Aquatic Ecology Impact Assessment Report for KSPX Weltevreden

Aquatic Ecology Impact Assessment

Project Number:

BHP2690

Prepared for:

BHP Billiton Energy Coal South Africa (Pty) Limited

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This document has been prepared by Digby Wells Environmental.

Report Type:	**Aquatic Ecology Impact Assessment**
Project Name:	**Aquatic Ecology Impact Assessment Report for KSPX Weltevreden**
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Name	**Responsibility**	**Signature**	**Date**
Brett Reimers	Report writing		February 2015
Brett Coutts	Report review		February 2015

EXECUTIVE SUMMARY

Digby Wells Environmental (Digby Wells) has been appointed by BECSA as the independent Environmental Assessment Practitioner (EAP) to conduct the Environmental Impact Assessment (EIA) according to the NEMA, as well as associated specialist studies for the opencast development at KPSX: Weltevreden, as well as the required Public Participation Process (PPP).

Digby Wells is a South African company with international expertise in delivering comprehensive environmental and social solutions, with specific focus on the mining and energy industries.

The Olifants River already has extensive industry and mining within its catchment, which travels through much of Mpumalanga. In an effort to safe guard biodiversity within the province the Mpumalanga conservation plan was created. It draws heavily on data previously recorded for the river health program of South Africa.

The river health program was developed for the assessment of aquatic riverine systems and is thus not suited to assessing the predominantly wetland dominated aquatic systems that is associated with the proposed project.

Department of water affairs and sanitation aquatic ecosystem water quality guidelines were exceeded at all sites during the low flow assessment, with oxygen concentrations consistently recorded below acceptable levels. Most conditions improved during the high flow. Oxygen levels appear to be of concern within the system, as only two sites achieved acceptable water quality standards. Low oxygen levels are common in wetland systems when water stagnates and a large degree of decomposition takes place exhausting the water of its available oxygen.

The techniques employed resulted in lower than anticipated scores for the aquatic macroinvertebrates as well as the fish assessment. The wetland nature of the site means that the available habitat is often small and found in isolated pools during most of the year. This makes it difficult for species to migrate to deeper waters in low flows. Potential sites of refugia include many farm dams on the property which although their levels fluctuate to a large degree appear to retain some water throughout the year.

As the site is predominantly a wetland, the aquatic assessment tool set is poorly adapted to quantify the current environmental condition from an aquatic ecology perspective, it is proposed that the wetland report should take precedence over the aquatic ecology findings.

Potential impacts associated with the proposed opencast mining include:

- Threats to water quality:
  - The introduction of hydraulic and petrochemicals into streams;
  - Contamination with substances containing high amounts of nutrients; and
  - After closure the potential for decant and acid mine water formation.

- Physical threats to rivers
  - Increased sedimentation may alter or remove certain habitat types;
  - Increased turbidity results in a reduction of light penetration which can reduce food availability; and
  - Alteration of stream hydrology.

Mitigation measures have been proposed, among which are dirty and clean water separation and biomonitoring for the life of the project as well as post closure.

The cumulative impacts along the Olifants Catchment cannot be discounted; the catchment already contains a large degree of coal mining.

Due to the nature of the site and the short comings of the RHP tools in under these circumstances it is believed that wetland report should take the lead as it is the predominant ecosystem in the area with the aquatic report playing a supportive role.

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1 Introduction

Digby Wells Environmental (Digby Wells) has been appointed by BHP Billiton Energy Coal South Africa Proprietary Limited (BECSA) as the independent Environmental Assessment Practitioner (EAP) to conduct the Environmental Impact Assessment (EIA) according to the NEMA, as well as associated specialist studies for the opencast development at KPSX: Weltevreden, as well as the required Public Participation Process (PPP).

The Olifants Catchment is often described as South Africa's hardest working river, large amounts of mining, heavy industry and agriculture take place within its boundaries. These anthropogenic impacts have resulted in a river system that is highly polluted and modified.

The Mpumalanga Biodiversity Conservation Plan (MBCP) was developed in order to identify and prioritise sensitive landscapes based on their biodiversity and sensitivity to degradation (Ferrar & Lotter 2007). The MBCP encompasses not only terrestrial systems but crucially aquatic ecosystems. It integrates information from sources including documents compiled for the South African River Health Program (RHP).

Those systems that have been determined to be healthy are given a class or ranking of A or B depending on the degree of modification that has occurred within their sub-catchments. Classes also exist from C to F these systems range from moderately impacted to critically modified.

An increase in anthropogenic activities in river catchments has placed great pressures upon local aquatic ecology (Van Vuren *et al.,* 1994). Activities such as mining have the potential to disrupt and modify associated aquatic conditions (Van Vuren *et al*., 1994). These activities have potential impacts on the habitat and physico-chemical components of aquatic ecosystems, and have shown to alter the ecology of freshwater systems (De Klerk *et al.,* 2012). Certain stressors in the environment have been shown to affect freshwater biota in specific measurable means and therefore can serve as effective indicators of changes in the aquatic environmental (Zhou *et al.,* 2008). Due to the importance and use of aquatic biota as indicators of integrity, it is important to monitor aquatic conditions for potential ecological degradation (Dickens and Graham, 2002).

This study aims at establishing baseline conditions in the aquatic systems associated with the proposed KPSX: Weltevreden Project area. This was conducted from two site surveys, one low flow and one high flow site survey which included rapid biomonitoring techniques such as macroinvertebrate assemblage assessments.

1.1 Site Description

The site is in Mpumalanga Province situated near the town of Ogies. Figure 1-1 shows the regional setting of the proposed Project area.

The proposed infrastructure layout is represented below in Figure 1-3, Figure 1-4 below indicates the sample points utilised for the site survey.

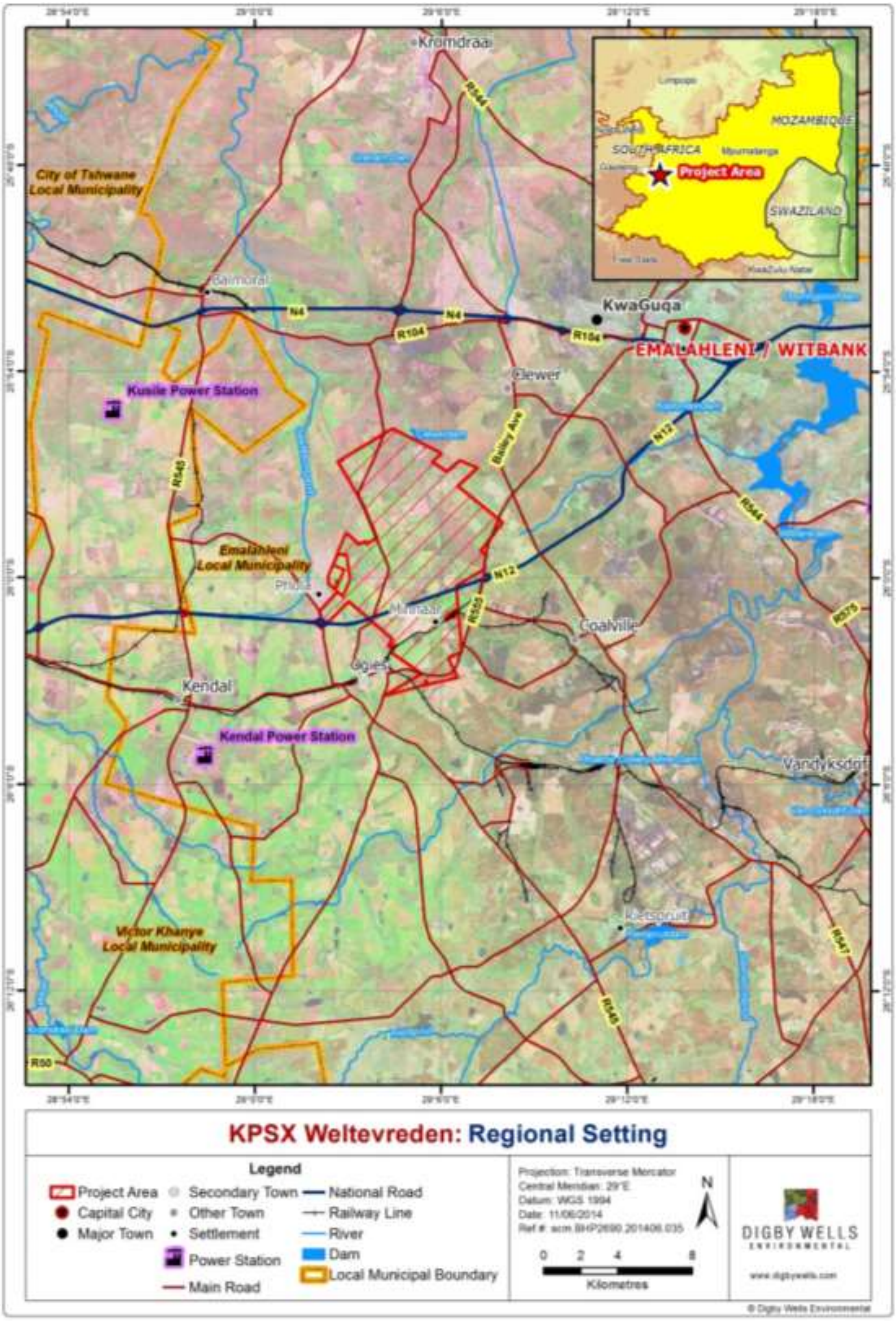

Figure 1-1: Regional Setting

1.1.1 Quaternary Catchments

The study area falls within the Upper Olifants section of the Olifants Catchment or Water Management Area (WMA) 4. The project area is situated on the watershed that divides three quaternary catchments namely: B11F, B11G, and B20G.

B11F’s and B11G’s rivers report to the Olifants River. The Tweefonteinspruit drains into the Klippoortjiespruit which enters the Olifants from B11F. The Noupoort River originates quaternary catchment B11G and is a tributary of the Olifants.

The Saalklapspruit which forms in the B20G quaternary catchment and reports to the Wilge River. The Wilge River is itself a tributary of the Olifants River. The associated quaternary catchments can be seen below in Figure 1-2.

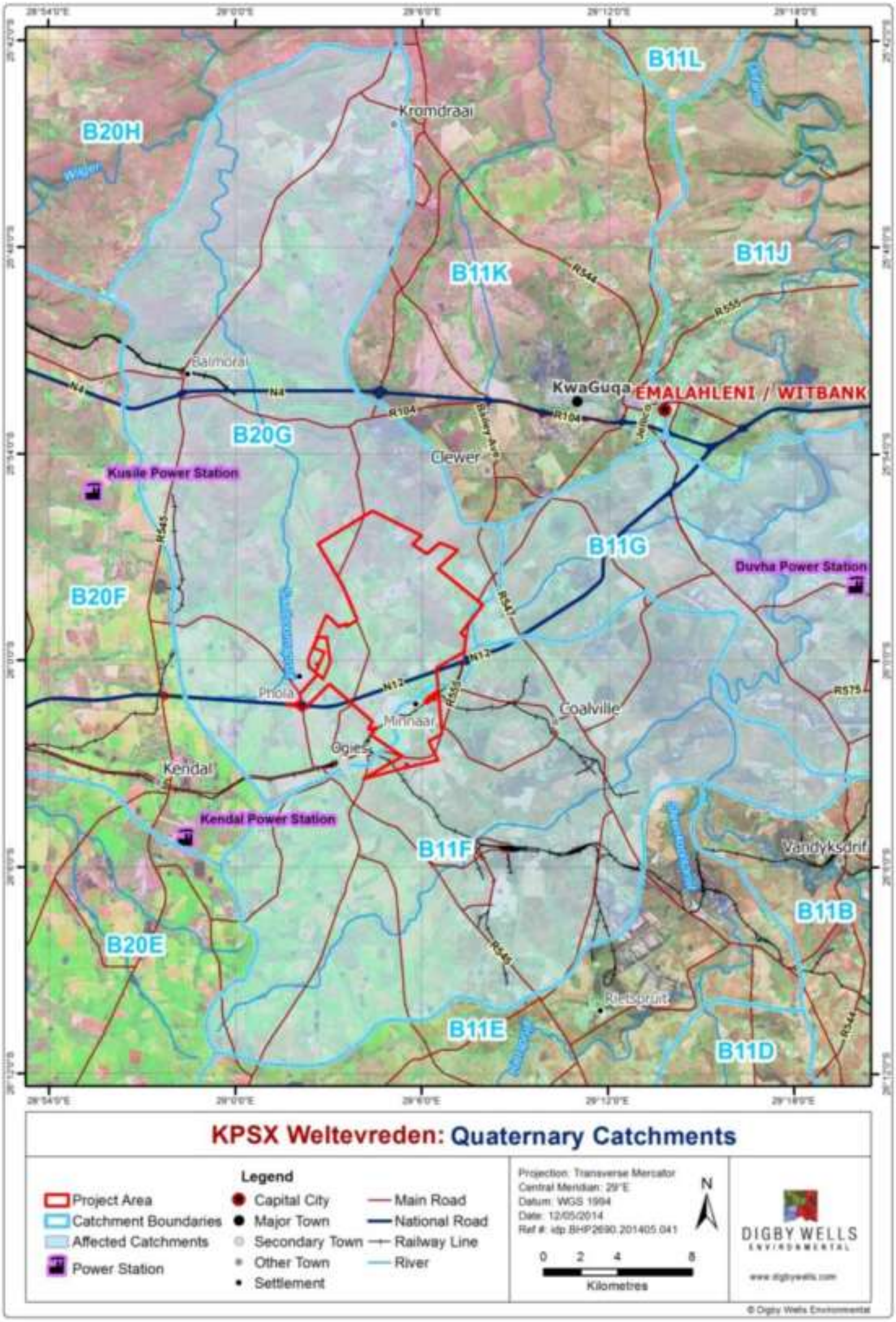

Figure 1-2: Quaternary catchment associated with the project area.

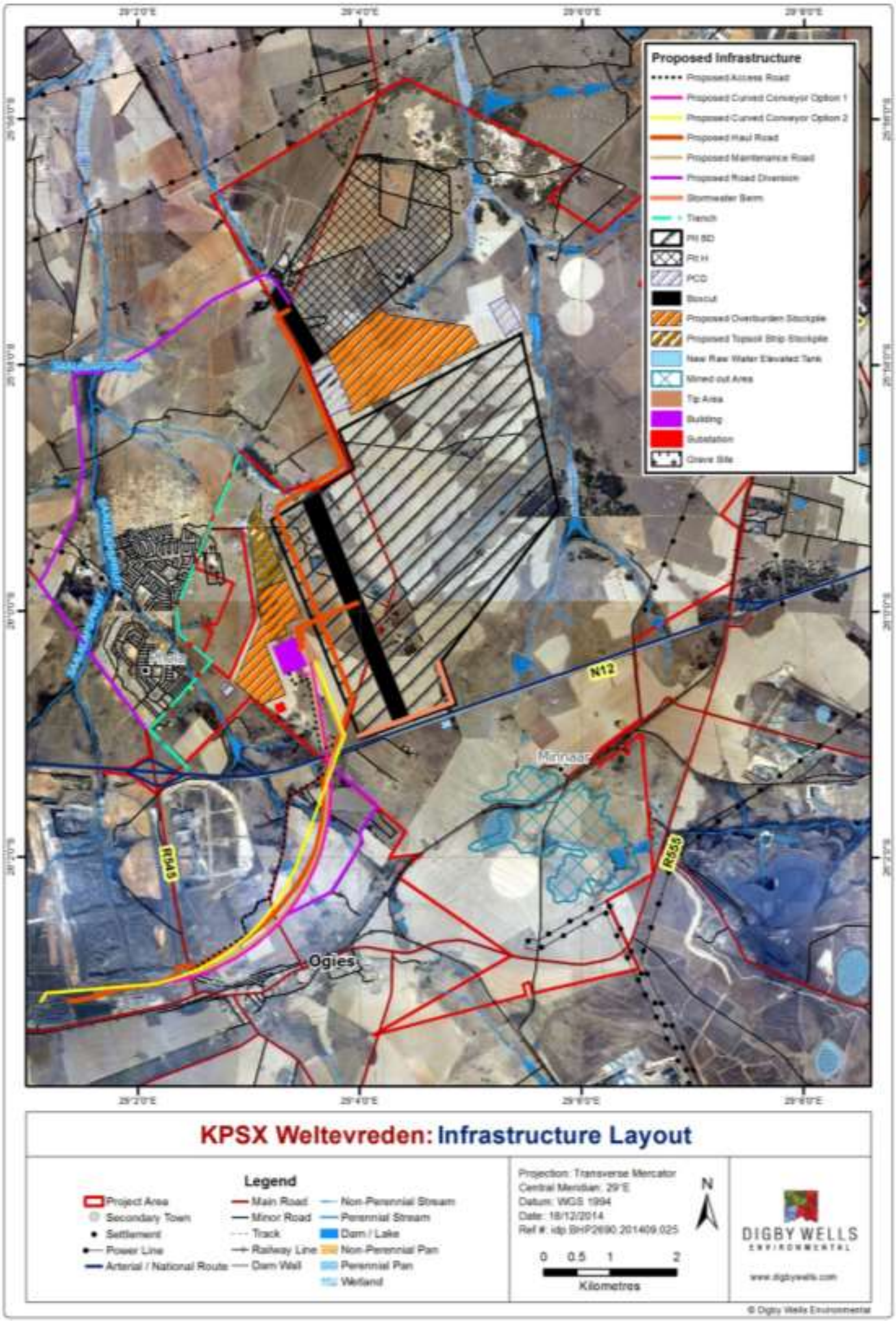

Figure 1-3: Infrastructure Layout

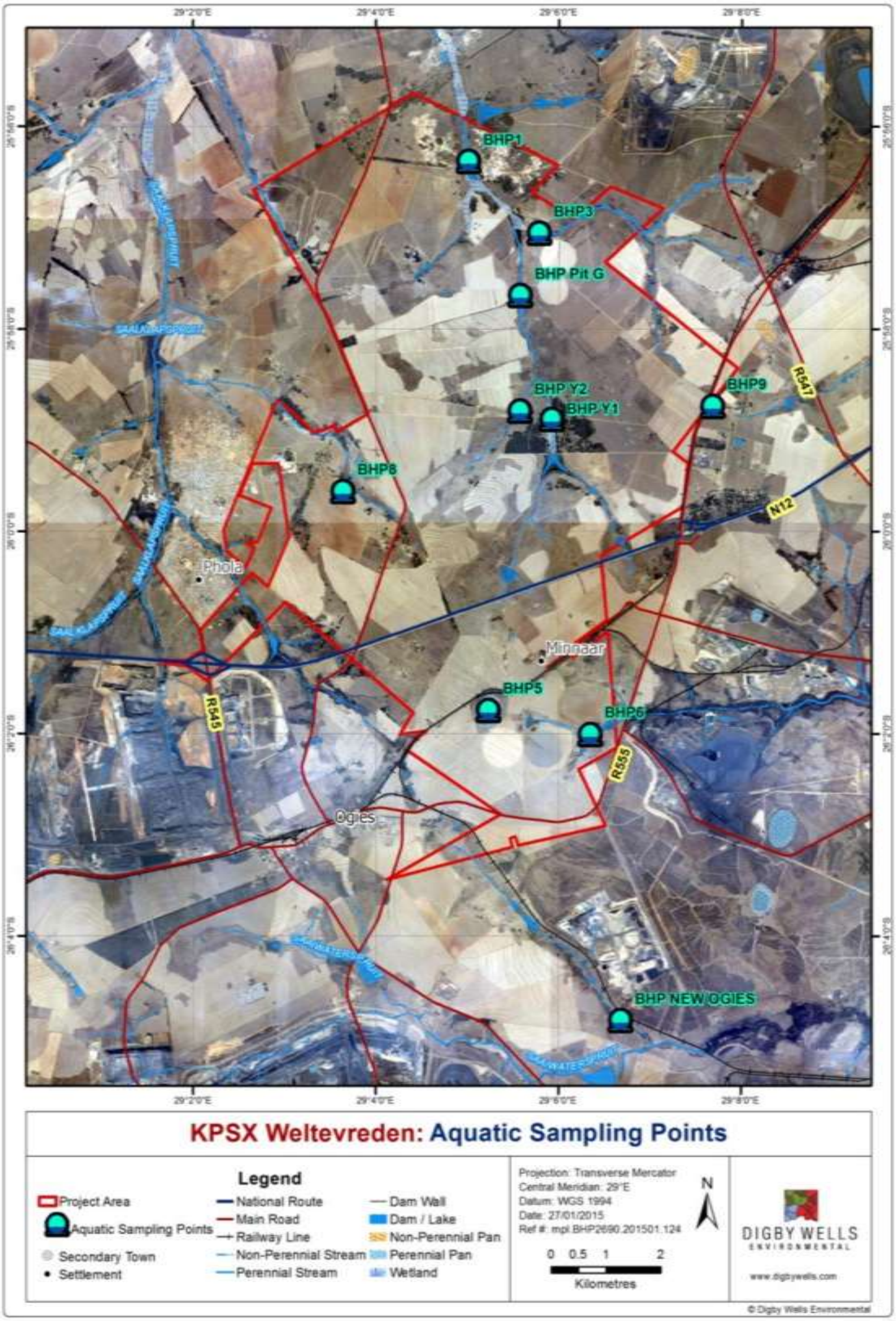

Figure 1-4: Aquatic sample points for the study area

1.1.2 Current and potential future management classes

Ecological classes range from natural systems to critically modified systems. Theese are ranked as follows:

A) Natural;
B) Largely Natural;
C) Moderately impacted;
D) Largely modified;
E) Seriously modified; and
F) Critically modified.

Table 1-1 demonstrates the current (present ecological and sensitivity) sensitivity of the catchment as well as what, if managed correctly it could become (its best attainable ecological management class).

Table 1-1: Summarising the current ecological and potentially achievable management classes

Quaternary Catchment	Estimated Importance and Sensitivity Category	Present Ecological and Sensitivity	Best Attainable Ecological Management Class
B20G	Moderate	Class C	Class C
B11F	Low/marginal	Class C	Class C
B11G	Low/marginal	Class C	Class C

Table adapted from Kleynhans (2000)

From the table it is evident that the systems are currently in a moderately state (Present ecological and sensitivity, PES) and are intended to stay in this state (best attainable ecological management class). This may be due to industrial or mining pressure on the catchments.

1.1.3 National Freshwater Ecological Priority Areas (NFEPA)

All of the above mentioned quaternary catchments fall outside of the defined NFEPA categories which imply that they are not currently priority areas in terms of the NFEPA guidelines (Nel *et al*. 2011).

1.1.4 Potential fish species within the affected rivers

Two of the quaternary catchments for the site do not have data on the expected fish species within their reach. The quaternary catchment B11G does however have reference data. Catchment B11F reports to B11G and it can be expected that they will have similar or related species within these catchments.

Quaternary catchment B20H was selected as a reference site for B20G as they both report to the Wilge River. B20H is affected by open cast mining within their catchments and as such may contain more sensitive species than B20G.

2 Scope of Work

Digby Wells Environmental (Digby Wells) was commissioned by BECSA to conduct an aquatic assessment as part of the Environmental Impact Assessment and Environmental Management Plan related to the application of a Section 102 amendment.

2.1 Terms of Reference

The following deliverables were agreed upon as part of the study:

- Low flow aquatic assessment;
- Aquatic ecology scoping report highlighting potential impacts posed by the proposed mining;
- A high flow aquatic assessment; and
- Aquatic ecology baseline and impact assessment report.

2.2 Legislation

The study conforms to the guidelines outlined in the Mpumalanga Conservation Plan

Further legal frameworks are outlined below in Table 2-1

Table 2-1: Table of legislation adhered to or consulted during the compilation of this report.

Framework or Legislation	Brief description
National South African Constitution (Constitution) Section 24	*"Everyone has the right to an environment that is not harmful to their health or well-being; and to have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that prevent pollution and ecological degradation; promote conservation; and secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development..."*
National Environmental Management Act , Act No 107 of 1998 (NEMA)	*Environmental Management must place people and their needs at the forefront of its concern. Development must be socially, environmentally and economically sustainable. Sustainable development requires the consideration of all relevant factors.* *The Environmental Impact Assessment (EIA) regulations (GN R. 385) dictate that any development that could result in significant environmental pollution or degradation is required to undertake an EIA process. The EIA regulations also provide for the formulation of*

	Environmental Management Frameworks for designated geographic areas to promote pro-active decision-making with regards to the choice of development alternatives.
National Biodiversity Act, Act 10 of 2004 (NEMBA) Chapter 3 and 4	*"To provide for the management and Conservation of South Africa's Biodiversity within the framework of the National Environmental Management Act, 1998;* *The protection of species and ecosystems that warrant national protection;* *The sustainable use of indigenous biological resources, the fair and equitable sharing of benefits arising from bioprospecting involving indigenous biological resources; the establishment of functions of a South African Biodiversity Institute, and for matters herewith."*
National Water Act, Act 36 of 1998 (NWA)	*Ensures sustainable use of water through the protection of quality of water resources for the benefit of all water users. Aquatic and wetland ecosystems are protected by legislation in order to secure ecologically sustainable development and use of the relevant water resources.*

3 Site Description

3.1 Location and notes

The project area in located within or boarders on three quaternary catchments, these are; B11F, B11G and B20G. The majority of the proposed infrastructure and footprint falls within B20F and to a lesser degree B11F. All of the river systems associated the project area drain into the Upper Olifants Catchment. The specific sites are detailed below in Table 3-1.

Table 3-1: Site location and notes

Site Name	GPS co-ordinates	Notes
BHP 1	25°55'7.85"S 29° 4'40.47"E	This site was the downstream monitoring point for the assessment. The stream forms as a result of the low water crossing. A large degree of instream vegetation was noted.
BHP 3	25°57'3.47"S 29° 5'46.99"E	This site forms as a result of seepage from the upstream dam it is characterised by steep crumbling banks and is well vegetated.
BHP Pit G	25°57'34.52"S 29° 5'36.54"E	This site forms as a result of the

Site Name	GPS co-ordinates	Notes
		overflow of the upstream dam. The stream occurs for a short distance before it begins pooling prior to becoming an channelled valley bottom wetland.
BHP Y1	25°58'53.88"S 29° 5'55.34"E	This site was identified during the desktop survey prior to the field survey; the site was an channelled valley bottom wetland.
BHP Y2	25°58'48.83"S 29° 5'34.29"E	BHP Y2 appears to form as a result of the seepage of the upstream dam, there is headward gully erosion where a stream is present.
BHP 9	25°58'45.94"S 29° 7'41.06"E	This is a pan within the B11G catchment bordering on the proposed project site.
BHP 5	26° 1'46.37"S 29° 5'13.95"E	This site is a large pan with a large degree of interaction with stock animals.
BHP 6	26° 2'0.57"S 29° 6'20.71"E	BHP 6 is a farm dam that appears to have a large seasonal variation
BHP New Ogies	26° 4'50.22"S 29° 6'40.71"E	The site is located in catchment B11F and is located downstream on the proposed project area within B11F
BHP 8	25°58'33.15"S 29° 2'27.10"E	This site is located downstream of the proposed project area and adjacent to the town of Phola.

3.2 Visual description of the sites

Below (

Table 3-2) is a selection of the images collected during the surveys as a visual description of the sites outlined in Table 3-1.

Table 3-2: Visual description of the aquatic survey points.

Site name	**Photographs**	
	Low Flow	**High Flow**
BHP 1		
BHP 3		

Site name	**Photographs**	
	Low Flow	**High Flow**
BHP Pit G	 	 
BHP Y1		
BHP Y2		

Site name	Photographs	
	Low Flow	**High Flow**
BHP 6		
BHP 5		
BHP New Ogies		

Site name	Photographs	
	Low Flow	**High Flow**
BHP 8		

4 Methodology

4.1 Survey timing

Two site visits were carried out, one during the low flow (or winter dry season: July 2014) and the other during the high flow (summer season: November 2014).

4.2 River Health Program

Table 4-1 demonstrates the descending order of river health classes.

Table 4-1: Classes of river systems within the RHP

Class	Description
A	Natural
B	Largely Natural
C	Moderately Modified
D	Largely Modified
E	Seriously Modified
F	Critically Modified

In 1994, the national Department of Water Affairs & Forestry (DWAF) initiated the South African River Health Programme (RHP). The initiative was aimed at gathering information on the ecological state of river ecosystems in South Africa (DWAF, 2011). In 1998 the national Water Act (Act No 36 of 1998), through the provision of an ecological reserve, sought to ensure the water required to maintain aquatic ecosystem integrity is available. The proposed strategy includes the protection of water resources to ensure their ability to support utilisation for the benefit of current and future generations; and the utilisation of water resources in the most efficient and effective manner, within the constraints set by the requirements for protection (DWAF, 2011).

4.3 Ecological Integrity

The methodology employed for the aquatic ecology impact assessment makes use of the methods designed for the South African River Health Program (RHP 2001). The RHP was designed to monitor and assess the freshwater river systems of South Africa. Their purpose is to aid in determining the ecological integrity of the river under study. It does this by assessing individual biophysical attributes associated with the river. These attributes are referred to as the drivers and responses of the aquatic ecosystem. The selected abiotic drivers and biological responses indicators for this study are discussed in greater detail below they include:

4.4 Abiotic driver assessment

- *In situ* water quality (DWAF, 1996);
- The Index of Habitat Integrity (IHI) (Kleynhans *et al*, 2008); and
- The Invertebrate Habitat Assessment System (IHAS) (McMillan, 2002).

4.5 Biotic response indicators assessment

- South African Scoring System 5 (SASS 5);
- Macroinvertebrate Assessment Index (MIRAI);and
- The Fish Response Assessment Index (FRAI).

According to Kleynhans and Louw (2007) the directional change in the attributes of the drivers and biota is referred to as a trend. Generally, an assessment may be approached from a driver perspective (Kleynhans & Louw, 2007). The driver components will be considered in order to determine the degree of contribution towards the current state of the biological communities. The ultimate objective is to determine if the biota have adapted to the current habitat template or are still in a state of flux (Kleynhans & Louw, 2007).

4.6 Water quality

Water quality is determined by a variety of factors including: physical, chemical, biological and aesthetic properties. These factors determine waters fitness for a variety of uses as well as for the protection of the health and integrity of aquatic ecosystems refers to the quality of water (DWAF, 1996). Various water quality parameters were all taken *in situ*, these include pH, temperature (°C), conductivity (µS/cm), oxygen content (mg/l) and oxygen saturation (DO %) using calibrated water quality meters.

The South African Water Quality Guidelines for Aquatic Ecosystems (DWAF, 1996) were applied to this study as the primary source of reference information. The South African Water Quality Guidelines contains information similar to that which is available in the international literature; however, the information provided is specifically formulated for Southern African aquatic ecosystems and water users (DWAF, 1996).

4.7 Habitat quality

An important factor which determines the survival of a species in an ecosystem is the state of the available habitat. The assessment of the composition of the surrounding physical habitat which influences the quality of the water resource and the condition of the resident aquatic community is referred to as a habitat assessment (Barbour *et al*. 1999).

As a result of habitat loss, alteration or degradation will cause the number of species to decline (Karr 1981). The diversity of biota dependant on the habitat will decrease if the habitat integrity decreases (Karr 1981).

4.7.1.1 Index of Habitat Integrity

The quality and diversity of the available habitat was assessed by means of the IHI (Kleynhans *et* al., 2008). The IHI was applied on a systems basis. The IHI integrity classes and a description of each class are presented in Table 6-1. This index assesses the number and severity of anthropogenic perturbations and the damage they potentially inflict on the habitat integrity.

Table 4-2: The IHI integrity classes and short descriptions of each class (Kleynhans *et al*., 2007)

Integrity Class	Description	IHI Score (%)
A	Natural	>90
B	Largely Natural	80 – 90
C	Moderately Modified	60 – 79
D	Largely Modified	40 – 59
E	Seriously Modified	20 – 39
F	Critically Modified	0 – 19

4.8 Aquatic Invertebrate Assessment

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

4.8.1.1 South African Scoring System Version 5

The SASS 5 is the current 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 such as Oligochaeta and Cnidaria, to highly sensitive families like Oligoneuridae. SASS results are expressed both as an index score (SASS score) and the Average Score Per recorded Taxon (ASPT value).

All SASS 5 and ASPT scores are compared with the SASS 5 Data Interpretation Guidelines (Dallas, 2007) for the relevant 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.

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

Figure 4-1 below is a representation of how the SASS 5 scores and the Average Score Per Taxon (ASPT) are used to calculate the health of a river system.

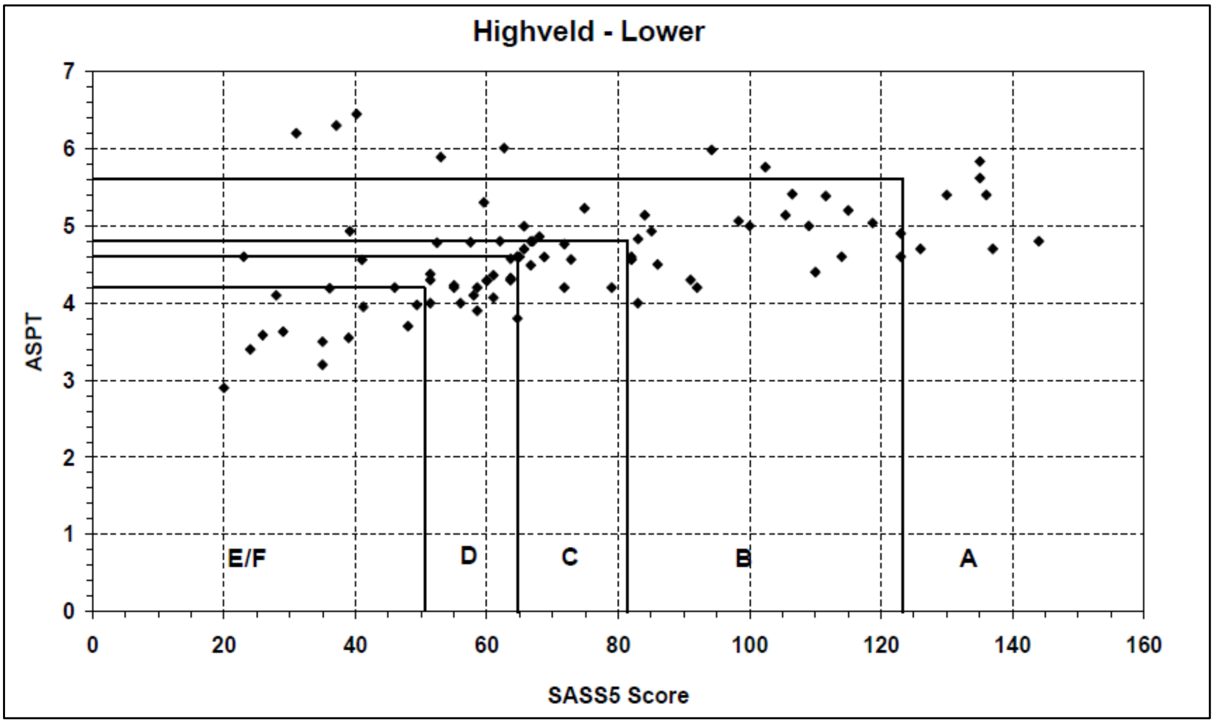

Figure 4-1: Biological banding for SASS5 interpretation

4.8.1.2 Macroinvertebrate Response Assessment Index

The aim of the MIRAI is to provide a habitat-based cause-and-effect base to interpret the deviation of the aquatic invertebrate community from the reference condition. This assessment does not exclude the calculation of SASS scores if required (Thirion, 2007). The four major components of a stream system that determine productivity for aquatic organisms are as follows:

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

4.8.1.3 Invertebrate Habitat Assessment System

The IHAS was specifically designed to be used in conjunction with the SASS 5, benthic macroinvertebrate assessments. 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 on the IHAS percentage scores is presented in Table 6-2.

Table 4-3: Description of IHAS scores with the respective percentage category (McMillan, 2002)

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

4.9 Fish Assessment

The information gained using FRAI gives an indication of the present ecological state of the river based on the fish assemblage structures observed. Fish species are then compared to those expected to be present for the Upper Olifants Catchment. The expected fish species list was developed from a literature survey and included sources such as (Kleynhans *et al*., 2007) and Skelton (2001).

4.10 Ecological Description

Ecological classification is a means by which current biophysical attributes of ecosystems are compared to the natural or close to natural reference conditions in order to determination and categorise of the systems integrity (Kleynhans and Louw, 2007). According to Iversen *et al*. (2000) EcoStatus may be defined as the totality of the features and characteristics of the system that bear upon its ability to support an appropriate natural flora and fauna. For the purpose of this study ecological classifications have been determined for biophysical attributes of the associated water courses.

5 Study Limitations

These are discussed in greater detail in Section 7. The aquatic ecosystems under investigation are predominantly wetlands with isolated areas of flow, almost always due to anthropogenic impacts such as the construction of low water crossings and dams.

Upon concluding the site investigation it was found that the sites associated with this proposed project are largely wetland sites. Some of the aquatics survey techniques could not accurately be applied in this instance due to the constraints placed on the above mentioned indices by the sampling protocols.

The results specific to aquatic sampling should be interpreted with caution. Their intention is to serve as a point of reference for later monitoring.

6 Results

Table 6-1 below displays the in situ water quality results obtained while on site. In situ data is collected in the field. It is a snap shot of the water quality parameters at the time of the survey.

Table 6-1: In situ water quality results for the aquatic sample points

Site	Acceptable Range (DWAF 2006)	BHP 1	BHP 3	BHP Pit G	BHP Y1	BHP Y2	BHP 9	BHP 5	BHP 6	BHP New Ogies	BHP 8
Low Flow											
Temperature (˚C)	5-30	8	14	14	Dry	11.8	Dry	9	11	11.4	14
pH	6.5-9	6.3	7.3	6.49	Dry	6.52	Dry	9.5	7.6	7.26	7.3
Conductivity (µS/cm)	<700	381	110	130	Dry	176	Dry	5500	450	179	102
Oxygen (%)	80-120	39	44	44	Dry	44	Dry	20	40	41	34
Oxygen (mg/l)	> 5	4.9	4.46	4.27	Dry	4.8	Dry	2.5	4	4.4	3.47
High Flow											
Temperature (˚C)	5-30	16	23.7	24	Dry	20	Dry	21	22	17.2	19.9
pH	6.5-9	6	7.46	7.15	Dry	6.3	Dry	9.6	8.8	6.2	7.41
Conductivity (µS/cm)	<700	730	227	96	Dry	140	Dry	22500	480	710	96.4
Oxygen (%)	80-120	61	32	86	Dry	78	Dry	Err	95	93	Err
Oxygen (mg/l)	> 5	6.36	3.04	7.54	Dry	6.8	Dry	Err	9.3	9	Err

Err: denotes a malfunction with the probe used to detect these variables.

6.1 Water quality

The various constituents of the *in situ* water quality analysis that fall outside the acceptable ranges (DWAF 1996) are highlighted per parameter in the sections below.

6.1.1 Temperature

All sites fall within acceptable temperature ranges for the DWAF (1996) aquatic ecosystem guidelines.

6.1.2 pH

6.1.2.1 Low flow

During the low flow survey sites BHP 1 BHP Pit G and BHP 9 exceeded the water quality guidelines. The first two sites were more acidic with lower pH values (pH 6.3 and pH 6.49 respectively) while BHP 9 exceeded the upper limit of the guidelines and was thus too basic at pH 9.5.

6.1.2.2 High flow

During the high flow sites BHP 1, BHP Pit G and BHP 5 fell outside of the prescribed limits for pH of aquatic ecosystems. BHP 1 and BHP Pit G were below the recommended range at pH 6.3 and 6.49 (slightly acidic) respectively while BHP 5 came in above the upper acceptable limit at pH 9.5 (slightly basic).

6.1.3 Conductivity

Conductivity is a measure of a substances ability to conduct electricity, in water this refers to the amount of dissociated ions that are available to pass on a charge. The conductivity in water is related to the total dissolved solids (dissolved minerals, salts or metals), and thus is a measure of the ionic potential of the water.

During the low flow survey BHP 5 was found to have nearly eight times higher conductivity than the maximum guideline amount at 5 500 µS/cm this increased further to 22 500 µS/cm in the high flow.

Site BHP 1 and BHP New Ogies increased from within acceptable limits during the low flow (BHP 381 µS/cm and BHP New Ogies 179 µS/cm) to 703 µS/cm and 710 µS/cm respectively in the high flow.

Sites BHP 3, BHP Pit G, BHP Y2 BHP 6 and BHP 8 all were below the recommended limit of 700 µS/cm during both surveys.

6.1.4 pH and Conductivity analysis

Below are two sets of graphs that depict the relationship between the *in situ* water quality results of conductivity and pH. The low flow graph is depicted in Figure 6-1 and the high flow results in Figure 6-2.

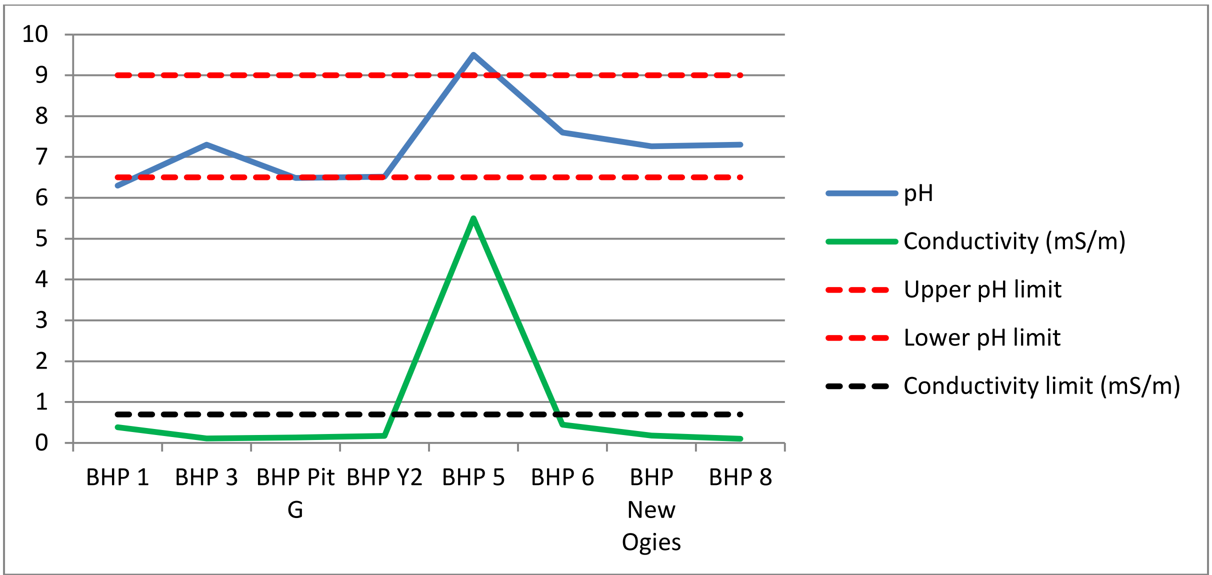

Figure 6-1: Low flow conductivity and pH results compared graphically

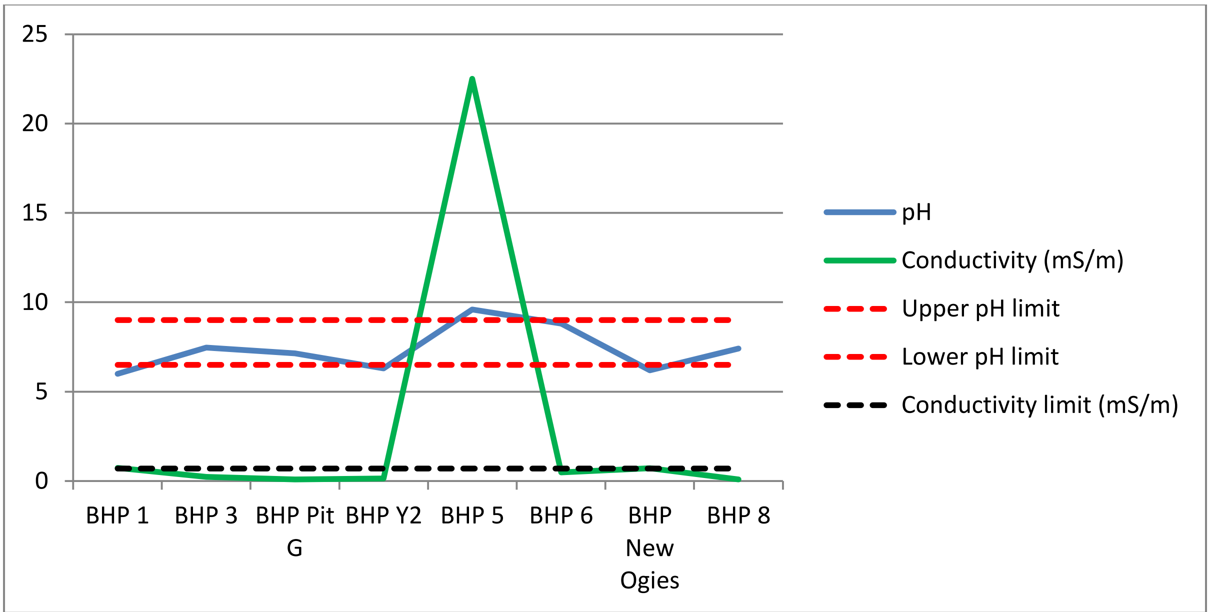

Figure 6-2: High flow conductivity and pH compared graphically

The graphs appear to show a mirrored increase in pH and conductivity specifically at site BHP 5.

6.1.5 Dissolved Oxygen

All streams surveyed during the low flow survey contained less oxygen than acceptable by aquatic ecosystem guidelines. This improved during the high flow with sites BHP Pit G, BHP 6 and BHP New Ogies coming in line with acceptable guidelines.

Interestingly sites BHP 1 and BHP 5 were below acceptable limits with regard to oxygen percentage recorded while within limits when values were recorded and milligrams per litre.

Error values recorded were as a result of equipment failure, water samples could not be attained for later assessment due to the nature of oxygen in water which depending on handling could either decrease or increase in the oxygen concentrations.

6.1.6 Dry sites

BHP Y1 and BHP 9 were consistently dry during both the low and high flow assessment.

BHP Y1 was a valley bottom wetland while BHP 9 appeared to be a dry pan. These sites were included in case of future inundation.

6.2 Habitat quality

6.2.1 Index of Habitat Integrity

Below in Table 6-2 are presented the IHI results for the aquatic impact assessment. The IHI gives an indication of whether or not the habitat available is suitable to aquatic organisms

Table 6-2: IHI results

IHI Results	
Instream IHI (%)	63.9
Instream IHI EC	C

The IHI reports a C value for the state of the habitat assessed. However as this index was designed for aquatic ecosystems, these results it should be interpreted with caution

The ecological category of C indicates that the habitat is in a moderately modified state.

6.3 Aquatic Invertebrate Assessment

The SASS version 5 is a rapid sampling procedure intended to be comparable to catchments in the same ecoregion in similar states of gradients. The sampling results are displayed below.

Table 6-3: Results of Sampling using the SASS version 5 technique

Site	BHP 1	BHP 3	BHP Pit G	BHP 6	BHP 8
Low Flow					
SASS Score	62	18	58	10	20
No of Taxa	14	12	15	4	5
ASPT	4.4	4.32	3.86	2.5	4
Ecological category	D	E/F	D	E/F	E/F
High Flow					
SASS Score	81	92	52	Levels too low	43
No of Taxa	16	20	15	Levels too low	13
ASPT	5.1	4.6	3.46	Levels too low	3.31
Ecological category	C	C/D	E/F	Levels too low	E/F

SASS5 scores range from C (moderately modified) to D (Largely modified) and into E/F (seriously modified).

These results should not be considered true SASS (ver 5) results, they were obtained using the SASS sampling techniques however the habitat available in most cases was not in line with the requirements for a SASS (ver 5) assessment. Sites sampled included dams and wetland areas.

6.3.1 Integrated habitat assessment system

The IHAS model assesses the suitability of the habitat to aquatic invertebrates. Below in Table 6-4 are the IHAS results for those sites sampled during the high and low flow using the SASS technique.

Table 6-4: IHAS results

	Sites			
	BHP 1	**BHP 3**	**BHP Pit G**	**BHP 8**
IHI Score (%)	71	59	58	53
Class	Good	Fair	Fair	Poor

The classes are determined and compared as a percentage. Any value below 55% is deemed to be poor, 55-64% is fair habitat, while 64-75% is good and above that is very good.

6.4 Fish Assessment

Fish are important markers of ecosystem health as such the presence and abundances are recorded for input into the FRAI model. The table below details the species previously reported for quaternary catchments B11G and B20H and those caught during the survey. Also included are the International Union for the Conservation of Nature's red data standings.

Table 6-5: Expected fish species for quaternary catchment B11G and B20H

Scientific Name	Common Name	Quaternary Catchment	Caught	IUCN Red data status (Ver 3)
Barbus anoplus	Chubby head barb	B11G & B20H	No	Least concern
Barbus neefi	Sidespot barb	B11G & B20H	No	Least concern
Barbus paludinosus	Straightfin barb	B11G & B20H	No	Least concern
Labeobarbus polylepis	Smallscale yellowfish	B11G & B20H	No	Least concern
Barbus trimaculatus	Theespot barb	B11G & B20H	No	Least concern
Cyprinus carpio	Carp (exotic)	B11G & B20H	No	Least

Scientific Name	Common Name	Quaternary Catchment	Caught	IUCN Red data status (Ver 3)
				concern
Clarias gariepinus	Sharptooth catfish	B11G	Yes	Least concern
Gabusia affinus	Mosquito fish (exotic)	B11G & B20H	No	Least concern
Labeo umbratus	Moggel	B11G	No	Least concern
Microterus salmoides	Largemouth bass (exotic)	B11G	Yes	Least concern
Pseudocrenulabus philander	Southern Mouthbrooder	B11G & B20H	Yes	Not Assessed
Tilapia sparrmanii	Banded tilapia	B11G	Yes	Least concern
Labeobarbus marequensis	Largescale yellowfish	B20H	No	Least concern
Labeo cylindricus	Redeye labeo	B20H	No	Least concern

Adapted from Kleynhans (2007)

Only four species of fish were caught these included *Clarius gariepinus*, *Pseudocrenulabris philander* and *Tilapia sparrmanii.* One exotic species was also captured; *Microterus salmoides* or largemouth bass is an invasive predatory species.

6.4.1 FRAI results

The results for the FRAI model are displayed below in Table 6-6. FRAI gives an indication of the river health based on the presence and abundance of fish species related to which species are expected in the catchment.

Table 6-6: FRAI results for the high and low flow

FRAI Results	
FRAI (%)	29.3
EC FRAI	E

The FRAI score of 29.3% is very low and falls within the ecological category of E or seriously modified systems.

As with the SASS (version 5) results the system was not conducive to an accurate FRAI assessment within the parameters of the protocol and the results are recorded here for potential comparison with future studies.

7 Discussion

7.1 Water Quality

7.1.1 A note on the dry sites

As noted in Section 6.1.6 (Results) BHP Y1 and BHP 9 were consistently dry through both surveys. BHP Y1 appeared to be a valley bottom wetland that had resulted due to ground flow seepage from the large farm dam directly upstream of the sample point.

Site BHP 9 appeared to be a pan, perhaps of endoheic function (rainwater fed). Or perhaps situated on a dry or none surface seeping aquifer.

As such neither of these sites could be assessed as aquatic ecosystems.

7.1.2 Temperature

Temperatures fall within the guideline range expected of aquatic systems. However, the pans in particular may exceed these water temperatures when water levels drop and high temperatures are maintained for a series of days.

7.1.3 pH

Site BHP 5 is a pan and as such all water that walls within the catchment is contained within the pan. The nature of such pans seldom allows for the flushing and transport away of any chemical constituents that may alter the chemical parameters of the pan.

7.1.4 Dissolved oxygen

Oxygen levels in water are influenced by the temperature of the water. As the temperature rises oxygen’s solubility decreases, this reduces the amount of oxygen that the water can retain. It is likely that with the sites that had oxygen levels within limits when measuring the mg/l and below guideline limits when the percentage of oxygen was measured were subject to higher temperatures on the day of the high flow survey.

7.1.5 Conductivity

The conductivity at site BHP 5 was a large outlier when compared to the other values observed. This is likely due to the inward draining nature of the pan and that is often used as a grazing pasture for cattle which would consume the water and increase the ions available to raise the conductivity by urinating and defecating within the system. BHP 5 increase from 5500 µS/cm to 22 500 µS/cm

The other outliers were recorded during the high flow survey, 730 µS/cm and 710 µS/cm at sites BHP 1 and BHP New Ogies respectively. This may have been due to lower than expected flows during the high flow survey. Greater evaporation from increasing temperatures would increase the concentration of solids within the water body. Other potential sources of impacts include surrounding farming or coal mining within the catchment as is the case with BHP New Ogies.

7.1.6 *In situ* water quality conclusion

Water quantities appeared to be greatly reduced when compared to the low flow survey this is likely as a result of the higher that usual rain fall during the 2013/2014 wet season.

Water quality appears to decrease as water levels drop. The high water levels during the low flow assessment are likely due to the previous wet season of 2013/2014. As the majority of the site consists of wetlands the passage of water through this landscape is slowed due to the surface roughness and the fine particle sizes of the soils.

7.2 Habitat Quality

7.2.1 Index of habitat integrity

The IHI results show that the system is considered to be in a C state (moderately modified). However this may not be a true reflection of the environment as many places along the water course are dry or channelled valley bottom wetlands. These wetlands would prevent migration up stream and potentially reduce the available spawning grounds.

7.2.2 Integrated habitat assessment system

IHAS results indicate that the habitat ranges from poor at site BHP 8 to fair at sites BHP 3 and BHP Pit G. While BHP 1, the downstream site, achieved a ranking of good. The downstream site’s results may be skewed do to the presence of manmade low water crossings. Multiple potential impacts including sand mining, coal mining and heavy vehicles were present in the catchment and within close proximity of the site. The low water crossing provided a bed rock like substrate and debris from construction was present in the stream channel.

7.3 Aquatic Invertebrate Assessment

7.3.1 SASS

All aquatic sites were compared with the Highveld Lower biological banding as per Dallas (2007). Sites ranged between moderately modified (BHP 1 during the high flow) largely modified (BHP 1, high flow, and BHP Pit G during the low flow) and seriously or critically modified (the remainder of sites during low and high flow).

The SASS protocol was not intended to be utilized in wetland systems. By and large the streams assessed were part of channelled valley bottom wetlands. SASS5 is not intended to be used in these circumstances it is recorded here as a baseline for further monitoring. Of more critical importance is the state of the wetlands. They occupy a much larger area and contain within them the aquatic sites that were assessed. The wetland areas are covered in much greater detail in the wetland report. The state of the wetlands are reported to be in a moderately to a largely modified state (PES C and D respectively).

7.3.2 MIRAI

As the SASS5 data was recorded from sites that fall outside of the protocols and intended parameters for the technique utilizing this information in a model designed to interpret these results would result in outputs with very little real world value. It was felt that since the SASS5 data was collected directly and there is little calculation involved aside from simple mathematical functions that it would serve as a better more robust baseline measure of the current state of the aquatic environment. To subject this data to comparisons and more complicated models intended for purely aquatic systems would remove what little meaning the data may possess.

7.4 Fish Assessment

The site is predominantly a wetland, stream rejuvenation occurs due to manmade structures such as low water bridges and dams. Free flowing water often seeps back into the ground shortly after it emerges; this leaves very limited pools for organisms to find refuge in during the low flow events. However various farm dams exist within the project area it is likely that fish find refuge in these locations and may migrate when water levels are high enough.

Only four fish species were caught during the survey, one of them *Microterus salmoides* is an alien invasive, These species are more tolerant to low flow volumes and were often small enough that low oxygen concentrations would be less of an issue due to smaller body volume to absorption area. *M. salmoides* is an intensely predatory fish and as such can alter community structure due to its feeding habits.

More sensitive species such as *Labeobarbus spp* and *Labeo sp* require flow and higher levels of oxygenation. Food scarcity and diversity may also be of concern given the low SASS5 scores.

7.5 Ecological Description

As previously made mention of the aquatic tool and protocols brought to bear in this study are not suited to predominantly wetland environments and as such the results would not be a true reflection of the current state of the environment, in this instance the wetland assessment should take precedent and be used first to inform decision making.

8 Impact Assessment

8.1 Introduction

The impacts of the development and operation of the opencast mining project on the receiving aquatic ecosystems associated with the project area were assessed at different stages of the development of the mine according to the methodology indicated in Table 8-2.

A clearly defined rating scale is used to assess each impact in terms of severity, spatial extent and duration (which determines the consequence) and in terms of the frequency of the activity and the frequency of the related impact (which determines the likelihood of occurrence). The overall impact significance is then determined using a significance rating matrix (Table 8-3) based on the scores obtained for consequence and likelihood of occurrence, to assign a final impact rating.

8.2 Project activities

The activities associated with the KPSX: Weltevreden Project are included in Table 8-1 below.

Table 8-1: Project Activities

Activity No.	Activity
Construction Phase	
1	The recruitment, procurement and employment of construction workers, engineers and contractors.
2	The transportation of construction material to the Project site via national, provincial and local roads.
3	Storage of fuel, lubricant and explosives in temporary facilities for the duration of the construction phase. These substances are classified as hazardous in terms of the Hazardous Substances Act, 1973 (Act No. 15 of 1973) and will be managed accordingly.

Activity No.	Activity
4	Site clearance and topsoil removal prior to the commencement of physical construction activities, as well as the open pit mining. This activity refers to the conversion of undeveloped, vacant land into industrial use.
5	Construction of surface infrastructure will take place, including the offices and fuel bay, haul roads, PCDs, coal tip and conveyor belt, pipelines and clean water canals and a high mast radio communication tower.
6	The construction of stockpiles, including topsoil, overburden and discard and emergency coal stockpiles.
7	The establishment of the initial boxcut and access ramps to the open pit mining areas.
Operational Phase	
8	Limited employment of skilled and unskilled labour will be required for the operation of the mine and support infrastructure.
9	Storage of fuel in diesel tanks, as well as lubricant and explosives in facilities for the duration of Project. These substances are classified as hazardous in terms of the Hazardous Substances Act, 1973 (Act No. 15 of 1973) and will be managed accordingly.
10	Drilling and blasting of the overburden rock for easy removal by excavators and dump trucks.
11	Coal removal by truck and shovel methods from the exposed coal seams. The coal is removed with shovels and transported to the plant by conveyor belt by trucks.
12	Vehicular activity on the proposed haul roads. Mining equipment will utilise the haul roads to access open pit areas, as well as to transport coal from the opencast pit to the plant and conveyor belt. The haul road will consist of wetland and stream crossings.
13	Mine water, or dirty water that is located within the opencast pits will need to be diverted by channels and berms to the PCDs to prevent clean water resources from being contaminated. Pipelines will pump the dirty water from the KPSX: Weltevreden PCDs to the KPS PCD.

Activity No.	Activity
14	Use of conveyor belts to transport the coal to the stockpiles at the KPS plant.
15	The PCDs will store all dirty water that has come into contact with the opencast pit, overburden stockpiles or emergency coal stockpile.
16	Operation and maintenance of the stockpiles, including topsoil, overburden and discard and ROM coal stockpiles.
17	Waste and sewage generation and disposal. All domestic, industrial and hazardous waste is produced during the mining process. Waste includes cans, plastics, used tyres and oil which must be disposed of in an appropriate manner by a contractor at a licensed waste disposal site. Sewage produced from the office buildings and ablutions will be treated at a sewage plant, septic tank or French drain system.
18	Concurrent replacement of overburden and topsoil and the re-vegetation of mined out strips. The mined strip will be backfilled with the overburden and compacted. Subsequently, the topsoil will be placed on top of the overburden and the area will be vegetated.
Decommissioning Phase	
19	Retrenchment of mine employees and staff will take place following the cessation of the mining operations and coal beneficiation activities.
20	Demolition of infrastructure will take place and includes the PCDs, haul roads, coal tip and conveyor belts, pipelines, high mast radio communication tower, fuel bay and mine offices and workshop.
21	Removal of fuel, lubricant and explosives will be required following the cessation of the mining activities to ensure that there is no health and safety risk to the environment and to people.
22	Final replacement of overburden and topsoil and the establishment of vegetation on the final open cast void. Overburden will be backfilled into the final void and compacted. Subsequently, topsoil will placed and the area vegetated.
23	Waste handling of scrap metal and used oil as a result of the Decommissioning Phase will be undertaken.

Activity No.	Activity
Post-closure Phase	
24	Post-closure monitoring and rehabilitation will determine the level of success of the rehabilitation, as well as to identify any additional measures that have to be undertaken to ensure that the mining area is restored to an adequate state. Monitoring will include surface water, groundwater, soil fertility and erosion, natural vegetation and alien invasive species and dust generation from the coal discard dumps.

Sections highlighted in green fall within the scope of activities that this report deals with.

8.3 Impact Rating Methodology

The methodology utilised to assess the significance of potential social and heritage impacts is discussed in detail below. The significance rating formula is as follows:

Significance = Consequence x Probability

Where

Consequence = Type of Impact x (Intensity + Spatial Scale + Duration)

And

Probability = Likelihood of an Impact Occurring

In addition, the formula for calculating consequence:

Type of Impact = ***+1*** *(Positive Impact) or* ***-1*** *(Negative Impact)*

The weight assigned to the various parameters for positive and negative social and heritage impacts is provided for in the formula and is presented in Table 8-2. The probability consequence matrix for social and heritage impacts is displayed in Table 8-3, with the impact significance rating described in Table 8-4.

Table 8-2: Aquatic Ecology Impact Assessment Parameter Ratings

Rating	Intensity		Spatial scale	Duration	Probability
	Negative Impacts ***(Type of Impact = -1)***	***Positive Impacts*** ***(Type of Impact = +1)***			
7	Very significant impact on the environment. Irreparable damage to highly valued species, habitat or ecosystem. Persistent severe damage. Irreparable damage to highly valued items of great cultural significance or complete breakdown of social order.	Noticeable, on-going social and environmental benefits which have improved the livelihoods and living standards of the local community in general and the environmental features.	International The effect will occur across international borders.	Permanent: No Mitigation The impact will remain long after the life of the Project.	Certain/ Definite. There are sound scientific reasons to expect that the impact will definitely occur.
6	Significant impact on highly valued species, habitat or ecosystem. Irreparable damage to highly valued items of cultural significance or breakdown of social order.	Great improvement to livelihoods and living standards of a large percentage of population, as well as significant increase in the quality of the	National Will affect the entire country.	Beyond Project Life The impact will remain for some time after the life of a Project.	Almost certain/Highly probable It is most likely that the impact will occur.

Rating	Intensity		Spatial scale	Duration	Probability
	Negative Impacts ***(Type of Impact = -1)***	***Positive Impacts*** ***(Type of Impact = +1)***			
		receiving environment.			
5	Very serious, long-term environmental impairment of ecosystem function that may take several years to rehabilitate. Very serious widespread social impacts. Irreparable damage to highly valued items.	On-going and widespread positive benefits to local communities which improves livelihoods, as well as a positive improvement to the receiving environment.	Province/ Region Will affect the entire province or region.	Project Life The impact will cease after the operational life span of the Project.	Likely The impact may occur.

Rating	**Intensity**		**Spatial scale**	**Duration**	**Probability**
	Negative Impacts ***(Type of Impact = -1)***	***Positive Impacts*** ***(Type of Impact = +1)***			
4	Serious medium term environmental effects. Environmental damage can be reversed in less than a year. On-going serious social issues. Significant damage to structures / items of cultural significance.	Average to intense social benefits to some people. Average to intense environmental enhancements.	Municipal Area Will affect the whole municipal area.	Long term 6-15 years.	Probable Has occurred here or elsewhere and could therefore occur.
3	Moderate, short-term effects but not affecting ecosystem function. Rehabilitation requires intervention of external specialists and can be done in less than a month. On-going social issues. Damage to items of cultural	Average, on-going positive benefits, not widespread but felt by some.	Local Extending across the site and to nearby settlements.	Medium term 1-5 years.	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.

Rating	Intensity		Spatial scale	Duration	Probability
	Negative Impacts ***(Type of Impact = -1)***	***Positive Impacts*** ***(Type of Impact = +1)***			
	significance.				
2	Minor effects on biological or physical environment. Environmental damage can be rehabilitated internally with/ without help of external consultants. Minor medium-term social impacts on local population. Mostly repairable. Cultural functions and processes not affected.	Low positive impacts experience by very few of population.	<u>Limited</u> Limited to the site and its immediate surroundings.	<u>Short term</u> Less than 1 year.	<u>Rare/ improbable</u> Conceivable, but only in extreme circumstances and/ or has not happened during lifetime of the Project but has happened elsewhere. The possibility of the impact materialising is very low as a result of design, historic experience or implementation of adequate mitigation measures.

Rating	**Intensity**		**Spatial scale**	**Duration**	**Probability**
	Negative Impacts ***(Type of Impact = -1)***	***Positive Impacts*** ***(Type of Impact = +1)***			
1	Limited damage to minimal area of low significance that will have no impact on the environment. Minimal social impacts, low-level repairable damage to commonplace structures.	Some low-level social and environmental benefits felt by very few of the population.	Very limited Limited to specific isolated parts of the site.	Immediate Less than 1 month.	Highly unlikely/None Expected never to happen.

Intensity will be reflected in the significance rating in the impact tables below.

Table 8-3: Probability Consequence Matrix for Environmental Impacts

		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 8-4: Significance Threshold Limits

Score	Description	Rating
109 to 147	A very beneficial impact which 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	An important positive impact. The impact is insufficient by itself to justify the implementation of the Project. These impacts will usually result in positive medium to long-term effect on the social and/or natural environment.	Minor (positive)
3 to 35	A small positive impact. The impact will result in medium to short term effects on the social and/or natural environment.	Negligible (positive)
-3 to -35	An acceptable negative impact for which mitigation is desirable but not essential. 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 social and/or natural environment.	Negligible (negative)

Score	Description	Rating
-36 to -72	An important negative impact which 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 social and/or natural environment.	Minor (negative)
-73 to -108	A serious negative impact which may prevent the implementation of the Project. These impacts would be considered by society as constituting a major and usually a long-term change to the (natural and/or social) environment and result in severe effects.	Moderate (negative)
-109 to -147	A very serious negative impact which 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.	Major (negative)

8.4 Impact Ratings

Below are detailed the impact assessments for the aquatic ecosystems within and associated with the proposed open cast coal mining activities. They are divided into the no go option and the proposed project impacts.

8.4.1 Impact intensity

All impacts have been rated as negative. For the purpose of simplicity all final values have been multiplied by negative one.

8.4.2 No go option

The impact tables and discussion below detail the potential impacts to the site if the status quo is maintained. Currently the majority of impacts from farming both crop production as well as stock farming.

Issue 1	**Deterioration of river banks**				
Parameters	**Severity**	**Spatial scale**	**Duration**	**Probability**	**Significance**
Impact 1	**Trampling**				
Pre-mitigation	Very Limited (1)	Local (3)	Medium Term (3)	Almost certain (6)	Minor (-42)

Issue 1	**Deterioration of river banks**				
Parameters	**Severity**	**Spatial scale**	**Duration**	**Probability**	**Significance**
Post-mitigation	Very Limited (1)	Limited (2)	Short term (2)	Probable (4)	Negligible (-20)
Impact 2	**Erosion**				
Pre-mitigation	Limited (2)	Local (3)	Medium Term (3)	Almost certain (6)	Minor (-36)
Post-mitigation	Very Limited (1)	Limited (2)	Medium Term (3)	Likely (5)	Minor (-25)

Physical damage to the river banks caused by watering stock animals in the river resulting in increased sedimentation which can increase the turbidity of the water limiting light penetration and reducing the algal base of the food web. This can have knock on affects by reducing abundance of certain macro invertebrates and fish.

Erosion can be caused by overgrazing, removing the vegetation layer that anchors the soil in place allows for rains and runoff to transport more top soils away. This has similar effects to trampling in conjunction with causing river bank erosion resulting in steep banks and gully formation.

Mitigation measures include installing troughs in the grazing fields to reduce the necessity of stock animals entering the river.

When erosion is observe engineering solutions can be install to reduce and rehabilitate the area by means of trapping the loose soil and allowing for revegetation to take place. However, it is far better to exercise good land use practises and rotate grazing fields to allow the grasses to recover and maintain their root structures.

Issue 1	**Pollution or contamination from farm practises**				
Parameters	**Severity**	**Spatial scale**	**Duration**	**Probability**	**Significance**
Impact 1	**Hydrocarbons or illegal disposal of motor oil**				
Pre-mitigation	Moderate (3)	Local (3)	Medium Term (3)	Probable (4)	Minor (-36)
Post-mitigation	Very Limited (1)	Limited (2)	Short term (2)	Probable (4)	Negligible (-20)
Impact 2	**Urban runoff**				
Pre-mitigation	Moderate (3)	Local (3)	Medium Term (3)	Almost certain (6)	Minor (-36)
Post-mitigation	Very Limited (1)	Limited (2)	Medium Term (3)	Likely (5)	Negligible (-30)

Relatively small amounts of used motor oil can contaminate very large bodies of water, reducing the health of the organisms that live within the water column and potentially harming people or livestock who drink from the contaminated source.

Waste water treatment works are often running past their design capacity and as a result discharged water can be below the intended standard. This discharged water may contain excess nutrients which can lead to algal growths within rivers. The algal growth alters the habitat and has the potential to impact on the community structure reducing biodiversity.

Illegal dumping should be policed and education campaigns need to be carried out to reduce the potential of these events taking place. It is essential that waste water treatment works are maintained and the capacity expanded as the population it services grows. Alternately passive water treatment schemes could be investigated to reduce the burden on the waste water works.

8.4.3 Proposed project potential impacts

The impact tables and discussion in this table detail the potential impacts to the aquatic ecosystem should the project go ahead.

8.4.3.1 Hydraulic and petrochemicals

Activity numbers (found in Table 8-1 above) associated with impact table below:

- Activity no 2
- Activity no 3
- Activity no 4
- Activity no 5
- Activity no 6
- Activity no 7
- Activity no 9
- Activity no 10
- Activity no 11
- Activity no 12
- Activity no 14

Issue 1	**Deterioration of water quality**				
Parameters	**Severity**	**Spatial scale**	**Duration**	**Probability**	**Significance**
Impact 1	**Contamination: Hydrocarbon spills**				
Construction Phase					
Pre-mitigation	Very Serious (5)	Limited (2)	Medium term (3)	Almost certain (6)	Minor (-60)
Post-mitigation	Serious (4)	Limited (2)	Medium Term (3)	Likely (5)	Minor (-45)
Operation Phase					
Pre-mitigation	Very Serious (5)	Limited (2)	Medium term (3)	Almost certain (6)	Minor (-60)
Post-mitigation	Serious (4)	Limited (2)	Medium Term (3)	Likely (5)	Minor (-45)

Issue 1	**Deterioration of water quality**				
Parameters	**Severity**	**Spatial scale**	**Duration**	**Probability**	**Significance**
Decommissioning Phase					
Pre-mitigation	Very Serious (5)	Limited (4)	Medium term (3)	Almost certain (6)	Minor (-66)
Post-mitigation	Serious (4)	Limited (2)	Medium Term (3)	Likely (5)	Minor (-45)

As can be seen from the above table the threats to water quality are many and need to be addressed in a comprehensive manner. Central to reducing contamination is the implementation of an effective and inclusive clean and dirty water separation system. Spill kits for hydrocarbon spill need to be present and easily accessible. All staff should be educated about the threat that these substances pose and how to either notify the personal responsible for clean up or how to contain the spill and limit the damage before professionals can be notified.

All workshop areas should have oil traps and adequate collection and disposal facilities.

8.4.3.2 PCD and tailings impacts

Activity numbers (found in Table 8-1 above) associated with impact table below:

- Activity no 13
- Activity no 15
- Activity no 17
- Activity no 20

Impact 2	**Contamination: PCD and tailing spills**				
Operations Phase					
Pre-mitigation	Very Serious (5)	Municipal (5)	Medium term (3)	Likely (5)	Minor (-65)
Post-mitigation	Very Serious (5)	Municipal (5)	Medium term (3)	Probable (4)	Minor (-52)

These facilities often contain among the most toxic of chemicals on a mine site. Overflows and spills are critical potential impacts that have the potential to poison streams for many years. The contaminants in these facilities have the potential to greatly increase the conductivity alter pH and reduce oxygen concentrations.

Mitigation actions include ensuring that the facilities are built for 1 in 100 year flood conditions. Enough freeboard needs to be maintained to cope with these flash flood events.

8.4.3.3 Decant

Closure phase not associated with any on activity.

Impact 3	**Contamination: Decant**

Closure Phase					
Pre-mitigation	Very Serious (6)	Municipal (4)	Beyond project life (6)	Likely (6)	Moderate (-96)
Post-mitigation	Serious (5)	Municipal (4)	Beyond project life (6)	Probable (5)	Moderate (-75)

After operations cease and pumping stops, water enters and begins to fills voids as well as interact with poorly designed waste rock dumps where it interacts with the pyritic rock and oxygen to form of acid mine water (AMW). Acid mine water has very high conductivity as a result of the dissolved ions picked up from previously deeply buried rock. AMW can depending on the makeup of the rock lead to acidic water. This poses multiple problems for the environment as well as man mad infrastructure It is extremely costly to treat this water back to drinking water standards.

Coal mining often results such water and is a growing cause of concern. Back filling of voids in consultation with rehabilitation specialists and engineers should take place to reduce the interaction of water with the pyritic material. Waste rock dumps should be designed in such a way that water infiltration is limited and if possible eliminated. This will isolate the material with the potential of forming AMW. The waste rock dumps will also need adequate storm water drainage systems that collect all dirty water in the pollution control dam facilities. Carbonaceous material will need to be placed back in the pit below the natural recharge level.

It is crucial that a monitoring program is set up to monitor the environmental trends and reduce the action time if the trend becomes negative.

8.4.3.4 Introduction of nutrients

Activity numbers (found in Table 8-1 above) associated with impact table below:

- Activity no 10
- Activity no 17
- Activity no 21

Impact 4	**Contamination: Introduction of nutrients**				
Operations phase					
Pre-mitigation	Moderate (3)	Local (3)	Medium term (3)	Probable (4)	Minor (-36)
Post-mitigation	Moderate (3)	Local (3)	Short term (2)	Unlikely (3)	Negligible (-18)

Explosives and other substances with high organic nitrates including fertilizers need to be appropriately stored to prevent these chemicals entering the aquatic systems and producing harmful algal blooms.

8.4.3.5 Physical alteration of rivers

Activity numbers (found in Table 8-1 above) associated with impact table below:

- Activity no 2
- Activity no 4
- Activity no 5
- Activity no 6
- Activity no 7
- Activity no 10
- Activity no 11
- Activity no 12
- Activity no 16
- Activity no 18
- Activity no 20
- Activity no 22

Issue 2	***Physical alteration of rivers***				
Parameters	***Severity***	***Spatial scale***	***Duration***	***Probability***	***Significance***
Impact 5	***Increased sedimentation***				
Construction Phase					
Pre-mitigation	Serious (4)	Local (3)	Project Life (5)	Likely (5)	Minor (-60)
Post-mitigation	Moderate (3)	Local (3)	Medium term (3)	Probable (4)	Minor (-36)
Operations Phase					
Pre-mitigation	Serious (4)	Local (3)	Project Life (5)	Likely (5)	Minor (-60)
Post-mitigation	Moderate (3)	Local (3)	Medium term (3)	Probable (4)	Minor (-36)
Closure Phase					
Pre-mitigation	Moderate (3)	Local (3)	Medium term (3)	probable (4)	Minor (-36)
Post-mitigation	Limited (2)	Local (3)	Medium term (3)	Probable (4)	Negligible (-32)

Sediments can enter the aquatic ecosystems in a number of ways. During construction and earth moving activities if buffers are not adhered to sand and waste rock can be deposited close to or into river or drainage channels. These sediments increase turbidity and reduce light penetration into the water column which intern reduces natural algal production, the foundation of the food web. Sediments in high enough concentrations can also irritate gills and result in epithelial damage. The most likely scenario is that these sediments when deposited will alter the hydrology of the river, covering stones and gravel and reducing habitat availability for aquatic organisms. Sediments can become trapped and lead to artificial wetland formation which is often colonised by a single species like *Phragmites australis* reducing overall biodiversity.

Mitigation actions include maintaining vegetation on stockpiles to prevent the transport of sediments downslope and into rivers. Machinery and personal should avoid entering the aquatic ecosystems.

9 Recommendations

It is recommended that the wetland ecology report take the lead and that the aquatic ecology report be viewed as supplementary to the wetland ecology impact assessment report. This is due to the aquatic systems being so closely linked to the wetlands on site. At all of the sites, the flowing rivers are nested within the greater wetland area. That being said the following recommendations are made to safe guard the aquatic systems that do exist on site:

- The wetland report recommends buffers of 200m as per our previous correspondence with the Department of Water Affairs and Sanitation. However, legislation recommends 100m buffers. Both of these buffers should be sufficient to protect the aquatic systems that are located within the wetland boundaries;
- Construction vehicles or any mine machinery should stay away from any aquatic system and should only enter these systems if the appropriate permission is obtained;
- Explosives will need to be consigned to a bunded area to prevent the interaction with water. Often explosives contain high amounts of Nitrogen which can lead to algal blooms in rivers and dams;
- Spillage kits should be available to contain and clean up hydrocarbon spills;
- Berms as well as clean and dirty water separation systems should be used to exclude mining vehicles and personal from entering the aquatic systems;
- An aquatic ecology monitoring program should be instigated from the outset of construction until operations have ceased and closure has taken place. The threat of decant should be monitored for. At least the following parameters should be monitored biannually (wet and dry season) by qualified specialists:
  - *In situ* and e*x* situ water quality constituents;
  - Sediment and water column metal analysis;
  - Toxicity testing;
  - Habitat integrity; and
  - Aquatic macroinvertebrates.

10 Cumulative impacts

The Olifants river system (WMA 4) services large and intensive industry and is readily acknowledged as one of South Africa’s hardest working rivers. Significant impacts have accrued within the system and the addition of more coal mining and the potential destruction of the head water reaches and associated wetlands which serve to filter and trap potentially dangerous metals and toxins should be carefully weighed against the country's economic and energy demands.

11 Conclusion

The aquatic systems on site are found within the wetland ecosystems. Buffers should be imposed on these systems to limit the potential for degradation. The system is predominantly a wetland system with limited areas of flowing water. These areas do contain macroinvertebrates and fish but it is not thought that the RHP assessment tools are appropriate for determining the ecological state of this area. Instead more weight should be given to the wetland report when considering the future of this project. The buffers recommended in the wetland report should be sufficient to protect the lotic waters located within.

The no-go impacts were seen to be negatively negligible and were largely related to farming practises.

The impacts for the proposed project range from negatively moderate to minor. Mitigation options have been recommended where possible to reduce the potential impacts.

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