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Proposed Development of an Underground Coal Mine and Associated Infrastructure, near Hendrina, Mpumalanga Province

Aquatic Ecology Assessment Report

Project Number:

XST3791

Prepared for:

Umcebo Mining (Pty) Ltd

March 2017

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Report Type:	**Aquatic Ecology Assessment Report**
Project Name:	**Proposed Development of an Underground Coal Mine and Associated Infrastructure, near Hendrina, Mpumalanga Province**
Project Code:	**XST3791**

Name	Responsibility	Signature	Date
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DECLARATION OF INDEPENDENCE

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I, Russell Tate as duly authorised representative of Digby Wells and Associates (South Africa) (Pty) Ltd., hereby confirm my independence (as well as that of Digby Wells and Associates (South Africa) (Pty) Ltd.) and declare that neither I nor Digby Wells and Associates (South Africa) (Pty) Ltd. have any interest, be it business, financial, personal or other, in any proposed activity, application or appeal in respect of Umcebo Mining (Pty) Ltd, other than fair remuneration for work performed, specifically in connection with the proposed development of an underground coal mine and associated infrastructure, located near Hendrina, Mpumalanga Province.

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EXECUTIVE SUMMARY

Umcebo Mining (Pty) Ltd (Umcebo), a subsidiary of Glencore Operations South Africa (Pty) Ltd (Glencore) is proposing the development and operation of a new underground coal mine and associated infrastructure at a site situated approximately 10-20 kilometres south east of Hendrina in the Mpumalanga Province of South Africa (the project).

Digby Wells Environmental was appointed by Umcebo as the independent environmental consultant to undertake the Environmental Impact Assessment (EIA) for the project. As part of the EIA, Digby Wells have completed an aquatic ecology specialist study to establish baseline conditions, complete an impact assessment and develop a monitoring programme for the project.

Umcebo currently holds two prospecting rights consisting of three underground reserve blocks referred to as Mooivley East, Mooivley West and Hendrina South. The prospecting rights are located in the Olifants River Water Management Area, within the B12A quaternary catchment which is the upper reaches of the Klein Olifants River system. In order to determine the baseline ecological status of rivers associated with the project, the associated waterbodies were assessed on a bi-annual basis, once during the high flow (March 2016) and once during the low flow (June 2016). Applying standard River Ecosystem Monitoring Programme (REMP) techniques, the Present Ecological Status (PES) of the river reach was determined. The results of the assessment derived an overall PES class of moderately/largely modified (class C/D). This class was derived due to the existing land use within the catchment area of the Klein Olifants River. The primary cause of the poor ecological status was found to be associated with various agricultural practices including extensive livestock agriculture which has resulted in erosion and subsequent sedimentation of the assessed river reaches.

Considering this baseline, an impact assessment was completed bearing in mind the planned project activities. A summary of the impact assessment is provided in the table below (Table 1).

Table 1: Summary of potential impacts

Interaction	Impact	Severity after mitigation
Phase: Construction		
Site clearance within associated wetland habitats and river catchment and construction of surface infrastructure	Increased runoff resulting in erosion and sedimentation of downstream habitats. Increased runoff from manmade structures resulting in the erosion and sedimentation of downstream river reaches	Minor

Interaction	Impact	Severity after mitigation
Phase: Construction		
Construction over watercourses	Construction over sensitive riparian habitats resulting in the loss and/or degradation of aquatic habitat	Moderate
Waste generation and disposal	Runoff containing pollutants and solid waste resulting in water and habitat quality degradation in downstream river reaches	Minor
Phase: Operational		
Underground blasting and mining	Undermining of wetlands and rivers leading to hydrological and geomorphic changes to the functioning of the ecosystem; particularly related to groundwater impacts	Minor
Storage, hauling, processing, conveying and stockpiling of coal	Runoff water which comes into contact with the carboniferous material will contain various pollutants that may contaminate downstream river reaches	Minor
Phase: Closure and Rehabilitation		
Removal of infrastructure and surface rehabilitation.	Similarly to the construction phase, the removal of the infrastructure will lead to potential negative impacts on the habitat integrity of the associated aquatic ecosystems	Minor
Underground mine closure and rehabilitation	Post-mining decant of groundwater will have negative impacts on the downstream water quality	Minor

Based on this impact assessment, several key impacts were identified, as follows:

- Potential impacts from a conveyor and road crossing on a watercourse at the Hendrina South prospecting right area;
- Potential significant impacts from undermining of wetlands and waterbodies; and
- Potential decant of Acid Mine Drainage during the closure and post-closure phases resulting in significant water quality modification in the Klein Olifants drainage.

Considering the above potential impacts, should the mining operation go ahead provision should be made to mitigate against the subsidence of land associated with waterbodies and wetland areas. Furthermore provision should be made for potential Acid Mine Drainage which will likely occur within the post-closure phase.

Key recommended monitoring conditions have been provided in this report along with various mitigation actions. Some key mitigation actions include the following:

- Buffer zone establishment: 50m from delineated wetland areas and 100m from riparian zones;
- Clean, dirty water separation and storm water management: Clean water should be managed in a manner according to the DWS Best Practice Guidelines;
- Exposed topsoil's and soil stockpiles must be revegetated to reduce erosion and subsequent sedimentation;
- Although a basic geotechnical study has been completed, recommendations from the report indicate that a comprehensive geotechnical study must be conducted to assess the risk for subsidence in areas associated with the Klein Olifants River. Mitigation actions to increase stability should be used in delineated high risk areas. These mitigation actions include limiting roads underneath the river system and thicker support pillars, however, detailed mitigation actions should be defined in the geotechnical study.
- Based on the revision of the mining plan, the coal reserve which is located at a depth less than 40m and associated with wetlands, will only be mined to a limited extent, with thick enough support pillars to avoid surface subsidence. This will reduce the risk of subsidence in local river catchments.
- Pollution Control Dams must be designed and operated in such a way that it will not spill more than once in 50 years. The dam must be able to contain the water required for operations, a storm event including a 0.8m freeboard at all times.
- Groundwater mitigation actions for potential Acid Mine Drainage will be elaborated once the groundwater study of this project is completed.

It is recommended that this report should not be considered in isolation and that other specialist reports should be reviewed including surface water, groundwater and wetland studies.

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1 Introduction

Umcebo Mining (Pty) Ltd (Umcebo), a subsidiary of Glencore Operations South Africa (Pty) Ltd (Glencore), is proposing the development and operation of a new underground coal mine and associated infrastructure at a site situated approximately 10-22 kilometres (km) south east of Hendrina in the Mpumalanga Province of South Africa (the project).

Umcebo currently holds two Prospecting Rights (PRs), namely, MP 1265 PR and MP 1266 PR, located within the Ermelo Coal Field. The total extent of MP 1265 PR (referred to as Mooivley East and Mooivley West) is 3 923 hectares (ha) and comprises the following farms and portions (Figure 6-2):

- Mooivley 219 IS – Portions 2, 4, 5 and Remaining Extent (RE) of the farm;
- Tweefontein 203 IS – Portions 2, 15, 16, 17 and Portion of Portion 14;
- Uitkyk 220 IS – Portions 2 and 3; and
- Orange Vallei 201 IS – Portions 1 and RE of the farm.

The total extent of MP 1266 PR (referred to as Hendrina South) is 2 787 ha and comprises the following farms and portions:

- Elim 247 IS - RE of the farm;
- Geluksdraai 240 IS – Portions 1 and 2;
- Orpenskraal 238 IS – RE of the farm; and
- Bosmanskrans 217 IS – Portions 1, 3, 4, 6, 8, 9 and RE of the farm.

The project area thus has a combined footprint of 6 714 ha and is located within the Steve Tshwete Local Municipality (STLM) and Msukaligwa Local Municipality (MLM).

1.1 Project Overview

The project area comprises three underground reserve blocks namely Mooivley East, Mooivley West and Hendrina South (Figure 6-2). Due to the depth of the resource (i.e. 32 m to 128 m below surface), underground mining will be used to access the ore body. The proposed mining method for the extraction of coal will be bord and pillar. In mechanised bord and pillar mining, extraction is achieved by developing a series of roadways (bords) in the coal seam connected by splits (cut-throughs) to form pillars and is done through the use of machinery referred to as a continuous miner. These pillars are left behind as part of a primary roof support system.

The two Mooivley reserves comprise two incline shafts which will be developed to gain access to the two underground areas whilst the Hendrina South reserve also comprises an incline shaft to gain access to one underground area. Mooivley West and Hendrina South will commence at the same time. Once Hendrina South is completed, Mooivley East mining activities will commence.

The estimated Life of Mine (LoM) will be 30 years[1] for all mining areas with a production rate of 2.4 million tonnes per annum at full capacity, with a total of approximately 78 million tonnes of Run of Mine (ROM). The mine will reach full production within the first four years.

The grade of coal is poor and therefore not suitable for export. The coal product will be transported to a nearby Eskom power station (i.e. Kusile, Kendal, Kriel, Grootvlei); via the existing road network.

Limited surface infrastructure will be established to support the mining activities. All proposed mine infrastructure has been reflected on Figure 9-2, Figure 9-3 and Figure 9-4 which includes the following:

- Crushing and Screening Plant;
- Overburden and Product Stockpiles;
- Access and Service Roads (with weighbridge);
- Overland Conveyors;
- Three Access Points to the Underground Reserve;
- Three Ventilation Shafts (one per access point);
- Office Complex (change house, workshop, offices);
- Three PCD and Water Pipelines;
- Five Aboveground Bulk Diesel Storage Tanks;
- Three Waste Bins (per shaft);
- Site Fencing;
- Diesel Generator and Sub-station;
- Water Treatment Plant; and
- Package Sewage Treatment Plant.

The project is proposed to commence with construction and development when all required licences and authorisations have been granted.

1.2 Project Activities

A detailed list of the project activities is presented below (Table 2). These activities will be considered to conduct the aquatic ecology impact assessment in section 9 of this report.

[1] The MRA will be made for an initial period of 30 years, the maximum allowed in terms of the provisions of Section 23 of the MPRDA. At the end of this period an application for renewal of the mining right will be made for any remaining reserves.

Table 2: Project Activities

Project Phase	Project Activity	Project Structures
Construction	Site Clearance	Topsoil Stockpiles
	Blasting and Excavation	Three Shaft Areas
	Construction of Surface Infrastructure	Crushing and Screening Plant Mine Offices Change House Workshop Overburden and Product Stockpiles Site Fencing Access and Service Roads (with weighbridge) Overland Conveyor Sewage Treatment Plant Three Pollution Control Dam Water Treatment Plant Diesel Storage Tanks Ventilation Shaft per mining right area
	Water Abstraction and Use	Water Tanks and Pipes
	Waste Generation and Disposal	Waste Skips
	Power Generation	Diesel Generator
Operations	Underground Blasting and Mining	Heavy Machinery and Equipment
	Stockpiling	Waste Rock Berms Product Stockpile
	Hauling/Conveying of Coal	Overland Conveyor Belt Haul and Access Roads
	Plant and Equipment Operations	Crushing and Screening Plant Workshop and Diesel Storage Tanks
	Water Use and Storage	Pollution Control Dam and Jo Jo Tanks
	Waste Generation and Storage	Sewage Treatment Plant Waste Skips
	Power Generation	Diesel Generator

Project Phase	Project Activity	Project Structures
Mine Decommissioning and Closure	Removal of infrastructure and surface rehabilitation	Crushing and Screening Plant Mine Offices Change House Workshop Overburden and Product Stockpiles Site Fencing Access and Service Roads (with weighbridge) Overland Conveyor Sewage Treatment Plant Three Pollution Control Dams Water Treatment Plant Diesel Storage Tanks Ventilation Shaft per mining right area
	Waste Generation and Disposal	Waste Skips

1.3 Terms of Reference

Digby Wells Environmental was contracted to complete an aquatic ecology baseline assessment of the water resources associated with the abovementioned proposed mining activities to support the Environmental Impact Assessment (EIA) and Environmental Management Plan (EMP). In addition, an evaluation of the identified potential impacts on the baseline aquatic ecosystems as a result of the proposed mining and mining related infrastructure development was conducted and mitigation measures recommended to avoid and/or minimise the impacts identified.

2 Details of the Specialist

Russell Tate is a published, registered Professional Scientist (Pr. Sci. Nat Aquatic Health: 400089/15) with an MSc in aquatic eco-toxicology. Russell has completed aquatic ecology related projects in South Africa, Mozambique, Botswana, Zambia, Ivory Coast, Ghana, Mali, Liberia, Sierra Leone, Senegal, Cameroon and throughout north, eastern and central Democratic Republic of Congo.

Considering the wide geographical range of the projects completed, Russell has a good technical understanding on the variable conditions within African rivers, as well as their biological compositions. This has allowed Russell to gain knowledge of a diversity of freshwater ecoregions within Africa.

3 Aims and Objectives

The aim of this study was to determine the pre-development aquatic ecosystem baseline condition prior to commencement of the proposed mining and mining related development. This was achieved by means of a detailed infield assessment on the aquatic ecosystem and calculation of the Present Ecological Status (PES) of the local watercourses associated with the proposed mining and mining related development.

In addition, all potential impacts on the aquatic ecosystems as a result of the proposed mining related development was identified, evaluated and mitigation measures were recommended to avoid, prevent, limit and/or minimize the identified impacts associated with the proposed development.

Lastly, based on the findings of the baseline and impact assessments, a monitoring programme was compiled to monitor various recommended aquatic ecosystem parameters on a long-term to identify any changes and/or impact to ensure compliance with local, provincial and national legislation including the Resource Water Quality Objectives (RWQO) and the National Water Act, 1998 (Act No. 36 of 1998) (NWA).

4 Methodology

4.1 Literature Review and Desktop Assessment

Published articles related to aquatic ecosystems of the region were reviewed to gain an understanding of the nature of the aquatic ecosystem of the surrounding environment. Desktop information consulted was based primarily on the most up to date version of the Desktop Assessment for the PES, Ecological Importance and Sensitivity (EIS) per Sub Quaternary Reaches (SQR) of Secondary Catchments in South Africa (Department of Water and Sanitation, 2016).

4.2 Fieldwork and Seasonal Influence

In order to identify temporal ecological trends within the associated river systems, a survey was conducted in the high flow season (15^{th} -17^{th} March 2016) and within the low flow season (7^{th} – 9^{th} June 2016).

4.3 Present Ecological Status

The PES of the associated aquatic ecosystems was determined using the River Eco-status Monitoring Programme (REMP) Ecological Classification manuals (Kleynhans and Louw, 2007). The PES was derived through the characterisation of the various biophysical attributes for the considered river systems as presented in the sections below.

4.4 Water Quality

Water quality was measured using a calibrated Extech DO 700 multimeter. Constituents considered included temperature, pH, Dissolved Oxygen (DO) (mg/l) and conductivity (µS/cm). The results of the Digby Wells Surface Water Assessment (DWE, 2016), in which the chemical analysis of water was completed, was used to supplement these results. Water quality guidelines used in this report are for Aquatic Ecosystems (DWAF, 1998).

4.5 Habitat Quality

The availability and diversity of aquatic habitat is important to consider in assessments due to the reliance and adaptations of aquatic biota to specific habitats types (Barbour *et. al*., 1996). Habitat quality and availability assessments are usually conducted alongside biological assessments that utilise fish and macroinvertebrates. Aquatic habitat (habitat) was assessed through visual observations on each river system considered.

4.5.1 Intermediate Habitat Integrity Assessment

To define a general habitat, for baseline purposes, the instream and riparian habitat was assessed and characterised according to “Procedure for Rapid Determination of Resource Directed Measures for River Ecosystems (Section D).

The Intermediate Habitat Integrity Assessment (IHIA) model was used to assess the integrity of the habitats from a riparian and instream perspective. The habitat integrity of a river refers to the maintenance of a balanced composition of physico-chemical and habitat characteristics on a temporal and spatial scale that are comparable to the characteristics of natural habitats of the region (Kleynhans, 1996). The criteria utilised in the assessment of habitat integrity in the current study are presented in Table 3.

Table 3: Criteria in the Assessment of Habitat Integrity

Criterion	Relevance
Water abstraction	Direct impact on habitat type, abundance and size. Also implicated in flow, bed, channel and water quality characteristics. Riparian vegetation may be influenced by a decrease in the supply of water.
Flow modification	Consequence of abstraction or regulation by impoundments. Changes in temporal and spatial characteristics of flow can have an impact on habitat attributes such as an increase in duration of low flow season, resulting in low availability of certain habitat types or water at the start of the breeding, flowering or growing season.
Bed modification	Regarded as the result of increased input of sediment from the catchment or a decrease in the ability of the river to transport sediment (Gordon *et. al*., 1993). Indirect indications of sedimentation are stream bank and catchment erosion. Purposeful alteration of the stream bed, e.g. the removal of rapids for navigation (Hilden & Rapport, 1993) is also included.

Criterion	Relevance
Channel modification	May be the result of a change in flow, which may alter channel characteristics causing a change in marginal instream and riparian habitat. Purposeful channel modification to improve drainage is also included.
Water quality modification	Originates from point and diffuse point sources. Measured directly or alternatively agricultural activities, human settlements and industrial activities may indicate the likelihood of modification. Aggravated by a decrease in the volume of water during low or no flow conditions.
Inundation	Destruction of riffle, rapid and riparian zone habitat. Obstruction to the movement of aquatic fauna and influences water quality and the movement of sediments (Gordon *et. al*., 1992).
Exotic macrophytes	Alteration of habitat by obstruction of flow and may influence water quality. Dependent upon the species involved and scale of infestation.
Exotic aquatic fauna	The disturbance of the stream bottom during feeding may influence the water quality and increase turbidity. Dependent upon the species involved and their abundance.
Solid waste disposal	A direct anthropogenic impact which may alter habitat structurally. Also a general indication of the misuse and mismanagement of the river.
Indigenous vegetation removal	Impairment of the buffer the vegetation forms to the movement of sediment and other catchment runoff products into the river (Gordon *et. al*., 1992). Refers to physical removal for farming, firewood and overgrazing.
Exotic vegetation encroachment	Excludes natural vegetation due to vigorous growth, causing bank instability and decreasing the buffering function of the riparian zone. Allochtonous organic matter input will also be changed. Riparian zone habitat diversity is also reduced.
Bank erosion	Decrease in bank stability will cause sedimentation and possible collapse of the river bank resulting in a loss or modification of both instream and riparian habitats. Increased erosion can be the result of natural vegetation removal, overgrazing or exotic vegetation encroachment.

The relevant criteria is then weighted and scored according to Kleynhans (1996), as seen in the tables below (Table 4 and Table 5).

Table 4: Table giving Descriptive Classes for the Assessment of Modifications to Habitat Integrity

Impact Category	Description	Score
None	No discernible impact or the modification is located in such a way that it has no impact on habitat quality, diversity, size and variability.	0
Small	The modification is limited to very few localities and the impact on habitat quality, diversity, size and variability are also very small.	1-5

Impact Category	Description	Score
Moderate	The modifications are present at a small number of localities and the impact on habitat quality, diversity, size and variability are also limited.	6-10
Large	The modification is generally present with a clearly detrimental impact on habitat quality, diversity, size and variability. Large areas are, however, not influenced.	11-15
Serious	The modification is frequently present and the habitat quality, diversity, size and variability in almost the whole of the defined area are affected. Only small areas are not influenced.	16-20
Critical	The modification is present overall with a high intensity. The habitat quality, diversity, size and variability in almost the whole of the defined section are influenced detrimentally.	21-25

Table 5: Criteria and Weights used for the Assessment of Habitat Integrity

Instream Criteria	Weight	Riparian Zone Criteria	Weight
Water abstraction	14	Indigenous vegetation removal	13
Flow modification	13	Exotic vegetation encroachment	12
Bed modification	13	Bank erosion	14
Channel modification	13	Channel modification	12
Water quality	14	Water abstraction	13
Inundation	10	Inundation	11
Exotic macrophytes	9	Flow modification	12
Exotic fauna	8	Water quality	13
Solid waste disposal	6		
TOTAL	**100**	**TOTAL**	**100**

Scores are calculated based on ratings received from the assessment. The estimated impacts of the criteria are summed and expressed as a percentage to arrive at a provisional habitat integrity assessment. The scores are placed into the IHIA categories (Kleynhans, 1996) as seen in Table 6.

It should be noted that the IHIA was based on regions assessed in the current studies and therefore may only constitute the assessment of conditions within the considered Sub Quaternary Reach (SQR) length.

Table 6: Intermediate Habitat Integrity Categories (Kleynhans, 1996)

Category	Description	Score
A	Unmodified, natural.	90-100
B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.	80-90
C	Moderately modified. A loss and change of natural habitat and biota have occurred but the basic ecosystem functions are still predominantly unchanged.	60-79
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.	40-59
E	The loss of natural habitat, biota and basic ecosystem functions is extensive.	20-39
F	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

4.6 Macroinvertebrates

Macroinvertebrate assemblages are good indicators of localised conditions because many benthic macroinvertebrates have limited migration patterns or a sessile mode of life. They are particularly well-suited for assessing site-specific impacts (upstream and downstream) (Barbour *et. al*., 1999). Benthic macroinvertebrate assemblages are made up of species that constitute a broad range of trophic levels and pollution tolerances, thus providing strong information for interpreting cumulative effects (Barbour *et. al*., 1999). The assessment and monitoring of benthic macroinvertebrate communities forms an integral part of the monitoring of the health of an aquatic ecosystem.

4.6.1 Integrated Habitat Assessment System (IHAS)

The Integrated Habitat Assessment System (IHAS) was specifically designed to be used in conjunction with the South African Scoring System version 5 (SASS5), benthic macroinvertebrate assessment. The IHAS assesses the availability of the biotopes at each site and expresses the availability and suitability of habitat for macroinvertebrates, this is determined as a percentage, where 100% represents "ideal" habitat availability. A description based of the IHAS percentage scores is presented in Table 7.

Table 7: Description of IHAS Scores with the Respective Percentage Category

IHAS Score (%)	Description
>75	Very Good
65–74	Good
55–64	Fair/Adequate
<55	Poor

4.6.2 South African Scoring System (version 5) (SASS5)

The SASS5 is the current biological index being used to assess the status of riverine macroinvertebrates in South Africa. According to Dickens and Graham (2002), the index is based on the presence of aquatic invertebrate families and the perceived sensitivity to water quality changes of these families. Different families exhibit different sensitivities to pollution, these sensitivities range from highly tolerant families (e.g. Muscidae and Psychodidae) to highly sensitive families (e.g. Oligoneuridae). SASS5 results are expressed both as an index score (SASS5 score) and the Average Score Per recorded Taxon (ASPT value).

Sampled invertebrates were identified using the “Aquatic Invertebrates of South African Rivers” (Gerber and Gabriel, 2002). Identification of organisms was made to family level (Thirion *et. al*., 1995; Dickens & Graham, 2002; Gerber & Gabriel, 2002).

All SASS5 and ASPT scores are compared with the SASS5 Data Interpretation Guidelines (Dallas, 2007) for the Highveld lower ecoregion. This method seeks to develop biological bands depicting the various ecological states and is derived from data contained within the Rivers Database and supplemented with other data not yet in the database. The table and figure below illustrate the biological banding and classification (Figure 4-1).

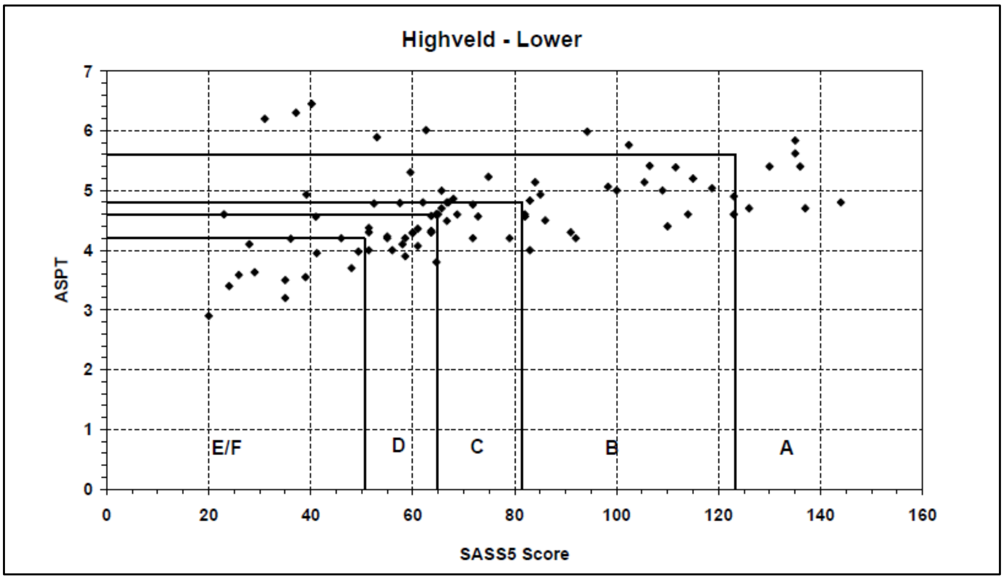

Figure 4-1: Guidelines used for the Interpretation and Classification of the SASS5 Scores (Dallas, 2007)

The SASS5 biotope scores will be used for habitat diversity comparison due to limitations in the IHAS methodology (Tate and Husted, 2015).

4.6.3 Macroinvertebrate Response Assessment Index (MIRAI)

The Macroinvertebrate Response Assessment Index (MIRAI) was used to provide a habitat-based cause-and-effect foundation to interpret the deviation of the aquatic invertebrate community from the calculated reference conditions for the Highveld Lower. This does not preclude the calculation of SASS5 scores if required (Thirion, 2007). The four major components of a stream system that determine productivity for aquatic macroinvertebrates are as follows:

- Flow regime;
- Physical habitat structure;
- Water quality; and
- Energy inputs from the watershed riparian vegetation assessment.

The results of the MIRAI will provide an indication of the current ecological category and therefore assist in the determination of the PES.

4.7 Fish Response Assessment Index

Due the depths of water observed at the sites, fish were captured by means electroshocking. All fish were captured, identified and counted in the field and released alive at the point of capture. Fish species were identified using the "Complete Guide to the Freshwater Fishes of Southern Africa" (Skelton, 2001). The identified fish species were compared to those expected to be present for the B12A quaternary catchment. The expected fish species list was developed from a literature survey and included sources such as (Kleynhans *et. al*., 2007) and Skelton (2001).

The information gained using the Fish Response Assessment Index (FRAI) provides an indication of the PES of the river based on the fish assemblage structures observed. It must be noted that a reach based FRAI assessment was completed. For this assessment it is assumed that habitat is evenly distributed. Frequency of Occurrence (FROC) ratings were adjusted according to the habitat available at each site.

5 Assumptions and Limitations

The methods outlined in this study assume that aquatic ecology within the associated river courses is evenly distributed. Access to several sites was not permissible due to land owner's refusal to allow aquatic specialists onsite during the March 2016 survey. These sites included several points on the lower reaches of the Klein Olifants River. These were however, accessible during the dry season.

No geotechnical studies on the potential for subsidence have yet been completed. Thus, the impact assessment for potential subsidence is assumed.

6 Study Site

The project is located in proximity to the town of Hendrina, Mpumalanga Province and falls within the Olifants Water Management Area. As illustrated in the figure below (Figure 6-1), the proposed mining right areas are located within the B12A and B11A quaternary catchments. The primary drainage of these catchments is the Klein Olifants River in the B12A quaternary catchment and the upper Olifants River in the B11A quaternary catchment (Figure 6-2).

The specific Sub-Quaternary-Reaches (SQR) that will potentially be affected by the proposed project is B12A-01309 (Klein Olifants River) and B11A-01369 (Olifants River).

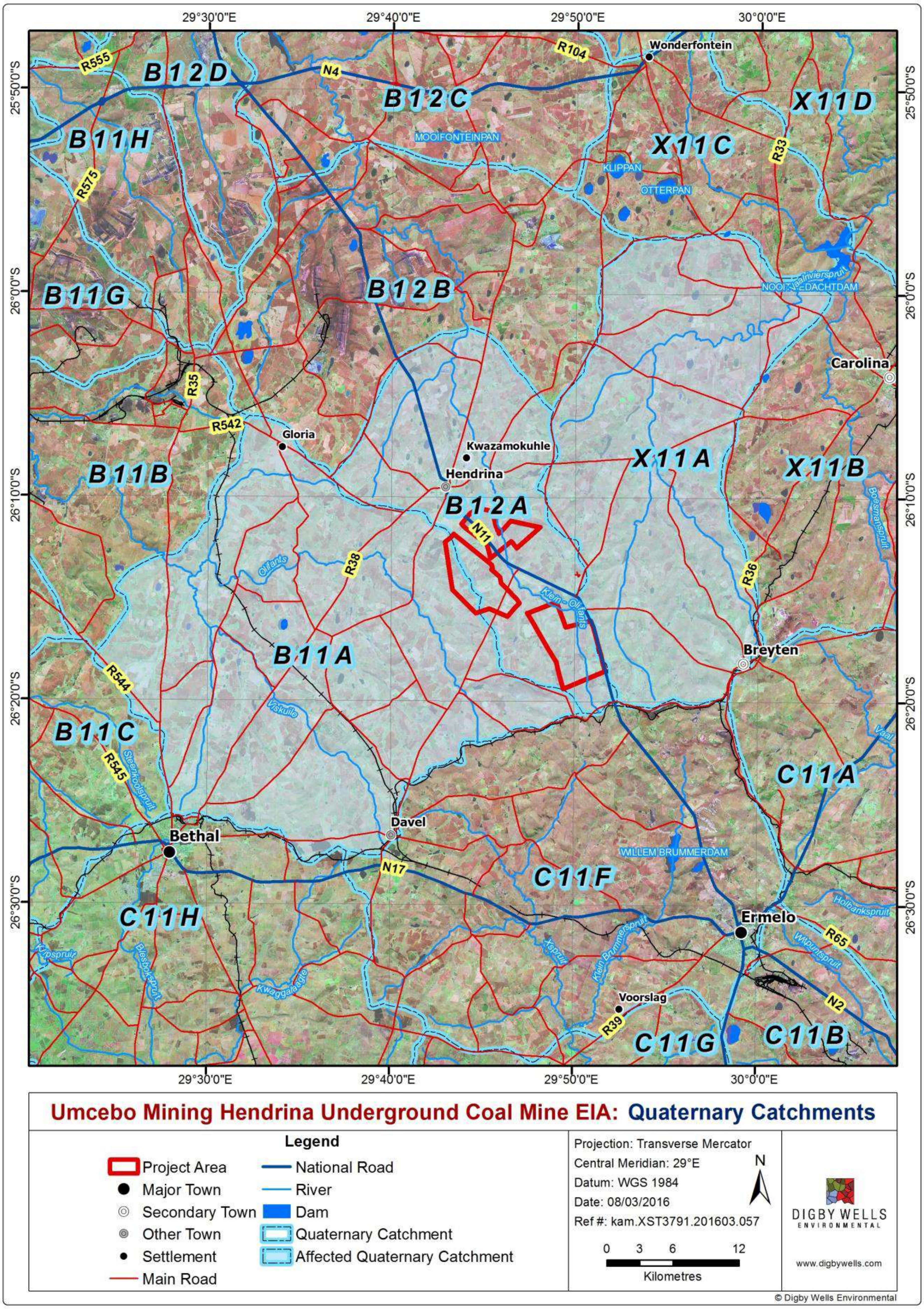

Figure 6-1: Location of the Proposed Mining Right Areas with regards to Quaternary Catchments

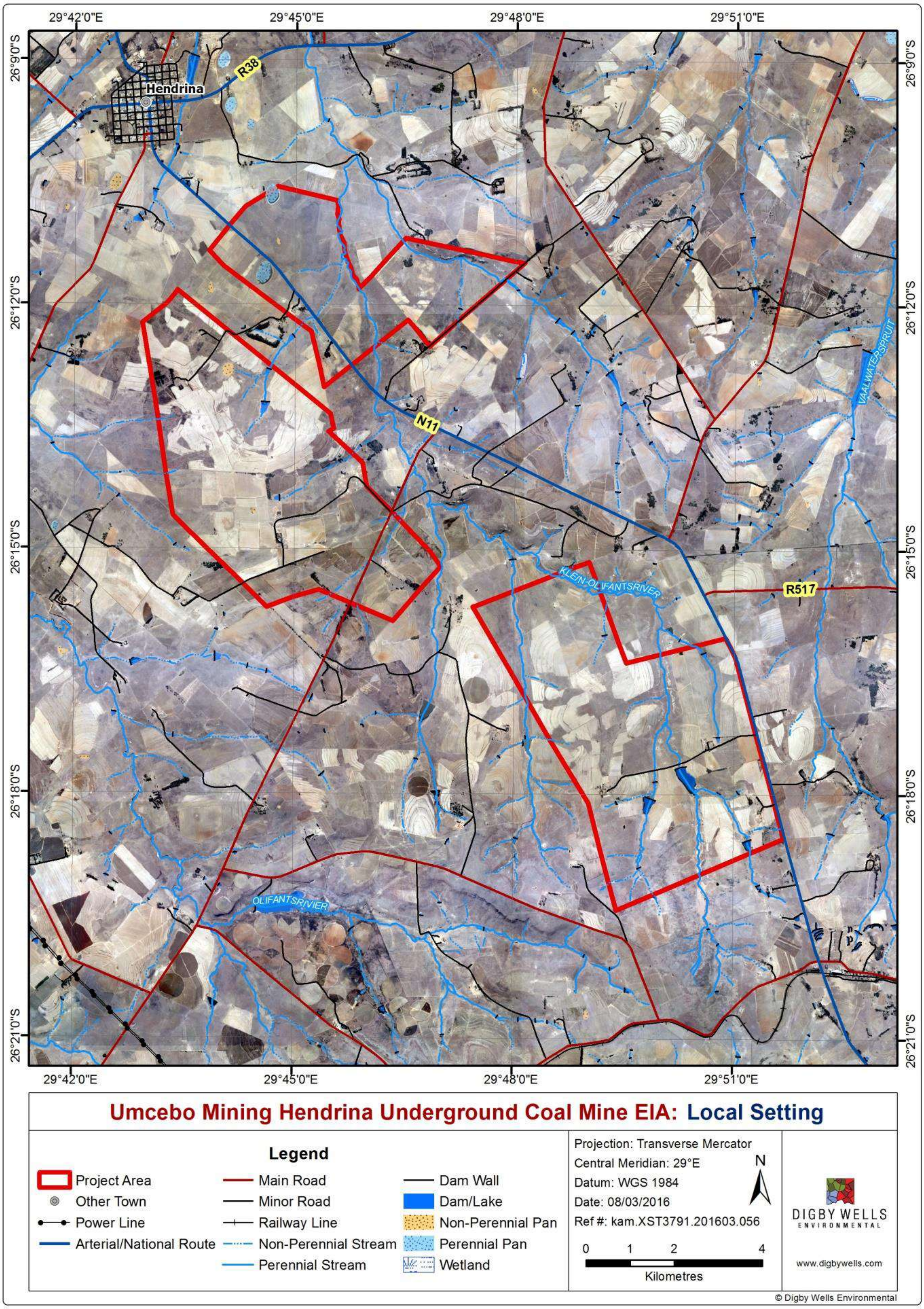

Figure 6-2: Local Setting of the Proposed Project

6.1 Klein Olifants River (B12A-01309)

The considered SQR forms part of the upper reaches or source zone of the Klein Olifants River. Considering this, topography is typical of the Highveld lower ecoregion, with gentle slopes and limited high gradient valley systems. The Klein Olifants river system within the study area has sandy substrates with intermittent bedrock (sandstone) in shallow reaches (Figure 6-3).

Figure 6-3: Typical Characteristics of the Upper Klein Olifants River, March 2016

The current land use within the B12A catchment includes irrigated and dryland agriculture, with numerous abstraction points and impoundments along the river system. In addition to crop agriculture, livestock farming including intensive cattle and sheep production is also abundant, often with the river being used as watering points for the animals.

Limited industrial activities have occurred historically or are present within this catchment area. In addition, residential activities occurring within the immediate region of the project area is limited to the lower reaches of the considered SQR where the town of Hendrina is located.

The available desktop information on the considered SQR is presented below (Table 8).

Table 8: Desktop Information for the B12A-01309 SQR

Component	Rating
Present Ecological Status	class C
Ecological Importance	High
Ecological Sensitivity	High
Recommended Ecological Class	class B

Considering the above findings the PES of the considered SQR is class C or moderately modified. This class has been derived based on the following criterion ratings:

- **Small Impacts:** Mining;
- **Moderate Impacts:** Abstraction, low water crossings, erosion, exotic vegetation, roads, urban areas and vegetation removal; and
- **Large Impacts:** Agricultural lands and small dams.

The ecological importance and sensitivity of the considered SQR was found to be rated as high. This high rating was derived based on the presence of endangered vegetation grassland units with wetland and riparian habitats. According to DWS (2015) there are 3 protected and four endemic wetland species likely found in the considered SQR.

The ecological sensitivity was found to be high due to the small river channel and limited water volumes within the river. Modification to water quality will thus likely have a larger effect due to low volumes within the river channels and subsequent lowered dilution capacity.

The recommended ecological class is largely natural (class B). This class was provided due to desktop PES category of class C and the absence of significant irreversible impacts in the catchment.

A total of six indigenous fish species are expected in SQR and these are presented in Table 9. The expected fish community is composed of predominantly tolerant taxa apart from *Barbus neefi* which is regarded as sensitive to changes in habitat and water quality.

Table 9: Expected Fish Species in the B12A-01309 SQR

Fish	Conservation Status
Barbus anoplus	Least concern
Barbus neefi	Least concern
Barbus paludinosus	Least concern
Clarias gariepinus	Least concern
Pseudocrenilabrus philander	Least concern
Tilapia sparmanni	Least concern

6.2 Olifants River (B11A-01369)

Only a single tributary of the B11A-01369 SQR is expected to be affected by the project. No infrastructure is planned within this catchment and thus is only considered on a desktop level. This unnamed tributary does not conform to the aquatic ecological conditions of the associated SQR as illustrated in the figures below (Figure 6-4 and Figure 6-5).

Based on available aerial imagery the unmanned tributary is a wetland system. Considering this, the unnamed tributary can be regarded as sensitive to habitat modification. Due to the limited presence of point source pollutants, impoundments and other habitat modifying activities in the catchment of the unnamed tributary, it is likely that the system is in a largely natural condition.

Based on the natural conditions in the unnamed tributary the biological sensitivity is likely high with organisms adapted to good water quality likely present within this tributary.

Figure 6-4: Typical Habitat in the Potentially Effected Unnamed Tributary of the B11A-01369 SQR (March 2016)

Figure 6-5: Typical Habitat in the B11A-01369 SQR (March 2016)

6.3 Sampling Points

A total of 11 sites were selected for this study. The location of the selected study sites in relation to the overall mining right area is presented in the figure below (Figure 6-6). Photographs of each site during the assessment are presented in Appendix A. As noted above not all sites were accessible for the high flow survey due to access restrictions. Additionally, during the low flow period several sites were dry and were therefore excluded for aquatic sampling.

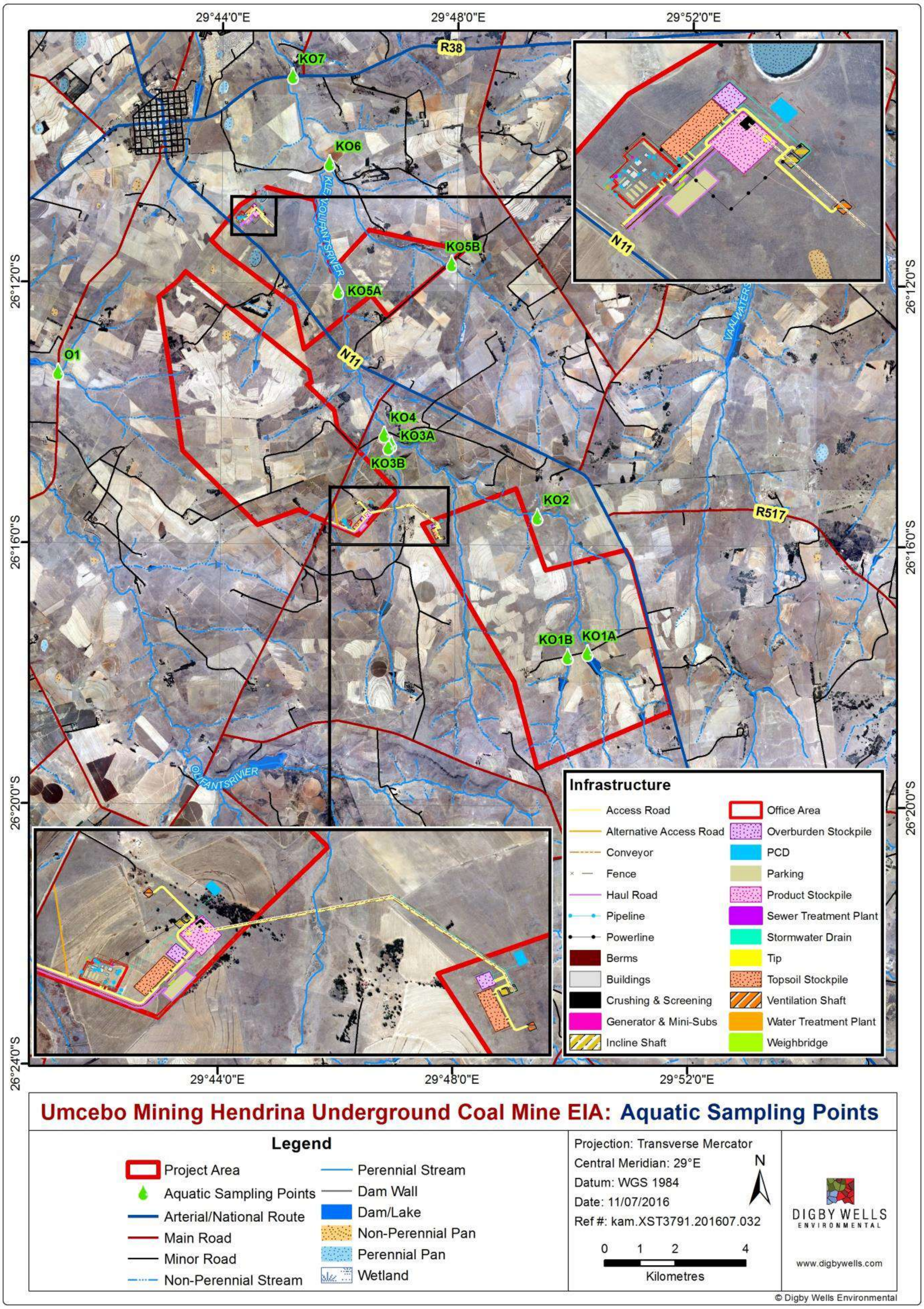

Figure 6-6: Aquatic Ecology Sampling Points

7 Baseline Environment

7.1 Water Quality

The results of the *in situ* water quality analysis are presented in Table 10 for the high flow (March 2016) and Table 11 for the low flow (June 2016) surveys.

Table 10: *In Situ* Water Quality Results for the March 2016 Survey

Constituent	Temperature (ºC)	pH	Conductivity (µS/cm)	Dissolved oxygen (mg/l)
Guidelines	**5-35**	**6-9**	**<700**	**>5**
KO1A	24	7.8	386	6.2
KO1B	25	8.1	419	7.6
KO2	18	7.5	357	5.5
KO3A	27	7.1	586	6.2
KO3B	DRY	DRY	DRY	DRY
KO4	23	7.3	313	5.1
KO5A	No Access	No Access	No Access	No Access
KO5B	DRY	DRY	DRY	DRY
KO6	No Access	No Access	No Access	No Access
KO7	29	7.7	255	5.3
O1	28	7.6	205	5.2

The *in situ* water quality analysis shows that temperature ranged from 18 ºC to 29 ºC as observed during the high flow period. The pH values were shown to range from 7.1 at KO3A to 8.1 at KO1B. Conductivity values ranged from 205 µS/cm at O1 to 586 µS/cm at KO3A. Dissolved oxygen concentrations were shown to range from 5.1 mg/l at KO4 to 7.6 mg/l at KO1B.

Table 11: *In Situ* Water Quality Results for the June 2016 Survey

Constituent	Temperature (ºC)	pH	Conductivity (µS/cm)	Dissolved oxygen (mg/l)
Guidelines	**5-25**	**6-9**	**<700**	**>5**
KO1A	8	7.8	828	5.3
KO1B	DRY	DRY	DRY	DRY
KO2	9.2	7.2	438	6.7
KO3A	DRY	DRY	DRY	DRY

Constituent	Temperature (ºC)	pH	Conductivity (µS/cm)	Dissolved oxygen (mg/l)
Guidelines	**5-25**	**6-9**	**<700**	**>5**
KO3B	DRY	DRY	DRY	DRY
KO4	7.2	7.4	452	5.6
KO5A	14	7.0	311	6.8
KO5B	DRY	DRY	DRY	DRY
KO6	17	6.9	351	6.4
O1	15	7.2	278	5.4

The *in situ* water quality analysis shows that temperature ranged from 7.2 ºC to 17 ºC as observed during the low flow period. The pH values were shown to range from 7.0 at KO5A to 7.4 at KO4. Conductivity values ranged from 278 µS/cm at O1 to 828 µS/cm at KO1A. Dissolved oxygen concentrations were shown to range from 5.3 mg/l at KO1A to 6.8 mg/l at KO5A.

Due to the limited degree of land use that is possible in the upper reaches of a river system, dissolved solid content in waterbodies are typically low. Despite the location of the selected study sites within the upper reaches of the Klein Olifants River, the results of the water quality assessment provide some indication that dissolved solid input into the river system is moderate during both the high and low flow periods. Although the concentrations at the majority of sites assessed were below the guideline threshold effect concentrations, the dissolved solid content is still considered to be elevated. In particular, at site KO1A the dissolved solid content was elevated above the threshold concentrations. Considering these results, it is clear that the water quality within the reach of the Klein Olifants River assessed is modified from what is expected of the upper reaches of a perennial river system.

The pH of the Klein Olifants River system was found to be within a neutral range and therefore would be ideal for aquatic organisms. In addition, temperature and dissolved oxygen content was also found to be within suitable ranges.

In conclusion, the water quality of the reach of the Klein Olifants River assessed has modified water quality with elevated dissolved solid content.

7.2 The Intermediate Habitat Integrity Assessment (IHIA)

The IHIA was completed on the SQR of concern (the Klein Olifants River) and populated with observations recorded during the various surveys. The results of the IHIA on instream habitat are presented in the table below (Table 12) with the riparian integrity assessment presented in Table 13.

Table 12: Intermediate Habitat Integrity Assessment for Instream Habitat

Instream	Average score	Score
Water abstraction	15.33	8.59
Flow modification	16.67	8.67
Bed modification	19.00	9.88
Channel modification	16.67	8.67
Water quality	11.67	6.53
Inundation	13.33	5.33
Exotic macrophytes	5.00	1.80
Exotic fauna	15.00	4.80
Solid waste disposal	5.00	1.20
Total Instream	**44**	
Category		**class D**

Table 13: Intermediate Habitat Integrity Assessment for Riparian Habitat

Riparian	Average score	Score
Indigenous vegetation removal	14.33	5.20
Exotic vegetation encroachment	11.67	4.80
Bank erosion	20.67	11.20
Channel modification	16.67	9.60
Water abstraction	13.33	5.20
Inundation	13.33	4.40
Flow modification	15.33	7.20
Water quality	11.67	5.20
Total Riparian	**47.2**	
Category		**class D**

The IHIA results of the instream and riparian habitats within the SQR are classified as class D or largely modified.

The central cause for the largely modified nature of the SQR habitat can be attributed to local livestock and dryland agricultural practices. Erosion, bed and flow modification criteria were rated high due to impacts from livestock. The upper reaches of the Klein Olifants River is extensively utilised for livestock watering. This has resulted in the sedimentation of the river system and alteration to the stream banks (Figure 7-1).

Figure 7-1: Erosion within the Klein Olifants River below Site KO2 (March 2016)

7.3 Macroinvertebrates

Sites which were inundated were selected for macroinvertebrate assessment.

7.3.1 Integrated Habitat Assessment System (IHAS) and Biotope Assessment

The results of the IHAS completed during the surveys are presented in the table below (Table 14).

Table 14: Integrated Habitat Assessment System results for the 2016 surveys

Site	Score	Suitability
KO1A	55	Fair
KO2	48	Poor
KO3A	48	Poor
KO4	63	Fair
KO5A	58	Fair
KO6	46	Poor
KO7	56	Fair

The results of the biotope diversity assessments are presented in the table below (Table 15).

Table 15: Invertebrate Biotope Diversity (2016)

Biotope	KO1A	KO2	KO3A	KO4	KO5A	KO6	KO7
Stones in current	0	0	0	0	0	0	0
Stones out of current	0	1	0	0	0	0	0
Bedrock	1	1	0	2	1	0	0
Aquatic Vegetation	0	3.5	3	3.5	3	3.5	1
Marginal Vegetation In Current	0	0	0	0	0	0	0.5
Marginal Vegetation Out Of Current	3.5	3	3	2.5	3	3	3
Gravel	0	0	0	0	0	3	0
Sand	0	2	2	3	2	3	3
Mud	3	2	2	3	2	2	3
Biotope Score	7.5	12.5	10	14	11	14.5	10.5
Biotope Score (%)	**16**	**27**	**22**	**31**	**24**	**32**	**23**
Biotope suitability	**Poor**	**Fair**	**Poor**	**Fair**	**Poor**	**Fair**	**Poor**

7.3.2 South African Scoring System

The results of the SASS5 assessments completed for the study are presented below (Table 16 and Table 17).

Table 16: SASS5 Results of the High Flow Survey

Site	KO1A	KO2	KO3A	KO4	KO7
SASS5	63	36	71	94	67
Taxa	14	11	16	20	18
ASPT	4.5	3.2	4.4	4.7	3.7
Category	D	E	C	B	D

The SASS5 scores obtained during the high flow survey ranged from 94 at KO4 to 36 at KO2. The taxa diversity at the sites ranged from 20 at KO4 to 11 at KO2. The ASPT values derived from the SASS5 scores ranged from 3.2 at KO2 to 4.7 at KO4.

Table 17: SASS5 Results of the Low Flow Survey

Site	KO1A	KO2	KO4	KO5A	KO6
SASS5	51	90	91	99	72
Taxa	14	22	20	22	17
ASPT	3.6	4.1	4.5	4.5	4.2
Category	D	B	B	B	C

The SASS5 scores obtained during the low flow survey ranged from 99 at KO5A to 51 at KO1A. The taxa diversity at the sites ranged from 22 at KO5A to 14 at KO1A. The ASPT values derived from the SASS5 scores ranged from 4.5 at KO5A and KO4 to 3.6 at KO1A.

The results of the SASS5 assessment provide an indication that instream conditions have modified the local aquatic macroinvertebrate assemblages. Although the SASS5 interpretation guidelines indicate that conditions were largely natural at several sites, several taxa were absent from the samples obtained at the sites.

Typical SASS5 scores in the Klein Olifants River show the presence of largely tolerant taxa adapted to marginal and instream vegetation and slow flowing water. Taxa specifically adapted to stones in current or flowing conditions were absent from the sites assessed. The MIRAI will provide further insight into the conditions in the assessed river system.

7.3.3 Macroinvertebrate Assessment Index

The results of the MIRAI assessment are presented in the table below (Table 18).

Table 18: MIRAI scores for the 2016 surveys

Invertebrate Metric Group	Score Calculated
Flow modification	42
Habitat	59
Water Quality	43
Ecological Score	**61**
Invertebrate Category	**class C**

The result of the MIRAI shows that the ecological category of the river reach was determined to be a class C or moderately modified.

The results of the MIRAI show that flow within the Klein Olifants River is modified from reference conditions. This conclusion is drawn from the fact that flow sensitive taxa, such as Heptageniidae were absent from the reach assessed. In addition, poor water quality within the reach assessed has had an impact on the macroinvertebrate assemblage and confirms the concluding remarks on dissolved solids and general water quality. It is further noted that although dissolved solid content was below threshold effect concentrations at many sites, the use of the river system to water livestock has resulted in the sedimentation and input of excessive nutrients into the system. The overall result of the invertebrate assessment provides an indication that the quality of both habitat and water quality is degraded in the assessed river reach.

7.4 Fish Response Assessment Index

The results of the FRAI assessment are presented in Table 19. It is noted that no red data species were captured during this assessment.

Table 19: FRAI Results of the 2016 Study

Fish Species	Reference Frequency of Occurrence	Observed Frequency of Occurrence
Barbus anoplus	4	2
Barbus neefi	4	0
Barbus paludinosus	4	3
Clarias gariepinus	1	1
Pseudocrenilabrus philander	3	2
Tilapia sparmanni	3	3
FRAI (Adjusted) %		71
Ecological category		Class C

The overall FRAI category was calculated to be moderately modified (class C). The assessment of the river reaches assessed in this study was used to derive the reference FROC. As observed in the above table, the sampled FROC of fish differed from the reference FROC. The expected species *Barbus neefi* is considered to be sensitive to habitat and water quality modification. The absence of this species from the study sites provides further confirmation that the upper reaches of the Klein Olifants River are impacted by local activities. In addition, the FROC for tolerant taxa such as *Pseudocrenilabrus philander* and *Barbus anoplus* was also below the expected/reference FROC. This can be attributed to the alteration of aquatic instream habitats whereby siltation and trampling of marginal vegetation has resulted in the loss of habitat for the above-mentioned taxa.

7.5 Present Ecological Status

The results of the ecological classification and PES for the river reach considered are provided in the table below (Table 20).

Table 20: The Present Ecological Status of the river reach in this study

Category	Score	Ecological category
Riparian Habitat Ecological Category	47	Largely modified
Fish Ecological Category	71	Moderately modified
Macroinvertebrate Ecological Category	61	Moderately modified
Ecostatus		class C/D Moderately/largely modified

The results of the ecological classification indicate that the PES of the reach assessed in this study is a class C/D or moderately/largely modified.

As discussed in the various sections above, modification of water and habitat quality within the upper reaches of the Klein Olifants River has resulted in the loss of suitable aquatic habitat which in turn has resulted in the alteration of the expected aquatic communities.

8 Sensitivity Analysis and No-Go Areas

Sensitive areas in respect to aquatic ecology include any areas associated with riverine or wetland habitats. Due to the rich, concentrated vertebrate and invertebrate diversity within the assessed river systems, further modification to habitat associated with the aquatic ecosystem could result in the decline PES. Considering this, a buffer zone of 100m between surface infrastructure and waterbodies (wetlands and rivers) (as delineated in the wetland assessment) are considered sensitive areas. These areas are illustrated in the figure below (Figure 8-1).

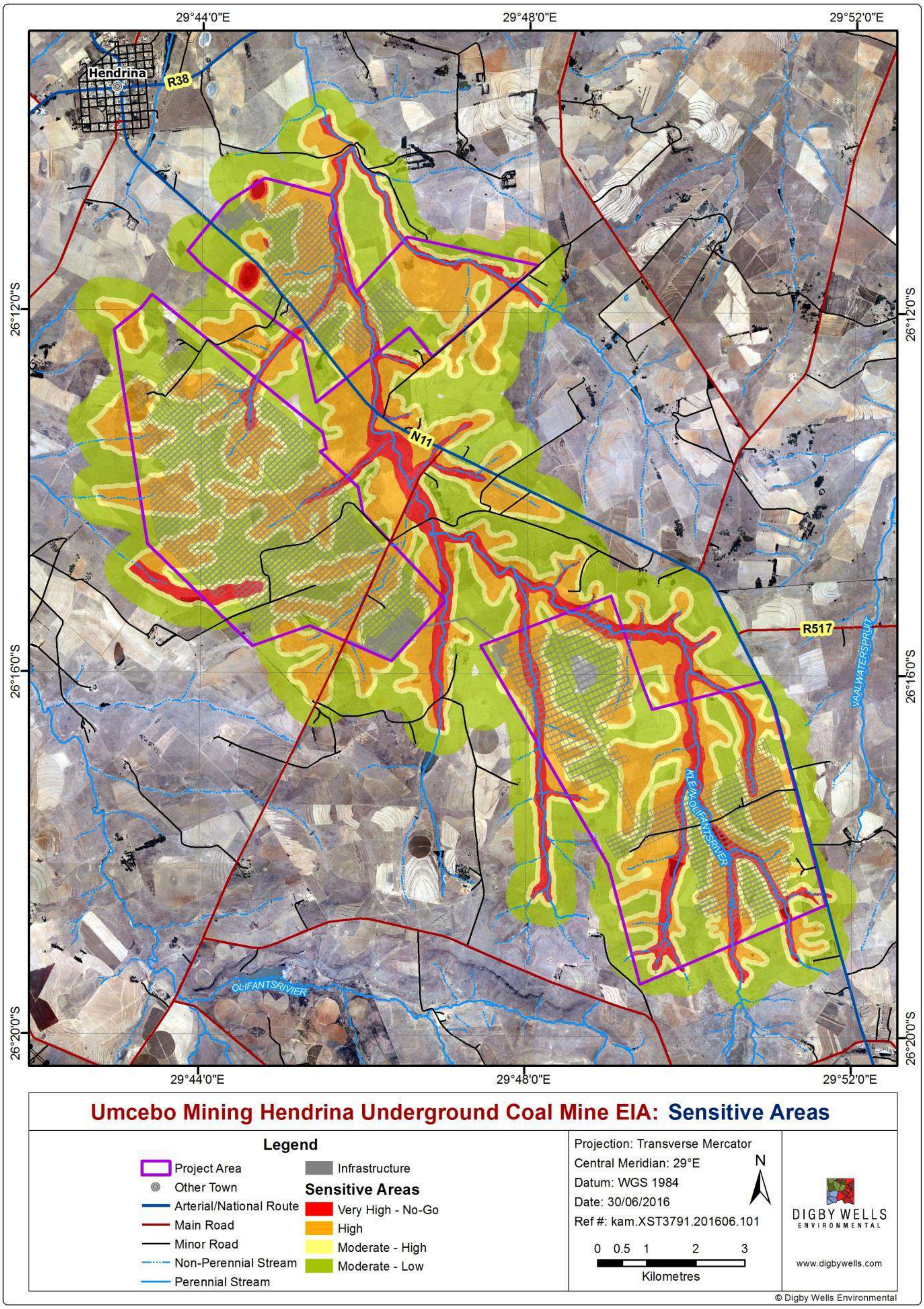

Figure 8-1: Sensitivity Area in relation to Aquatic Ecology

9 Aquatic Impact Assessment

9.1 Methodology used in Determining and Ranking the Nature, Significance, Consequence, Extent, Duration and Probability of Potential Environmental Impacts and Risks

Details of the impact assessment methodology used to determine the significance of physical, bio-physical and socio-economic impacts are provided below.

The significance rating process follows the established impact/risk assessment formula:

Significance = Consequence x Probability x Nature

Where

Consequence = Intensity + Extent + Duration

And

Probability = Likelihood of an impact occurring

And

Nature = Positive (+1) or negative (-1) impact

Note: In the formula for calculating consequence, the type of impact is multiplied by +1 for positive impacts and -1 for negative impacts.

The matrix calculates the rating out of 147, whereby Intensity, Extent, Duration and Probability are each rated out of seven as indicated in Table 23. The weight assigned to the various parameters is then multiplied by +1 for positive and -1 for negative impacts.

Impacts are rated prior to mitigation and again after consideration of the mitigation measure proposed in this report. The significance of an impact is then determined and categorised into one of eight categories, as indicated in Table 22, which is extracted from Table 21. The description of the significance ratings is discussed in Table 23.

It is important to note that the pre-mitigation rating takes into consideration the activity as proposed, i.e. there may already be certain types of mitigation measures included in the design (for example due to legal requirements). If the potential impact is still considered too high, additional mitigation measures are proposed.

Table 21: Impact Assessment Parameter Ratings

Rating	Intensity/Replacability		Extent	Duration/Reversibility	Probability
	Negative Impacts (Nature = -1)	**Positive Impacts (Nature = +1)**			
7	Irreplaceable loss or damage to biological or physical resources or highly sensitive environments. Irreplaceable damage to highly sensitive cultural/social resources.	Noticeable, on-going natural and / or social benefits which have improved the overall conditions of the baseline.	International The effect will occur across international borders.	Permanent: The impact is irreversible, even with management, and will remain after the life of the project.	Definite: There are sound scientific reasons to expect that the impact will definitely occur. >80% probability.
6	Irreplaceable loss or damage to biological or physical resources or moderate to highly sensitive environments. Irreplaceable damage to cultural/social resources of moderate to highly sensitivity.	Great improvement to the overall conditions of a large percentage of the baseline.	National Will affect the entire country.	Beyond project life: The impact will remain for some time after the life of the project and is potentially irreversible even with management.	Almost certain / Highly probable: It is most likely that the impact will occur. <80% probability.

Rating	Intensity/Replacability		Extent	Duration/Reversibility	Probability
	Negative Impacts (Nature = -1)	**Positive Impacts (Nature = +1)**			
5	Serious loss and/or damage to physical or biological resources or highly sensitive environments, limiting ecosystem function. Very serious widespread social impacts. Irreparable damage to highly valued items.	On-going and widespread benefits to local communities and natural features of the landscape.	Province/ Region Will affect the entire province or region.	Project Life (>15 years): The impact will cease after the operational life span of the project and can be reversed with sufficient management.	Likely: The impact may occur. <65% probability.
4	Serious loss and/or damage to physical or biological resources or moderately sensitive environments, limiting ecosystem function. On-going serious social issues. Significant damage to structures / items of cultural significance.	Average to intense natural and / or social benefits to some elements of the baseline.	Municipal Area Will affect the whole municipal area.	Long term: 6-15 years and impact can be reversed with management.	Probable: Has occurred here or elsewhere and could therefore occur. <50% probability.

Rating	Intensity/Replacability		Extent	Duration/Reversibility	Probability
	Negative Impacts (Nature = -1)	Positive Impacts (Nature = +1)			
3	Moderate loss and/or damage to biological or physical resources of low to moderately sensitive environments and, limiting ecosystem function. On-going social issues. Damage to items of cultural significance.	Average, on-going positive benefits, not widespread but felt by some elements of the baseline.	Local Local extending only as far as the development site area.	Medium term: 1-5 years and impact can be reversed with minimal management.	Unlikely: Has not happened yet but could happen once in the lifetime of the project, therefore there is a possibility that the impact will occur. <25% probability.
2	Minor loss and/or effects to biological or physical resources or low sensitive environments, not affecting ecosystem functioning. Minor medium-term social impacts on local population. Mostly repairable. Cultural functions and processes not affected.	Low positive impacts experience by a small percentage of the baseline.	Limited Limited to the site and its immediate surroundings.	Short term: Less than 1 year and is reversible.	Rare / improbable: Conceivable, but only in extreme circumstances. The possibility of the impact materialising is very low as a result of design, historic experience or implementation of adequate mitigation measures. <10% probability.

Rating	Intensity/Replacability		Extent	Duration/Reversibility	Probability
	Negative Impacts (Nature = -1)	Positive Impacts (Nature = +1)			
1	Minimal to no loss and/or effect to biological or physical resources, not affecting ecosystem functioning. Minimal social impacts, low-level repairable damage to commonplace structures.	Some low-level natural and / or social benefits felt by a very small percentage of the baseline.	Very limited/Isolated Limited to specific isolated parts of the site.	Immediate: Less than 1 month and is completely reversible without management.	Highly unlikely / None: Expected never to happen. <1% probability.

Table 22: Probability/Consequence Matrix

Significance

Probability																																						
7	-147	-140	-133	-126	-119	-112	-105	-98	-91	-84	-77	-70	-63	-56	-49	-42	-35	-28	-21	21	28	35	42	49	56	63	70	77	84	91	98	105	112	119	126	133	140	147
6	-126	-120	-114	-108	-102	-96	-90	-84	-78	-72	-66	-60	-54	-48	-42	-36	-30	-24	-18	18	24	30	36	42	48	54	60	66	72	78	84	90	96	102	108	114	120	126
5	-105	-100	-95	-90	-85	-80	-75	-70	-65	-60	-55	-50	-45	-40	-35	-30	-25	-20	-15	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105
4	-84	-80	-76	-72	-68	-64	-60	-56	-52	-48	-44	-40	-36	-32	-28	-24	-20	-16	-12	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80	84
3	-63	-60	-57	-54	-51	-48	-45	-42	-39	-36	-33	-30	-27	-24	-21	-18	-15	-12	-9	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60	63
2	-42	-40	-38	-36	-34	-32	-30	-28	-26	-24	-22	-20	-18	-16	-14	-12	-10	-8	-6	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42
1	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21

Consequence

Table 23: Significance Rating Description

Score	Description	Rating
109 to 147	A very beneficial impact that may be sufficient by itself to justify implementation of the project. The impact may result in permanent positive change	Major (positive) (+)
73 to 108	A beneficial impact which may help to justify the implementation of the project. These impacts would be considered by society as constituting a major and usually a long-term positive change to the (natural and / or social) environment	Moderate (positive) (+)
36 to 72	A positive impact. These impacts will usually result in positive medium to long-term effect on the natural and / or social environment	Minor (positive) (+)
3 to 35	A small positive impact. The impact will result in medium to short term effects on the natural and / or social environment	Negligible (positive) (+)
-3 to -35	An acceptable negative impact for which mitigation is desirable. The impact by itself is insufficient even in combination with other low impacts to prevent the development being approved. These impacts will result in negative medium to short term effects on the natural and / or social environment	Negligible (negative) (-)
-36 to -72	A minor negative impact requires mitigation. The impact is insufficient by itself to prevent the implementation of the project but which in conjunction with other impacts may prevent its implementation. These impacts will usually result in negative medium to long-term effect on the natural and / or social environment	Minor (negative) (-)
-73 to -108	A moderate negative impact may prevent the implementation of the project. These impacts would be considered as constituting a major and usually a long-term change to the (natural and / or social) environment and result in severe changes.	Moderate (negative) (-)
-109 to -147	A major negative impact may be sufficient by itself to prevent implementation of the project. The impact may result in permanent change. Very often these impacts are immitigable and usually result in very severe effects. The impacts are likely to be irreversible and/or irreplaceable.	Major (negative) (-)

9.2 Impact Assessment: Summary of Project Layout and Aquatic Ecosystems

As observed in Figure 9-1, the surface infrastructure is limited to particular sections of the mining right areas. Based on the surface infrastructure layout, river crossings by access roads, fences and conveyor systems are proposed. In addition, the underground mine plan layout, depicted below along with the interactions between mine plan and the delineated wetlands (Figure 9-1), show that several wetland and riverine habitats will be undermined. These specific impacts will be discussed for each project phase.

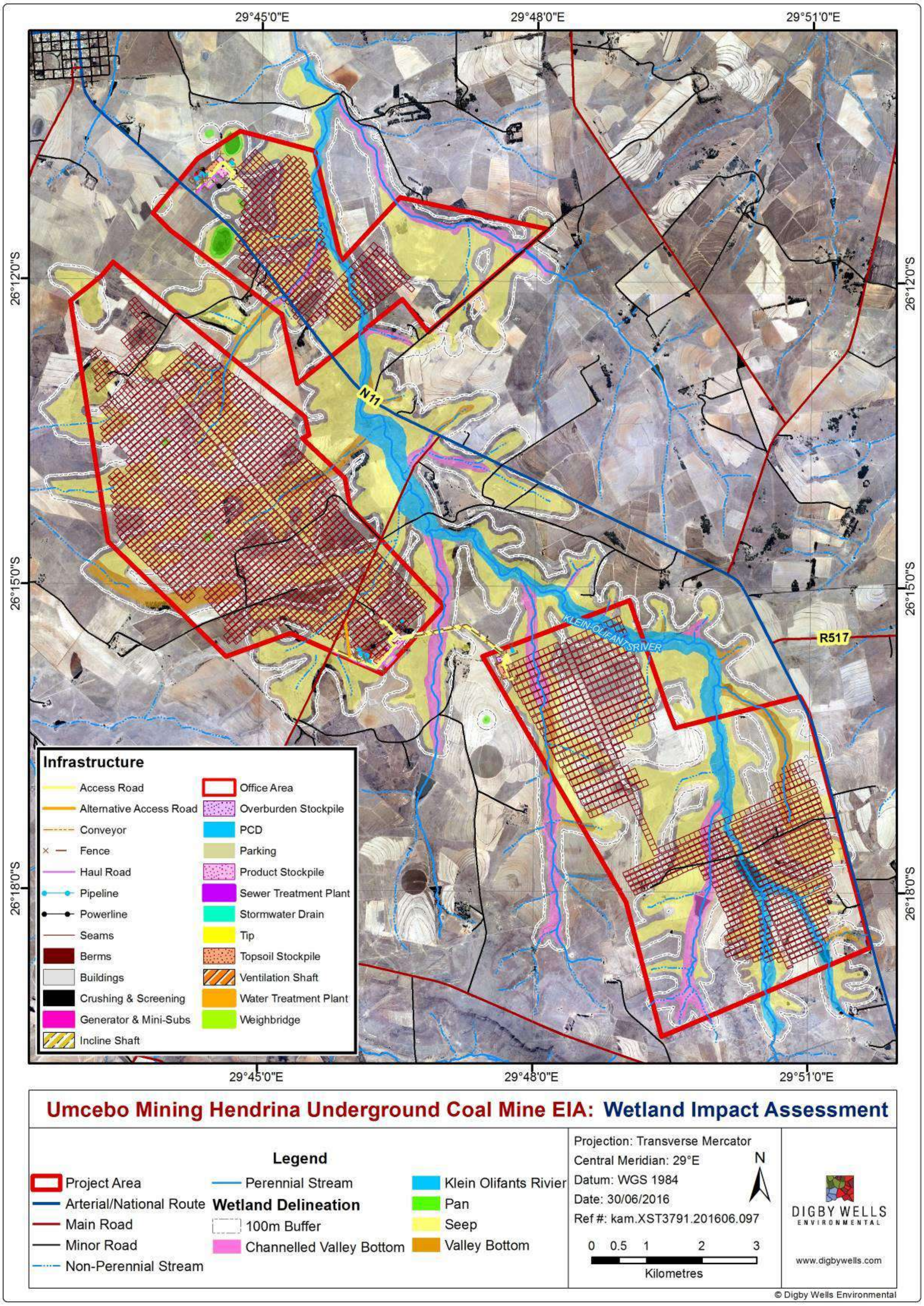

Figure 9-1: Underground Mine Layout and Wetland Delineations

9.2.1 Construction Phase Impact Assessment: Aquatic Ecology

The interactions between the construction phase activities and the impacts to aquatic ecology are summarised below (Table 24).

Table 24: Interactions and impacts to aquatic ecology for the construction phase

Interaction	Impact
Site clearance within associated wetland habitats and river catchment and construction of surface infrastructure	Increased runoff resulting in erosion and sedimentation of downstream habitats. Increased runoff from man-made structures (offices, conveyer belt, paved areas, mining infrastructure etc.)resulting in the erosion and sedimentation of downstream river reaches such as the Klien Olifants and its associated tributaries
Construction over watercourses	Construction over sensitive riparian habitats resulting in the loss and/or degradation of aquatic habitat
Waste generation and disposal	Runoff containing pollutants and solid waste resulting in water and habitat quality degradation in downstream river reaches

9.2.1.1 Impact Description: Water and Habitat Quality Deterioration

The activities and interactions listed above (Table 24) have the potential to degrade water and habitat quality within the Klein Olifants River system. Water quality impacts may include increased dissolved/suspended solids, as well as potential persistent pollutants within the water column and sediments of the associated watercourse. In addition, general water chemistry modification may occur as a result of changed salt balances. Habitat quality impacts may include sedimentation, bed, channel and flow modification, as well as the general loss of aquatic habitat through direct modification during the construction of watercourse crossings.

Although the PES (baseline) of the river reach assessed was derived to be largely modified from reference conditions, further deterioration is possible and thus a potential decline in the PES could be observed. In addition, erosion and sedimentation of the rivers is currently widespread in the current catchment area and additional habitat loss will result in the overall lowering of the PES.

9.2.1.2 Management Objectives

The objective for management is to preserve the PES and prevent further degradation of local aquatic environments. This objective can be achieved through the management of potential water and habitat quality impacts as listed in the section below.

9.2.1.3 Management Actions

General mitigation actions provided in the surface water, wetlands and groundwater studies (Digby Wells, 2016) for this project should be used to guide the effective management of aquatic resources potentially affected by the project. However, important management actions are briefly listed below.

The establishment of a clearly marked buffer zone, which is defined as a region of natural vegetation between the rivers/ wetlands and the proposed activity, is the primary management action that should take place. Literature suggests that a buffer zone can reduce aquatic habitat and water quality impacts of large developments, making this management action of particular importance (WRC, 2014). According to Water Research Commission (2014) the efficacy of a buffer is related to the distance between the river system and the zone of disturbance. Therefore, by increasing the length of a buffer, the potential aquatic modification related to the proposed activity is reduced. Considering this, it is recommended that, a buffer zone of 100 m is placed between infrastructure and riparian zones or the 1:100 floodline (whichever is largest). The designated buffer zones should then be demarcated using signage or fences.

The layout of infrastructure and the delineated relevant buffer zones are presented in the figures below (Figure 9-2, Figure 9-3 and Figure 9-4). As observed in these figures the surface infrastructure at Mooivley East lies within an endorheic pan seep wetland and thus will likely affect the water and habitat conditions in the freshwater pan. The layout of surface infrastructure at Mooivley West shows a limited interaction with the delineated buffer zones whilst the infrastructure of the Hendrina South area lies within a delineated seep wetland. As per the mitigation actions listed in the wetlands report, the proposal must investigate possibilities to optimise the placement of the infrastructure for Mooivley East and Hendrina South outside of the delineated wetland areas.

The removal of vegetative cover, as well as the construction of roads has been recognised as being responsible for increased runoff, sedimentation and subsequent water and habitat quality degradation in downstream portions of river systems (WRC, 2014). As such the careful management of vegetation removal and sedimentation control should take place. This can be achieved through:

- Minimise the removal of vegetation in the infrastructure footprint area;
- Revegetation of the construction footprint as soon as possible;
- Storm water must be diverted from construction activities and managed in such a manner to disperse runoff and prevent the concentration of storm water flow;
- Storm water must be diverted from construction activities and managed in such a manner to disperse runoff and prevent the concentration of storm water flow;
- Sequential removal of the vegetation (not all vegetation immediately); and
- The vegetation of unpaved roadsides.

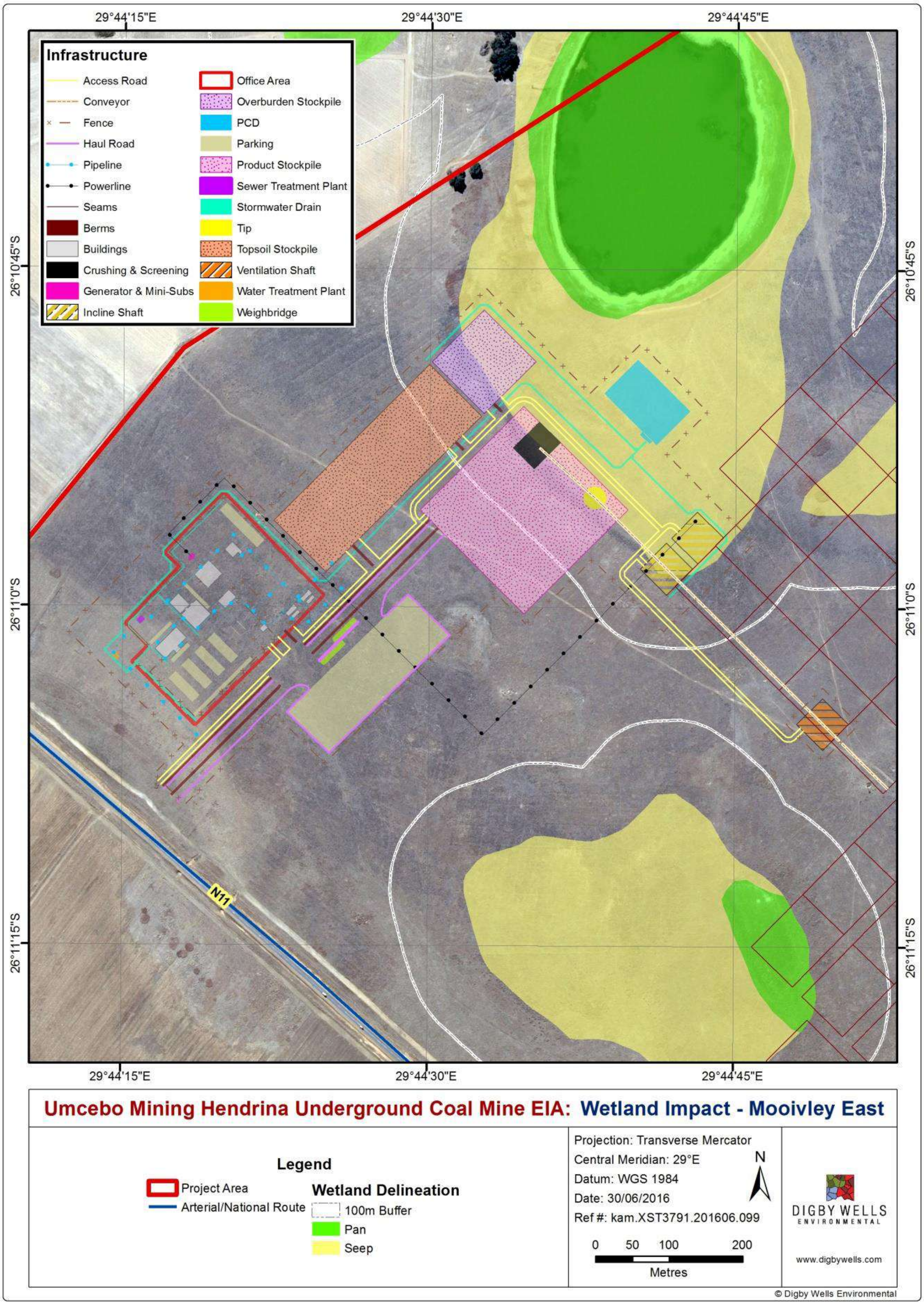

Figure 9-2: Mooivley East Infrastructure and Buffers

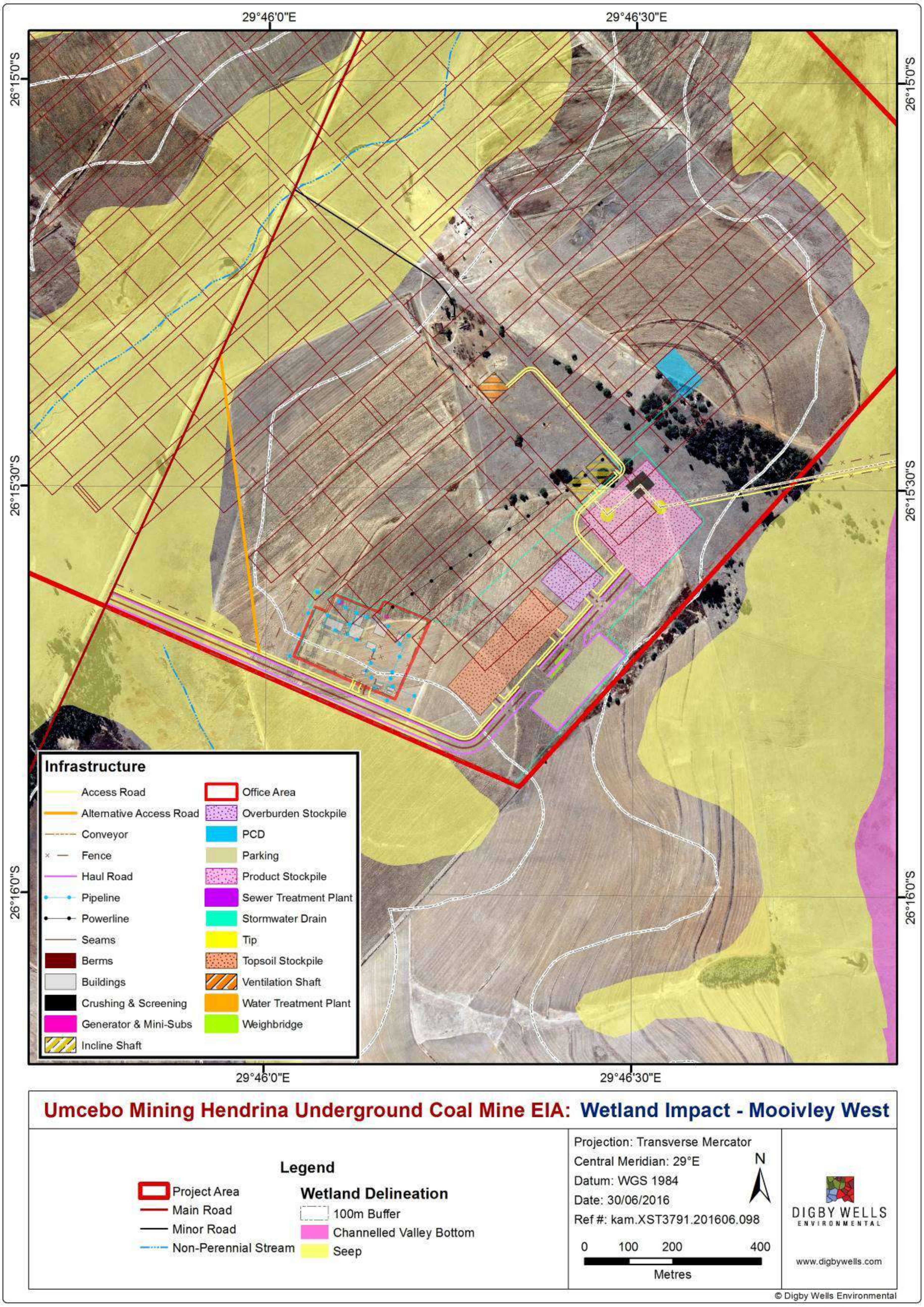

Figure 9-3: Mooivley West Infrastructure and Buffers

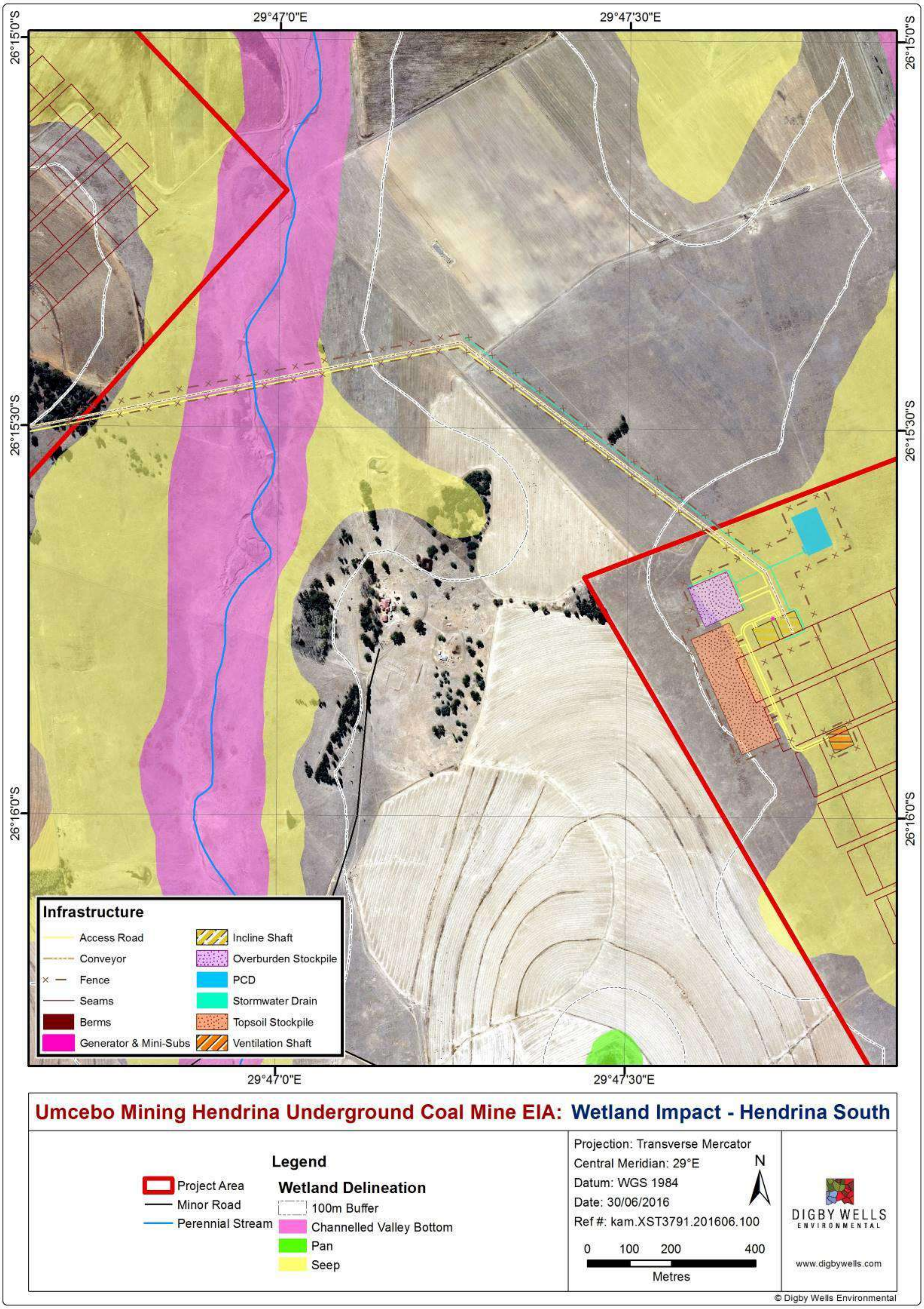

Figure 9-4: Hendrina South Infrastructure and Buffers

During the various phases of the project, waste generated and stored can result in the runoff and seepage of contaminated water from the various activities which can cause degradation of the aquatic ecosystems PES. In order to prevent this, the use of diversion and containment management is of importance. This can be achieved through effective groundwater and surface water management as per the Digby Wells surface and groundwater studies (2016); however management actions are briefly listed below:

- Diversion trench and berm systems which diverts clean storm water around pollution sources and convey and contain dirty water to central pollution control dams;
- Barrier systems, including synthetic, clay and geological or other approved mitigation methods to minimise contaminated seepage and runoff from entering the local aquatic systems. Details pertaining to the type of lining will be provided in the surface water report;;
- Storm water must be diverted from construction activities and managed in such a manner to disperse runoff and prevent the concentration of storm water flow; and
- The planting of indigenous vegetation around pollution control dams should be completed as this has been shown to be effective in erosion and nutrient control.

The construction of conveyors and road infrastructure over the river system at Hendrina South (Figure 9-4) would negatively influence the local aquatic habitat. As such, it is important to consider the following management actions:

- No crossings over riffle/rapid habitats. These should be avoided as these are the most sensitive; slow deep/shallow habitats should be favoured;
- The crossing points should be stabilised to reduce the resulting erosion and downstream sedimentation;
- Structures must not be damaged by floods exceeding the magnitude of those which may occur on average once in every 50 years;
- The indiscriminate use of heavy vehicles and machinery within the instream and riparian habitat will result in the compaction of soils and vegetation and must be controlled;
- Erosion prevention mechanisms such as gabions must be employed to ensure the sustainability of all structures to prevent instream sedimentation;
- The crossing points should be unobtrusive (outside riparian and instream habitat) to prevent the obstruction and subsequent habitat modification of downstream portions;
- No runoff from areas containing high suspended soils shall be allowed to flow directly into any river system;
- Soils adjacent to the river that have been compacted must be loosened to allow for seed germination; and

- Stockpiling of removed topsoil and sand must be done outside the 1:100 floodline or delineated riparian habitat (whichever is greater). This will prevent solids from washing into the river.

9.2.1.4 Impact Ratings

Table 25: Potential Impacts of the Construction Phase

<table>
<tr><th>Dimension</th><th>Rating</th><th>Motivation</th><th>Significance</th></tr>
<tr><td colspan="4">Activity and Interaction: Site clearance within associated wetland habitats and river catchment</td></tr>
<tr><td colspan="4">Impact Description: Increased runoff and erosion within the Klein Olifants River</td></tr>
<tr><td colspan="4">Prior to Mitigation/Management</td></tr>
<tr><td>Duration</td><td>Project Life (5)</td><td>Once vegetation is cleared, no re-vegetation will occur until the closure phase of the project.</td><td rowspan="5">Moderate (negative) – 78</td></tr>
<tr><td>Extent</td><td>Local (3)</td><td>The extent of the impact will likely affect the downstream regions.</td></tr>
<tr><td>Intensity x type of impact</td><td>High - Negative (-5)</td><td>Aquatic ecosystems are sensitive to disturbance and thus any impact is regarded as serious.</td></tr>
<tr><td>Probability</td><td>Almost Certain (6)</td><td>It is highly likely this impact will occur.</td></tr>
<tr><td>Nature</td><td colspan="2">Negative</td></tr>
<tr><td colspan="4">Mitigation/Management Actions</td></tr>
<tr><td colspan="4">
Minimise and keep the footprint as small as possible;
Buffer zones (100 m wetlands and 100 m riparian), where these areas cannot be avoided a Wetland offset strategy should be implemented;
Revegetation of the construction footprint as soon as possible;
Storm water must be diverted from construction activities and managed in such a manner to disperse runoff and prevent the concentration of storm water flow;
Storm water from the adjacent area must be diverted around the construction site and activities to ensure that clean storm water is not contaminated;
Storm water must be diverted from construction activities and managed in such a manner to disperse runoff and prevent the concentration of storm water flow;
Sequential removal of the vegetation (not all vegetation immediately); and
The revegetation of unpaved roadsides.
</td></tr>
<tr><td colspan="4">Post-Mitigation</td></tr>
<tr><td>Duration</td><td>Project Life (5)</td><td>Once vegetation is cleared, no re-vegetation will occur until the closure phase of the project. Although storm water management will mitigate.</td><td>Minor (negative) – 52</td></tr>
</table>

Dimension	Rating	Motivation	Significance
Extent	Local (3)	The extent of the impact will likely affect the downstream regions.	
Intensity x type of impact	High - Negative (-5)	Aquatic ecosystems are sensitive to disturbance and thus any impact is regarded as serious.	
Probability	4 (Probable)	The likelihood of the impact occurring is reduced by the mitigation.	
Nature	Negative		

Dimension	Rating	Motivation	Significance
Activity and Interaction: Construction over sensitive riparian habitats resulting in the loss of degradation of aquatic habitat			
Impact Description: The loss of aquatic habitat as a result of construction activities within a river channel			
Prior to Mitigation/Management			
Duration	Beyond Project Life (6)	Once the riverine soils and instream habitat has been modified, rehabilitation of the footprint will likely take longer than the closure phase.	Moderate (negative) – 84
Extent	Local (3)	The extent of the impact will likely only affect the immediate downstream regions.	
Intensity x type of impact	High - Negative (-5)	Aquatic ecosystems are sensitive to disturbance and thus any impact is regarded as serious.	
Probability	Almost Certain (6)	It is highly likely this impact will occur.	
Nature	Negative		
Mitigation/Management Actions			
- No crossings over riffle/rapid habitats. These should be avoided as these are the most sensitive; slow deep/shallow habitats should be favoured; - All crossings should be designed in such a way that it will reduce the potential for erosion and downstream sedimentation; - The crossing points should be stabilised with gabions to reduce the resulting erosion and downstream sedimentation;			

Dimension	Rating	Motivation	Significance
- Structures must not be damaged by floods exceeding the magnitude of those which may occur on average once in every 50 years; - The indiscriminate use of heavy vehicles and machinery within the instream and riparian habitat will result in the compaction of soils and vegetation and must be controlled and avoided; - Erosion prevention mechanisms must be employed to ensure the sustainability of all structures to prevent instream sedimentation; - The crossing points should be unobtrusive (outside riparian and instream habitat) to prevent the obstruction and subsequent habitat modification of downstream portions; - Diversion trenches and berms should convey dirty water to the pollution control dams so as to contain runoff.; and - Soils adjacent to the river that have been compacted must be loosened to allow for germination.			
Post-Mitigation			
Duration	Beyond Project Life (6)	Once the riverine soils and instream habitat has been modified, rehabilitation of the footprint will likely take longer than the closure phase.	Moderate (negative) – 78
Extent	Limited (2)	The extent of the impact will be reduced to the footprint area by mitigation actions.	
Intensity x type of impact	High - Negative (-5)	Aquatic ecosystems are sensitive to disturbance and thus any impact is regarded as serious.	
Probability	Almost Certain (6)	It is highly likely this impact will occur.	
Nature	Negative		

Dimension	Rating	Motivation	Significance
Activity and Interaction: Waste storage and generation			
Impact Description: Runoff containing pollutants and increased water velocity resulting in water and habitat quality degradation in downstream river reaches			
Prior to Mitigation/Management			
Duration	Medium Term (3)	The impact will likely occur throughout the construction phase.	Minor (negative) – 66

Dimension	Rating	Motivation	Significance
Extent	Local (3)	The extent of the impact will likely only affect the immediate downstream regions.	
Intensity x type of impact	High - Negative (-5)	Aquatic ecosystems are sensitive to disturbance and thus any impact is regarded as serious.	
Probability	Almost Certain (6)	It is highly likely this impact will occur.	
Nature	Negative		
Mitigation/Management Actions			
▪ Diversion trench and berm systems which diverts clean storm water around pollution sources and convey and contain dirty water to central pollution control dams; ▪ Barrier systems, including synthetic, clay and geological or other approved mitigation methods to minimise contaminated seepage and runoff from entering the local aquatic systems. Details pertaining to the type of lining will be provided in the surface water report; ▪ Storm water must be diverted from construction activities and managed in such a manner to disperse runoff and prevent the concentration of storm water flow; and ▪ The planting of indigenous vegetation around pollution control dams and structures should be completed as this has been shown to be effective in erosion and nutrient control.			
Post-Mitigation			
Duration	Medium Term (3)	The impact will likely occur throughout the construction phase.	Minor (negative) – 44
Extent	Local (3)	The extent of the impact will likely only affect the immediate downstream regions.	
Intensity x type of impact	High - Negative (-5)	Aquatic ecosystems are sensitive to disturbance and thus any impact is regarded as serious.	
Probability	Probable (4)	Mitigation actions will reduce the likelihood of the impact occurring.	
Nature	Negative		

9.2.2 Operational Phase

The interactions between the operational phase activities and the impacts to aquatic ecology are summarised below (Table 26).

It is important to note that at the time of the impact ratings, no geotechnical data or any safety factors of the underground workings were available. The assumption was made that detailed geotechnical investigations would be conducted and that the required safety factor will be sufficient to prevent any subsidence and associated surface cracks of the undermined areas to prevent any serious negative impacts with regards to subsidence within the undermined wetland areas. The groundwater study completed as part of this project indicates that mine dewatering will only result in the lowering of the water table within the mine footprint area.

Table 26: Interactions and impacts to aquatic ecology for the operation phase

Interaction		Impact
1	Underground blasting and mining	Undermining of wetlands and rivers leading to hydrological and geomorphic changes to the functioning of the ecosystem; particularly related to groundwater impacts
2	Storage, hauling, processing, conveying and stockpiling of coal	Runoff water which comes into contact with the carboniferous material will contain various pollutants that may contaminate downstream river reaches

9.2.2.1 Impact Description: Water and Habitat Quality Impacts

As discussed in the construction phase, the activities and interactions listed above (Table 26) have the potential to degrade water and habitat quality within the Klein Olifants River system. The major anticipated impacts would result from subsidence of areas associated with the wetland and riverine areas. The subsidence of land can alter the hydrology of the river catchment resulting in major effects to local aquatic biota.

The storage of carboniferous material presents a contamination risk to the downstream river reaches. During rainfall events, runoff which has been in contact with this material may enter local aquatic ecosystems. Once rainwater is in contact with the carboniferous material, dissolved substances will alter downstream water chemistry resulting in the loss of sensitive aquatic biota.

Water quality alteration within the Klein Olifants River will have negative effects on local aquatic ecology resulting in a decrease of the PES.

9.2.2.2 Management Objectives

The objective for management is to preserve the PES and prevent further degradation of local aquatic environments. This objective can be achieved through the management of potential water and habitat quality impacts as listed in the section below.

9.2.2.3 Management Actions

A geotechnical study detailing the degree of risk associated with the subsidence of areas located under wetlands/rivers was completed (Patho et al. 2016). Based on the report the following findings were provided. The mining of the coal reserve at a depth of 40m or more would result in stable surface conditions (no subsidence), provided that appropriate pillar designs are conducted and implemented. There was however approximately 251 hectares of coal reserve which is located at a depth less than 40m and directly associated with wetlands and rivers.

Based on the results of the study the mine plan should be adapted to support or avoid high risk subsidence areas and/or ensure a sufficient safety factor and sufficient pillar support to prevent subsidence and associated cracks forming in the undermined wetland areas to protect wetlands and aquatic ecosystems.

During the operational phase of the proposed project, the storage and handling of carboniferous material can result in the degradation of downstream aquatic ecosystems.

To prevent this, the use of diversion and containment management is of importance. This can be achieved through effective groundwater and surface water management as per the Digby Wells surface and groundwater studies (2016); however important management actions are briefly listed below:

- Clean, dirty water separation and stormwater management: Clean water should be managed in a manner according to the Department of Water and Sanitation Best Practice Guidelines;
- Exposed topsoil's and soil stockpiles must be revegetated to reduce erosion and subsequent sedimentation;
- Pollution Control Dams must be designed and operated in such a way that it will not spill more than once in 50 years. The dam must be able to contain the water required for operations, a storm event including a 0.8m freeboard at all times;.
- Barrier systems, including synthetic, clay and geological or other approved mitigation methods to minimise contaminated seepage and runoff from entering the local aquatic systems. Details pertaining to the type of lining will be provided in the surface water report;
- Storm water must be diverted from construction activities and managed in such a manner to disperse runoff and prevent the concentration of storm water flow; and
- The planting of indigenous vegetation around pollution control dams and structures should be completed as this has been shown to be effective in erosion and nutrient control.

- Overburden and topsoil stockpiles should be managed to minimise infiltration of contaminants to the groundwater. Mitigation methods that should be considered include:
  - Management of the stockpile shape to control the ease with which water can run off from the facility.
  - The vegetation of the stockpile and covering them with soil to minimise rainfall infiltration and mobilisation of dissolved metals.
  - Implementation of a lime cover on overburden stockpiles to neutralise acidity.

9.2.2.4 Impact Ratings

Table 27: Impact Ratings for the Operational Phase

Dimension	Rating	Motivation	Significance
Activity and Interaction: Underground blasting and mining			
Impact Description: Subsidence of land within the river catchment and subsidence of land underneath river channels (32m to 128m)			
Prior to Mitigation/Management			
Duration	Permanent (7)	The undermining of a river course and resulting subsidence will be a permanent impact.	Moderate (negative) – 102
Extent	Municipal (4)	The impact would likely impact on the water balance of the Klein Olifants River and thus beyond a local extent.	
Intensity x type of impact	Serious - negative (-6)	The loss of the headwaters of a river system will seriously affect the functioning of the downstream river reaches.	
Probability	Almost certain (6)	Should mining occur, there is a very high likelihood of the impact occurring.	
Nature	Negative		
Mitigation/Management Actions			
▪ Complete a geotechnical study to identify high risk subsidence areas and avoid or mitigate to support them through the abovementioned geotechnical study; ▪ Ensure sufficient pillar support and safety factors to prevent subsidence of undermined wetland areas; and ▪ The highest safety factor must possible must be used for areas of shallow mining (35m to 70m at least).			
Post-Mitigation			
Duration	Permanent (7)	The impact, should it occur, would still be a permanent feature.	Minor (negative) – 68
Extent	Municipal (4)	Should subsidence occur, the impact to the Klien Olifants River specifically the water balance is likely to extend beyond the project site (local extent)	

Dimension	Rating	Motivation	Significance
Intensity x type of impact	Serious - negative (-6)	The impact may result in a loss of headwater of the Klien Olifants River which may have a direct effect on the downsteam areas and ultimately limit ecosystem functioning	
Probability	Probable (4)	Should high risk areas be avoided and the risk limited for the undermining of rivers, the likelihood of subsidence is reduced and therefore reduced.	
Nature	Negative		

Dimension	Rating	Motivation	Significance
Activity and Interaction: Storage, hauling, processing, conveying and stockpiling of coal			
Impact Description: Contamination of surface water through contaminated runoff and contaminated seepage influx			
Prior to Mitigation/Management			
Duration	Project life (5)	The impact will occur throughout the life of mine.	Moderate (negative) – 84
Extent	Local (3)	Water quality impacts would likely only affect the upper reaches of the Klein Olifants River until dilution with clean water reduces the concentration of contaminants.	
Intensity x type of impact	Serious - negative (-6)	The degradation of water quality will likely impact on all sensitive aquatic biota thereby resulting in their loss from the ecosystem.	
Probability	Almost certain (6)	There is a high likelihood of the impact occurring.	
Nature	Negative		
Mitigation/Management Actions			

<table>
<tr><th>Dimension</th><th>Rating</th><th>Motivation</th><th>Significance</th></tr>
<tr><td colspan="4">▪ Effective surface water management (see surface water report);
▪ Clean and dirty water separation should be managed in accordance with the surface water report;
▪ Exposed topsoil’s and soil stockpiles must be revegetated to reduce erosion and subsequent sedimentation;
▪ Pollution Control Dams must be designed and operated in such a way that it will not spill more than once in 50 years. The dam must be able to contain the water required for operations, a storm event including a 0.8m freeboard at all times.</td></tr>
<tr><td colspan="4">Post-Mitigation</td></tr>
<tr><td>Duration</td><td>Project life (5)</td><td>The impact will occur throughout the life of mine.</td><td rowspan="5">Minor (negative) – 56</td></tr>
<tr><td>Extent</td><td>Local (3)</td><td>Water quality impacts would likely only affect the upper reaches of the Klein Olifants River until dilution with clean water reduces the concentration of contaminants.</td></tr>
<tr><td>Intensity x type of impact</td><td>Serious - negative (-6)</td><td>The degradation of water quality will likely impact on all sensitive aquatic biota thereby resulting in their loss from the ecosystem.</td></tr>
<tr><td>Probability</td><td>Probable (4)</td><td>Mitigation actions will reduce the likelihood of the impact.</td></tr>
<tr><td>Nature</td><td colspan="2">Negative</td></tr>
</table>

9.2.3 Closure and Rehabilitation Phase

The following interactions between the closure and rehabilitation phase activities and the impacts to aquatic ecology are summarised below (Table 28).

Table 28: Rehabilitation and Closure Phase Interactions

<table>
<tr><th colspan="2">Interaction</th><th>Impact</th></tr>
<tr><td>1</td><td>Removal of infrastructure and surface rehabilitation</td><td>Similarly to the construction phase, the removal of the infrastructure will lead to potential negative impacts on the habitat integrity of the associated aquatic ecosystems</td></tr>
<tr><td>2</td><td>Underground mine closure and rehabilitation</td><td>Post-mining decant of groundwater will have negative impacts on the downstream water quality</td></tr>
</table>

9.2.3.1 Impact Description: Water and Habitat Quality Impacts

Similarly to the construction phase the removal of infrastructure and rehabilitation activities will be a large scale operation and thus has the potential to contaminate surface water. Particular areas which will require attention includes the, the crushing and screening areas and pollution control facilities. The rehabilitation of these areas will require special attention to avoid contamination of the surrounding aquatic ecosystems.

Typically, following the cessation of underground mining activities groundwater returns to the voids created by the mining process. This process results in the contamination of the groundwater resource. Following this influx of groundwater, seepage and decant at specific locations can result in the ingress of contaminated water in downstream river systems, thus severely degrading the local PES. The groundwater study completed for this project has modelled simulations that show that after approximately 30 years from closure, the decant of contaminated water will exit the proposed shaft in Mooivley East. It should be noted that this is not the only location that decant may occur.

9.2.3.2 Management Objectives

The objective for management is to preserve the PES and prevent further degradation of local aquatic environments. This objective can be achieved through the management of potential water and habitat quality impacts as listed in the section below.

9.2.3.3 Management Actions

As described in the construction phase, a clearly demarcated buffer zone of 100m from wetland and 100m from riparian areas must be maintained.

To mitigate against the decant of contaminated water, the actions recommended in groundwater report of this project should be considered. However, water treatment and the discharge of clean water is an option available to reduce the ingress of contaminated water. According to the groundwater report, the capture of decant before joining associated watercourses, the treatment and reintroduction of clean water is recommended.

9.2.3.4 Impact Ratings

Dimension	Rating	Motivation	Significance
Activity and Interaction: Removal of infrastructure and surface rehabilitation.			
Impact Description: Increased runoff and erosion within the Klein Olifants River			
Prior to Mitigation/Management			
Duration	Medium term (3)	The impact will only occur during the closure and decommissioning phase.	Minor (negative) – 66
Extent	Local (3)	The extent of the impact will likely affect the downstream regions.	

Dimension	Rating	Motivation	Significance
Intensity x type of impact	High - Negative (-5)	Aquatic ecosystems are sensitive to disturbance and thus any impact is regarded as serious.	
Probability	Almost Certain (6)	It is highly likely this impact will occur.	
Nature	Negative		
Mitigation/Management Actions			
▪ Established buffer zones: 100m from wetland and 100m from riparian areas; ▪ Stormwater management plan.			
Post-Mitigation			
Duration	Medium term (3)	The impact will only occur during the phase.	Minor (negative) – 44
Extent	Local (3)	The extent of the impact will likely affect the downstream regions.	
Intensity x type of impact	High - Negative (-5)	Aquatic ecosystems are sensitive to disturbance and thus any impact is regarded as serious.	
Probability	Probable (4)	The impact could happen.	
Nature	Negative		

Dimension	Rating	Motivation	Significance
Activity and Interaction: Underground mine closure and rehabilitation			
Impact Description: Decant of severely contaminated water into local aquatic ecosystems			
Prior to Mitigation/Management			
Duration	Permanent (7)	Decant of contaminated water will likely be permanent.	Major (negative) – 126
Extent	Municipal (4)	Decant is likely to flow to the pan at Mooivley East and which may result in a change in salt balance to the entire upper reach of the Klein Olifants River.	
Intensity x type of impact	Serious - negative (-6)	The change of water quality in the headwaters of a river system will seriously affect the functioning of the downstream river reaches.	

Dimension	Rating	Motivation	Significance
Probability	Definite (7)	Should mining occur, there is a very high likelihood of the impact occurring.	
Nature	Negative		
		Mitigation/Management Actions	
▪ Decant treatment plan; and ▪ Water treatment options.			
		Post-Mitigation	
Duration	Permanent (7)	The decant of contaminated water will likely be permanent.	
Extent	Municipal (4)	The impact will change salt balances of the entire upper reach of the Klein Olifants River.	
Intensity x type of impact	Serious - negative (-6)	The change of water quality in the headwaters of a river system will seriously affect the functioning of the downstream river reaches.	Minor (negative) – 51
Probability	Unlikely (3)	If water treatment is completed, there will likely be no impact.	
Nature	Negative		

10 Cumulative Impacts

The following cumulative impacts have been identified, and can occur due to the proposed development:

- Cumulative deterioration of water quality within the Klein Olifants headwaters; and
- Cumulative deterioration of aquatic habitat.

The PES of the river reach associated with the proposal is currently modified as a result of habitat quality modification compounded by moderate water quality modification. The proposed project will likely not affect water quality of this reach until the closure phase, where-after Acid Mine Water is expected to decant, thus resulting in further water quality degradation. When considering downstream regions, the impoundment located a few kilometres downstream (Middleburg Dam) of the proposed project will likely act to concentrate pollutants during this phase and therefore serve to largely impact local aquatic biota within this system (Kingsford, 2000).

Dissolved solids (salinity) of the rivers within the Upper Olifants River catchment have been increasing as a result of extensive coal mining operations (RHP, 2001). Therefore, it is probable that the proposed project will contribute toward these increasing dissolved solids and further degradation of water quality within the Olifants River. Considering this, if mitigation actions are not put in place to treat potential Acid Mine Drainage, the effects thereof will be significant.

11 Unplanned Events and Low Risks

The planned activities will have known impacts as discussed above; however, unplanned events may happen on any project that may have potential impacts which will need mitigation and management. Table 29 is a summary of the findings from an aquatic ecology perspective. Please note not all potential unplanned events may be captured herein and this must therefore be managed throughout all phases.

Table 29: Unplanned Events, Low Risks and their Management Measures

Unplanned event	Potential impact	Mitigation/ Management/ Monitoring
Hydrocarbon spill into riverine habitat	Contamination of sediments and water resources associated with the spillage.	A spill response kit must be available at all times. The incident must be reported on and if necessary an aquatic ecology specialist must investigate the extent of the impact and provide rehabilitation recommendations.
Uncontrolled erosion	Sedimentation of downstream river reach.	Erosion control measures must be put in place.
PCD overflow	The degradation of downstream water quality.	The overflow must be stopped immediately and the impacted area remediated. Spill protection berms must be put in place in the event of a serious spillage.
Subsidence of undermined areas, particularly where coal resource was shallow (above 50)	This will have a major negative impact to the linked aquatic ecosystems such as altered hydrological functioning.	An aquatic ecologist specialist must investigate the extent of the impact and provide rehabilitation recommendations.

12 Environmental Management Plan

The objective of an Environmental Management Plan (EMP) is to present mitigation (a) to manage undue or reasonably avoidable adverse impacts associated with the development of a project and (b) to enhance potential positives.

12.1 Project Activities with Potentially Significant Impacts

The following is a summary of the identified significant impacts to wetlands that will require mitigation measures for the project to go ahead.

Table 30: Potentially significant project impacts

Activity		Impact
Construction Phase		
1	Site clearance within associated wetland habitats and river catchment and construction of surface infrastructure	Increased runoff resulting in erosion and sedimentation of downstream habitats. Increased runoff from manmade structures resulting in the erosion and sedimentation of downstream river reaches.
2	Construction over watercourses	Construction over sensitive riparian habitats resulting in the loss of degradation of aquatic habitat.
Operational Phase		
1	Underground blasting and mining	Undermining of wetlands and rivers leading to hydrological and geomorphic changes to the functioning of the ecosystem; particularly related to groundwater impacts.
2	Storage, hauling, processing, conveying and stockpiling of coal	Runoff water which may come into contact with the carboniferous material will contain various pollutants that may contaminate downstream river reaches.
Rehabilitation Phase		
1	Underground mine closure and rehabilitation	Post-mining decant of groundwater will have negative impacts on the downstream water quality

12.2 Summary of Mitigation and Management

Table 31 provides a summary of the proposed project activities, environmental aspects and impacts on the receiving environment. Information on the frequency of mitigation, relevant legal requirements, recommended management plans, timing of implementation, and roles / responsibilities of persons implementing the EMP. All of the mitigation measures have been previously listed in the impact assessment tables as well.

Table 31: Mitigation and Management Plan

<table>
<tr><th>Activities</th><th>Potential Impact</th><th>Size and scale of disturbance</th><th>Aspects Affected</th><th>Phase</th><th>Mitigation Type/Measures</th><th>Compliance with standards/Standard to be achieved</th><th>Time period for Implementation</th></tr>
<tr><td>Site clearance within associated wetland habitats and river catchment and construction of surface infrastructure</td><td>Increased runoff resulting in erosion and sedimentation of downstream habitats. Increased runoff from manmade structures resulting in the erosion and sedimentation of downstream river reaches</td><td>Local</td><td rowspan="2">Aquatic Ecology</td><td rowspan="2">Construction phase</td><td>▪ Buffer zones (100 m wetlands and100 m riparian), where these areas cannot be avoided a Wetland offset strategy should be implemented;
▪ Revegetation of the construction footprint as soon as possible;
▪ Storm water must be diverted from construction activities and managed in such a manner to disperse runoff and prevent the concentration of storm water flow; and
▪ Sequential removal of the vegetation (not all vegetation immediately); and the vegetation of unpaved roadsides.</td><td rowspan="2">The National Water Act (NWA), 1998 (Act No. 36 of 1998).</td><td rowspan="2">Design and construction phase</td></tr>
<tr><td>Construction over watercourses</td><td>Construction over sensitive riparian habitats resulting in the loss of degradation of aquatic habitat</td><td>Limited</td><td>▪ No crossings over riffle/rapid habitats. These should be avoided as these are the most sensitive; slow deep/shallow habitats should be favoured;
▪ The crossing points should be stabilised to reduce the resulting erosion and downstream sedimentation;
▪ Structures must not be damaged by floods exceeding the magnitude of those which may occur on average once in every 50 years;
▪ The indiscriminate use of heavy vehicles and machinery within the instream and riparian habitat will result in the compaction of soils and vegetation and must be controlled;
▪ Erosion prevention mechanisms must be employed to ensure the sustainability of all structures to prevent instream sedimentation;
▪ The crossing points should be unobtrusive (outside riparian and instream habitat) to prevent the obstruction and subsequent habitat modification of downstream portions (plinths); and</td></tr>
</table>

Activities	Potential Impact	Size and scale of disturbance	Aspects Affected	Phase	Mitigation Type/Measures	Compliance with standards/Standard to be achieved	Time period for Implementation
					▪ Diversion trenches and berms should convey dirty water to the pollution control dams so as to contain runoff.		
Waste generation and disposal	Runoff containing pollutants and solid waste resulting in water and habitat quality degradation in downstream river reaches.	Local			▪ Diversion trench and berm systems which diverts clean storm water around pollution sources and convey and contain dirty water to central pollution control dams; ▪ Barrier systems, including synthetic, clay and geological or other approved mitigation methods to minimise contaminated seepage and runoff from entering the local aquatic systems. Details pertaining to the type of lining will be provided in the surface water report; ▪ Storm water must be diverted from construction activities and managed in such a manner to disperse runoff and prevent the concentration of storm water flow; and ▪ The planting of indigenous vegetation around pollution control impoundments and structures should be completed as this has been shown to be effective in erosion and nutrient control.		
Underground blasting and mining	Undermining of wetlands and rivers leading to hydrological and geomorphic changes to the functioning of the ecosystem; particularly related to groundwater impacts.	Municipality	Aquatic Ecology	Operation phase	▪ Complete a geotechnical study to identify high risk subsidence areas and use measures to increase support in high risk areas; ▪ The highest safety factor must possible must be used for areas of shallow mining (35m to 70m at least).	The National Water Act (NWA), 1998 (Act No. 36 of 1998).	Operation phase

Activities	Potential Impact	Size and scale of disturbance	Aspects Affected	Phase	Mitigation Type/Measures	Compliance with standards/Standard to be achieved	Time period for Implementation
Storage, hauling, processing, conveying and stockpiling of coal	Runoff water which may come into contact with the carboniferous material will contain various pollutants that may contaminate downstream river reaches.	Local			▪ Clean and dirty water separation; ▪ Clean, dirty water separation and stormwater management: Clean water should be managed in a manner according to the Department of Water and Sanitation Best Practice Guidelines; ▪ Exposed topsoil's and soil stockpiles must be revegetated to reduce erosion and subsequent sedimentation; ▪ Pollution Control Dams must be designed and operated in such a way that it will not spill more than once in 50 years. The dam must be able to contain the water required for operations, a storm event including a 0.8m freeboard at all times; ▪ Channel systems must be made with concrete to reduce seepage; ▪ Storm water must be diverted from construction activities and managed in such a manner to disperse runoff and prevent the concentration of storm water flow; and ▪ The planting of indigenous vegetation around pollution control dams and structures should be completed as this has been shown to be effective in erosion and nutrient control.		
Removal of infrastructure and surface rehabilitation.	Similarly to the construction phase, the removal of the infrastructure will lead to potential negative impacts on the integrity of the associated aquatic ecosystems	Local	Surface water	Rehabilitation and closure phase	▪ Buffer zones (100 m wetlands and 100 m riparian), where these areas cannot be avoided a Wetland offset strategy should be implemented.	The National Water Act (NWA), 1998 (Act No. 36 of 1998).	Rehabilitation and closure phase
Underground mine closure and rehabilitation	Post-mining decant of groundwater will have negative impacts on the downstream water quality	Municipality			▪ Decant capture and treatment.		

12.3 Monitoring Plan

An aquatic biomonitoring programme is an essential management tool. The monitoring programme should be designed to enable the detection of potential negative impacts brought about by the project. Table 32 highlights some important aspects to monitor in reference to aquatic biota for the duration of the proposal.

Table 32: Aquatic Ecology Monitoring Programme

Location	Monitoring objectives	Frequency of monitoring	Parameters to be monitored
Current sites used in this study (Figure 6-6).	Overall PES of the Klein Olifants River	Bi-annual (dry and wet season)	Standard River Ecosystem Monitoring Programme (Ecostatus) methods. The precise methods stipulated in this study. See section 4.
Current sites used in this study (see appendix A).	Determine if water quality deterioration is occurring.	Bi-annual	SASS5 scores should not decrease more than 25% and be related to mining activities.
Site used in this study and the surface water assessment.	Determine if water quality deterioration is occurring.	Monthly	Standard water quality monitoring, as per the surface water specialist report.
Current sites used in this study.	Determine if water/habitat quality deterioration is occurring.	Bi-annual	Standard River Ecosystem Monitoring Programme (Ecostatus) methods. The precise methods stipulated in this study. See section 4

Table 33: Monitoring Plan

Activities	Impacts requiring monitoring programmes	Functional requirements for monitoring	Roles and responsibilities (For the execution of the monitoring programmes)	Monitoring and reporting frequency and time periods for implementing impact management actions
All activities	Degradation of aquatic resources	The monitoring of river reaches associated with the various mining right areas should be completed. Important areas to consider are the reaches downstream of the mining rights. The monitoring of these reaches can provide information on whether the proposed project is having an impact on water resources.	The environmental officer is responsible for the monitoring of aquatic ecology. The responsible person conducting the monitoring needs to be professionally registered, SASS5 accredited and hold relevant qualification in biological or water sciences.	Bi-annual (twice a year)

13 Consultation Undertaken

No consultation has been undertaken for completion of the aquatic ecology study. Consultation is being undertaken as part of the EIA process for the project.

13.1 Comments and Responses

Results from the draft EIA comment period will be incorporated into the finalised report. There were no comments specific to aquatic ecology made during the scoping phase of the project.

14 Conclusions and Recommendations

To determine the baseline ecological status of rivers associated with the project, the uppermost reaches of the Klein Olifants River within the B12A quaternary catchment were assessed on a bi-annual basis. Applying standard River Ecosystem Monitoring Programme techniques the PES of the river reach was determined. The results of the assessment derived an overall PES class of moderately/largely modified (class C/D). This class was derived due to the existing impacts within the catchment area of the Klein Olifants River. The central cause of the poor ecological status was found to be associated with various agricultural practices which have resulted in the erosion and subsequent sedimentation of the assessed river reach.

Considering this baseline, an impact assessment was completed using the available activity list for the proposed project. Based on this impact assessment, several key impacts were identified. The key impacts identified included:

- Potential impacts from a conveyor and road crossing on a watercourse at the Hendrina South prospecting right area;
- Potential significant impacts from undermining of wetlands and waterbodies; and
- Potential decant of Acid Mine Drainage during the closure and post-closure phases resulting in significant water quality modification in the Klein Olifants drainage.

Considering the above potential impacts, should the mining operation go ahead provision should be made to mitigate against the subsidence of land associated with waterbodies and wetland areas. Furthermore provision should be made for potential Acid Mine Drainage which will likely occur within the post-closure phase.

Key recommended monitoring conditions have been provided in this report along with various mitigation actions. Some key mitigation actions include the following:

- Buffer zone establishment: 50m from delineated wetland areas and 100m from riparian zones;
- Clean, dirty water separation and storm water management: Clean water should be managed in a manner according to the DWS Best Practice Guidelines;

- Exposed topsoil's and soil stockpiles must be revegetated to reduce erosion and subsequent sedimentation;
- Although a basic geotechnical study has been completed, recommendations from the report indicate that a comprehensive geotechnical study must be conducted to assess the risk for subsidence in areas associated with the Klein Olifants River. Mitigation actions to increase stability should be used in delineated high risk areas. These mitigation actions include limiting roads underneath the river system and thicker support pillars, however, detailed mitigation actions should be defined in the geotechnical study.
- Based on the revision of the mining plan, the coal reserve which is located at a depth less than 40m and associated with wetlands, will only be mined to a limited extent, with thick enough support pillars to avoid surface subsidence. This will reduce the risk of subsidence in local river catchments.
- Pollution Control Dams must be designed and operated in such a way that it will not spill more than once in 50 years. The dam must be able to contain the water required for operations, a storm event including a 0.8m freeboard at all times.
- Groundwater mitigation actions for potential Acid Mine Drainage will be elaborated once the groundwater study of this project is completed.

It is recommended that this report should not be considered in isolation and that other specialist reports should be reviewed including surface water, groundwater and wetland studies.

15 References

Barbour MT, Gerristen J, Snyder DB, Stribling JB (1999) Rapid bioassessment protocols for Use in Stream and Wadeable Rivers: Periphton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. US Environmental Protection Agency, Office of Water, Washington DC.

Dallas HF (2007). River Health Programme: South African Scoring System (SASS) Data Interpretation Guidelines. Institute of Natural Resources and Department of Water Affairs and Forestry.

Department of Water Affairs (2016) A Desktop Assessment of the Present Ecological State, Ecological Importance and Ecological Sensitivity per Sub Quaternary Reaches for Secondary Catchments in South Africa. Draft. Compiled by RQS-RDM.

Dickens CWS, Graham PM.(2002). The South African Scoring System (SASS), Version 5, Rapid bioassessment method for rivers. African Journal of Aquatic Science. 27**:** 1–10.

Digby Wells Environmental (2016). Environmental Impact Assessment, Environmental Management Plan and Water Use Licence Application for the Proposed Hendrina Reserve Project, Mpumalanga, XST3791.

Directorate: Water Resource Classification. Department of Water Affairs, South Africa, (2014). Determination of Resource Quality Objectives in the Upper Vaal and Lower Vaal Water Management Areas (WMA8 and WMA10) – WP10533 and WP10536. Draft Resource Quality Objectives Gazette

Driver A, Nel JL, Snaddon K, Murray K, Roux DJ, Hill L, Swartz ER, Manuel J, Funke N (2011) Implementation Manual for Freshwater Ecosystem Priority Areas. Water Research Commission. Report Number 1801/1/11, ISBN 978-1-4312-0147-1

DWAF (Department Of Water Affairs And Forestry) (1996). South African water quality guidelines (Second Edition). Aquatic Ecosystems. Department of Water Affairs and Forestry, Pretoria.

Gerber, A. & Gabriel, M.J.M. (2002). Aquatic Invertebrates of South African Rivers: Field Guide. Institute for Water Quality Services, Department of Water Affairs and Forestry, Pretoria

Golder Associates. (2013). Consolidated Environmental Management Programme Report-Aquatic Study. Report Number: 13023-10723-2.

Government Gazette (16 April 2013). Publication of lists of species that are threatened or protected, activities that are prohibited and exemption from restriction. *Government Gazette,* No. 36375, Notice 389 of 2013, 104-218.

Kleynhans CJ (2007). Module D: Fish Response Assessment Index in River EcoClassification: Manual for EcoStatus Determination (version 2) Joint Water Research Commission and Department of Water Affairs and Forestry report. WRC Report No. TT330/08.

Kleynhans CJ, (1996) A qualitative procedure for the assessment of the habitat integrity status of the Luvuvhu River. *Journal of Aquatic Ecosystem Health* 5: 41-54.

Kleynhans CJ, Louw MD (2007). Module A: EcoClassification and EcoStatus determination in River EcoClassification: Manual for EcoStatus Determination (version 2). Joint Water Resource Commission and Department of Water Affairs and Forestry report. WRC Report No. TT 329/08.

Kleynhans CJ, Louw MD, Moolman J (2007). Reference frequency of occurrence of fish species in South Africa. Report produced for the Department of Water Affairs and Forestry (Resource Quality Services) and the Water Research Commission.

Kleynhans, C.J. & Louw, M.D. (2007). Module A: EcoClassification and EcoStatus determination in River EcoClassification: Manual for EcoStatus Determination (version 2). Joint Water Resource Commission and Department of Water Affairs and Forestry report. WRC Report No. TT 329/08

Macfarlane DM, Bredin IP, Adams JB, Zungu MM, Bate GC, Dickens CWS. (2014). Preliminary guideline for the determination of buffer zones for rivers, wetlands and estuaries. WRC Report No TT310/14, Water Research Commission, Pretoria.

McMillan PH, (1998). An integrated habitat assessment system (IHAS v2) for the rapid biological assessment of rivers and streams. Division of the Environment and Forestry Technology, Report No. ENV-P-I 98132. CSIR, Pretoria.

Patho S, Ingram J, Selai C, Swanepoel D (2016). Hendrina geotechnical assessment of the Mooivley (East and West) and Hendrina South underground mining reserves where these are planned within the vicinity of wetlands and the Klein Olifants River. Report NumberL RE_GEN 01_12-16.

Rowntree KM, Ziervogel G (1999) Development of an index of stream geomorphology for the assessment of river health. National Aquatic Ecosystem Biomonitoring Programme. Report Series No.7.

Skelton PH (2001). A complete guide to freshwater fishes of southern Africa. Struik Publishers, South Africa.

Tate RB, Husted A (2015) Aquatic macroinvertebrate responses to pollution of the Boesmanspruit river system above Carolina, South Africa. *African Journal of Aquatic Science*. 1-11.

Thirion CA, Mocke A, Woest R (1995). Biological monitoring of streams and rivers using SASS4. A Users Manual. Internal Report No. N 000/00REQ/1195. Institute for Water Quality Studies. Department of Water Affairs and Forestry. 46.

Thirion, C. (2007). Module E: Macroinvertebrate Response Assessment Index in River EcoClassification: Manual for EcoStatus Determination (version 2). Joint Water Research Commission and Department of Water Affairs and Forestry report. WRC Report No. TT 332/08.

Van Dam, H., Mertens, A. & Sinkeldam, J. (1994). A coded checklist and ecological indicator values of freshwater diatoms from the Netherlands. *Netherlands Journal of Aquatic Ecology*, 28: 133-177.

Van Vuren JHJ, Du Preez HH, Deacon AR (1994) Effect of Pollutants on the Physiology of Fish in the Olifants River (Eastern Transvaal). WRC Report No. 350/1/94. Water Research Commission, Pretoria, South Africa.

Appendix A: Site Photographs and Locations

Table 1: Site photos obtained during the 2016 surveys

Site	GPS	Photograph
KO1A	-26.294138° 29.837692°	
KO1B	-26.295152° 29.832075°	

Site	GPS	Photograph
KO2	-26.259461° 29.823274°	
KO3A	-26.241064° 29.781672°	
KO3B	-26.241667° 29.780880°	

Site	GPS	Photograph
KO4	-26.238541° 29.779605°	
KO5A	-26.201905° 29.766362°	
KO5B	-26.194766° 29.798475°	

Site	GPS	Photograph
KO6	-26.169235° 29.763670°	
KO7	-26.146995° 29.753234°