stockpiles are well managed and have measures such as berms and hessian sheets implemented to prevent erosion and sedimentation which may ultimately lead to transformation of aquatic habitat areas;

- All soils compacted as a result of construction activities falling outside of development footprint areas should be ripped and profiled;
- A suitable alien-vegetation control programme must be put in place so as to prevent further encroachment as a result of disturbance to the surrounding terrestrial zones;
- As much vegetation growth as possible should be promoted within the proposed development area during all phases in order to protect soils and vegetation clearance should be kept to a minimum as the biomass in the area is not very high and so therefore plants will not grow quickly;
- No use of clean surface water or any groundwater which potentially recharges the watercourses in the area should take place. In this regard specific mention is made of any water use which will affect the instream flow in the Klein Marico River and the associated tributaries;
- Very strict control of water consumption must take place and detailed monitoring must take place where all water usage must continuously be optimised;
- Upstream dewatering boreholes should be considered to minimise the creation of dirty water and this clean water should be used to recharge the natural systems downstream of the mining rights areas;
- Permit only essential construction personnel within 100m of all riparian systems;
- All areas of increased ecological sensitivity should be designated as No-Go areas and be off limits to all unauthorised vehicles and personnel during all phases of the proposed Doornhoek mining project;
- No crossing of the aquatic resources should take place and the substrate conditions of the aquatic resources and stream connectivity must be maintained;
- Restrict construction to the drier winter months to avoid sedimentation of the aquatic resources in the vicinity of the proposed Doornhoek mining project;
- No material may be dumped or stockpiled within any rivers, tributaries or drainage lines in the vicinity of the proposed Doornhoek mining project.

IMPACT 2: IMPACTS ON WATER QUALITY

If all constituents in the cumulative decant or seepage from the proposed Doornhoek mining project are within the applicable target water quality ranges (DWAF, 1996), then the activities will not contribute significantly to an unacceptable cumulative impact. Thus, a conservative approach is to be taken (the Precautionary Principle should be applied), in this case to account for possible discharge of pollutants by future activities in the river catchment as well as to ensure that as far as possible all possible seepage or risk of seepage is suitably mitigated and prevented as far as possible.

The Klein Marico River and its associated tributaries occur in a severely water stressed area and are fed largely through an extensive system of underground aquifers and springs, which as described in Section 3.1.2 for the Quaternary Catchment of concern (A31D), have been assigned a Water Resource Category: Good and a Class B PES category (DWA, 2012). It is thus considered critical that any activities which may result in any alterations to groundwater quality as well any surface water associated with surface water recharge of the Klein Marico River and its associated tributaries receive adequate attention when considering impacts on reduced water quality and the impact it may have on the aquatic community. Close monitoring of any spatial or temporal trends is advised.

Increased sediment load

Increased erosion of disturbed surfaces means that the run-off contains a higher silt or sediment load which may be discharged into the Klein Marico River and its associated tributaries and drainage lines. As a result of the current natural state of the mining rights area, the vegetation cover causes friction to rainfall run-off. This reduces flow velocities and consequently shear forces between the water and the ground surface, resulting in the ground surface remaining intact and not being eroded away. If for any reason the ground surface is disturbed and the flow velocities are increased, then there is potential for increased erosion to occur. Increased sediment load contains suspended solids. If there are too many suspended solids in the water this can negatively affect biological life.

The following activities are likely to cause an increase in movement of sediment loads, or directly increase erosion:

- Canalisation of run-off would potentially lead to the creation of super critical flows which would lead to erosion and incision of drainage lines affected. Furthermore, the mobilised sediment would lead to sedimentation in the receiving environment which in turn would affect habitat integrity and aquatic biota.
- Stripping (vegetation clearance) of mining areas prior to excavation of stockpile areas;
- Construction of hard-standing areas that increase run-off volumes, including roads, buildings and paved areas; and
- Construction activities that loosen the ground surface.

Impaired water quality due to pollutants, with special mention of Fluorides, discharged from processing plant and treated ore

Wastewater from the process may contain pollutants in excess of the target water quality ranges for the water uses of the receiving water body. Any spills/leakages of wastewater would thus impact negatively on the surface water quality. A further consideration is the run-off of pollutants from the process plant area following rainfall, due to the activities within that area.

Groundwater concentrations of Fluoride in the vicinity of the proposed Doornhoek Fluorspar mine are significantly elevated from those recorded in the surface water resources present, specifically the Groot Marico and the Klein Marico Rivers and their associated tributaries. The proposed mining activities have the potential to result in both increases or decreases in these concentrations as a result of changes to the water chemistry with specific mention of changes in pH, contact with air and contact with additional suspended solids and other exposed minerals. Should this water come into contact with the receiving surface water resources, a toxicological impact could be expressed on the aquatic life present if dissolved salt concentrations and concentrations of specific constituents differ significantly.

Impaired water quality due to pollutants in run-off from stockpiles

It is likely that run-off from the stockpiles will have a different chemical composition to natural run-off. In this event, it is best practice to keep ‘dirty’ water from stockpile run-off separate from ‘clean’ water from natural run-off.

Impaired water quality due to petrochemical spills

Fuel or oil spills from vehicles could contaminate surface water resources. Leakages, spills or run-off from vehicle wash bays, workshop facilities, fuel depots or storage facilities of potentially polluting substances could contaminate surface water resources.

Impaired water quality due to pollutants in water released from mining areas

Overflow of water (decant), whether surface or ground, from the mining areas could release pollutants to the surface water environment if geochemical testing indicates any water quality issue such as salinization, with special mention of increased concentrations of fluorides or fluorite salts reaching the surface water resources.

Seepage emanating from the ore stockpiles and the tailings dam facility:

Seepage of dirty water from the proposed tailings storage facility as well as seepage from the ore stockpiles and storage dumps are likely to contaminate the groundwater resources in the vicinity of the proposed Doornhoek mining project. The groundwater resources in this area are extensive and such an impact is thus likely to have severe impacts on the water quality both locally as well as on a regional scale.

Spills or leaks associated with faulty infrastructure:

Dirty water emanating from the proposed mining process is likely to reach the receiving environment as a result of surface water runoff or seepage to the groundwater resources as a result of spills or leaks associated with mining infrastructure. Potential inadequate management of dirty water is likely to have severe impacts on the water quality of the aquatic resources present, both locally as well as on a regional scale.

Decant associated with open cast pits:

Potential inadequate closure and rehabilitation leading to ongoing pollution from contaminating sources such as overburden dumps and latent dirty water areas may impact on water quality, with special mention of contaminated dirty water decant generated from in-filled opencast pits. Decant resulting from dirty water in the open cast pits will need to be carefully controlled and dirty water appropriately managed and treated in all phases of the proposed mining project.

The following aspects of instream water quality could be affected:

- Impacts on riparian vegetation structures due to impaired water quality;
- Build-up of contaminants in sediments leading to the creation of a sediment sink and chronic source of potential water contamination;
- Latent release of contaminants in sediments leading to the formation of an ongoing source of potential water contamination; and
- Impacts on groundwater quality, which could manifest in surface water sources.

Specific mitigations for impact to water quality include the following:

- Ensure that as far as possible all infrastructures are placed outside of drainage and river areas. In particular, mention is made of the need to not encroach on the aquatic resources in the vicinity of the Klein Marico River with a minimum buffer of 100m around all aquatic resources maintained in line with the requirements of regulation GN704 of the National Water Act;
- Permit only essential construction personnel within 100m of all riparian systems;
- Keep all demarcated sensitive zones outside of the construction area off limits during the construction phase of the development;
- Limit the footprint area of the construction activity to what is absolutely essential in order to minimise the loss of clean water runoff areas and the concomitant recharge of streams in the area;

- Design of infrastructure should be environmentally and structurally sound and all possible precautions taken to prevent spillage or seepage to the groundwater resources present;
- Any dirty water facilities should be lined with an HDPE liner or drainage barrier system (as required) to prevent seepage;
- Clear separation of clean and dirty water must take place and diversion of clean water around future operational areas (if applicable) must ensure minimisation of the loss of catchment yield;
- Clean and dirty water separation systems should be the first systems developed on site;
- Very clear and well managed clean and dirty water separation must take place in line with the requirements of regulation GN704 of the National Water Act;
- Prevent run-off from dirty water areas entering stream systems through ensuring clear separation of clean and dirty water areas;
- Dirty water dams must be adequately designed to contain a 1:50 24 hour storm water event;
- All dirty water facilities must be managed in such a way as to ensure that storage and surge capacity is available if a rainfall event occurs;
- It must be ensured that the design and construction of all infrastructure prevents failure;
- Infrastructure must be monitored for seepages and erosion;
- Dirty water dams should be off stream structures and not within the natural drainage system of the area, thereby minimising impacts to water quality and loss or transformation of aquatic habitat;
- Ensure that the mine process water system is managed in such a way as to prevent discharge to the receiving environment and to prevent discharge of dirty water;
- Dirty water must be recycled back into the mining system;
- Upstream dewatering boreholes should be considered to minimise the creation of dirty water and this clean water should be used to recharge the natural systems downstream of the mining rights areas;
- Ensure that all stockpiles are well managed and have measures such as berms and hessian sheets implemented to prevent erosion and sedimentation which may ultimately lead to impaired water quality and in turn, transformation of aquatic habitat areas;
- Implement measures to contain seepage as far as possible to prevent contamination of the groundwater regime. If necessary, treated ore stockpile areas should be lined with an HDPE liner or drainage barrier system (as required) to prevent seepage to the groundwater resources;

- All vehicles must be regularly inspected for leaks;
- Re-fuelling must take place on a sealed surface area to prevent ingress of hydrocarbons into topsoil;
- It must be ensured that all hazardous storage containers and storage areas comply with the relevant SABS standards to prevent leakage;
- All hazardous chemicals must be stored on specified surfaces;
- All spills should be immediately cleaned up and treated accordingly;
- Appropriate sanitary facilities must be provided for the duration of the construction activities and all waste must be removed to an appropriate waste facility;
- No dumping of waste should take place. If any spills occur, they should be immediately cleaned up;
- Monitor all systems for erosion and incision;
- Close monitoring of water quality (surface water, groundwater and process water) must take place. Monitoring of water quality should take place at a minimum frequency of once a month (when surface water is present) during which time major salts and basic metals, are monitored along with basic parameters such as pH, Total Suspended Solids (TSS) and Total Dissolved Solids (TDS), dissolved oxygen and Electrical Conductivity (EC). Specific mention is made of the need to monitor concentrations of fluoride in the groundwater resources;
- Should fluoride concentrations reach an undesirable level, suitable mitigation measures should be implemented such as flocculation/precipitation with calcite (crushed limestone);
- Precipitate should be prevented from reaching the aquatic resources through a suitable filtration, or another appropriate removal process so as to prevent sedimentation of the surface water resources present as well as alterations to water clarity and water chemistry;
- Ongoing aquatic ecological monitoring must take place on a bi-annual basis by an SA RHP Accredited assessor in order to identify any emerging issues in the receiving environment;
- A baseline toxicological assessment of the groundwater and surface water resources should take place before commencing with the proposed Doornhoek mining project. Toxicity testing of the proposed Doornhoek mining project's process water facilities, the groundwater and surface water resources present should take place quarterly and concurrently with the biomonitoring program in order to monitor the toxicological risk of the process water system to the receiving environment and in particular the groundwater resources. These ongoing toxicological tests should be compared to

baseline data to monitor and manage any emerging impacts over time. Tests should include the following test organisms as a minimum:

- *Vibrio fischeri;*
- *Daphnia pulex; and*
- Algal Growth Potential;

➢ The groundwater pollution plume should be modeled and appropriately monitored. Any impacts to the groundwater resources in the vicinity of the proposed Doornhoek mining project will need to be suitably and timeously mitigated to prevent impacts further downstream and potentially on a regional scale;

➢ The proposed Doornhoek mining project must be managed as a zero discharge facility, however definitive toxicological testing according to the Direct Estimation of Ecological Effect Potential (DEEEP) protocol should take place should it become evident that process water discharge or decant of groundwater will occur in order to define safe discharge volumes and ensure sufficient dilution.

IMPACT 3: LOSS OF AQUATIC HABITAT

Habitat transformation and destruction is the alteration of a natural habitat to the point that it is rendered unfit to support species dependent upon it as their home territory. Loss or transformation of habitat may cause a reduction of biodiversity, due to organisms previously using the area being displaced or destroyed. Riverine systems and particularly temporary riverine systems or river systems that have very low flows as part of their annual hydrological cycles are particularly susceptible to changes in habitat condition. The proposed mining activity of the proposed Doornhoek mining project has the potential to lead to habitat loss and/or alteration of the aquatic and riparian resources on the mining rights area.

Factors which could potentially lead to an impact include:

➢ Potentially poor planning leading to the placement of infrastructure within non-perennial drainage lines, with special mention of the overburden stockpile areas as well as roads, road crossings and bridges all may alter the aquatic habitat;

➢ Potentially inadequate design of infrastructure leading to changes to instream habitat and changes to system hydrology, which may alter the aquatic habitat;

➢ Potentially inadequate separation of clean and dirty water areas and the prevention of the release of sediment rich water may alter the aquatic habitat within the receiving environment;

- Site clearing and the removal of vegetation, as well as road construction and the disturbance of soils, may lead to increased runoff and erosion, which may alter the aquatic habitat;
- Earthworks in the vicinity of drainage systems leading to increased runoff and erosion and altered runoff patterns may alter the aquatic habitat;
- Open cast mining activities may lead to a cone of depression as a result of dewatering activities, which may result in a lowering of the groundwater table and a loss of surface water recharge to the surface water systems present;
- Construction of bridge crossings altering streamflow patterns and water velocities may alter the aquatic habitat;
- Alien vegetation encroachment will impact on and alter the aquatic habitat;
- Inadequate separation of clean and dirty water areas may alter the aquatic habitat;
- Mining related activities leading to increased disturbance of soils and drainage lines, which may alter the aquatic habitat;
- Any activities which lead to the reduction of flow in the systems and the use of surface and groundwater sources for production water may alter the aquatic habitat; and
- Ongoing pollution from inappropriately decommissioned structures may result in alterations to the aquatic habitat.

Aspects of instream habitat that is likely to be affected include the following:

- Erosion and incision of the riparian zone;
- Altered wetting patterns leading to impacts on riparian zone continuity;
- Loss of low flow refugia;
- Altered substrate conditions from sandy conditions to more muddy conditions;
- Altered depth and flow regimes in the major drainage systems; and
- Alien vegetation proliferation.

Specific mitigation measures for impacts to aquatic habitat include the following:

- Ensure that as far as possible all infrastructures are placed outside of drainage and river areas. In particular, mention is made of the need to not encroach on the riparian systems near the Klein Marico River and its associated tributaries with a minimum buffer of 100m around all aquatic resources maintained in line with the requirements of regulation GN704 of the National Water Act;
- Permit only essential construction personnel within 100m of all riparian systems;
- Keep all demarcated sensitive zones outside of the construction area off limits during the construction phase of the development;

- Implement alien vegetation control program within the riparian zones with special mention of water loving tree species such as *Populus x canescens* and invasive species such as *Arundo donax* and *Typha capensis*;
- Ensure that all stockpiles are well managed and have measures such as berms and hessian sheets implemented to prevent erosion and sedimentation which may ultimately lead to transformation of aquatic habitat areas;
- Dirty water dams should be off stream structures and not within the natural drainage system of the area, thereby minimising impacts loss or transformation of aquatic habitat;
- Dirty water dams should be off stream structures and not within the natural drainage system of the area, thereby minimising impacts from inundation and siltation;
- Limit the footprint area of the construction activity to what is absolutely essential in order to avoid disturbance of soils leading to runoff, erosion and sedimentation and loss of instream flow and stream recharge;
- Monitor all systems for erosion and incision;
- Monitor all affected riparian systems for moisture stress;
- An extensive monitoring programme will need to be implemented to track the cone of depression on an ongoing basis for the life of the mine and suitable mitigation measures will be required to protect surface water recharge in the vicinity of the proposed mining project;
- An extensive monitoring programme will need to be implemented to tract the cone of depression on an ongoing basis for the life of the mine and suitable mitigation measures will be required to protect surface water recharge in the vicinity of the proposed development. Monitor all potentially affected riparian zones for changes in riparian vegetation structure;
- Ongoing aquatic ecological monitoring must take place on a bi-annual basis by an SA RHP Accredited assessor;
- Ongoing aquatic biomonitoring should take place in order to identify any emerging issues in the receiving environment for the life of the proposed mining project.

IMPACT 4: LOSS OF AQUATIC BIODIVERSITY AND SENSITIVE TAXA

The planned mining activities of the proposed Doornhoek mining project have the potential to lead to a loss of aquatic biodiversity as impacts on instream flow, water quality and habitat will all affect species diversity and especially more sensitive taxa and species of conservation concern.

Loss or a decrease of aquatic biodiversity and sensitive taxa is largely driven by impacts stressed by instream flow, altered water quality and habitat loss. The aquatic ecosystems in the region of the subject property provide suitable habitat for rare and endangered species conservation and hence have a high significance with reference to sensitive taxa, most notably the red data Marico barbs (*E. motebensis*). Habitat degradation from impacts such as water extraction, flow modification/river regulation and sedimentation are considered serious threats to the aquatic resources present. Given the largely natural to moderately modified state (according to the PES, EIS and groundwater categorizations in the March 2012 DWA report, number RDM/WMA 1,3/00/CON/CLA/0112A, as well as field verifications) of the aquatic resources within the larger area surrounding the proposed Doornhoek mining project, the aquatic ecosystems are considered to be sensitive. Any mining activities, if not adequately mitigated, are expected to have a detrimental impact on aquatic ecosystems function, including fish communities, in the subject property. Mining in the direct vicinity of any aquatic ecosystems is thus discouraged and very well contemplated, executed and managed clean and dirty water separation systems will be required. In addition, due to the extensive groundwater systems and springs feeding many of the surface water systems present, very strict measures and management will need to be put in place so as to prevent any seepage to and contamination thereof.

The monitoring of aquatic communities such as macro-invertebrates and fish within aquatic systems vary over season and other factors such as weather play a vital role when field studies are conducted. It is thus crucial to implement a regular monitoring strategy which will increase the data set and understanding of the aquatic community within the surrounding aquatic systems linked in the vicinity of the proposed mining area. It is recommended that a biannual high flow (Summer) and low flow (Winter) biomonitoring strategy be implemented as part of the ongoing monitoring program with an initial quarterly assessment prior to major construction in the area. Regular monitoring of the groundwater resources is deemed critical so as to promote early identification and mitigation of any arising issues and impacts.

The following activities are deemed likely to impact the aquatic biodiversity and sensitivity of the receiving environment:

- Potentially poor planning leading to the placement of infrastructure within non-perennial drainage lines with special mention of the overburden stockpile areas, road crossings and bridges may lead to a loss in aquatic biodiversity;
- Potentially inadequate design of infrastructure leading to changes to instream habitat and to system hydrology, which may lead to a loss in aquatic biodiversity;

- Potentially inadequate design of infrastructure leading to contamination of water and sediments in the streams, which may lead to a loss in aquatic biodiversity;
- Site clearing, the removal of vegetation and road construction may lead to a loss in aquatic biodiversity;
- Earthworks and other mining construction activities in the vicinity of riparian areas may lead to a loss in aquatic biodiversity;
- Construction of bridge crossings altering streamflow patterns and water velocities may lead to a loss in aquatic biodiversity;
- Inadequate separation of clean and dirty water areas may lead to a loss in aquatic biodiversity;
- Ongoing disturbance of soils with general operational activities may lead to a loss in aquatic biodiversity;
- Inadequate separation of clean and dirty water areas may lead to a loss in aquatic biodiversity;
- Loss of instream flow due to abstraction for water for production may lead to a loss in aquatic biodiversity;
- Seepage from the ore stockpiles, the stockpile silos and the proposed tailings storage facility may lead to a loss in aquatic biodiversity;
- Potential discharge from the mine process water system with special mention of Return Water Dams and any Dirty Water Dams may lead to a loss in aquatic biodiversity;
- Sewage discharge from mine offices and camps may lead to a loss in aquatic biodiversity;
- Disturbance of soils as part of demolition activities may lead to a loss in aquatic biodiversity;
- Inadequate closure leading to post closure impacts on water quality may lead to a loss in aquatic biodiversity; and
- Ongoing erosion of disturbed areas that have not been adequately rehabilitated may lead to a loss in aquatic biodiversity.

Aspects of aquatic biodiversity likely to be affected include the following:

- Sedimentation and loss of natural substrates;
- Altered stream channel forms;
- Increased turbidity of water;
- Loss of refugia;
- Deterioration in water quality;
- Loss of flow sensitive macro-invertebrates and fish;
- Loss of water-sensitive macro-invertebrates and fish;

- Loss of riparian vegetation species; and
- Eutrophication of the aquatic ecosystems.

Specific mitigation measures for impacts to aquatic habitat include the following:

- Ensure that as far as possible all infrastructures are placed outside of drainage and river areas. In particular mention is made of the need to not encroach on the riparian systems near the Klein Marico River and its associated drainage lines with a minimum buffer of 100m around all riparian systems maintained in line with the requirements of regulation GN704 of the National Water Act;
- No use of clean surface water or any groundwater which potentially recharges the watercourses in the area should take place. In this regard specific mention is made of any water use which will affect the instream flow in the Klein Marico River and the associated tributaries and in turn affect more sensitive taxa which require faster flowing habitat;
- Dirty water dams should be off stream and tributary structures and not within the natural drainage system of the area, thereby minimising impacts from loss of instream flow and downstream recharge;
- Permit only essential construction personnel within 100m of all riparian systems;
- Keep all demarcated sensitive zones outside of the construction area off limits during the construction and operational phase of the development;
- Implement an ongoing alien vegetation control program for the life of the proposed mining project including both the pre-construction and closure phases of the project;
- Very clear and well managed clean and dirty water separation must take place in line with the requirements of regulation GN704 of the National Water Act;
- Dirty water dams must be adequately designed to contain a 1:50 24 hour storm water event;
- All dirty water facilities must be managed in such a way as to ensure that storage and surge capacity is available if a rainfall event occurs;
- Limit the footprint area of the construction activity to what is absolutely essential in order to minimise the loss of clean water runoff areas and the concomitant recharge of streams in the area and the disturbance of soils leading to runoff, erosion and sedimentation;
- Ensure that all spills are immediately cleaned up;
- All hazardous chemicals must be stored on specified surfaces;
- Ensure that all stockpiles are well managed and have measures such as berms and hessian sheets implemented to prevent erosion and sedimentation which may ultimately lead to transformation of aquatic habitat areas;

- Dirty water dams should be off stream structures and not within the natural drainage system of the area, thereby minimising impacts loss or transformation of aquatic habitat;
- Keep all demarcated sensitive zones outside of the construction area off limits during the construction phase of the development as well as during the operational phase of the mine;
- Dirty water dams should be off stream structures and not within the natural drainage system of the area, thereby minimising impacts from inundation and siltation;
- Any areas where active erosion is observed must be rehabilitated and berms utilised to slow movement of water;
- Prevent run-off from dirty water areas entering stream systems through ensuring clear separation of clean and dirty water areas;
- Ensure that the mine process water system is managed in such a way as to prevent discharge to the receiving environment and to prevent discharge of dirty water;
- Implement measures to contain seepage as far as possible to prevent contamination of the groundwater regime;
- Monitor all systems for erosion and incision;
- Activities of the proposed Doornhoek mining project are likely to result in a cone of depression affecting the groundwater aquifers present, with specific mention of a general lowering of the water table in the vicinity of the proposed activities, as well as a loss in water pressure;
- Very strict control of water consumption must take place and detailed monitoring must take place and where all water usage must continuously be optimised;
- Upstream dewatering boreholes should be considered to minimise the creation of dirty water and this clean water should be used to recharge the natural systems downstream of the mining rights areas, so as to aid in the prevention of the contamination of the groundwater resources without compromising on surface water recharge further downstream;
- Monitor all affected riparian systems for moisture stress;
- Monitor all potentially affected riparian zones for changes in riparian vegetation structure;
- Ongoing aquatic ecological monitoring must take place on a bi-annual basis by an SA RHP Accredited assessor in order to identify any emerging issues in the receiving environment;
- Monitor all dirty water facilities using toxicological screening methods and implement the calculation of discharge dilution factors by means of the Direct Estimation of

Ecological Effect Potential (DEEEP) protocol should any discharges to the receiving environment become necessary;
- Toxicological monitoring of the receiving and process water systems on a quarterly basis.

5.1.1 Probable latent impacts

Even with extensive mitigation, latent impacts on the receiving aquatic environment are deemed possible. The following points highlight the key latent impacts that have been identified:

- Reduced availability of refugia for aquatic and wetland biota;
- Altered riparian and wetland vegetation structures;
- Ongoing salinisation of the water courses in the area;
- Impacts on dissolved oxygen concentration and saturation;
- Loss of aquatic taxa intolerant to poor quality water;
- Sedimentation of the systems may occur long after mining has ceased;
- Eroded and incised streams are unlikely to be rehabilitated;
- Silted up refuge pools are unlikely to be naturally rehabilitated and are unlikely to be rehabilitated by the mine;
- Loss of some flow dependent species is likely;
- Loss of some species less tolerant of water quality changes is likely;
- Loss of some low flow refugia is possible.

5.1.2 Positive offsets

- The aquatic resources in the vicinity of the proposed project are currently impacted significantly by alien and invasive vegetation encroachment, with special mention of water loving shrubs, trees (Acacia mearnsii) and reeds, which serve to reduce surface water recharge and instream flow;
- The implementation of an ongoing, correctly implemented, alien vegetation removal programme for the life of the mine and into the closure and post-closure phases is likely to have a significant positive effect on surface water recharge to the surrounding systems and further on to the aquatic resources further downstream in the catchment;
- Restoration of stream flow and connectivity in these systems may have positive benefits to the aquatic communities likely to occur at these points, with special mention of species reliant on migration routes along the systems.

5.2 Impact assessment conclusion

This report, after consideration and description of the aquatic ecological integrity of the resources in and in the vicinity of the mining rights area and mining footprint area, must guide the Environmental Assessment Practitioner (EAP), authorities and mining company, by means of presentation and discussion of the gathered data, as well as presentation of recommendations, as to the viability of the proposed mining development from an aquatic ecological point of view. In terms of the findings of the aquatic study, should the proposed Doornhoek mining project proceed, the preferred surface infrastructure, Layout Option 4, is recommended in terms of preservation of the aquatic integrity of the surface water resources present, however, Layout Options 1 and 3 may also be considered. Layout Option 2 is regarded as the least suitable option since it affects the upper reaches of the drainage lines associated with the Klein Marico River and its associated tributaries and may result in direct impacts to the aquatic resources further downstream.

The Doornhoek mining project is located within an area of increased ecological importance and sensitivity in terms of the groundwater resources present (DWA, 2012). The groundwater resources in this area play a significant role in the recharge of aquifers and of the surface water resources in the vicinity of the proposed project. Therefore, on this basis, should the project proceed it is considered likely that the project will have an ecological impact of the groundwater resources present, both within and potentially beyond the boundaries of the project. The potential for post-closure impacts on both water quality as well as water quantity, with special mention of the groundwater resources present, are of concern. Therefore, unless it is considered economically feasible to treat and/or contain all potential sources of contaminated water which may affect the receiving environment post-closure indefinitely to pre-mining water quality standards in such a way as to support the post closure land use and land capability, which supports the adjacent land uses, and to ensure rehabilitation back to natural or largely natural land capability, the project is regarded as posing a high long term impact on the regions' underground water resources in terms of fluoride contamination. In addition, should fluorides result in any precipitate, forming fluorite salts, these salts have the potential to significantly affect the surface water resources present in the form of impacts to water clarity and sedimentation. It is highly recommended that should it nonetheless be deemed appropriate to mine the resource from a cumulative sustainable development point of view, as much infrastructure as possible be moved to the areas where historical disturbance as a result of anthropogenic activity has occurred. In addition, the infrastructure required to access the resource must be kept to the absolute minimum. Furthermore, extensive mitigation must be applied during the construction and operational phases of the project to ensure that no unacceptable impact takes place beyond the surface infrastructure footprint. In this regard particular mention is made of the management of the groundwater, surface water and the dirty water area of the mine footprint and the impact of mining related activities on the aquatic resources both in and further downstream of the mining rights area. Strict monitoring throughout the life of the mine and post-closure is required in order to ensure the health and functioning of the aquatic ecosystems is retained. The water resources will need to be rehabilitated in such a way as to support the larger drainage systems at the same level as those evident in the pre-mining condition and with particular mention of ensuring that no significant impact takes place on the groundwater, surface water and downstream river systems. It is deemed important that a desktop reserve model be run on the Klein Marico river at a point a short distance downstream of the proposed mining operations in order to determine the EWR. This will allow site specific instream flow and water quality requirements to be determined which in turn will allow for improved planning and decision making to ensure that reserve requirements on a local scale can be met. In order to meet this objective, rehabilitation will need to be well planned and a suitably qualified ecologist must form part of the management team through the entire life cycle of the project and to guide the rehabilitation (including concurrent rehabilitation) and closure objectives of the mine.

From the results of the assessment it is evident that prior to mitigation, all impacts on the ecology of the Klein Marico River and its associated tributaries are either high or medium-high, with special mention of impacts to groundwater quality and the likelihood that the proposed activities will result in a cone of depression that unless adequately managed, may result in loss of surface water recharge, loss of groundwater pressure as well as moisture stress for wetland and riparian vegetation. In addition, impacts to surface water clarity and sedimentation of the surface water resources are considered possible. However, with mitigation, most impacts may be reduced to low or negligible impacts (See Appendix 8).

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APPENDIX 1: Project Key Staff

Stephen van Staden
SACNASP REG.NO: **400134/05**

Stephen van Staden completed an undergraduate degree in Zoology, Geography and Environmental Management at RAU. On completion of this degree, he undertook an honours course in Aquatic health through the Zoology department at RAU. In 2002 he began a Masters degree in environmental management, where he did his mini dissertation in the field of aquatic resource management, also undertaken at RAU. At the same time, Stephen began building a career by first working at an environmental consultancy specialising in town planning developments, after which he moved to a larger firm in late 2002. From 2002 to the end of 2003, he managed the monitoring division and acted as a specialist consultant on water resource management issues and other environmental processes and applications. In late 2003, Stephen started consulting as an independent environmental scientist, specialising in water resource management under the banner of Scientific Aquatic Services. In addition to aquatic ecological assessments, clients started enquiring about terrestrial ecological assessments and biodiversity assessments. Stephen, in conjunction with other qualified ecologists, began facilitating these studies as well as highly specialised studies on specific endangered species, including grass owls, arachnids, invertebrates and various vegetation species. Scientific Aquatic Services soon became recognised as a company capable of producing high quality terrestrial ecological assessments. Stephen soon began diversifying into other fields, including the development of EIA process, EMPR activities and mine closure studies.

Stephen has experience on well over 1000 environmental assessment projects with specific mention of aquatic and wetland ecological studies, as well as terrestrial ecological assessments and project management of environmental studies. Stephen has a professional career spanning more than 10 years, of which almost the entire period has been as the owner and Managing member of Scientific Aquatic Services and the project manager on most projects undertaken by the company. Stephen has also obtained extensive experience in wetland and aquatic assessments in the Limpopo Plains aquatic ecoregion.

Stephen is registered by the SA RHP as an accredited aquatic biomonitoring specialist and is also registered as a Professional Natural Scientist with the South African Council for Natural Scientific Professions (SACNASP) in the field of ecology. Stephen is also a member of the Gauteng Wetland Forum and South African Soil Surveyors Association (SASSO).

Kieren Jayne Bremner

Kieren Jayne Bremner completed an undergraduate degree in Zoology and Biochemistry at the Rand Afrikaans University. On completion of this degree, she undertook an honours course in Natural Sciences focussing on Aquatic health through the Zoology department at the University of Johannesburg. She began a Masters degree in Aquatic Health and Environmental Management and in 2007 she began building a career by first working at an engineering firm (TWP Consultants) in the Environmental Management department as a Junior Environmental Scientist, where she was exposed to various sectors of the Environmental Management field such as water use licensing, BAs, EIAs and public participation. During this time she was given the opportunity to initiate and manage various aquatic biomonitoring programmes within the mining and energy production sectors within South Africa. In 2009, Kieren moved to Scientific Aquatic Services, where she began working as an Aquatic Ecologist and Junior Wetland Ecologist. She gained invaluable and extensive experience in the biomonitoring and water monitoring field in rivers and wetlands throughout South Africa. In 2014, having left SAS, Kieren began working at the Sustainable Seas Trust, in the Eastern Cape, where she assisted in fund-raising for the implementation of “Hope Spots” for 6 areas along the South African coastline as well as contributed towards the Education and Awareness Campaign for conservation of our South African Coastline. Kieren also joined Estuary Care in Kenton-on-Sea, Eastern Cape, where she was responsible for monitoring the water quality of the Bushmans and Kariega Estuaries and reporting of spatial and temporal trends. In 2015, Kieren returned to SAS. Kieren is registered by the SA RHP as an accredited biomonitoring specialist.

APPENDIX 2: Indemnity and Terms of Use of this Report

The findings, results, observations, conclusions and recommendations presented 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.

SAS cc 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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APPENDIX 3: Legislative Requirements

Minerals and petroleum Resource Development Act (MPRDA) (Act 28 of 2002);

The obtaining of a New Order Mining Right (NOMR) is governed by the MPRDA. The MPRDA requires the applicant to apply to the DMR for a NOMR which triggers a process of compliance with the various applicable sections of the MPRDA. The NOMR process requires environmental authorisation in terms of the MPRDA Regulations and specifically requires the preparation of a Scoping Report, an Environmental Impact Assessment (EIA) and Environmental Management Programme (EMP), and a Public Participation Process. In order to inform the development of an EIA and EMP, specialist baseline studies are required in order to define the sensitivities and risks associated with the project area and within the sphere of influence of the project.

National Environmental Management Act (Act 107 of 1998)

- The National Environmental Management Act (Act 107 of 1998) and the associated Regulations (Listing No R. 544, No R. 545 and R. 546) as amended in June 2010, 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 process or the Environmental Impact Assessment (EIA) process depending on the nature of the activity and scale of the impact.

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 Affairs (DWA).
- Any area within a wetland or riparian zone is therefore excluded from development unless authorisation is obtained from DWA in terms of Section 21 of the NWA.

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 NWA, 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 proposed 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 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.

APPENDIX 4: Method of Assessment

Literature Review

Water resources are generally classified according to the degree of modification or level of impairment. The classes used by the South African River Health Program (RHP) will be used as the basis of classification of the systems in the study area.

The **Department of Water and Sanitation (DWS) Resource Quality Services (RQS) PES/EIS database** was utilised to obtain additional 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, EWR sites and Hydro WMS sites.

Information for sub-quaternary catchment reach (SQR) A31D-01019 (Klein Marico River) is applicable. Key information on background conditions within the study area, as contained in this database and pertaining to the Present Ecological State (PES), ecological importance and ecological sensitivity for the Klein Marico River, is reported on.

In addition, two other reports on the Crocodile (West) Marico WMA were consulted, namely **State-of-Rivers-Report Number 9 (River Health Programme 2005)** as well as **Ecological Water Requirements Report number RDM/WMA 1,3/00/CON/CLA/0312 (Department of Water Affairs 2011)**.

Aquatic Ecological Assessment sites and site selection

As part of the feasibility study 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 proposed mining activities planned at this stage;
- Site location in relation to the existing infrastructure and activities in the area;
- 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.

Visual Assessment of Aquatic Assessment Points

Each site was selected in order to identify current conditions, with specific reference to impacts from surrounding activities where applicable. Both natural constraints placed on ecosystem structure and function, as well as anthropogenic alterations to the systems identified, was identified by observing conditions and relating them to professional experience. Photographs of each site were taken to provide visual records of the conditions at the time of assessment. Factors which were noted in the site-specific visual assessments included the following:

- Upstream and downstream significance of each point, where applicable;
- Significance of the point in relation to the study area;
- stream morphology;
- instream and riparian habitat diversity;
- stream continuity;
- erosion potential;
- depth flow and substrate characteristics;
- signs of physical disturbance of the area; and
- other life forms reliant on aquatic ecosystems.

Physico-chemical Water Quality Data

On site testing of biota specific water quality variables took place on all sites where surface water was present. 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).

Intermediate Habitat Integrity Assessment (IHIA)

It is important to assess the habitat of riverine systems 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 sites was assessed 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), was used using the site specific application protocols. 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 was 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 were analysed separately, and the final assessment was then made separately for each, in accordance with Kemper' (1999) approach to Habitat Integrity Assessment. Data for the riparian zone is, 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 was 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 sites. The method classifies Habitat Integrity into one of six classes, ranging from unmodified/natural (Class A), to critically modified (Class F).

Invertebrate Habitat Suitability (Invertebrate Habitat Assessment: IHAS)

The Invertebrate Habitat Assessment System (IHAS) was applied to sites DHK BP1, DHK BP2, DHK BP3, DHK BP4 and DHK BP5 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%: habitat diversity and structure is inadequate for supporting a diverse aquatic macro-invertebrate community.
- 65%-75%: habitat diversity and structure is adequate for supporting a diverse aquatic macro-invertebrate community.
- >75%: habitat diversity and structure is highly suited for supporting a diverse aquatic macro-invertebrate community.

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.

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[2]. Results are defensible because their generation can be traced through an outlined process. The latter pertains to a suite of rules that convert assessor estimates into ratings and converts multiple ratings into an Ecological Category.

Table 4a: 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
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

Aquatic Macro-Invertebrates: South African Scoring System (SASS5)

Aquatic macro-invertebrate communities of the accessible sites (DHK B1, DHK B2, DHK B3, DHK B4, DHK B5 and DHKK 4) 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 South African Scoring System (SASS5) protocol as defined by Dickens & Graham (2001). All work was undertaken by an accredited South African Scoring System, version 5 (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

[2] Kleynhans et al, 2007

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.

The perceived reference state for the local streams was determined with consideration of the ecoregion conditions as well as site-specific conditions encountered during the assessments. Based on lack of flow in the systems the reference scores were defined as a SASS5 score of 150 and an Average Score Per Taxon (ASPT) of 5.9. Interpretation of the results in relation to the reference scores was made according to the classification of SASS5 scores presented in the SASS5 methodology published by Dickens and Graham (2001) as well as according to Dallas (2007).

Table 4b: Definition of Present State Classes in terms of SASS and ASPT scores as presented in Dickens and Graham (2001)

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

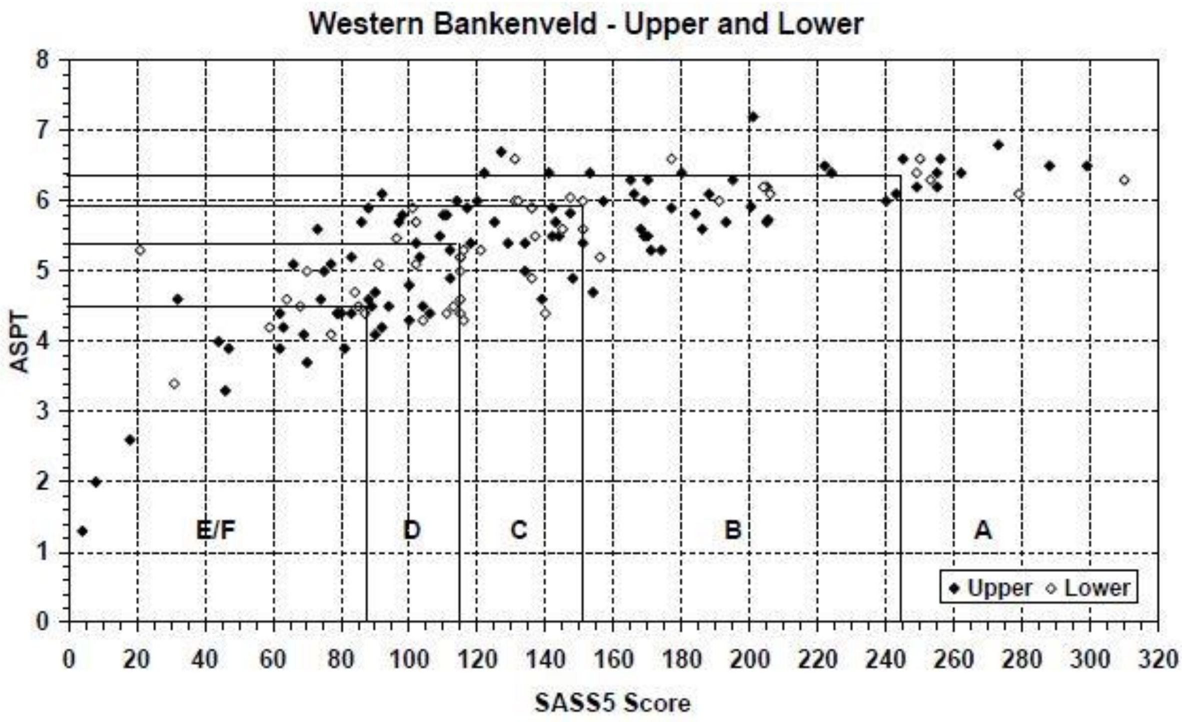

Figure 4a: SASS5 Classification using biological bands calculated from percentiles for the Western Bankenveld ecoregion, Dallas, 2007

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 Ecostatus Category (EC) 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 two respective systems assessed, namely the unnamed tributary of the Klein Marico River (DHK B1 and DHK B2) as well as the Klein Marico River (DHK B3, DHK B4 and DHK B5), following methodology described by Thirion (2007).

Aquatic macro-invertebrates expected at each point were derived both from the Department of Water and Sanitation (DWS) Resource Quality Services (RQS) PES/EIS database and supplemented with taxa actually collected at the five sites assessed.

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 habitat cover rating (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 sites was graphically expressed as habitat cover ratings (HCR) for different flow-depth classes as a stacked bar chart.

Fish biota: Fish Response Assessment Index (FRAI)

The FRAI (Kleynhans 2007) 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). Fish species expected to occur in the system are summarised in the table on the next page.

Table 4c: Intolerance ratings as well as FROC (Kleynhans et al., 2007) scores for naturally occurring fish species expected to occur in the Klein Marico River and surrounding area. Footnotes indicate sources used to compile the list. Where FROC scores were not available, a score of "1" was allocated.

SPECIES NAME	COMMON NAME	INTOLE-RANCE RATING [1]	FROC score	COMMENTS
Amphilius uranoscopus [3]	*Stargazer (mountain catfish)*	4.8	3	Okovango and Zambezi systems, east coast rivers south to Mkuze in northern Kwa-Zulu Natal
Barbus anoplus [4]	Chubbyhead Barb	2.6	1	Widely distributed from Highveld, Limpopo to upland KwaZulu-Natal, Transkei and the Orange Basin including the Karoo.
Enteromius bifrenatus [4]	Hyphen barb	2.8	1	Widespread in the northern parts of southern Africa, including the Limpopo River systems
Enteromius motebensis [3] (Red Data List species)	Marico barb	3.1	3	The headwater tributaries of the Marico, Crocodile and Steelpoort branches of the Limpopo River System.
Enteromius paludinosis [3,5]	Straightfin barb	1.8	3	Widespread
Enteromius trimaculatus [2]	Threespot barb	2.2	3	Common in many river systems of southern Africa
Enteromius unitaeniatus [2]	Longbeard barb	1.7	3	Widely distributed in southern Africa
Cyprinus carpio [4]	Carp	1.4	1	Widespread throughout southern Africa.
Labeo cylindricus [4]	Redeye labeo	3.1	1	Widespread East-African rivers down to Phongolo system in KwaZulu-Natal
Oreochromis mossambicus [2]	Mozambique tilapia	1.3	3	East coastal rivers from the Lower Zambezi River south to the Bushman's system, Eastern Cape.
Pseudocrenilabrus philander [2,5]	Southern mouthbrooder	1.3	3	From the Orange and southern KwaZulu-Natal northwards throughout the region. Extends to southern Congo tributaries and Lake Malawi.
Tilapia sparrmanii[2]	Banded Tilapia	1.3	3	Extensively translocated south of the Orange in the Cape.

1 Intolerance ratings: Tolerant: 1-2; Moderately tolerant :> 2-3; Moderately Intolerant: >3-4; Intolerant: >4

2 Listed in Kleynhans *et al.* (2007) for Crocodile (W) Marico quaternary catchment **A31D** with FROC scores also provided by Kleynhans *et al.* (2007);

3 Listed in Kleynhans *et al.* (2007) for Crocodile (W) Marico quaternary catchment **A31A** with FROC scores also provided by Kleynhans *et al.* (2007);

4 Based on distribution maps in Skelton (2001), these species may also potentially occur in this area. Frequency of occurrence (FROC) score not listed for these species for this system in Kleynhans *et al.* (2007). For the purposes of this a FROC score of "1" was allocated;

5 Department of Water and Sanitation (DWS) Resource Quality Services (RQS) PES/EIS database lists these species for the Groot Marico River. The same species composition is expected in the Klein Marico River;

Aquatic EIS assessment

The EIS method considers a number of biotic and habitat determinants surmised to indicate either importance or sensitivity. The determinants are rated according to a four-point scale (Table 4d). The median of the resultant score is calculated to derive the EIS category.

Table 4d: Ecological importance and sensitivity categories (DWAF, 1999)

EISC	General Description	Range of median
Very high	Quaternaries/delineations that are considered to be unique on a national and international level based on unique biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) are usually very sensitive to flow modifications and have no or only a small capacity for use.	>3-4
High	Quaternaries/delineations that are considered to be unique on a national scale based on their biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) may be sensitive to flow modifications but in some cases may have substantial capacity for use.	>2-≤3
Moderate	Quaternaries/delineations that are considered to be unique on a provincial or local scale due to biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) are not usually very sensitive to flow modifications and often have substantial capacity for use.	>1-≤2
Low/ marginal	Quaternaries/delineations that is not unique on any scale. These rivers (in terms of biota and habitat) are generally not very sensitive to flow modifications and usually have substantial capacity for use.	≤1

ECOLOGICAL IMPACT ASSESSMENT METHODOLOGY

In order for the EAP to allow for sufficient consideration of all environmental impacts, impacts were assessed using a common, defensible method of assessing significance that will enable comparisons to be made between risks/impacts and will enable authorities, stakeholders and the client to understand the process and rationale upon which risks/impacts have been assessed. The method to be used for assessing risks/impacts is outlined in the sections below.

The first stage of risk/impact assessment is the identification of environmental activities, aspects and impacts. This is supported by the identification of receptors and resources, which allows for an understanding of the impact pathway and an assessment of the sensitivity to change. The definitions used in the impact assessment are presented below.

- An **activity** is a distinct process or task undertaken by an organisation for which a responsibility can be assigned. Activities also include facilities or infrastructure that are possessed by an organisation.

- An **environmental aspect** is an 'element of an organizations activities, products and services which can interact with the environment'[3]. The interaction of an aspect with the environment may result in an impact.
- **Environmental risks/impacts** are the consequences of these aspects on environmental resources or receptors of particular value or sensitivity, for example, disturbance due to noise and health effects due to poorer air quality. In the case where the impact is on human health or well-being, this should be stated. Similarly, where the receptor is not anthropogenic, then it should, where possible, be stipulated what the receptor is.
- **Receptors** can comprise, but are not limited to, people or human-made systems, such as local residents, communities and social infrastructure, as well as components of the biophysical environment such as wetlands, flora and riverine systems.
- **Resources** include components of the biophysical environment.
- **Frequency of activity** refers to how often the proposed activity will take place.
- **Frequency of impact** refers to the frequency with which a stressor (aspect) will impact on the receptor.
- **Severity** refers to the degree of change to the receptor status in terms of the reversibility of the impact; sensitivity of receptor to stressor; duration of impact (increasing or decreasing with time); controversy potential and precedent setting; threat to environmental and health standards.
- **Spatial extent** refers to the geographical scale of the impact.
- **Duration** refers to the length of time over which the stressor will cause a change in the resource or receptor.

The significance of the impact is then assessed by rating each variable numerically according to the defined criteria. Refer to the table below. The purpose of the rating is to develop a clear understanding of influences and processes associated with each impact. The severity, spatial scope and duration of the impact together comprise the consequence of the impact and when summed can obtain a maximum value of 15. The frequency of the activity and the frequency of the impact together comprise the likelihood of the impact occurring and can obtain a maximum value of 10. The values for likelihood and consequence of the impact are then read off a significance-rating matrix and are used to determine whether mitigation is necessary[4].

[3] The definition has been aligned with that used in the ISO 14001 Standard.

[4] Some risks/impacts that have low significance will however still require mitigation

The assessment of significance is undertaken twice. Initial, significance is based on only natural and existing mitigation measures (including built-in engineering designs). The subsequent assessment takes into account the recommended management measures required to mitigate the impacts. Measures such as demolishing infrastructure, and reinstatement and rehabilitation of land, are considered post-mitigation.

The model outcome of the impacts was then assessed in terms of impact certainty and consideration of available information. The Precautionary Principle is applied in line with South Africa's National Environmental Management Act (No. 108 of 1997) in instances of uncertainty or lack of information, by increasing assigned ratings or adjusting final model outcomes. In certain instances, where a variable or outcome requires rational adjustment due to model limitations, the model outcomes have been adjusted.

Table 4e: Criteria for assessing significance of impacts

LIKELIHOOD AND CONSEQUENCE DESCRIPTORS

Aspect	Description	Weight
Probability	Improbable	1
	Probable	2
	Highly Probable	4
	Definite	5
Duration	Short term	1
	Medium term	3
	Long term	4
	Permanent	5
Scale	Local	1
	Site	2
	Regional	3
Magnitude	Low	2
	Medium	6
	High	8
Significance		
	Negligible	</=20
	Low	</=40
	Moderate	</=60
	High	>60

The following points were considered when undertaking the assessment:

- Risks and impacts were analysed in the context of the *project's area of influence* encompassing:
    - Primary project site and related facilities that the client and its contractors develops or controls;

- Areas potentially impacted by cumulative impacts for further planned development of the project, any existing project or condition and other project-related developments; and
- Areas potentially affected by impacts from unplanned but predictable developments caused by the project that may occur later or at a different location.

➢ Risks/Impacts were assessed for all stages of the project cycle including:
- Pre-Construction;
- Construction;
- Operation; and
- Decommissioning and Closure; and
- Post-Closure.

Mitigation measure development

The following points present the key concepts considered in the development of mitigation measures for the proposed development.

➢ *Mitigation* and *performance improvement measures* and actions that address the risks and impacts[5] 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*.

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

APPENDIX 5: IHIA

Klein Marico River

Instream Zone Habitat Integrity

Reach	ASSESSMENT DATE	Water abstraction	Flow modification	Bed modification	Channel modification	Water quality	Inundation	Exotic macrophytes	Exotic fauna	Solid waste disposal	Total Score (%)	Classification
	Weights	14	13	13	13	14	10	9	8	6		
DHK B3	October 2014	0	4	6	4	4	0	0	6	2	88.1	B (Largely natural)
	May 2016	0	16	8	4	2	6	0	0	2	65.7	C (Moderately modified)
DHK B4	October 2014	2	4	6	2	8	0	0	4	2	86.4	B (Largely natural)
	May 2016	0	16	14	2	2	4	0	0	6	70.9	C (Moderately modified)
DHK B5	October 2014	4	4	6	2	12	0	0	4	2	78.4	C (Moderately modified)
DHKK 4	May 2016	0	2	2	0	2	0	0	0	0	96.8	A (Natural)

None *Small* *Moderate* *Large* *Serious* *Critical*

Riparian Zone Habitat Integrity

Reach	ASSESSMENT DATE	Vegetation removal	Alien encroachment	Bank erosion	Water abstraction	Flow modification	Channel modification	Water quality	Inundation	Total Score (%)	Classification
	Weights	13	12	14	12	13	11	12	13		
DHK B3	October 2014	11	7	4	0	0	0	0	0	85.2	B (Largely natural)
	May 2016	11	7	4	0	2	2	0	0	81.7	B (Largely natural)
DHK B4	October 2014	7	6	1	1	0	0	8	0	88.8	B (Largely natural)
	May 2016	7	6	14	0	4	0	0	0	82.8	B (Largely natural)
DHK B5	October 2014	7	4	1	3	0	0	12	0	69.9	C (Moderately modified)
DHKK 4	May 2016	0	0	2	0	2	2	0	0	96.9	A (Natural)

None *Small* *Moderate* *Large* *Serious* *Critical*

REACH	ASSESSMENT DATE	INSTREAM HABITAT	RIPARIAN ZONE	IHI SCORE	CLASS
DHK B3	October 2014	88.1	85.2	86.6	B (Largely natural)
	May 2016	65.7	81.7	73.7	C (Moderately modified)
DHK B4	October 2014	86.4	88.8	87.6	B (Largely natural)
	May 2016	70.9	82.8	76.8	C (Moderately modified)
DHK B5	October 2014	78.4	69.9	74.1	C (Moderately modified)
DHKK 4	May 2016	96.8	96.9	96.9	A (Natural)

Unnamed tributary of the Klein Marico River

Instream Zone Habitat Integrity

Reach	ASSESSMENT DATE	Water abstraction	Flow modification	Bed modification	Channel modification	Water quality	Inundation	Exotic macrophytes	Exotic fauna	Solid waste disposal	Total Score (%)	Classification
	Weights	14	13	13	13	14	10	9	8	6		
DHK B1	October 2014	21	21	9	16	0	7	0	0	2	25.5	E (Extensive loss)
	May 2016	21	21	9	16	0	7	0	0	2	25.5	E (Extensive loss)
DHK B2	October 2014	19	8	6	7	4	0	0	6	4	59.9	C (Moderately modified)
	May 2016	19	12	16	7	4	8	0	6	4	40.9	D (Largely modified)

None *Small* *Moderate* *Large* *Serious* *Critical*

Riparian Zone Habitat Integrity

Reach	ASSESSMENT DATE	Vegetation removal	Alien encroachment	Bank erosion	Water abstraction	Flow modification	Channel modification	Water quality	Inundation	Total Score (%)	Classification
	Weights	13	12	14	12	13	11	12	13		
DHK B1	October 2014	11	7	0	9	9	9	0	4	71.6	C (Moderately modified)
	May 2016	11	7	0	9	9	9	0	4	71.6	C (Moderately modified)
DHK B2	October 2014	13	16	9	6	6	6	0	0	55.4	D (Largely modified)
	May 2016	13	16	9	6	16	6	0	0	45.9	D (Largely modified)

None *Small* *Moderate* *Large* *Serious* *Critical*

REACH	ASSESSMENT DATE	INSTREAM HABITAT	RIPARIAN ZONE	IHI SCORE	CLASS
DHK B1	October 2014	25.5	71.6	48.5	D (Largely modified)
	May 2016	25.5	71.6	48.5	D (Largely modified)
DHK B2	October 2014	59.9	55.4	57.7	D (Largely modified)
	May 2016	40.9	45.9	43.4	D (Largely modified)

APPENDIX 6: IHAS Score sheets

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)						
River Name: UNNAMED TRIB						
Site Name: DHK B1	**Date**: 24/09/2014					
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):				8	
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):				12	
	HABITAT TOTAL (MAX 55):				20	
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				32	
	TOTAL IHAS SCORE (%):				52	

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)

River Name: UNNAMED TRIB
Site Name: DHK B2
Date: 24/09/2014

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):			13		
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):				0	
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):				27	
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					32
	TOTAL IHAS SCORE (%):				59	

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)						
River Name: KLEIN MARICO						
Site Name: DHK B3	**Date**: 24/09/2014					
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):			11		
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):				13	
	HABITAT TOTAL (MAX 55):				35	
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					30
	TOTAL IHAS SCORE (%):				65	

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)						
River Name: KLEIN MARICO						
Site Name: DHK B4	**Date**: 24/09/2014					
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):			13		
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):				5	
	HABITAT TOTAL (MAX 55):				28	
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 (%):				57	

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)						
River Name: KLEIN MARICO						
Site Name: DHK B5	**Date**: 24/09/2014					
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):				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: 'corr' = correct time)		under		corr		over
(** NOTE: you must still fill in the SIC section)						
	Other Habitat Score (max 20):				10	
	HABITAT TOTAL (MAX 55):				20	
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					34
	TOTAL IHAS SCORE (%):				54	

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)						
River Name:						
Site Name: DHK B1	**Date**: 27/05/2016					
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):			8		
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):				13	
	HABITAT TOTAL (MAX 55):				30	
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				42	
	TOTAL IHAS SCORE (%):				72	

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)

River Name:
Site Name: DHK B2
Date: 26/05/2016

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):				7	
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):				11	
	HABITAT TOTAL (MAX 55):				18	

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				28	
	TOTAL IHAS SCORE (%):				46	

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)

River Name:
Site Name: DHK B3
Date: 26/05/2016

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):				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):				9	
	HABITAT TOTAL (MAX 55):				22	
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					33
	TOTAL IHAS SCORE (%):				55	

River Name:						
Site Name: DHK B4	**Date**: 26/05/2016					
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):				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):				11	
	HABITAT TOTAL (MAX 55):				20	
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				24	
	TOTAL IHAS SCORE (%):				44	

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)

River Name:
Site Name: DHKK4 **Date**: 26/05/2016

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):				8	
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):				15	
	HABITAT TOTAL (MAX 55):				23	
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 45):				37	
	TOTAL IHAS SCORE (%):				60	

APPENDIX 7: SASS5 Score sheets

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET																		
DATE: 24/09/2014	**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: DHK B1	**ANNELIDA:**						Gerridae*	5		A	A	A	Ceratopogonidae	5				
RIVER: UNNAMED TRIB	Oligochaeta	1					Hydrometridae*	6					Chironomidae	2		A	A	A
SITE DESCRIPTION: SPRING SOURCE	Leeches	3					Naucoridae*	7					Culicidae*	1				
WEATHER CONDITION: WARM DRY	**CRUSTACEA:**						Nepidae*	3					Dixidae*	10				
TEMP: 21.7 °C	Amphipoda	13					Notonectidae*	3		A	A	B	Empididae	6				
Ph: 7.53	Potamonautidae*	3					Pleidae*	4					Ephydridae	3				
DO: 7.45 mg/l	Atyidae	8		B	A	B	Veliidae/M..veliidae*	5		A		A	Muscidae	1				
Cond: 453 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		1		1	Hydropsychidae 1sp	4					Ancylidae	6				
M VEG OOC: 2 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				
MUD: 2	Ephemeridae	15					Polycentropodidae	12					Physidae*	3				
HAND PICKING/VISUAL OBS:	Heptageniidae	13					Psychomyiidae/Xiphocen.	8					Planorbidae*	3				
FLOW: LOW	Leptophlebiidae	9					**CASED CADDIS:**						Thiaridae*	3				
TURBIDITY: LOW	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	27	23	32
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6					**NO OF TAXA:**		0	6	5	7
	Chlorocyphidae	10					Petrothrincidae SWC	11					**ASPT:**		0	4.5	5	4.6
	Chlorolestidae	8					Pisuliidae	10					**IHAS**:		52%			
	Coenagrionidae	4					Sericostomatidae SWC	13					**OTHER BIOTA**:					
	Lestidae	8					**COLEOPTERA:**											
SIGNS OF POLLUTION:	Platycnemidae	10					Dytiscidae*	5					**COMMENTS**:					
	Protoneuridae	8					Elmidae/Dryopidae*	8					* = airbreathers					
	Zygoptera juvs.	6					Gyrinidae*	5			1	1	SWC = South Western Cape					
	Aeshnidae	8					Halipidae*	5					T = Tropical					
	Corduliidae	8					Helodidae	12					ST = Sub-tropical					
OTHER OBSERVATIONS:	Gomphidae	6					Hydraenidae*	8					S = Stone & rock					
	Libellulidae	4					Hydrophilidae*	5					VG = all vegetation					
	LEPIDOPTERA:						Limnichidae	10					GSM = gravel, sand & mud					
	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: 24/09/2014	**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: DHK B2	**ANNELIDA:**						Gerridae*	5					Ceratopogonidae	5				
RIVER: UNNAMED TRIB	Oligochaeta	1					Hydrometridae*	6					Chironomidae	2				
SITE DESCRIPTION: D/S NEAR CONT	Leeches	3					Naucoridae*	7					Culicidae*	1			**1**	**1**
WEATHER CONDITION: WARM/DRY	**CRUSTACEA:**						Nepidae*	3					Dixidae*	10				
TEMP: 17.5 °C	Amphipoda	13					Notonectidae*	3					Empididae	6				
Ph: 7.92	Potamonautidae*	3	**1**			**1**	Pleidae*	4					Ephydridae	3				
DO: 8.29 mg/l	Atyidae	8	**A**			**A**	Veliidae/M..veliidae*	5	**A**			**A**	Muscidae	1				
Cond: 515 mS/m	Palaemonidae	10					**MEGALOPTERA:**						Psychodidae	1				
BIOTOPES SAMPLED:	**HYDRACARINA**	8					Cordalidae	8					Simuliidae	5	**A**		**A**	**B**
SIC: 3 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	**A**		**A**	**B**	Hydropsychidae >2 sp	12					Hydrobiidae*	3				
SAND:	Caenidae	6					Philopotamidae	10	**A**			**A**	Lymnaeidae*	3				
MUD: 2	Ephemeridae	15					Polycentropodidae	12					Physidae*	3				
HAND PICKING/VISUAL OBS: YES	Heptageniidae	13					Psychomyiidae/Xiphocen.	8					Planorbidae*	3				
FLOW: LOW	Leptophlebiidae	9					**CASED CADDIS:**						Thiaridae*	3				
TURBIDITY: LOW	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:**		48	0	30	61
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6					**NO OF TAXA:**		7	0	4	9
	Chlorocyphidae	10					Petrothrincidae SWC	11					**ASPT:**		7	0.0	8	6.8
	Chlorolestidae	8					Pisuliidae	10					**IHAS**:		59%			
	Coenagrionidae	4					Sericostomatidae SWC	13					**OTHER BIOTA**:					
	Lestidae	8					**COLEOPTERA:**											
SIGNS OF POLLUTION:	Platycnemidae	10					Dytiscidae*	5					**COMMENTS**:					
	Protoneuridae	8					Elmidae/Dryopidae*	8					* = airbreathers					
	Zygoptera juvs.	6					Gyrinidae*	5	**A**			**A**	SWC = South Western Cape					
	Aeshnidae	8					Halipidae*	5					T = Tropical					
	Corduliidae	8					Helodidae	12					ST = Sub-tropical					
OTHER OBSERVATIONS:	Gomphidae	6					Hydraenidae*	8					S = Stone & rock					
	Libellulidae	4					Hydrophilidae*	5					VG = all vegetation					
	LEPIDOPTERA:						Limnichidae	10					GSM = gravel, sand & mud					
	Pyralidae	12			**1**	**1**	Psephenidae	10					1=1, A=2-10, B=10-100, C=100-1000, D=>1000					

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET

DATE: 24/09/2014	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: DHK B3	**ANNELIDA:**						Gerridae*	5					Ceratopogonidae	5				
RIVER: KLEIN MARICO	Oligochaeta	1	1		1	A	Hydrometridae*	6					Chironomidae	2	A	1	A	B
SITE DESCRIPTION: U/S PROP MINE	Leeches	3					Naucoridae*	7					Culicidae*	1			A	A
WEATHER CONDITION: WARM / DRY	**CRUSTACEA:**						Nepidae*	3					Dixidae*	10				
TEMP: 19.4 °C	Amphipoda	13					Notonectidae*	3		C	B	B	Empididae	6				
Ph: 6.96	Potamonautidae*	3					Pleidae*	4					Ephydridae	3				
DO: 6.23 mg/l	Atyidae	8	A	C	A	C	Veliidae/M..veliidae*	5					Muscidae	1				
Cond: 453 mS/m	Palaemonidae	10					**MEGALOPTERA:**						Psychodidae	1				
BIOTOPES SAMPLED:	**HYDRACARINA**	8					Cordalidae	8					Simuliidae	5	A	A		B
SIC: 2 TIME: minutes	**PLECOPTERA:**						Sialidae	6					Syrphidae*	1				
SOOC:	Notonemouridae	14					**TRICHOPTERA**						Tabanidae	5				
BEDROCK:	Perlidae	12					Dipseudopsidae	10					Tipulidae	5				
AQUATIC VEG: 5 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: 3	Baetidae >2 sp	12	B	C		C	Hydropsychidae >2 sp	12					Hydrobiidae*	3				
SAND: 2	Caenidae	6	A			A	Philopotamidae	10					Lymnaeidae*	3				
MUD: 2	Ephemeridae	15					Polycentropodidae	12					Physidae*	3				
HAND PICKING/VISUAL OBS: YES	Heptageniidae	13					Psychomyiidae/Xiphocen.	8					Planorbidae*	3				
FLOW: LOW	Leptophlebiidae	9	1			1	**CASED CADDIS:**						Thiaridae*	3				
TURBIDITY: LOW	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:**		52	49	20	70
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6					**NO OF TAXA:**		9	9	6	14
	Chlorocyphidae	10					Petrothrincidae SWC	11					**ASPT:**		6	5.4	3	5.0
	Chlorolestidae	8					Pisuliidae	10					**IHAS**:	65%				
	Coenagrionidae	4	A			A	Sericostomatidae SWC	13					**OTHER BIOTA**:					
	Lestidae	8					**COLEOPTERA:**						B.ANO? / P.PHI					
SIGNS OF POLLUTION:	Platycnemidae	10					Dytiscidae*	5		A		A	**COMMENTS**:					
	Protoneuridae	8					Elmidae/Dryopidae*	8					* = airbreathers					
	Zygoptera juvs.	6					Gyrinidae*	5	A	A	A	B	SWC = South Western Cape					
	Aeshnidae	8					Halipidae*	5					T = Tropical					
	Corduliidae	8					Helodidae	12					ST = Sub-tropical					
OTHER OBSERVATIONS:	Gomphidae	6					Hydraenidae*	8					S = Stone & rock					
	Libellulidae	4		1		1	Hydrophilidae*	5		B		B	VG = all vegetation					
	LEPIDOPTERA:						Limnichidae	10					GSM = gravel, sand & mud					
	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: 24/09/2014	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: DHK B4	**ANNELIDA:**						Gerridae*	5		A		A	Ceratopogonidae	5				
RIVER: KLEIN MARICO	Oligochaeta	1					Hydrometridae*	6					Chironomidae	2	1			1
SITE DESCRIPTION: MID POINT	Leeches	3					Naucoridae*	7					Culicidae*	1				
WEATHER CONDITION: WARM / CLEAR	**CRUSTACEA:**						Nepidae*	3					Dixidae*	10				
TEMP: 18.5 °C	Amphipoda	13					Notonectidae*	3		B		B	Empididae	6				
Ph: 7.82	Potamonautidae*	3					Pleidae*	4					Ephydridae	3				
DO: 6.86 mg/l	Atyidae	8	A	B		B	Veliidae/M..veliidae*	5					Muscidae	1				
Cond: 379 mS/m	Palaemonidae	10					**MEGALOPTERA:**						Psychodidae	1				
BIOTOPES SAMPLED:	**HYDRACARINA**	8					Cordalidae	8					Simuliidae	5	B			B
SIC: 2 TIME: minutes	**PLECOPTERA:**						Sialidae	6					Syrphidae*	1				
SOOC: 1	Notonemouridae	14					**TRICHOPTERA**						Tabanidae	5				
BEDROCK:	Perlidae	12					Dipseudopsidae	10					Tipulidae	5				
AQUATIC VEG: DOM SP:	**EPHEMEROPTERA**						Ecnomidae	8					**GASTROPODA**					
M VEG IC: 1 DOM SP:	Baetidae 1sp	4					Hydropsychidae 1sp	4					Ancylidae	6				
M VEG OOC: 2 DOM SP:	Baetidae 2 sp	6					Hydropsychidae 2 sp	6					Bulininae*	3				
GRAVEL:	Baetidae >2 sp	12	A	B		B	Hydropsychidae >2 sp	12					Hydrobiidae*	3				
SAND:	Caenidae	6	A			A	Philopotamidae	10					Lymnaeidae*	3				
MUD:	Ephemeridae	15					Polycentropodidae	12					Physidae*	3	1			1
HAND PICKING/VISUAL OBS: YES	Heptageniidae	13					Psychomyiidae/Xiphocen.	8					Planorbidae*	3				
FLOW: LOW	Leptophlebiidae	9					**CASED CADDIS:**						Thiaridae*	3				
TURBIDITY: LOW	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:**		51	41	5	67
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6					**NO OF TAXA:**		9	6	1	12
	Chlorocyphidae	10					Petrothrincidae SWC	11					**ASPT:**		6	6.8	5	5.6
	Chlorolestidae	8					Pisuliidae	10					**IHAS**:		57%			
	Coenagrionidae	4					Sericostomatidae SWC	13					**OTHER BIOTA**:					
	Lestidae	8					**COLEOPTERA:**						XENOPOS / DAPHNIA					
SIGNS OF POLLUTION:	Platycnemidae	10					Dytiscidae*	5	A	A		B	**COMMENTS**:					
	Protoneuridae	8					Elmidae/Dryopidae*	8					* = airbreathers					
	Zygoptera juvs.	6					Gyrinidae*	5	A			A	SWC = South Western Cape					
	Aeshnidae	8		1		1	Halipidae*	5					T = Tropical					
	Corduliidae	8					Helodidae	12					ST = Sub-tropical					
OTHER OBSERVATIONS:	Gomphidae	6					Hydraenidae*	8					S = Stone & rock					
	Libellulidae	4					Hydrophilidae*	5	1		A	A	VG = all vegetation					
	LEPIDOPTERA:						Limnichidae	10					GSM = gravel, sand & mud					
	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: 29/09/2014	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		A		A	Blepharoceridae	15				
SITE CODE: DHK B5	**ANNELIDA:**						Gerridae*	5		A		A	Ceratopogonidae	5		1		1
RIVER: KLEIN MARICO	Oligochaeta	1					Hydrometridae*	6					Chironomidae	2			A	A
SITE DESCRIPTION: D/S ALL PROP MINE	Leeches	3					Naucoridae*	7					Culicidae*	1		1		
WEATHER CONDITION:	**CRUSTACEA:**						Nepidae*	3					Dixidae*	10				
TEMP: 17.4 °C	Amphipoda	13					Notonectidae*	3		1		1	Empididae	6				
Ph: 7.59	Potamonautidae*	3		1		1	Pleidae*	4					Ephydridae	3				
DO: 7.39 mg/l	Atyidae	8					Veliidae/M..veliidae*	5		A		A	Muscidae	1				
Cond: 526 mS/m	Palaemonidae	10					**MEGALOPTERA:**						Psychodidae	1				
BIOTOPES SAMPLED:	**HYDRACARINA**	8					Cordalidae	8					Simuliidae	5			C	C
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: 4	Baetidae >2 sp	12		B	A	B	Hydropsychidae >2 sp	12					Hydrobiidae*	3				
SAND:	Caenidae	6			A	A	Philopotamidae	10					Lymnaeidae*	3				
MUD:	Ephemeridae	15					Polycentropodidae	12					Physidae*	3				
HAND PICKING/VISUAL OBS: YES	Heptageniidae	13					Psychomyiidae/Xiphocen.	8					Planorbidae*	3				
FLOW: LOW	Leptophlebiidae	9					**CASED CADDIS:**						Thiaridae*	3				
TURBIDITY: LOW	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	63	30	70
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6					**NO OF TAXA:**		0	13	5	14
	Chlorocyphidae	10					Petrothrincidae SWC	11					**ASPT:**		0	4.8	6	5.0
	Chlorolestidae	8					Pisuliidae	10					**IHAS**:	54%				
	Coenagrionidae	4		A		A	Sericostomatidae SWC	13					**OTHER BIOTA**:					
	Lestidae	8		1		1	**COLEOPTERA:**											
SIGNS OF POLLUTION:	Platycnemidae	10					Dytiscidae*	5		A			**COMMENTS**:					
	Protoneuridae	8					Elmidae/Dryopidae*	8					* = airbreathers					
	Zygoptera juvs.	6					Gyrinidae*	5		A	1	A	SWC = South Western Cape					
	Aeshnidae	8					Halipidae*	5					T = Tropical					
	Corduliidae	8					Helodidae	12					ST = Sub-tropical					
OTHER OBSERVATIONS:	Gomphidae	6					Hydraenidae*	8					S = Stone & rock					
	Libellulidae	4		1		1	Hydrophilidae*	5					VG = all vegetation					
	LEPIDOPTERA:						Limnichidae	10					GSM = gravel, sand & mud					
	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: 27/05/2016	**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			•	**1**	Blepharoceridae	15				
SITE CODE: DHK B1	**ANNELIDA:**						Gerridae*	5		**B**		**B**	Ceratopogonidae	5			**A**	**A**
RIVER:	Oligochaeta	1			•	**1**	Hydrometridae*	6					Chironomidae	2		**A**	**A**	**B**
SITE DESCRIPTION: REP.	Leeches	3					Naucoridae*	7					Culicidae*	1				
WEATHER CONDITION: COOL AND CLEAR	**CRUSTACEA:**						Nepidae*	3					Dixidae*	10				
TEMP: 19.5 °C	Amphipoda	13					Notonectidae*	3		**A**	**A**	**B**	Empididae	6				
Ph: 7.98	Potamonautidae*	3		•			Pleidae*	4					Ephydridae	3				
DO: mg/l	Atyidae	8		**A**	**A**	**B**	Veliidae/M..veliidae*	5	**A**	**B**		**B**	Muscidae	1				
Cond: 53.0 mS/m	Palaemonidae	10					**MEGALOPTERA:**						Psychodidae	1				
BIOTOPES SAMPLED:	**HYDRACARINA**	8	•	•		**A**	Cordalidae	8					Simuliidae	5	**A**		**A**	**B**
SIC: TIME: minutes	**PLECOPTERA:**						Sialidae	6					Syrphidae*	1				
SOOC:	Notonemouridae	14					**TRICHOPTERA**						Tabanidae	5				
BEDROCK:	Perlidae	12					Dipseudopsidae	10					Tipulidae	5			•	**1**
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	**A**			**B**	Hydropsychidae >2 sp	12					Hydrobiidae*	3				
SAND:	Caenidae	6		**A**		**A**	Philopotamidae	10					Lymnaeidae*	3				
MUD:	Ephemeridae	15					Polycentropodidae	12					Physidae*	3				
HAND PICKING/VISUAL OBS:	Heptageniidae	13					Psychomyiidae/Xiphocen.	8					Planorbidae*	3		•		**1**
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:**		36	61	38	91
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6					**NO OF TAXA:**		5	13	9	18
	Chlorocyphidae	10					Petrothrincidae SWC	11					**ASPT:**		7	4.7	4	5.1
	Chlorolestidae	8					Pisuliidae	10					**IHAS**:		72%			
	Coenagrionidae	4		**A**		**A**	Sericostomatidae SWC	13					**OTHER BIOTA**:					
	Lestidae	8					**COLEOPTERA:**											
SIGNS OF POLLUTION:	Platycnemidae	10					Dytiscidae*	5		**A**		**A**	**COMMENTS**:					
	Protoneuridae	8					Elmidae/Dryopidae*	8					HOT SPRING					
	Zygoptera juvs.	6					Gyrinidae*	5		**A**		**A**						
	Aeshnidae	8					Halipidae*	5										
	Corduliidae	8					Helodidae	12					* = airbreathers					
OTHER OBSERVATIONS:	Gomphidae	6	**A**		**A**	**B**	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: 26/05/2016	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		A	A	B	Blepharoceridae	15				
SITE CODE: DHK B2	**ANNELIDA:**						Gerridae*	5					Ceratopogonidae	5		•		1
RIVER:	Oligochaeta	1		•		1	Hydrometridae*	6					Chironomidae	2		A	A	B
SITE DESCRIPTION:	Leeches	3					Naucoridae*	7					Culicidae*	1			•	1
WEATHER CONDITION: COOL AND CLEAR	**CRUSTACEA:**						Nepidae*	3					Dixidae*	10				
TEMP: 13.4 °C	Amphipoda	13					Notonectidae*	3		A		A	Empididae	6				
Ph: 7.80	Potamonautidae*	3		•	A	A	Pleidae*	4					Ephydridae	3				
DO: mg/l	Atyidae	8		B	•	B	Veliidae/M..veliidae*	5		A		A	Muscidae	1				
Cond: 64.0 mS/m	Palaemonidae	10					**MEGALOPTERA:**						Psychodidae	1				
BIOTOPES SAMPLED:	**HYDRACARINA**	8		•		1	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					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	46	17	47
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6					**NO OF TAXA:**		0	11	5	12
	Chlorocyphidae	10					Petrothrincidae SWC	11					**ASPT:**		0	4.2	3	3.9
	Chlorolestidae	8					Pisuliidae	10					**IHAS**:	46%				
	Coenagrionidae	4		•		1	Sericostomatidae SWC	13					**OTHER BIOTA**:					
	Lestidae	8					**COLEOPTERA:**						TADPOLE					
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		•		1	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: 26/05/2016	**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: DHK B3	**ANNELIDA:**						Gerridae*	5		B		B	Ceratopogonidae	5		A	•	A
RIVER:	Oligochaeta	1					Hydrometridae*	6					Chironomidae	2	A		A	B
SITE DESCRIPTION: REP.	Leeches	3					Naucoridae*	7					Culicidae*	1		A	•	A
WEATHER CONDITION: WARM AND CLEAR	**CRUSTACEA:**						Nepidae*	3					Dixidae*	10				
TEMP: 15.7 °C	Amphipoda	13					Notonectidae*	3	A	A	A	B	Empididae	6				
Ph: 7.73	Potamonautidae*	3					Pleidae*	4		•		1	Ephydridae	3				
DO: mg/l	Atyidae	8	•	B	•	B	Veliidae/M..veliidae*	5		A		A	Muscidae	1				
Cond: 52.0 mS/m	Palaemonidae	10					**MEGALOPTERA:**						Psychodidae	1				
BIOTOPES SAMPLED:	**HYDRACARINA**	8	•	A	•	A	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		A		A	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		A		A
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:**		21	54	39	64
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6					**NO OF TAXA:**		4	10	8	12
	Chlorocyphidae	10					Petrothrincidae SWC	11					**ASPT:**		5	5.4	5	5.3
	Chlorolestidae	8					Pisuliidae	10					**IHAS**:	55%				
	Coenagrionidae	4					Sericostomatidae SWC	13					**OTHER BIOTA**:					
	Lestidae	8			A	A	**COLEOPTERA:**						DAPHNIA					
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					

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET

DATE: 26/05/2016	**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			**B**	**B**	Blepharoceridae	15				
SITE CODE: DHK B4	**ANNELIDA:**						Gerridae*	5		**B**	•	**B**	Ceratopogonidae	5			•	**1**
RIVER:	Oligochaeta	1			•	**1**	Hydrometridae*	6					Chironomidae	2		**A**	**A**	**B**
SITE DESCRIPTION: REP.	Leeches	3					Naucoridae*	7					Culicidae*	1		**B**		**B**
WEATHER CONDITION: COOL AND CLEAR	**CRUSTACEA:**						Nepidae*	3					Dixidae*	10				
TEMP: 13.7 °C	Amphipoda	13		•		**1**	Notonectidae*	3		**B**	**B**	**C**	Empididae	6				
Ph: 7.91	Potamonautidae*	3					Pleidae*	4					Ephydridae	3				
DO: mg/l	Atyidae	8					Veliidae/M..veliidae*	5		**A**		**A**	Muscidae	1				
Cond: 48.0 mS/m	Palaemonidae	10					**MEGALOPTERA:**						Psychodidae	1				
BIOTOPES SAMPLED:	**HYDRACARINA**	8		**A**		**A**	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**		**B**	Hydropsychidae >2 sp	12					Hydrobiidae*	3				
SAND:	Caenidae	6		•		**1**	Philopotamidae	10					Lymnaeidae*	3				
MUD:	Ephemeridae	15					Polycentropodidae	12					Physidae*	3				
HAND PICKING/VISUAL OBS:	Heptageniidae	13					Psychomyiidae/Xiphocen.	8					Planorbidae*	3		**A**		**A**
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	71	19	80
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6					**NO OF TAXA:**		0	12	6	15
	Chlorocyphidae	10					Petrothrincidae SWC	11					**ASPT:**		0	5.9	3	5.3
	Chlorolestidae	8					Pisuliidae	10					**IHAS**:	44%				
	Coenagrionidae	4					Sericostomatidae SWC	13					**OTHER BIOTA**:					
	Lestidae	8		**A**		**A**	**COLEOPTERA:**						5 x FISH, 2 x FROGS					
SIGNS OF POLLUTION:	Platycnemidae	10					Dytiscidae*	5		**A**		**A**	**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					

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET

DATE: 26/05/2016	**TAXON**		**S**	**VG**	**GSM**	**TOT**	**TAXON**		**S**	**VG**	**GSM**	**TOT**	**TAXON**		**S**	**VG**	**GSM**	**TOT**
GRID REFERENCE:	**PORIFERA**	5	A			A	**HEMIPTERA:**						**DIPTERA:**					
S:°	**COELENTERATA**	1					Belostomatidae*	3					Athericidae	10				
E:°	**TURBELLARIA**	3	**A**			**A**	Corixidae*	3	**B**		**B**	**C**	Blepharoceridae	15				
SITE CODE: DHKK4	**ANNELIDA:**						Gerridae*	5		**B**	•	**B**	Ceratopogonidae	5			**A**	**A**
RIVER: 1	Oligochaeta	1			•	**1**	Hydrometridae*	6					Chironomidae	2	**A**	**A**	**B**	**B**
SITE DESCRIPTION: REP.	Leeches	3					Naucoridae*	7					Culicidae*	1				
WEATHER CONDITION: HOT AND CLEAR	**CRUSTACEA:**						Nepidae*	3					Dixidae*	10				
TEMP: 15.7 °C	Amphipoda	13					Notonectidae*	3		**A**	**A**	**B**	Empididae	6				
Ph: 8.04	Potamonautidae*	3					Pleidae*	4			•	**1**	Ephydridae	3				
DO: mg/l	Atyidae	8		**B**		**B**	Veliidae/M..veliidae*	5		**B**		**B**	Muscidae	1				
Cond:48.0 mS/m	Palaemonidae	10					**MEGALOPTERA:**						Psychodidae	1				
BIOTOPES SAMPLED:	**HYDRACARINA**	8			**A**	**A**	Cordalidae	8					Simuliidae	5	•			**1**
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**	Hydropsychidae >2 sp	12					Hydrobiidae*	3				
SAND:	Caenidae	6	**A**		•	**A**	Philopotamidae	10	**A**			**A**	Lymnaeidae*	3				
MUD:	Ephemeridae	15					Polycentropodidae	12					Physidae*	3				
HAND PICKING/VISUAL OBS:	Heptageniidae	13					Psychomyiidae/Xiphocen.	8					Planorbidae*	3		**A**		**A**
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:**		41	51	43	114
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6					**NO OF TAXA:**		7	10	10	21
	Chlorocyphidae	10					Petrothrincidae SWC	11					**ASPT:**		6	5.1	4	5.4
	Chlorolestidae	8					Pisuliidae	10					**IHAS**:	60%				
	Coenagrionidae	4		•		**1**	Sericostomatidae SWC	13					**OTHER BIOTA**:					
	Lestidae	8					**COLEOPTERA:**						TP, DAPHNIA					
SIGNS OF POLLUTION:	Platycnemidae	10					Dytiscidae*	5					**COMMENTS**:					
	Protoneuridae	8					Elmidae/Dryopidae*	8										
	Zygoptera juvs.	6					Gyrinidae*	5		**A**		**A**						
	Aeshnidae	8					Halipidae*	5										
	Corduliidae	8					Helodidae	12					* = airbreathers					
OTHER OBSERVATIONS:	Gomphidae	6			•	**1**	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		•		**1**	Psephenidae	10					1=1, A=2-10, B=10-100, C=100-1000, D=>1000					

APPENDIX 8: Impact Assessment – The Plomp Method

Loss of instream flow

Nr	Activity	Without or With Mitigation	Significance	Mitigation Measures	Mitigation Effect
			Magnitude		
Planning Phase					
1	Potentially poor planning leading to extensive dirty water areas which need to be managed which may reduce the mean annual run-off (MAR) to the non-perennial drainage systems in the area.	**WOM**	Low	* Ensure that as far as possible all infrastructures are placed outside of drainage and river areas. In particular mention is made of the need to not encroach on the riparian systems near the Klein Marico River and its associated tributaries with a minimum buffer of 100m around all riparian systems maintained in line with the requirements of regulation GN704 of the National Water Act. Layout option 2 (Figure 25) is thus strongly discouraged from an aquatic health perspective * Ensure that sound environmental management is in place during the planning phase * Dirty water dams should be off stream and tributary structures and not within the natural drainage system of the area, thereby minimising impacts loss of instream flow and downstream recharge * Dirty water dams should be off stream structures and not within the natural drainage system of the area, thereby minimising impacts from inundation and siltation * Minimise loss of aquatic features where possible through planning and suitable layouts. Special mention is made of Layout Option 2, which is not recommended from an aquatic health point of view	May cause irreplaceable loss of resources
		WM	Negligible		Can be avoided, managed or mitigated
2	Stormwater designs leading to rapid release of water which in turn may lead to a loss of streamflow regulation capabilities in the area	**WOM**	Moderate		Can be reversed
		WM	Low		Can be avoided, managed or mitigated
3	Use of surface runoff and groundwater sources for the supply of production water for the mining project may alter the flow in the receiving systems	**WOM**	High		May cause irreplaceable loss of resources
		WM	Low		Can be avoided, managed or mitigated
4	Use of Layout Option 2 may impact on the instream flow of the receiving systems.	**WOM**	High		May cause irreplaceable loss of resources
		WM	Negligible		Can be avoided, managed or mitigated
Construction Phase					
5	Disturbance of soils during the construction phase could lead to erosion and sedimentation of the aquatic resources present, thus resulting in a loss of instream flow.	**WOM**	High	* Limit the footprint area of the construction activity to what is absolutely essential in order to minimise the loss of clean water runoff areas and the concomitant recharge of streams in the area * If it is absolutely unavoidable that either the Klein Marico River or its associated tributaries will be affected, disturbance must be minimised and suitably rehabilitated * Ensure	May cause irreplaceable loss of resources

Nr	Activity	Without or With Mitigation	Significance	Mitigation Measures	Mitigation Effect
	Loss of instream flow				
			Magnitude		
		WM	Negligible	that no incision and canalisation of the aquatic resources present takes place as a result of site clearing and construction activities * All erosion noted within the study area should be remedied immediately and included as part of the ongoing rehabilitation plan * During the construction phase of the proposed Doornhoek mining project, erosion berms should be installed on roadways to prevent gully formation and siltation of the aquatic resources. The following points should serve to guide the placement of erosion berms: • Where the track has slope of less than 2%, berms every 50m should be installed; • Where the track slopes between 2% and 10%, berms every 25m should be installed; • Where the track slopes between 10%-15%, berms every 20m should be installed; • Where the track has slope greater than 15%, berms every 10m should be installed * All soils compacted as a result of construction activities falling outside of development footprint areas should be ripped and profiled * As much vegetation growth as possible should be promoted within the proposed development area during all phases in order to protect soils and vegetation clearance should be kept to a minimum as the biomass in the area is not very high and so hence the plants will not grow quickly * No use of clean surface water or any groundwater which potentially recharges the watercourses in the area should take place. In this regard specific mention is made of any water use which will affect the instream flow in the Klein Marico River and the associated tributaries * Very strict control of water consumption must take place and detailed monitoring must take place and where all water usage must continuously be optimised * Permit only essential construction personnel within 100m of all riparian system * All areas of increased ecological sensitivity should be designated as No-Go areas and be off limits to all unauthorised vehicles and personnel during the construction phase of the proposed Doornhoek mining project * No crossing of the aquatic resources should take place and the substrate conditions of the aquatic resources and stream connectivity must be	Can be avoided, managed or mitigated
6	Construction of clean and dirty water separation structures for dirty water control purposes may lead to altered flow levels. In addition, upstream dewatering boreholes may result in a loss of flow further downstream.	WOM	Moderate		May cause irreplaceable loss of resources
		WM	Negligible		Can be avoided, managed or mitigated
7	Change in surface coverage. Development of the mining rights area will change the surface coverage in some areas from vegetated soil to buildings, hardened gravel roads, paved areas (parking) and compacted earth.	WOM	High		May cause irreplaceable loss of resources
		WM	Low		Can be avoided, managed or mitigated

	Loss of instream flow				
Nr	**Activity**	**Without or With Mitigation**	**Significance**	**Mitigation Measures**	**Mitigation Effect**
			Magnitude		
				maintained * Restrict construction to the drier winter months to avoid sedimentation of the aquatic resources in the vicinity of the proposed Doornhoek mining project * No material may be dumped or stocklined within any rivers, tributaries or drainage lines in the vicinity of the proposed Doornhoek mining project.	
Operational Phase					
8	Loss of MAR from dirty water areas may impact on the instream flow of the receiving systems.	**WOM**	High	* Limit the footprint area of the operational activities to what is absolutely essential in order to minimise the loss of clean water runoff areas and the concomitant recharge of streams in the area * If it is absolutely unavoidable that either the Klein Marico River or its associated tributaries will be affected, disturbance must be minimised and suitably rehabilitated * Ensure that no incision and canalisation of the aquatic resources present takes place as a result of operational activities * All erosion noted within the study area should be remedied immediately and included as part of the ongoing rehabilitation plan * During the construction and operational phases of the proposed Doornhoek mining project, erosion berms should be installed on roadways to prevent gully formation and siltation of the aquatic resources. The following points should serve to guide the placement of erosion berms: • Where the track has slope of less than 2%, berms every 50m should be installed; • Where the track slopes between 2% and 10%, berms every 25m should be installed; • Where the track slopes between 10%-15%, berms every 20m should be installed; • Where the track has slope greater than 15%, berms every 10m should be installed * Ensure that all stockpiles are well managed and have measures such as berms and hessian sheets implemented to prevent erosion and sedimentation which may ultimately lead to transformation of aquatic habitat areas * As much vegetation growth as possible should be promoted within the proposed development area during the operational phase in order to protect soils and vegetation clearance should be kept to a	Can be reversed
		WM	Low		Can be avoided, managed or mitigated
9	Loss of water through clean and dirty water separation may alter instream flow on the receiving systems. In addition, upstream dewatering boreholes may result in a loss of flow further downstream.	**WOM**	High		Can be reversed
		WM	Negligible		Can be avoided, managed or mitigated
10	Impact on natural streamflow regulation and stream recharge due to altered hydrology in the area may lead to altered instream flow	**WOM**	Moderate		May cause irreplaceable loss of resources
		WM	Negligible		May cause irreplaceable loss of resources
11	Intercepting run-off around mining activities and infrastructure could reduce the amount of time that water	**WOM**	Low		Can be reversed

Loss of instream flow

Nr	Activity	Without or With Mitigation	Significance	Mitigation Measures	Mitigation Effect
			Magnitude		
	would take to reach the Klein Marico River and its associated tributaries and may lead to "flash flood" events on varying scales.	**WM**	Negligible	minimum as the biomass in the area is not very high and so hence the plants will not grow quickly * No use of clean surface water or any groundwater which potentially recharges the watercourses in the area should take place. In this regard specific mention is made of any water use which will affect the instream flow in the Klein Marico River and the associated tributaries * Very strict control of water consumption must take place and detailed monitoring must take place and where all water usage must continuously be optimised * Upstream dewatering boreholes should be considered to minimise the creation of dirty water and this clean water should be used to recharge the natural systems downstream of the mining rights areas * Permit only essential personnel within 100m of all riparian systems * All areas of increased ecological sensitivity should be designated as No-Go areas and be off limits to all unauthorised vehicles and personnel during the operational phase of the proposed Doornhoek mining project * No crossing of the aquatic resources should take place and the substrate conditions of the aquatic resources and stream connectivity must be maintained * No material may be dumped or stocklined within any rivers, tributaries or drainage lines in the vicinity of the proposed Doornhoek mining project.	Can be avoided, managed or mitigated
12	Capture of run-off and capture of rainfall (inundation) in the 'dirty'/impacted areas would lower instream flow in the receiving environment.	**WOM**	High		Can be avoided, managed or mitigated
		WM	Negligible		Can be avoided, managed or mitigated
Closure and Decommissioning Phase					
13	Loss of MAR from latent dirty water areas may still impact on the flow even after operational phase.	**WOM**	High	* Ensure that as far as possible all infrastructures are removed and footprint areas are suitably rehabilitated. It is considered essential that no decommissioning activities take place within the drainage and river areas. In particular mention is made of the need to not encroach on the riparian systems near the Klein Marico River and its associated tributaries with a minimum buffer of 100m around all riparian systems maintained in line with the requirements of regulation GN704 of the National Water Act * Ensure that sound environmental management is in place during the decommissioning phase * Ensure that there is a clear separation of clean	May cause irreplaceable loss of resources
		WM	Negligible		Can be avoided, managed or mitigated

Loss of instream flow

Nr	Activity	Without or With Mitigation	Significance	Mitigation Measures	Mitigation Effect
			Magnitude		
14	Loss of water to inadequately rehabilitated areas may still have an impact on the flow post operational phase.	**WOM**	Moderate	and dirty water. No dirty water should be allowed to come into contact with the receiving environment during the decommissioning phase of the proposed Doornhoek mining project * Limit the footprint area of the decommissioning activity to what is absolutely essential in order to minimise the loss of clean water runoff areas and the concomitant recharge of streams in the area * If it is absolutely unavoidable that either the Klein Marico River or its associated tributaries will be affected, disturbance must be minimised and suitably rehabilitated * Ensure that no incision and canalisation of the aquatic resources present takes place as a result of decommissioning activities * All erosion noted within the study area should be remedied immediately and included as part of the ongoing rehabilitation plan * Ensure that decommissioning of all stockpiles are well managed and have measures such as berms and hessian sheets implemented to prevent erosion and sedimentation which may ultimately lead to transformation of aquatic habitat areas * As much vegetation growth as possible should be promoted within the proposed development area during the decommissioning phase in order to protect soils and vegetation clearance should be kept to a minimum as the biomass in the area is not very high and so hence the plants will not grow quickly * Permit only essential personnel within 100m of all riparian systems * All areas of increased ecological sensitivity should be designated as No-Go areas and be off limits to all unauthorised vehicles and personnel during the decommissioning phase of the proposed Doornhoek mining project * No crossing of the aquatic resources should take place and the substrate conditions of the aquatic resources and stream connectivity must be maintained * No material may be dumped within any rivers, tributaries or drainage lines in the vicinity of the proposed Doornhoek mining project.	Can be reversed
		WM	Negligible		Can be avoided, managed or mitigated
15	Impact on natural streamflow regulation and stream recharge due to altered hydrology in the area may impact on the flow post operational phase	**WOM**	Moderate		May cause irreplaceable loss of resources
		WM	Negligible		Can be avoided, managed or mitigated
Post-Closure Phase					
16	Loss of MAR from latent dirty water areas may still impact on the flow even after decommissioning phase.	**WOM**	High	* Ongoing monitoring of the process water system and selected boreholes should take place for a period of at least three years post closure to monitor and mitigate any groundwater contamination plume post-closure as a result of seepage from latent dirty water areas * Ensure that no incision and	May cause irreplaceable loss of resources
		WM	Negligible		Can be avoided, managed or mitigated

Loss of instream flow

Nr	Activity	Without or With Mitigation	Significance	Mitigation Measures	Mitigation Effect
			Magnitude		
17	Loss of water to inadequately rehabilitated areas may still have an impact on the flow post decommissioning phase.	**WOM**	Moderate	canalisation of the aquatic resources present takes place as a result of inadequately rehabilitated mining areas * All erosion noted within the study area should be remedied immediately and included as part of the ongoing rehabilitation plan for a period of at least three years post-closure* As much vegetation growth as possible should be promoted to protect soils and vegetation clearance should be kept to a minimum as the biomass in the area is not very high and so hence the plants will not grow quickly and an ongoing alien vegetation control programme should be put in place for a period of at least three years post-closure, with special mention of the removal of invasive water loving trees * Permit only essential personnel within 100m of all riparian systems * No crossing of the aquatic resources should take place and the substrate conditions of the aquatic resources and stream connectivity must be maintained.	Can be reversed
		WM	Negligible		Can be avoided, managed or mitigated
18	Impact on natural streamflow regulation and stream recharge due to altered hydrology in the area may impact on the flow post decommissioning phase	**WOM**	High		May cause irreplaceable loss of resources
		WM	Negligible		Can be avoided, managed or mitigated
19	Ongoing erosion and sedimentation of the aquatic resources, which will result in a loss of instream flow due to inadequate rehabilitation of affected areas.	**WOM**	Moderate		May cause irreplaceable loss of resources
		WM	Negligible		Can be avoided, managed or mitigated

	Impacts on water quality				
Nr	**Activity**	**Without or With Mitigation**	**Significance**	**Mitigation Measures**	**Mitigation Effect**
			Magnitude		
Planning Phase					
1	Potentially poor planning leading to extensive and complex dirty water areas which need to be managed may impact on water quality.	**WOM**	High	* Ensure that as far as possible all infrastructures are placed outside of drainage and river areas. In particular, mention is made of the need to not encroach on the aquatic resources in the vicinity of the Klein Marico River with a minimum buffer of 100m around all aquatic resources maintained in line with the requirements of regulation GN704 of the National Water Act * Design of infrastructure should be environmentally and structurally sound and all possible precautions taken to prevent spillage or seepage to the groundwater resources present * Any dirty water facilities should be lined with an HDPE liner or drainage barrier system (as required) to prevent seepage * Dirty water dams must be adequately designed to contain a 1:50 24 hour storm water event * It must be ensured that the design of all infrastructure prevents failure * Dirty water dams should be off stream structures and not within the natural drainage system of the area, thereby minimising impacts to water quality and loss or transformation of aquatic habitat	May cause irreplaceable loss of resources
		WM	Low		Can be avoided, managed or mitigated
2	Potentially poor planning leading to placement of polluting structures in non-perennial drainage lines which would increase mobility of pollutants and may impact on water quality.	**WOM**	High		Can be reversed
		WM	Negligible		Can be avoided, managed or mitigated
3	Potentially inadequate separation of clean and dirty water areas leading to contaminated water leaving the defined dirty water area may impact in water quality.	**WOM**	Moderate		May cause irreplaceable loss of resources
		WM	Low		Can be avoided, managed or mitigated
4	Clean and dirty water systems not being designed adequately to ensure protection of the water resources.	**WOM**	Moderate		May cause irreplaceable loss of resources
		WM	Negligible		Can be avoided, managed or mitigated
Construction Phase					
5	Clean and dirty water systems not being constructed to the required specifications to prevent contamination of clean water areas may impact on water quality.	**WOM**	High	* Permit only essential construction personnel within 100m of all riparian systems * Keep all demarcated sensitive zones outside of the construction area off limits during the construction phase of the development * Limit the footprint area of the construction activity to what is absolutely essential in order to minimise the loss of clean water runoff areas and the concomitant recharge of streams in the area * Any dirty water facilities should be lined with an HDPE liner or drainage barrier system (as required) to prevent seepage * Clear separation of clean and dirty water must take place and diversion of clean water around future operational areas (if applicable) must	May cause irreplaceable loss of resources
		WM	Low		Can be avoided, managed or mitigated
6	Major earthworks and construction activities may lead to impacts on water quality as a result of erosion and	**WOM**	High		May cause irreplaceable loss of resources

Impacts on water quality					
Nr	**Activity**	**Without or With Mitigation**	**Significance**	**Mitigation Measures**	**Mitigation Effect**
			Magnitude		
	sedimentation as well as resulting in the oxidation of pyrites. In addition,, there is a risk of the release of metals to the surface and groundwater resources as a result of tillage and blasting.	**WM**	Negligible	ensure minimisation of the loss of catchment yield * Clean and dirty water separation systems should be the first systems developed on site * Very clear and well managed clean and dirty water separation must take place in line with the requirements of regulation GN704 of the National Water Act * Prevent run-off from dirty water areas entering stream systems through ensuring clear separation of clean and dirty water areas; * Dirty water dams must be adequately designed to contain a 1:50 24 hour storm water event * It must be ensured that the construction of all infrastructure prevents failure * Dirty water dams should be off stream structures and not within the natural drainage system of the area, thereby minimising impacts to water quality and loss or transformation of aquatic habitat * Upstream dewatering boreholes should be considered to minimise the creation of dirty water and this clean water should be used to recharge the natural systems downstream of the mining rights areas * All vehicles must be regularly inspected for leaks * Re-fuelling must take place on a sealed surface area to prevent ingress of hydrocarbons into topsoil * It must be ensured that all hazardous storage containers and storage areas comply with the relevant SABS standards to prevent leakage * All hazardous chemicals must be stored on specified surfaces * All spills should be immediately cleaned up and treated accordingly * Appropriate sanitary facilities must be provided for the duration of the construction activities and all waste must be removed to an appropriate waste facility * No dumping of waste should take place. If any spills occur, they should be immediately cleaned up * Monitor all systems for erosion and incision * Close monitoring of water quality (surface water, groundwater and process water) must take place. Monitoring of water quality should take place at a minimum frequency of once a month (when surface water is present) during which time major salts and basic metals, are monitored along with basic parameters such as pH, Total Suspended Solids (TSS) and Total Dissolved Solids (TDS), dissolved oxygen and Electrical Conductivity (EC) * Ongoing aquatic ecological monitoring must take place on a bi-annual basis by an SA RHP Accredited assessor * Ongoing aquatic biomonitoring should take place in order to identify any emerging issues in the receiving environment * A groundwater pollution plume should be	Can be avoided, managed or mitigated
7	Poor housekeeping and management may lead to impacts on water quality.	**WOM**	High		Can be reversed
		WM	Low		Can be avoided, managed or mitigated
8	Spills and other unplanned events may impact on water quality.	**WOM**	High		Can be reversed
		WM	Low		Can be avoided, managed or mitigated

Nr	Activity	Without or With Mitigation	Significance	Mitigation Measures	Mitigation Effect
	Impacts on water quality				
			Magnitude		
				modelled and appropriately monitored. Any impacts to the groundwater resources in the vicinity of the proposed Doornhoek mining project will need to be suitably and timeously mitigated to prevent impacts further downstream and potentially on a regional scale	
Operational Phase					
9	Mining activities and the establishment of mining waste may impact on water quality and thus needs to be managed to prevent pollution.	**WOM**	High	* Any dirty water facilities should be lined with an HDPE liner or drainage barrier system (as required) to prevent seepage * Clear separation of clean and dirty water must take place and diversion of clean water around operational areas (if applicable) must ensure minimisation of the loss of catchment yield * Very clear and well managed clean and dirty water separation must take place in line with the requirements of regulation GN704 of the National Water Act * Prevent run-off from dirty water areas entering stream systems through ensuring clear separation of clean and dirty water areas * All dirty water facilities must be managed in such a way as to ensure that storage and surge capacity is available if a rainfall event occurs * Infrastructure must be monitored for seepages and erosion * Ensure that the mine process water system is managed in such a way as to prevent discharge to the receiving environment and to prevent discharge of dirty water * Dirty water must be recycled back into the mining system * Upstream dewatering boreholes should be considered to minimise the creation of dirty water and this clean water should be used to recharge the natural systems downstream of the mining rights areas * Ensure that all stockpiles are well managed and have measures such as berms and hessian sheets implemented to prevent erosion and sedimentation which may ultimately lead to impaired water quality and in turn, transformation of aquatic habitat areas * Implement measures to contain seepage as far as possible to prevent contamination of the groundwater regime. If necessary, treated ore stockpile areas should be lined with an HDPE liner or drainage barrier system (as required) to prevent seepage to the groundwater resources * All vehicles must be regularly inspected for leaks * Re-fuelling must take place on a	May cause irreplaceable loss of resources
		WM	Negligible		Can be avoided, managed or mitigated
10	Clean and dirty water systems not being maintained and operated to the required specifications to prevent contamination of clean water areas may impact on water quality.	**WOM**	High		May cause irreplaceable loss of resources
		WM	Negligible		Can be avoided, managed or mitigated
11	Poor housekeeping and management during operational phase may lead to impacts on water quality.	**WOM**	Moderate		May cause irreplaceable loss of resources
		WM	Negligible		Can be avoided, managed or mitigated
12	Major earthworks and operational activities may lead to impacts on water quality as a result of erosion and sedimentation as well as resulting in the oxidation of pyrites. In addition, there is a risk of the release of metals to the surface and groundwater	**WOM**	High		May cause irreplaceable loss of resources
		WM	Negligible		Can be avoided, managed or mitigated

Nr	Activity	Without or With Mitigation	Significance	Mitigation Measures	Mitigation Effect
	Impacts on water quality				
			Magnitude		
	resources as a result of tillage and blasting.			sealed surface area to prevent ingress of hydrocarbons into topsoil * It must be ensured that all hazardous storage containers and storage areas comply with the relevant SABS standards to prevent leakage * All hazardous chemicals must be stored on specified surfaces * All spills should be immediately cleaned up and treated accordingly * Appropriate sanitary facilities must be provided for the duration of the operational activities and all waste must be removed to an appropriate waste facility * No dumping of waste should take place. If any spills occur, they should be immediately cleaned up * Monitor all systems for erosion and incision * Close monitoring of water quality (surface water, groundwater and process water) must take place. Monitoring of water quality should take place at a minimum frequency of once a month (when surface water is present) during which time major salts and basic metals, are monitored along with basic parameters such as pH, Total Suspended Solids (TSS) and Total Dissolved Solids (TDS), dissolved oxygen and Electrical Conductivity (EC) * Ongoing aquatic ecological monitoring must take place on a bi-annual basis by an SA RHP Accredited assessor * Ongoing aquatic biomonitoring should take place in order to identify any emerging issues in the receiving environment * Toxicity testing of the proposed Doornhoek mining project's process water facilities should take place quarterly and concurrently with the biomonitoring program in order to monitor the toxicological risk of the process water system to the receiving environment and in particular the groundwater resources. Tests should include the following test organisms as a minimum: Vibrio fischeri, Daphnia pulex; and Algal Growth Potential * A groundwater pollution plume should be modelled and appropriately monitored. Any impacts to the groundwater resources in the vicinity of the proposed Doornhoek mining project will need to be suitably and timeously mitigated to prevent impacts further downstream and potentially on a regional scale * The proposed Doornhoek mining project must be managed as a zero discharge facility, however definitive toxicological testing according to the Direct Estimation of Ecological Effect Potential (DEEEP) protocol should take place should it become evident that process water discharge or decant of groundwater will occur in order to define safe discharge volumes and ensure sufficient dilution.	
13	Spills and other unplanned events during operational phase may impact on water quality.	**WOM**	High		May cause irreplaceable loss of resources
		WM	Negligible		Can be avoided, managed or mitigated

Impacts on water quality

Nr	Activity	Without or With Mitigation	Significance / Magnitude	Mitigation Measures	Mitigation Effect
Closure and Decommissioning Phase					
14	Inadequate closure and rehabilitation leading to ongoing pollution from contaminating sources such as discard dumps and latent dirty water areas may impact on water quality.	WOM	High	* Ensure that as far as possible all decommissioning of infrastructures take place outside of drainage and river areas. In particular, mention is made of the need to not encroach on the aquatic resources in the vicinity of the Klein Marico River with a minimum buffer of 100m around all aquatic resources maintained in line with the requirements of regulation GN704 of the National Water Act * Permit only essential personnel within 100m of all riparian systems * Very clear and well managed clean and dirty water separation must take place in line with the requirements of regulation GN704 of the National Water Act * Prevent run-off from dirty water areas entering stream systems through ensuring clear separation of clean and dirty water areas * Dirty water dams must be adequately designed to contain a 1:50 24 hour storm water event * Any remaining infrastructure must be monitored for seepages and erosion * Ensure that any latent dirty water systems are managed in such a way as to prevent discharge to the receiving environment and to prevent discharge of dirty water * Monitor all systems for erosion and incision * Ongoing monitoring of water quality (surface water, groundwater and process water) must take place. Monitoring of water quality should take place at a minimum frequency of once a month (when surface water is present) during which time major salts and basic metals, are monitored along with basic parameters such as pH, Total Suspended Solids (TSS) and Total Dissolved Solids (TDS), dissolved oxygen and Electrical Conductivity (EC) * Ongoing aquatic ecological monitoring must take place on a bi-annual basis by an SA RHP Accredited assessor in order to identify any emerging issues in the receiving environment * Toxicity testing of the proposed Doornhoek mining project's process water facilities should take place quarterly and concurrently with the biomonitoring program in order to monitor the toxicological risk of the process water system to the receiving environment and in particular the groundwater resources. Tests should include the following test organisms as a minimum: Vibrio fischeri, Daphnia pulex and Algal Growth Potential * Any impacts to the groundwater resources in the vicinity of the proposed Doornhoek mining project will need to be suitably and	May cause irreplaceable loss of resources
		WM	Negligible		Can be avoided, managed or mitigated
15	Clean and dirty water systems not being maintained or decommissioned properly to the required specifications to prevent contamination of clean water areas may impact on water quality.	WOM	High		May cause irreplaceable loss of resources
		WM	Negligible		Can be avoided, managed or mitigated
16	Poor housekeeping and management during decommissioning phase may lead to impacts on water quality.	WOM	High		May cause irreplaceable loss of resources
		WM	Negligible		Can be avoided, managed or mitigated
17	Spills and other unplanned events during decommissioning phase may impact on water quality.	WOM	Moderate		Can be reversed
		WM	Negligible		Can be avoided, managed or mitigated

Impacts on water quality					
Nr	**Activity**	**Without or With Mitigation**	**Significance**	**Mitigation Measures**	**Mitigation Effect**
			Magnitude		
				timeously mitigated to prevent impacts further downstream and potentially on a regional scale.	
Post-Closure Phase					
18	Inadequate closure and rehabilitation leading to ongoing pollution from contaminating sources such as discard dumps and latent dirty water areas may impact on water quality.	**WOM**	High	* Implement measures to contain seepage as far as possible to prevent contamination of the groundwater regime as a result of latent dirt water facilities * Ongoing monitoring of all systems for erosion and incision * Close monitoring of water quality (surface water, groundwater and process water) must take place. Monitoring of water quality should take place at a minimum frequency of once a month (when surface water is present) during which time major salts and basic metals, are monitored along with basic parameters such as pH, Total Suspended Solids (TSS) and Total Dissolved Solids (TDS), dissolved oxygen and Electrical Conductivity (EC) should take place for a period of at least 3 years post closure * Ongoing aquatic ecological monitoring must take place on a bi-annual basis by an SA RHP Accredited assessor to identify any emerging issues in the receiving environment for a period of at least 3 years post closure * The groundwater pollution plume should be appropriately monitored for a period of at least 3 years post closure. Any impacts to the groundwater resources in the vicinity of the proposed Doornhoek mining project will need to be suitably and timeously mitigated to prevent impacts further downstream and potentially on a regional scale	May cause irreplaceable loss of resources
		WM	Negligible		Can be avoided, managed or mitigated
19	Clean and dirty water systems not being maintained or decommissioned properly to the required specifications to prevent contamination of clean water areas may impact on water quality.	**WOM**	High		May cause irreplaceable loss of resources
		WM	Negligible		Can be avoided, managed or mitigated
20	Inadequate rehabilitation of mining areas leading to erosion and sedimentation of the aquatic resources present.	**WOM**	High		May cause irreplaceable loss of resources
		WM	Negligible		Can be avoided, managed or mitigated

Loss of aquatic habitat					
Nr	**Activity**	**Without or With Mitigation**	**Significance**	**Mitigation Measures**	**Mitigation Effect**
			Magnitude		
Planning Phase					
1	Potentially poor planning leading to the placement of infrastructure within non-perennial drainage lines, with special mention of the waste stockpile areas as well as roads, road crossings and bridges all may alter the aquatic habitat.	**WOM**	Moderate	Ensure that as far as possible all infrastructures are placed outside of drainage and river areas. In particular, mention is made of the need to not encroach on the riparian systems near the Klein Marico River and its associated tributaries with a minimum buffer of 100m around all aquatic resources maintained in line with the requirements of regulation GN704 of the National Water Act * Dirty water dams should be off stream structures and not within the natural drainage system of the area, thereby minimising impacts loss or transformation of aquatic habitat * Dirty water dams should be off stream structures and not within the natural drainage system of the area, thereby minimising impacts from inundation and siltation	Can be reversed
		WM	Negligible		Can be avoided, managed or mitigated
2	Potentially inadequate design of infrastructure leading to changes to instream habitat.	**WOM**	Moderate		May cause irreplaceable loss of resources
		WM	Negligible		Can be avoided, managed or mitigated
3	Potentially inadequate design of infrastructure leading to changes to system hydrology may alter the aquatic habitat.	**WOM**	Moderate		May cause irreplaceable loss of resources
		WM	Negligible		Can be avoided, managed or mitigated
4	Potentially inadequate separation of clean and dirty water areas and the prevention of the release of sediment rich water may alter the aquatic habitat within the receiving environment.	**WOM**	High		May cause irreplaceable loss of resources
		WM	Low		Can be avoided, managed or mitigated
Construction Phase					
5	Site clearing and the removal of vegetation leading to increased runoff and erosion may alter the aquatic habitat.	**WOM**	High	Ensure that as far as possible all infrastructures are placed outside of drainage and river areas. In particular, mention is made of the need to not encroach on the riparian systems near the Klein Marico River and its associated tributaries with a minimum buffer of 100m around all aquatic resources maintained in line with the requirements of regulation GN704 of the National Water Act * Permit only essential construction personnel within	Can be reversed
		WM	Negligible		Can be avoided, managed or mitigated
6	Site clearing and road construction and the disturbance of soils leading to	**WOM**	Moderate		Can be reversed

	Loss of aquatic habitat				
Nr	**Activity**	**Without or With Mitigation**	**Significance**	**Mitigation Measures**	**Mitigation Effect**
			Magnitude		
	increased erosion may alter the aquatic habitat.	**WM**	Negligible	100m of all riparian systems * Keep all demarcated sensitive zones outside of the construction area off limits during the construction phase of the development * Implement alien vegetation control program within the riparian zones with special mention of water loving tree species and invasive species such as Arundo donax and Typha capensis * Limit the footprint area of the construction activity to what is absolutely essential in order to disturbance of soils leading to runoff, erosion and sedimentation and loss of instream flow and stream recharge * Monitor all systems for erosion and incision * Monitor all affected riparian systems for moisture stress * Monitor all potentially affected riparian zones for changes in riparian vegetation structure * Ongoing aquatic ecological monitoring must take place on a bi-annual basis by an SA RHP Accredited assessor * Ongoing aquatic biomonitoring should take place in order to identify any emerging issues in the receiving environment	Can be avoided, managed or mitigated
7	Earthworks in the vicinity of drainage systems leading to increased runoff and erosion and altered runoff patterns may alter the aquatic habitat.	**WOM**	High		Can be reversed
		WM	Negligible		Can be avoided, managed or mitigated
8	Alien vegetation encroachment will impact on and alter the aquatic habitat.	**WOM**	High		Can be reversed
		WM	Negligible		Can be avoided, managed or mitigated
Operational Phase					
9	Ongoing disturbance of soils during general operational activities may alter the aquatic habitat.	**WOM**	High	Permit only essential operational personnel within 100m of all riparian systems * Keep all demarcated sensitive zones outside of the operational area off limits during the operational phase of the development * Implement alien vegetation control program within the riparian zones with special mention of water loving tree species and invasive species such as Arundo donax and Typha capensis * Ensure that all stockpiles are well managed and have measures such as berms and hessian sheets implemented to prevent erosion and sedimentation which may ultimately lead to transformation of aquatic habitat areas * Monitor all systems for erosion and incision * Monitor all affected riparian systems for moisture stress * Monitor all potentially affected riparian zones for changes in riparian vegetation structure * Ongoing aquatic ecological monitoring must take place on a bi-annual basis by an SA RHP Accredited assessor to identify any emerging issues in the receiving environment.	Can be reversed
		WM	Negligible		Can be avoided, managed or mitigated
10	Inadequate separation of clean and dirty water areas may alter the aquatic habitat during the operational phase.	**WOM**	High		May cause irreplaceable loss of resources
		WM	Low		Can be avoided, managed or mitigated
11	Mining related activities leading to increased disturbance of soils and drainage lines may alter the aquatic habitat.	**WOM**	Moderate		Can be reversed
		WM	Negligible		Can be avoided, managed or mitigated
12	Any activities which lead to the reduction of flow in the system with special mention of the use of surface and groundwater sources for production water may alter the aquatic habitat.	**WOM**	High		May cause irreplaceable loss of resources
		WM	Moderate		Can be avoided, managed or mitigated

Loss of aquatic habitat					
Nr	**Activity**	**Without or With Mitigation**	**Significance**	**Mitigation Measures**	**Mitigation Effect**
			Magnitude		
13	Alien vegetation encroachment will impact on and alter the aquatic habitat.	**WOM**	High		Can be reversed
		WM	Low		Can be avoided, managed or mitigated
Closure and Decommissioning Phase					
14	Disturbance of soils as part of demolition activities may alter the aquatic habitat.	**WOM**	Low	Ensure that as far as possible all decommissioning activities take place outside of drainage and river areas. In particular, mention is made of the need to not encroach on the riparian systems near the Klein Marico River and its associated tributaries with a minimum buffer of 100m around all aquatic resources maintained in line with the requirements of regulation GN704 of the National Water Act * Permit only essential personnel within 100m of all riparian systems * Keep all demarcated sensitive zones outside of the decommissioning area off limits during the decommissioning phase of the project * Ongoing adherence to the alien vegetation control program within the riparian zones with special mention of water loving tree species and invasive species such as Arundo donax and Typha capensis * Monitor all systems for erosion and incision * Monitor all affected riparian systems for moisture stress * Monitor all potentially affected riparian zones for changes in riparian vegetation structure * Ongoing aquatic ecological monitoring must take place on a bi-annual basis by an SA RHP Accredited assessor in order to identify any emerging issues in the receiving environment	Can be reversed
		WM	Negligible		Can be avoided, managed or mitigated
15	Inadequate separation of clean and dirty water areas may alter the aquatic habitat during the decommissioning phase.	**WOM**	High		May cause irreplaceable loss of resources
		WM	Low		Can be avoided, managed or mitigated
16	Ongoing pollution from inappropriately decommissioned structures may alter the aquatic habitat.	**WOM**	Moderate		May cause irreplaceable loss of resources
		WM	Negligible		Can be avoided, managed or mitigated
17	Alien vegetation encroachment will impact on and alter the aquatic habitat.	**WOM**	High		Can be reversed
		WM	Low		Can be avoided, managed or mitigated
Post-Closure Phase					
18	Inadequate separation of clean and dirty water areas may alter the aquatic habitat during the decommissioning phase.	**WOM**	High	Ongoing monitoring of the process water system and selected boreholes should take place for a period of at least three years post closure to monitor and mitigate any groundwater contamination plume post-closure as a result of seepage from latent dirty water areas * Ensure that no incision and canalisation of the aquatic resources present takes place as a result of inadequately rehabilitated mining areas * All erosion noted within the study area should be remedied immediately and included as part of the ongoing rehabilitation plan for a period of at least three years post-closure* As much	May cause irreplaceable loss of resources
		WM	Low		Can be avoided, managed or mitigated
19		**WOM**	High		May cause irreplaceable loss of resources

Loss of aquatic habitat					
Nr	**Activity**	**Without or With Mitigation**	**Significance**	**Mitigation Measures**	**Mitigation Effect**
			Magnitude		
	Ongoing pollution from inappropriately decommissioned structures may alter the aquatic habitat.	**WM**	Low	vegetation growth as possible should be promoted to protect soils and vegetation clearance should be kept to a minimum as the biomass in the area is not very high and so hence the plants will not grow quickly * Ongoing adherence to the alien vegetation control program within the riparian zones with special mention of water loving tree species and invasive species such as Arundo donax and Typha capensis * Monitor all affected riparian systems for moisture stress * Monitor all potentially affected riparian zones for changes in riparian vegetation structure * Ongoing aquatic ecological monitoring must take place on a bi-annual basis by an SA RHP Accredited assessor in order to identify any emerging issues in the receiving environment	Can be avoided, managed or mitigated
20	Alien vegetation encroachment will impact on and alter the aquatic habitat.	**WOM**	High		May cause irreplaceable loss of resources
		WM	Negligible		Can be avoided, managed or mitigated

Loss of aquatic biodiversity and sensitive taxa					
Nr	**Activity**	**Without or With Mitigation**	**Significance**	**Mitigation Measures**	**Mitigation Effect**
			Magnitude		
Planning Phase					
1	Potentially poor planning leading to the placement of infrastructure within non-perennial drainage lines with special mention of the overburden stockpile areas, road crossings and bridges may lead to a loss in aquatic biodiversity.	**WOM**	Moderate	Ensure that as far as possible all infrastructures are placed outside of drainage and river areas. In particular, mention is made of the need to not encroach on the riparian systems near the Klein Marico River and its associated drainage lines with a minimum buffer of 100m around all riparian systems maintained in line with the requirements of regulation GN704 of the National Water Act. Layout	May cause irreplaceable loss of resources
		WM	Negligible		May cause irreplaceable loss of resources

Nr	Activity	Without or With Mitigation	Significance	Mitigation Measures	Mitigation Effect
	Loss of aquatic biodiversity and sensitive taxa				
			Magnitude		
2	Potentially inadequate design of infrastructure leading to changes to instream habitat may lead to a loss in aquatic biodiversity.	**WOM**	Moderate	option 2 is strongly discouraged from an aquatic health point of view * Dirty water dams must be adequately designed to contain a 1:50 24 hour storm water event * Dirty water dams and tailings facilities should be off stream and tributary structures and not within the natural drainage system of the area, thereby minimising impacts loss of instream flow and downstream recharge * Implement an ongoing alien vegetation control program to be initiated in the pre-construction phase of the project * The project design should limit the footprint area of the proposed mining activities to what is absolutely essential in order to minimise the loss of clean water runoff areas and the concomitant recharge of streams in the area and the disturbance of soils leading to runoff, erosion and sedimentation * Dirty water dams should be off stream structures and not within the natural drainage system of the area, thereby minimising impacts loss or transformation of aquatic habitat * Dirty water dams should be off stream structures and not within the natural drainage system of the area, thereby minimising impacts from inundation and siltation * Ensure that measures to contain seepage as far as possible to prevent contamination of the groundwater regime are implemented into the design of mining infrastructure * Upstream dewatering boreholes should be considered to minimise the creation of dirty water and this clean water should be used to recharge the natural systems downstream of the mining rights areas so as to aid in the prevention of the contamination of the groundwater resources without compromising on surface water recharge further downstream;	May cause irreplaceable loss of resources
		WM	Negligible		May cause irreplaceable loss of resources
3	Potentially inadequate design of infrastructure leading to changes to system hydrology may lead to a loss in aquatic biodiversity.	**WOM**	Moderate		May cause irreplaceable loss of resources
		WM	Negligible		May cause irreplaceable loss of resources
4	Potentially inadequate design of infrastructure leading to contamination of water and sediments in the streams may lead to a loss in aquatic biodiversity.	**WOM**	High		May cause irreplaceable loss of resources
		WM	Low		Can be avoided, managed or mitigated
Construction Phase					
5	Site clearing and the removal of vegetation may lead to a loss in aquatic biodiversity. Site clearing and	**WOM**	High	No use of clean surface water or any groundwater which potentially recharges the watercourses in the area should take place. In this regard specific mention is made of any water use which will affect	May cause irreplaceable loss of resources

Nr	Activity	Without or With Mitigation	Significance	Mitigation Measures	Mitigation Effect
	Loss of aquatic biodiversity and sensitive taxa				
			Magnitude		
	road construction may lead to a loss in aquatic biodiversity.	**WM**	Negligible	the instream flow in the Klein Marico River and the associated tributaries and in turn affect more sensitive taxa which require faster flowing habitat * Very strict control of water consumption must take place and detailed monitoring must take place and where all water usage must continuously be optimised * Permit only essential construction personnel within 100m of all riparian systems * Keep all demarcated sensitive zones outside of the construction area off limits during the construction phase of the development * Ongoing implementation of the alien vegetation control program * Very clear and well managed clean and dirty water separation must take place in line with the requirements of regulation GN704 of the National Water Act * All dirty water facilities must be managed in such a way as to ensure that storage and surge capacity is available if a rainfall event occurs * Limit the footprint area of the construction activity to what is absolutely essential in order to minimise the loss of clean water runoff areas and the concomitant recharge of streams in the area and the disturbance of soils leading to runoff, erosion and sedimentation * Ensure that all spills are immediately cleaned up * All hazardous chemicals must be stored on specified surfaces * Keep all demarcated sensitive zones outside of the construction area off limits during the construction phase of the development as well as during the operational phase of the mine * Any areas where active erosion is observed must be rehabilitated and berms utilised to slow movement of water * Prevent run-off from dirty water areas entering stream systems through ensuring clear separation of clean and dirty water areas * Monitor all systems for erosion and incision * Monitor all affected riparian systems for moisture stress * Monitor all potentially affected riparian zones for changes in riparian vegetation structure * Ongoing aquatic ecological monitoring must take place on a bi-annual basis by an SA RHP Accredited assessor * Ongoing aquatic biomonitoring should take place in order to identify any emerging issues in the receiving environment	Can be avoided, managed or mitigated
6	Earthworks and other mining construction activities in the vicinity of wetland and riparian areas may lead to a loss in aquatic biodiversity.	**WOM**	High		May cause irreplaceable loss of resources
		WM	Negligible		Can be avoided, managed or mitigated
7	Placement of infrastructure within non-perennial drainage lines with special mention of the overburden stockpile areas, road crossings and bridges may lead to a loss in aquatic biodiversity.	**WOM**	High		May cause irreplaceable loss of resources
		WM	Negligible		Can be avoided, managed or mitigated
8	Inadequate separation of clean and dirty water areas may lead to a loss in aquatic biodiversity.	**WOM**	High		May cause irreplaceable loss of resources
		WM	Low		Can be avoided, managed or mitigated

Loss of aquatic biodiversity and sensitive taxa

Nr	Activity	Without or With Mitigation	Significance / Magnitude	Mitigation Measures	Mitigation Effect
Operational Phase					
9	Ongoing disturbance of soils with general operational activities may lead to a loss in aquatic biodiversity.	**WOM**	High	No use of clean surface water or any groundwater which potentially recharges the watercourses in the area should take place. In this regard specific mention is made of any water use which will affect the instream flow in the Klein Marico River and the associated tributaries and in turn affect more sensitive taxa which require faster flowing habitat * Very strict control of water consumption must take place and detailed monitoring must take place and where all water usage must continuously be optimised * Permit only essential operating personnel within 100m of all riparian systems * Keep all demarcated sensitive zones outside of the operational area off limits during the operational phase of the development Ongoing implementation of the alien vegetation control program * Very clear and well managed clean and dirty water separation must take place in line with the requirements of regulation GN704 of the National Water Act * All dirty water facilities must be managed in such a way as to ensure that storage and surge capacity is available if a rainfall event occurs * Limit the footprint area of the operational activity to what is absolutely essential in order to minimise the loss of clean water runoff areas and the concomitant recharge of streams in the area and the disturbance of soils leading to runoff, erosion and sedimentation * Ensure that all spills are immediately cleaned up * All hazardous chemicals must be stored on specified surfaces * Ensure that all stockpiles are well managed and have measures such as berms and hessian sheets implemented to prevent erosion and sedimentation which may ultimately lead to transformation of aquatic habitat areas * Any areas where active erosion is observed must be rehabilitated and berms utilised to slow movement of water * Prevent run-off from dirty water areas entering stream systems through ensuring clear separation of clean and dirty water areas *	Can be reversed
		WM	Negligible		Can be avoided, managed or mitigated
10	Inadequate separation of clean and dirty water areas may lead to a loss in aquatic biodiversity.	**WOM**	High		May cause irreplaceable loss of resources
		WM	Low		Can be avoided, managed or mitigated
11	Loss of instream flow due to abstraction for water for production may lead to a loss in aquatic biodiversity.	**WOM**	Moderate		Can be reversed
		WM	Negligible		Can be avoided, managed or mitigated
12	Seepage from the discard dumps and overburden stockpiles may lead to a loss in aquatic biodiversity.	**WOM**	High		May cause irreplaceable loss of resources
		WM	Moderate		May cause irreplaceable loss of resources
13	Potential discharge from the mine process water system with special mention of RWD and any PCD's may lead to a loss in aquatic biodiversity.	**WOM**	High		Can be reversed
		WM	Low		Can be avoided, managed or mitigated

Loss of aquatic biodiversity and sensitive taxa					
Nr	**Activity**	**Without or With Mitigation**	**Significance**	**Mitigation Measures**	**Mitigation Effect**
			Magnitude		
14	Sewage discharge from mine offices and camps may lead to a loss in aquatic biodiversity.	**WOM**	Low	Ensure that the mine process water system is managed in such a way as to prevent discharge to the receiving environment and to prevent discharge of dirty water * Implement measures to contain seepage as far as possible to prevent contamination of the groundwater regime * Monitor all systems for erosion and incision * Monitor all affected riparian systems for moisture stress * Monitor all potentially affected riparian zones for changes in riparian vegetation structure * Ongoing aquatic ecological monitoring must take place on a bi-annual basis by an SA RHP Accredited assessor * Ongoing aquatic biomonitoring should take place in order to identify any emerging issues in the receiving environment; Ø Monitor all dirty water control facilities using toxicological screening methods and implement the calculation of discharge dilution factors by means of the Direct Estimation of Ecological Effect Potential (DEEEP) protocol * Toxicological monitoring of the receiving and process water systems on a quarterly basis.	Can be reversed
		WM	Negligible		Can be avoided, managed or mitigated
15	Increased concentrations of fluorides or fluoride salts reaching the surface water resources may lead to a loss in aquatic biodiversity	**WOM**	High		May cause irreplaceable loss of resources
		WM	Moderate		May cause irreplaceable loss of resources
Closure and Decommissioning Phase					
16	Disturbance of soils as part of demolition activities may lead to a loss in aquatic biodiversity.	**WOM**	Low	Ensure that as far as possible all decommissioning activities take place outside of drainage and river areas. In particular mention is made of the need to not encroach on the riparian systems near the Klein Marico River and its associated drainage lines with a minimum buffer of 100m around all riparian systems maintained in line with the requirements of regulation GN704 of the National Water Act * No use of clean surface water or any groundwater which potentially recharges the watercourses in the area should take place. In this regard specific mention is made of any water use which will affect the instream flow in the Klein Marico River and the associated tributaries and in turn affect more sensitive taxa which require faster flowing habitat * Very strict control of water consumption must take place and detailed monitoring must take place and where all water usage must continuously be optimised * Permit only essential	May cause irreplaceable loss of resources
		WM	Negligible		Can be reversed
17	Inadequate separation of clean and dirty water areas may lead to a loss in aquatic biodiversity.	**WOM**	High		May cause irreplaceable loss of resources
		WM	Low		Can be avoided, managed or mitigated

Loss of aquatic biodiversity and sensitive taxa

Nr	Activity	Without or With Mitigation	Significance	Mitigation Measures	Mitigation Effect
			Magnitude		
18	Seepage from any latent discard dumps and dirty water areas may lead to a loss in aquatic biodiversity.	**WOM**	High	personnel within 100m of all riparian systems * Keep all demarcated sensitive zones outside of the decommissioning area off limits during the decommissioning phase of the development * Ongoing adherence to the alien vegetation control program * Very clear and well managed clean and dirty water separation must take place in line with the requirements of regulation GN704 of the National Water Act * Limit the footprint area of the decommissioning activities to what is absolutely essential in order to minimise the loss of clean water runoff areas and the concomitant recharge of streams in the area and the disturbance of soils leading to runoff, erosion and sedimentation * Ensure that all spills are immediately cleaned up * All hazardous chemicals must be stored on specified surfaces * Any areas where active erosion is observed must be rehabilitated and berms utilised to slow movement of water * Implement measures to contain seepage from latent dirty water areas as far as possible to prevent contamination of the groundwater regime * Monitor all systems for erosion and incision * Monitor all affected riparian systems for moisture stress * Monitor all potentially affected riparian zones for changes in riparian vegetation structure * Ongoing aquatic ecological monitoring must take place on a bi-annual basis by an SA RHP Accredited assessor * Ongoing aquatic biomonitoring should take place in order to identify any emerging issues in the receiving environment * Monitor all dirty water control facilities using toxicological screening methods and implement the calculation of discharge dilution factors by means of the Direct Estimation of Ecological Effect Potential (DEEEP) protocol; Ø Toxicological monitoring of the receiving and process water systems on a quarterly basis.	May cause irreplaceable loss of resources
		WM	Moderate		May cause irreplaceable loss of resources
19	Inadequate closure leading to post closure impacts on water quality may lead to a loss in aquatic biodiversity.	**WOM**	High		May cause irreplaceable loss of resources
		WM	Negligible		Can be avoided, managed or mitigated
20	Ongoing erosion of disturbed areas that have not been adequately rehabilitated may lead to a loss in aquatic biodiversity.	**WOM**	Moderate		May cause irreplaceable loss of resources
		WM	Negligible		Can be avoided, managed or mitigated
Post-Closure Phase					

Nr	Activity	Without or With Mitigation	Significance	Mitigation Measures	Mitigation Effect
	Loss of aquatic biodiversity and sensitive taxa				
			Magnitude		
21	Ongoing erosion of disturbed areas that have not been adequately rehabilitated may lead to a loss in aquatic biodiversity.	WOM	Moderate	Ongoing monitoring of the process water system and selected boreholes should take place for a period of at least three years post closure to monitor and mitigate any groundwater contamination plume post-closure as a result of seepage from latent dirty water areas * Ensure that no incision and canalisation of the aquatic resources present takes place as a result of inadequately rehabilitated mining areas * All erosion noted within the study area should be remedied immediately and included as part of the ongoing rehabilitation plan for a period of at least three years post-closure* As much vegetation growth as possible should be promoted to protect soils and vegetation clearance should be kept to a minimum as the biomass in the area is not very high and so hence the plants will not grow quickly * Ongoing adherence to the alien vegetation control program within the riparian zones with special mention of water loving tree species and invasive species such as Arundo donax and Typha capensis * Monitor all affected riparian systems for moisture stress * Monitor all potentially affected riparian zones for changes in riparian vegetation structure * Ongoing aquatic ecological monitoring must take place on a bi-annual basis by an SA RHP Accredited assessor in order to identify any emerging issues in the receiving environment	May cause irreplaceable loss of resources
		WM	Negligible		Can be avoided, managed or mitigated
22	Inadequate separation of clean and dirty water areas may lead to a loss in aquatic biodiversity.	WOM	High		May cause irreplaceable loss of resources
		WM	Low		Can be avoided, managed or mitigated
23	Seepage from any latent discard dumps and dirty water areas may lead to a loss in aquatic biodiversity.	WOM	High		May cause irreplaceable loss of resources
		WM	Moderate		May cause irreplaceable loss of resources
24	Potential post closure impacts on water quality may lead to a loss in aquatic biodiversity.	WOM	High		May cause irreplaceable loss of resources
		WM	Moderate		May cause irreplaceable loss of resources