Proposed Open Pit Magnetite Mine and Concentrator Plant, Mokopane, Limpopo Province

Aquatic Ecology Report

Project Number:

VMC3049

Prepared for:

Pamish Investments No. 39 (Pty) Ltd

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Digby Wells and Associates (South Africa) (Pty) Ltd
(Subsidiary of Digby Wells & Associates (Pty) Ltd). Co. Reg. No. 2010/008577/07. Turnberry Office Park, 48 Grosvenor Road, Bryanston, 2191. Private Bag X10046, Randburg, 2125, South Africa
Tel: +27 11 789 9495, Fax: +27 11 789 9498, info@digbywells.com, www.digbywells.com

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Project Name:	**Proposed Open Pit Magnetite Mine and Concentrator Plant, Mokopane, Limpopo Province**
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Name	**Responsibility**	**Signature**	**Date**
Brett Reimers Cand. Sci. Nat.	Report Compilation		June 2015
Russell Tate Pr. Sci. Nat.	Report Review		June 2015
Phil Patton Pr.Sci.Nat.	Report Review		June 2015

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EXECUTIVE SUMMARY

Pamish Investment No 39 (Pty) Ltd appointed Digby Wells Environmental to conduct the environmental and social impact assessment for the proposed magnetite mine north of Mokopane in Limpopo province.

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).

Two rivers (the Mogalakwena River as well as the Sterk River) running through three quaternary catchments (A62B, A61G and A61J) are potentially at risk from the proposed project (approximately 3 km from the proposed infrastructure). In order to assess the potential impacts the following aims were considered.

The aim of the project was to determine the present ecological status of the aquatic ecosystems associated with the proposed magnetite mining project. From this baseline data the potential impacts associated with the proposed project were determined as well as how severe they may be. In order to assess the aquatic ecosystems, tools developed by the river health program (RHP) were implemented, these included:

- *In situ* water quality analysis;
- The Intermediate habitat integrity assessment (IHIA);
- South African Scoring System version 5, (SASS5);
- The Macroinvertebrate response assessment index (MIRAI);
- Invertebrate habitat assessment system; as well as
- The fish response assessment index (FRAI).

Of note, *Oreochromis mossambicus* was found on site in both rivers associated with the proposed project, it is listed as near threatened due to hybridization with *Oreochromis niloticus* which was not found on site.

The aquatic ecosystems were found to range between natural to moderately modified depending on which index was assessed. This allowed for the determination of the PES which was found to be class C (moderately modified) for the Mogalakwena River and class B (largely natural) for the Sterk River.

The aquatic ecology impacts rating section was divided into three sections namely, water quality impacts, water quantity impacts and aquatic habitat impacts. The current land use impacts were found to be negligible to negative. They originate from farming activities within the quaternary catchment, as well as, from the effects of impoundments and mining activities upstream within both the Mogalakwena and Sterk Rivers.

Impacts associated with the proposed project were ranked between negligibly negative and moderately negative before mitigation. With mitigation all impact rankings can be reduced with appropriate actions.

A discrepancy between the SASS5 and the FRAI model was identified and may likely be due to increased flows within the catchments associated with the sites. It stands to reason that the invertebrates would react to improving conditions faster than the slower to recruit fish species. The Eco Status of the rivers was determined to be class B and class C for the Sterk and Mogalakwena Rivers respectively. From the Geochemistry and Waste Classification Report (Digby Wells 2015) the acid generating potential of the ore appears to be low to negligible however there are many other potential aquatic ecology impacts associated with mining and as such the use of adequate buffers and biomonitoring throughout the life of mine, as well as during closure should be carried out.

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1 Introduction

Digby Wells Environmental (Digby Wells) was appointed by Pamish Investment No. 39 (Pty) Ltd. to compile the Environmental and Social Impact Assessment (ESIA) for the proposed Magnetite mine located North West of Mokopane in Limpopo Province.

The proposed mining area falls within the Mogalakwena local municipality, it is associated with three quaternary catchments (A62B, A61G and A61J) through which two main rivers run. These rivers are the Mogalakwena River which is fed by the Nyl River in its upper catchment. The Sterk River is the second affected river which flows into and supplements the Mogalakwena River. The Mogalakwena River forms part of the Limpopo River catchment.

Van Vuren *et al.,* (1994) state that increase in anthropogenic activities in river catchments has placed pressures upon local aquatic ecology. Activities such as mining have the potential to disrupt and modify associated aquatic conditions (Van Vuren *et al*., 1994). These activities have the potential to impact 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).

1.1 Study Aims

This aquatic ecology baseline and impact assessment aims to elucidate the current Present Ecological Status (PES), define the baseline for the potentially affected aquatic ecosystems and determine what impacts the proposed project may have on the aquatic biota within these streams.

1.2 Terms of Reference

This report builds on the scoping phase aquatic ecology assessment and defines the baseline for the affected aquatic ecosystems associated with the proposed magnetite mine. This report is an aquatic ecology baseline and impact assessment report and forms part of the specialist studies for consideration as per of the environmental and social impact assessment (ESIA). The purpose of the ESIA is to identify in detail the impacts that will occur as a result of this project and proposed management and mitigation actions to reduce the scale of the impacts.

2 Methodology

2.1 Survey Timing

Two site visits were carried out as part of the aquatic impact assessment; these took place in January and April 2015, and comprised the high and low flow survey respectively.

2.2 Project Team

The Digby Wells aquatic ecology unit will be completing the proposed project. This unit comprises of two aquatic specialists. Brett Reimers holds a master's degree in applied marine science, a SASS5 accreditation, is a candidate natural scientist (SACNASP) as well as a certificated wetland specialist. Russell Tate, the aquatic ecology unit manager, holds a master's degree in aquatic health, is SASS5 accredited and professionally registered with the SACNASP.

2.3 River Health Program

The methods, data and models that form part of the river health program (RHP) meet or exceed the requirements of the international finance corporation (IFC).

Table 2-1 demonstrates the descending order of river health classes.

Table 2-1: 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).

2.4 Ecological Integrity

The methodology employed for this assessment makes use of the methods designed for the South African RHP (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:

2.5 Abiotic Driver Assessment

- *In situ* water quality (DWAF, 1996);
- The Intermediate Habitat Integrity Assessment (IHIA) (Kemper, 1999); and
- The Invertebrate Habitat Assessment System (IHAS) (McMillan, 2002).

2.6 Biotic Response Indicators Assessment

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

2.7 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. The parameters against which water quality components are assessed were defined by the Department of Water Affairs and Forestry (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.

2.8 Habitat Quality

An important factor which determines the survival of 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 the number of species may decline (Karr 1981).

2.8.1 Intermediate Habitat Integrity Assessment

In order 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), 1999".

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 2-2.

Table 2-2: Criteria in the Assessment of Habitat Integrity (Kleynhans, 1996)

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.
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.

Criterion	Relevance
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 2-3 and Table 2-4).

Table 2-3: Table giving Descriptive Classes for the Assessment of Modifications to Habitat Integrity (Kleynhans, 1996)

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
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 2-4: Criteria and Weights used for the Assessment of Habitat Integrity (Kleynhans, 1996)

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 then calculated based on ratings received from the assessment. The estimated impacts of the criteria are then summed and expressed as a percentage to arrive at a provisional habitat integrity assessment. The scores are then placed into the Intermediate habitat integrity categories (Kleynhans, 1996) as seen in Table 2-5.

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 SQR length.

Table 2-5: 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

Category	Description	Score
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

2.9 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).

2.9.1 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 2-1 and Figure 2-2 below are representations of how the SASS 5 scores and the Average Score Per Taxon (ASPT) are used to calculate the health of a river system.

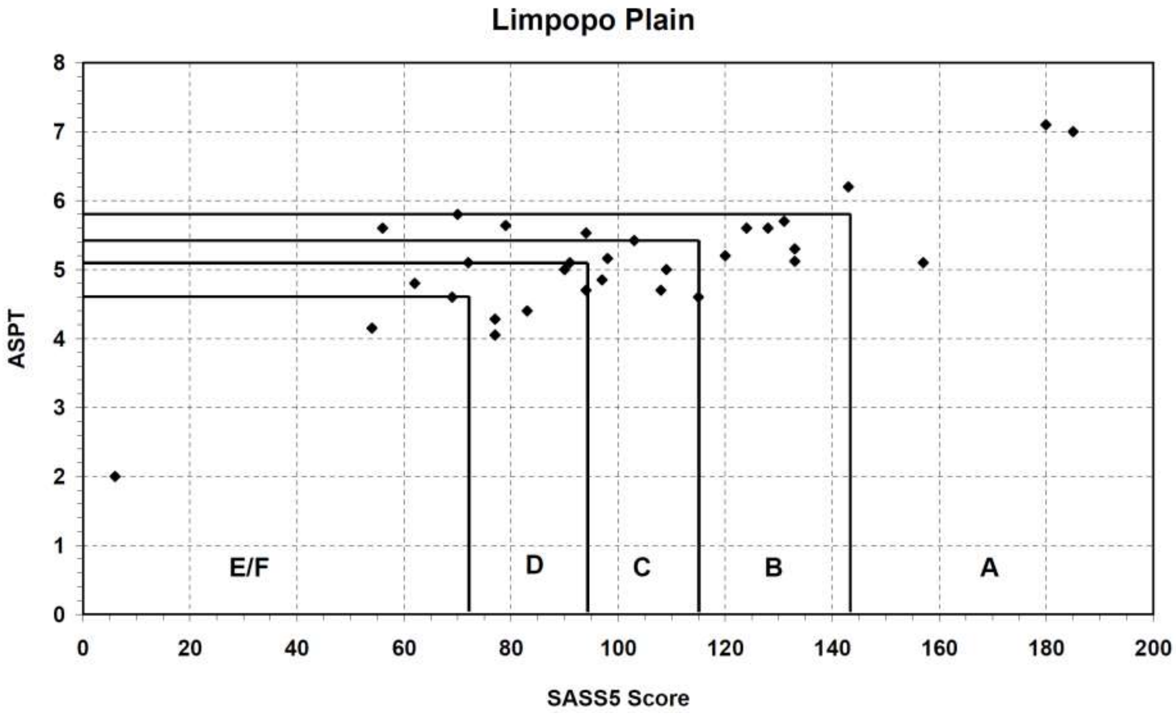

Figure 2-1: Biological Banding for SASS5 Interpretation

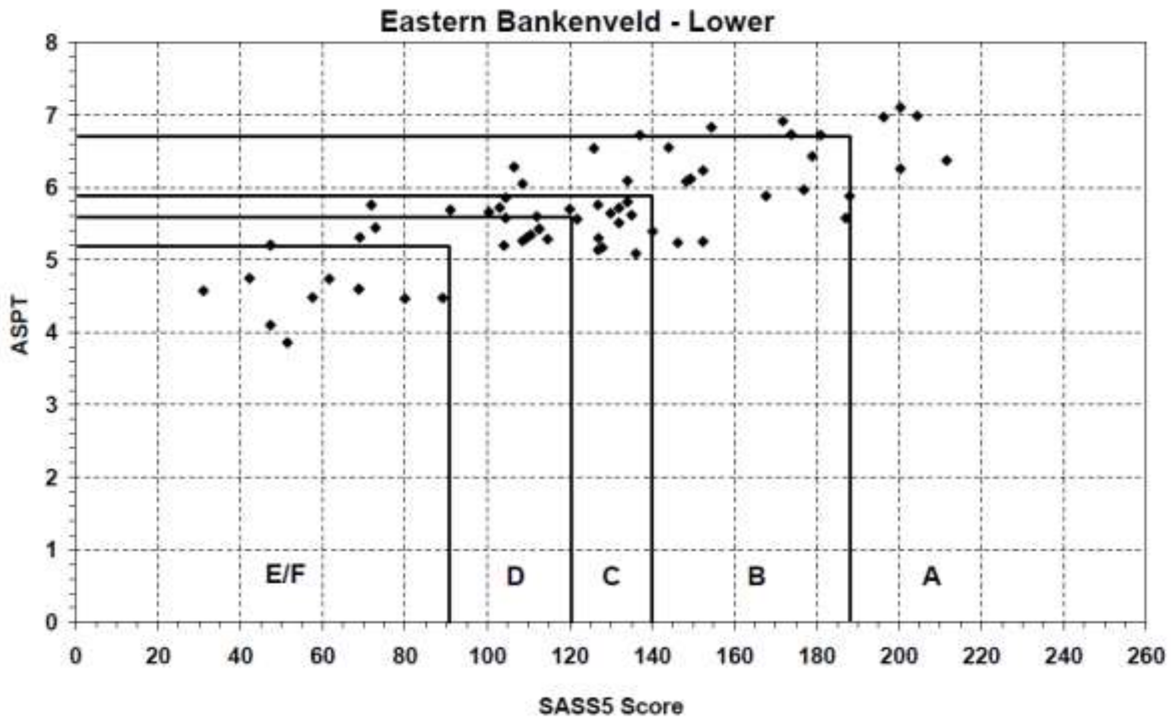

Figure 2-2: Eastern Bankenveld SASS5 Biological Banding

2.9.2 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 SASS5 scores (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.

2.9.3 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.

2.9.4 Biotopes

The IHAS will be used in conjunction with the SASS 5 biotope ratings to define site specific invertebrate habitat conditions.

2.9.5 Erosion

The habitat assessment included fixed point photographs as well as an erosion inspection.

Table 2-6: 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

2.10 Fish Assessment

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

2.11 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.

2.12 Impact Methodology

Details of the impact assessment methodology used to determine the significance of physical and bio-physical 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

The matrix calculates the rating out of 147, whereby intensity, extent, duration and probability are each rated out of seven as indicated in Table 2-7. 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 has been applied; post-mitigation is referred to as the residual impact. The significance of an impact is determined and categorised into one of seven categories (The descriptions of the significance ratings are presented in Table 2-9.

It is important to note that the pre-mitigation rating takes into consideration the activity as proposed, (i.e., there may already be some mitigation included in the engineering design). If the specialist determines the potential impact is still too high, additional mitigation measures are proposed.

Table 2-7: Impact Assessment Parameter Ratings

Rating	Intensity/Replicability		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.
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.

Rating	Intensity/Replicability		Extent	Duration/reversibility	Probability
	Negative impacts (Nature = -1)	**Positive impacts (Nature = +1)**			
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.
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.

Rating	Intensity/Replicability		Extent	Duration/reversibility	Probability
	Negative impacts (Nature = -1)	**Positive impacts (Nature = +1)**			
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.
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 2-8: 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
Consequence	-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

Table 2-9: 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	An 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) (-)

3 Study Area

The study area as well as the project boundary and National Freshwater Ecosystem Priority Areas (NFEPA) river status is shown below in Figure 3-1.

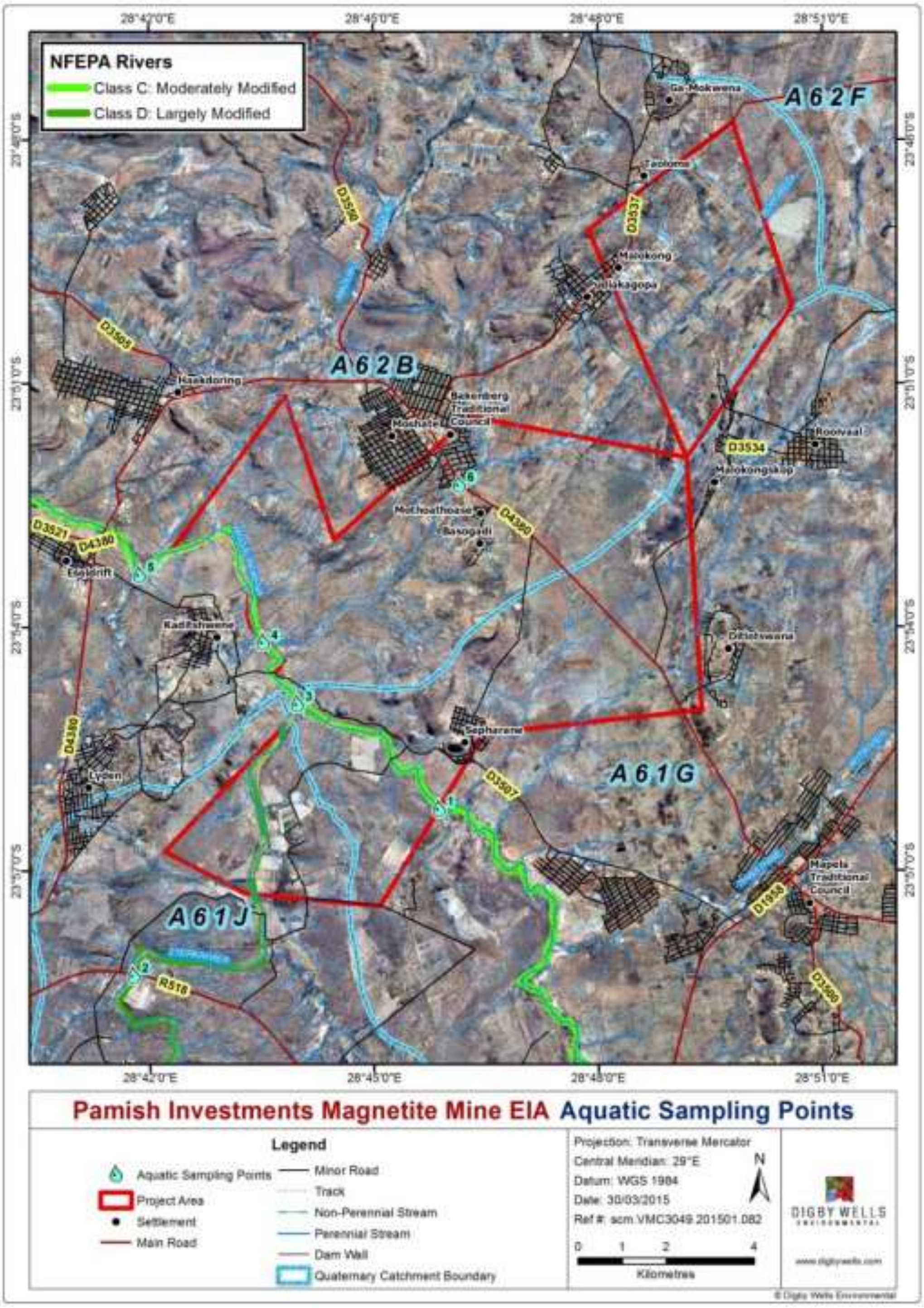

Figure 3-1: Site Visit Locations, NFEPA Ranking as well as Quaternary Catchments for the Aquatic Ecology Survey

3.1 Desktop Information

South Africa is divided into 26 primary drainage areas or catchments, these drainage areas are given codes between A to X. These are further subdivided into secondary, tertiary and quaternary catchments. Quaternary catchments are the smallest management units. However within the quaternary catchments are Sub Quaternary Reaches (SQR), these are the smallest units for which the PES has been calculated. The table below (Table 3-1) illustrates the data available for the SQRs associated with the proposed site, while Figure 3-2 demonstrates the SQRs potentially affected by the proposed mine. The main river systems assessed for this survey were the Mogalakwena and the Sterk Rivers.

Table 3-1: Desktop SQR data for the rivers associated with the proposed project area (DWS 2014)

SQR	River Name	PES	Description of PES	Ecological integrity	Ecological sensitivity
A62B-00223	Mogalakwena River	class C	Moderately modified	Moderate	Moderate
A61G-00248	Mogalakwena River	class D	Largely modified	Moderate	Moderate
A61J-00267	Sterk River	class C	Moderately modified	High	High

From the table above it can be seen that the systems associated with the proposed project range from moderately modified (class C) to largely modified (class D). The Mogalakwena River has a moderate ecological sensitivity (ES) and ecological importance (EI), while the Sterk River is considered to have a high EI and ES.

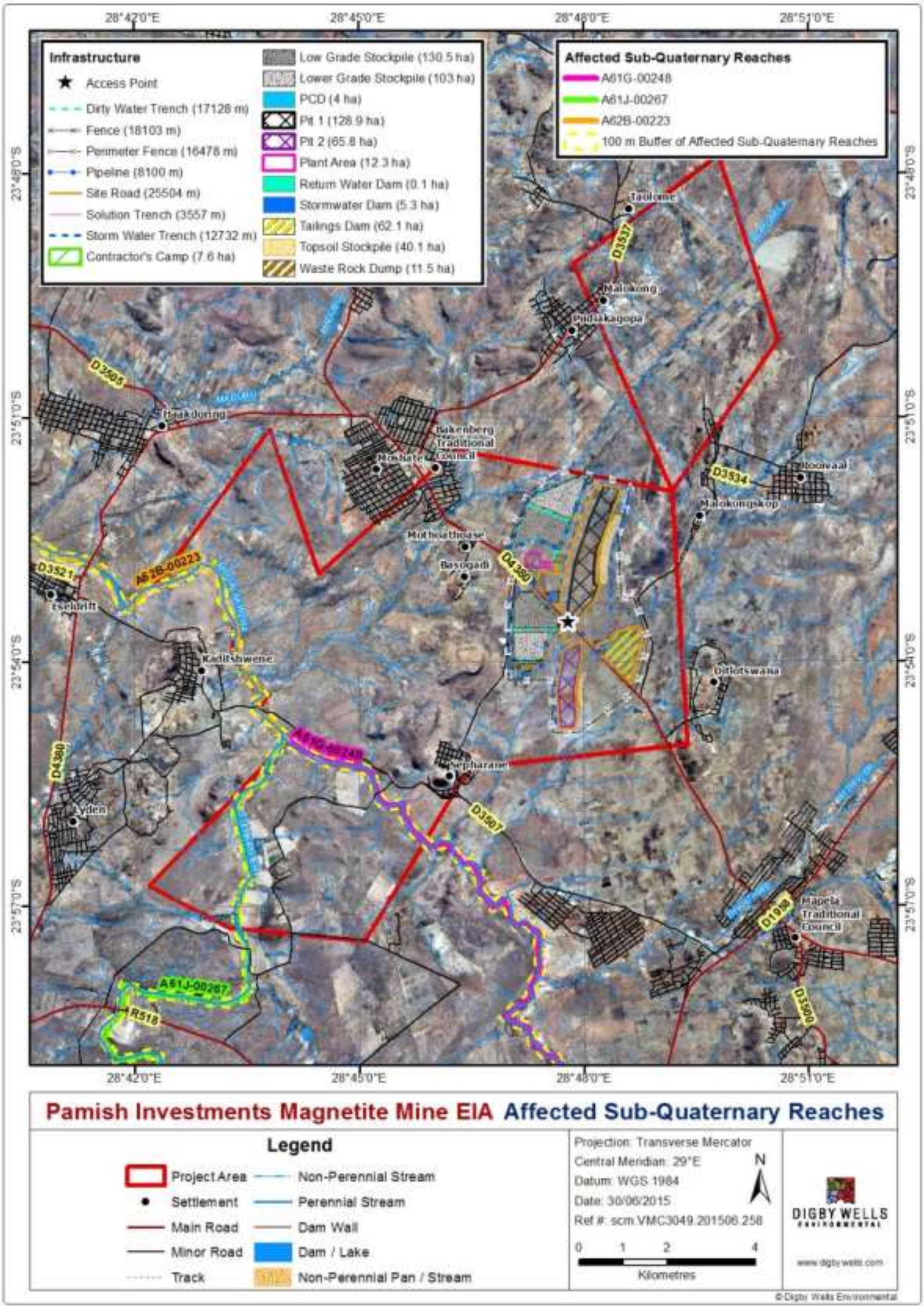

Figure 3-2: The Sub-Quaternary reaches associated with the Proposed Project

Table 3-2, below, outlines the largest impacts within each SQR

Table 3-2: Impacts Recorded within the associated SQRs

SQR	River name	Impacts				
		Critical	Serious	large	Moderate	Small
A62B-00223	Mogalakwena River	None	None	Agricultural fields, bed and channel disturbance, grazing, urbanization	Algal growth, erosion, overgrazing, urban areas, sedimentation, vegetation removal	Abstraction, small dams, alien vegetation, inundation
A61G-00248	Mogalakwena River	None	Grazing, vegetation removal	Agricultural fields, bed and channel disturbance, erosion, overgrazing/ trampling, roads, sedimentation	Abstraction, algal growth low water crossings, alien vegetation, urbanization	Small dams, runoff/effluent
A61J-00267	Sterk River	None	Inundation	Abstraction, small dams	Algal growth, irrigation, sedimentation, vegetation removal	Agricultural fields, bed and channel disturbance, alien vegetation, runoff/effluent , irrigation

In total, six sites were selected to collect data, these points are shown below in greater detail (Table 3-3).

Table 3-3: Locations and Site Photos of the Aquatic Sampling Sites

Site name and GPS position	Photograph
MAG1 24°00'57.305" S 28°48'32.659" E	
MAG2 23°58'16.476"S 28°41'46.710"E	

Site name and GPS position	Photograph
MAG3 23° 54' 55.952" S 28° 43' 58.385" E	
MAG4 23° 54' 10.447" S 28° 43' 31.079" E	

Site name and GPS position	Photograph
MAG5 23° 53' 20.197" S 23° 53' 20.197" S	
MAG6 23° 52' 14.214" S 28° 46' 8.830" E	

4 Study Limitations

During the high flow survey, high river flow volumes made accurate fish sampling difficult. As a result the diversity of recorded fish species may need to be viewed with caution.

During the high flow survey, the dissolved oxygen meter was faulty and as such no dissolved oxygen data could be recorded.

Due to time constraints, surveys were conducted in relatively short time frames (January 2015 and April 2015). The low flow may not have been wholly representative of low flow conditions, as the survey was conducted at the beginning of the low flow while water levels were likely higher than would be expected later in the season. Therefore the data obtained may need to be read with some circumspection.

5 Results

The results are displayed as per the methodology above.

5.1 Water Quality

The *in situ* water quality results are presented below in Table 5-1.

Table 5-1: Water Quality Data for the High and Low Flow Assessment

Site	MAG1	MAG2	MAG3	MAG4	MAG5	Reference parameters: DWAF (1996)
High Flow						
Temperature (˚C)	err	24	23.9	23.7	23.8	5-30
Conductivity (µS/cm)	513*	91.2	537	158.7	154.3	<700
pH	8.41*	8.2	8.8	8.6	8.4	6.5-9
Low Flow						
Temperature (˚C)	27	24.5	26.3	27.3	23	5-30
Conductivity (µS/cm)	630	100.1	170.4	104.5	124	<700
pH	9.2	7.5	7.9	7.2	7.8	6.5-9
Dissolved oxygen (mg/l)	10	8.4	err	5.1	6.0	5
Dissolved oxygen (%)	120	85	err	65	71	60
"err" denotes a malfunction of the water quality meter						
* denotes data collected during the surface water site visit downstream of MAG1 and analysed offsite in a lab						

During the high flow temperatures ranged between 23.7˚C and 24˚C, while during the low flow survey temperatures ranged between 23˚C and 27.3˚C. Conductivity recorded during both the high and low flows were consistently below the guideline level of 700µS/cm, ranging between 91.2µS/cm and 537µS/cm. The pH during the high flow ranged between 8.2 and 8.8 while during the low flow the recorded range was between pH 7.2 and pH 7.9.

5.2 Habitat Quality

5.2.1 Intermediate Habitat Assessment Index

The results for the IHIA are displayed below. The Sterk and the Mogalakwena River systems have been separated to allow for more detail to be highlighted between the reaches. The information is presented below in Table 5-2 and Table 5-3.

Table 5-2: Sterk River IHIA Results

Component	Average	Score
Instream		
Water abstraction	5	2.8
Flow modification	5	2.6
Bed modification	7	3.64
Channel modification	5	2.6
Water quality	5	2.8
Inundation	10	4
Exotic macrophytes	0	0
Exotic fauna	0	0
Solid waste disposal	10	2.4
Total Instream	**79.16**	
Class C		
Riparian		
Indigenous vegetation removal	5	2.6
Exotic vegetation encroachment	6	2.88
Bank erosion	10	5.6
Channel modification	5	2.4
Water abstraction	7	3.64
Inundation	10	4.4
Flow modification	10	4.8
Water quality	7	3.64
Total Riparian	**70.04**	
Class C		

Instream habitat in the Sterk River scored 79% placing it within class B or Largely Natural while the vegetation habitat scored 70% placing it within class C or moderately modified.

Table 5-3: Mogalakwena IHIA Results

Component	Average	Score
Instream		
Water abstraction	17.5	9.8
Flow modification	12.5	6.5
Bed modification	11	5.72
Channel modification	10	5.2
Water quality	5	2.8
Inundation	10.5	4.2
Exotic macrophytes	0	0
Exotic fauna	10	3.2
Solid waste disposal	7	1.68
Total Instream	**60.9**	
Class C		
Riparian		
Indigenous vegetation removal	10	5.2
Exotic vegetation encroachment	9	4.32
Bank erosion	10	5.6
Channel modification	5	2.4
Water abstraction	6.5	3.64
Inundation	8.5	4.4
Flow modification	10	4.8
Water quality	6.5	3.64
Total Riparian	**66**	
Class C		

Instream habitat in the Mogalakwena River scored 60.9% placing it within class C or moderately modified, while the vegetation habitat also fell within class C with a score of 66%.

5.3 Aquatic Invertebrate Assessment

The results of the components of the aquatic invertebrate assessment are detailed below.

5.3.1 SASS5

The results for the SASS5 assessment are presented below in Table 5-4 (high flow) and Table 5-5 (low flow). Data within the tables is recorded to one significant figure.

Table 5-4: SASS5 High Flow Assessment

Sites	MAG1	MAG2	MAG 4*	MAG5
SASS5 Score	89	105	68	89
No of Taxa	15	16	10	12
ASPT	5.9	6.6	6.8	7.4
Ecological Class	**Class C**	**Class A**	**Class A**	**Class A**
* denotes poor sampling conditions (flooding)				

SASS5 scores ranged between 89 and 109, the number of taxa recorded at each site was between 12 and 16 resulting in ASPT of 5.9 to 7.4.

Table 5-5: SASS5 Low Flow Assessment

Sites	MAG1	MAG2	MAG 4	MAG5
SASS Score	Dry	166	149	84
No of Taxa	Dry	25	21	15
ASPT	Dry	6.6	7.1	5.6
Ecological Class	**Dry**	**Class A**	**Class A**	**Class B**

Of the sites recorded with sufficient water SASS5 scores ranged between 84 and 172, the number of taxa recorded ranged between 25 and 15. This means that the ASPT were recorded as 6.9 and 5.6.

5.3.1.1 SASS5 Biotope Ratings

Table 5-6: Biotopes Ranking for the SASS5 Sites Assessed (Rankings out of 5)

Biotopes	MAG1	MAG2	MAG4	MAG5
Stones in Current	4	4	2	2
Stone out of current	3	4	1	0
Bedrock	2	2	5	3
Aquatic vegetation	2	0	0	0
Marginal vegetation in current	3	4	2	0
Marginal vegetation out of current	2	4	1	0
Gravel	3	0	0	4
Sand	3	0	0	3

Biotopes	MAG1	MAG2	MAG4	MAG5
Mud	3	0	0	2
Biotope score	25	18	11	12
Biotope score (%)	55.6	40	24	26.7

The biotope scores ranged from 24% to 55.6%. The higher the percentage score the better the habitat types present.

Examples of two sensitive taxa sampled during the survey are shown below in Figure 5-1.

Figure 5-1: Sensitive Macroinvertebrates Sampled during the Survey

5.3.2 MIRAI

The Table 5-7 and Table 5-8 below illustrate the outcomes of the MIRAI model for the Sterk River and Mogalakwena River systems respectively.

Table 5-7: MIRAI Results for the High and Low Flow Aquatic Surveys in the Sterk River

Invertebrate Metric Group	Score Calculated
Flow modification	89.8
Habitat	95.8
Water Quality	95.4
Connectivity and seasonality	80
Ecological Score	**91.12**
Invertebrate Category	**class A/B**

Table 5-8: MIRAI Results for the High and Low Flow Aquatic Surveys in the Mogalakwena River

Invertebrate Metric Group	Score Calculated
Flow modification	75.2
Habitat	65.5
Water Quality	80.0
Connectivity and seasonality	60.0
Ecological Score	**69.7**
Invertebrate Category	**class C**

The score attained by the systems associated with the proposed project are class A /B for the Sterk River reach and class C for the Mogalakwena River reach. These scores fall within the "largely natural" and "moderately modified" bands at 91 and 69.7% respectively.

5.3.3 Invertebrate Habitat Assessment System

The results for the IHAS model are illustrated below in Table 5-9.

Table 5-9: Results of the IHAS Model for the High and Low Flow Surveys

Component	MAG1	MAG2	MAG3	MAG4	MAG5
Sampling habitat	43	48	45	45	29
Stream condition	20	34	29	29	27
Total	65	82	59	74	56
Class	**Fair**	**Very good**	**Fair**	**Good**	**Fair**

5.4 Fish Assessment

The results of the FRAI model are depicted below in Table 5-10 and Table 5-11.

Table 5-10: FRAI Results for the Sterk River System

Scientific names: reference species	Reference Frequency of Occurrence	Observed Frequency of Occurrence
Aplocheilichthys johnstoni, Gunther, 1893	2.00	1.00
Barbus bifrenatus, Fowler, 1935	2.00	1.00
Labeobarbus marequensis, Smith, 1841	3.00	2.00
Barbus paludinosus, Peters, 1852	4.00	4.00
Barbus trimaculatus, Peters, 1852	4.00	4.00
Barbus unitaeniatus, Günther, 1866	5.00	5.00
Barbus viviparus Weber, 1897	2.00	1.00
Chetia flaviventris, Trewavas, 1961	2.00	1.00
Clarias gariepinus, Burchell, 1822	5.00	4.00
Chiloglanis paratus, Crass, 1960	2.00	2.00
Labeo cylindricus, Peters, 1852	2.00	2.00
Labeo molybdinus, du Plessis, 1963	2.00	1.00
Micralestes acutidens Peters, 1852	4.00	3.00
Mesobola brevianalis, Boulenger, 1908	3.00	2.00
Marcusenius macrolepidotus Peters, 1852	2.00	1.00
Oreochromis mossambicus, Peters, 1852	2.00	1.00
Petrocephalus wesselsi kramer & van der Bank, 2000	2.00	1.00
Pseudocrenilabrus philander, Weber, 1897	5.00	5.00
Schilbe intermedius, Rüppell, 1832	3.00	1.00
Tilapia sparrmanii, Smith, 1840	4.00	4.00
Chiloglanis pretoriae, van der Horst, 1931	1.00	2.00
Tilapia rendalli, Boulenger, 1896	1.00	2.00
FRAI (Adjusted) %	80.5	
Ecological category	**Class B/C**	

Table 5-11: FRAI Results for the Mogalakwena River System

Scientific names: reference species	Reference Frequency of Occurrence	Observed Frequency of Occurrence
Aplocheilichthys johnstoni, Gunther, 1893	2.00	1.00
Barbus bifrenatus, Fowler, 1935	2.00	1.00
Labeobarbus marequensis, Smith, 1841	3.00	3.00
Barbus paludinosus, Peters, 1852	4.00	3.00
Barbus trimaculatus, Peters, 1852	4.00	4.00
Barbus unitaeniatus, Günther, 1866	5.00	5.00
Barbus viviparus Weber, 1897	2.00	0.00
Chetia flaviventris, Trewavas, 1961	2.00	0.00
Clarias gariepinus, Burchell, 1822	5.00	3.00
Chiloglanis paratus, Crass, 1960	2.00	2.00
Labeo cylindricus, Peters, 1852	2.00	1.00
Labeo molybdinus, du Plessis, 1963	2.00	1.00
Micralestes acutidens Peters, 1852	4.00	3.00
Mesobola brevianalis, Boulenger, 1908	3.00	2.00
Marcusenius macrolepidotus Peters, 1852	2.00	1.00
Oreochromis mossambicus, Peters, 1852	2.00	1.00
Petrocephalus wesselsi Kramer & van der Bank, 2000	2.00	1.00
Pseudocrenilabrus philander, Weber, 1897	5.00	5.00
Schilbe intermedius, Rüppell, 1832	3.00	1.00
Tilapia sparrmanii, Smith, 1840	5.00	5.00
Chiloglanis pretoriae, van der Horst, 1931	1.00	1.00
Tilapia rendalli, Boulenger, 1896	1.00	1.00
FRAI (Adjusted) %	77.4	
Ecological category	**Class C**	

The FRAI results were found to be class B/C (largely natural/moderately modified) and class C (moderately modified) with scores ranging between 77.4 and 80.5% for the Mogalakwena and Sterk Rivers respectively.

A few examples of the species sampled during the survey are presented below in Figure 5-2.

Figure 5-2: A) *Labeo cylindricus* B) *Tilapia rendalii* C) *Barbus trimaculatus* D) *Mesobolus brevianalis*

5.5 Present Ecological Status

The PES of the associated river systems are presented below in Table 5-12.

Table 5-12: Components Comprising the Present Ecological Status

Mogalakwena River			**Sterk River**		
Component	**Class**		**Component**	**Class**	
IHIA	Class C		IHIA	Class C	
SASS5	Class A		SASS5	Class A/B	
MIRAI	Class C		MIRAI	Class A/B	
FRAI	Class C		FRAI	Class B/C	
ECOStatus	**Class C**	**73.6%**	**PES**	**Class B**	**85.8%**

The PES of the Mogalakwena River was found to be class C or moderately modified, while the Sterk River was determined to be class B or largely natural/moderately modified.

6 Discussion

6.1 Water Quality

During the high flow survey an equipment failure resulted in the loss of *in situ* water quality data at site MAG1, when returning for the low flow survey MAG1 was dry. No *in situ* water quality data was therefore available for site MAG1 from the aquatics survey, however data obtained from the surface water scoping report (Digby Wells 2015) show that water quality. Surface water data was used to supplement the high flow survey data. The pH and the conductivity were found to be within acceptable limits.

*In situ w*ater quality at all sites fell within DWAF (1996) guideline levels during both surveys. The average of and standard deviation (SD) within the data is presented below in Table 6-1. Standard deviation is a measure of the variability within a data set and gives one an idea of the dispersion of the data points.

Table 6-1: High and Low Flow Basic Statistical Analysis of the *in situ* Water Quality Results of the Mogalakwena River

Surveys	Temperature (˚C)	Conductivity (µS/cm)	pH
Mean			
High Flow	23.8	283.3	8.6
Low Flow	25.53	133	7.6
Standard deviation			
High Flow	0.1	219.7	0.2
Low Flow	2.25	33.9	0.38

On average, higher temperatures were recorded during the low flow. Although the low flow is considered part of the dry season or winter sample season temperatures in Limpopo remain relatively high. The increase in temperatures may also be as a result of the lower flow volumes which would allow more heat to accumulate, as opposed to be dispersed, in the rivers. The average temperature during the high and low flow surveys were 23.8˚C and 25.5˚C with a SD of 0.1 and 2.25 respectively.

Conductivity during the high flow averaged 283.3 µS/cm while during the low flow it averaged less at 133 µS/cm. This was largely due to the elevated conductivity at Site MAG3 which raised the SD to 219.7 compared to 33.9 from the low flow survey.

The pH during the high flow was more basic averaging pH 8.5, which increased in acidity during the low flow to an average of pH 7.6. These values still fall within acceptable guideline values (DWAF, 1996) The pH values recorded obtained low SDs of 0.2 (high flow) and 0.38 (low flow).

The water quality was found to be of a sufficient standard to allow even organisms sensitive to changes in water quality to survive and reproduce.

During the low flow it was observed that upstream sites in the Mogalakwena catchment dried up. Reduced water quantity will likely negatively impact on water quality, conductivity, as well as the concentration of chemicals will increase as water is lost to infiltration and evaporation.

6.2 Habitat Quality

6.2.1 Sterk River

The instream habitat of the Sterk River was assessed to be between largely natural/moderately modified at 79%, while the vegetation habitat achieved a score of 70% or moderately modified. The Sterk River appeared to have strong flows during both surveys. At the confluence of the Sterk River and the Mogalakwena River, the Sterk River rejuvenates the Mogalakwena.

6.2.1.1 Flow

Flow volumes appeared to be high during both the high and low flows within the Sterk River (Figure 6-1). Due to multiple dams and likely a large degree of agricultural returns flows to the Sterk River.

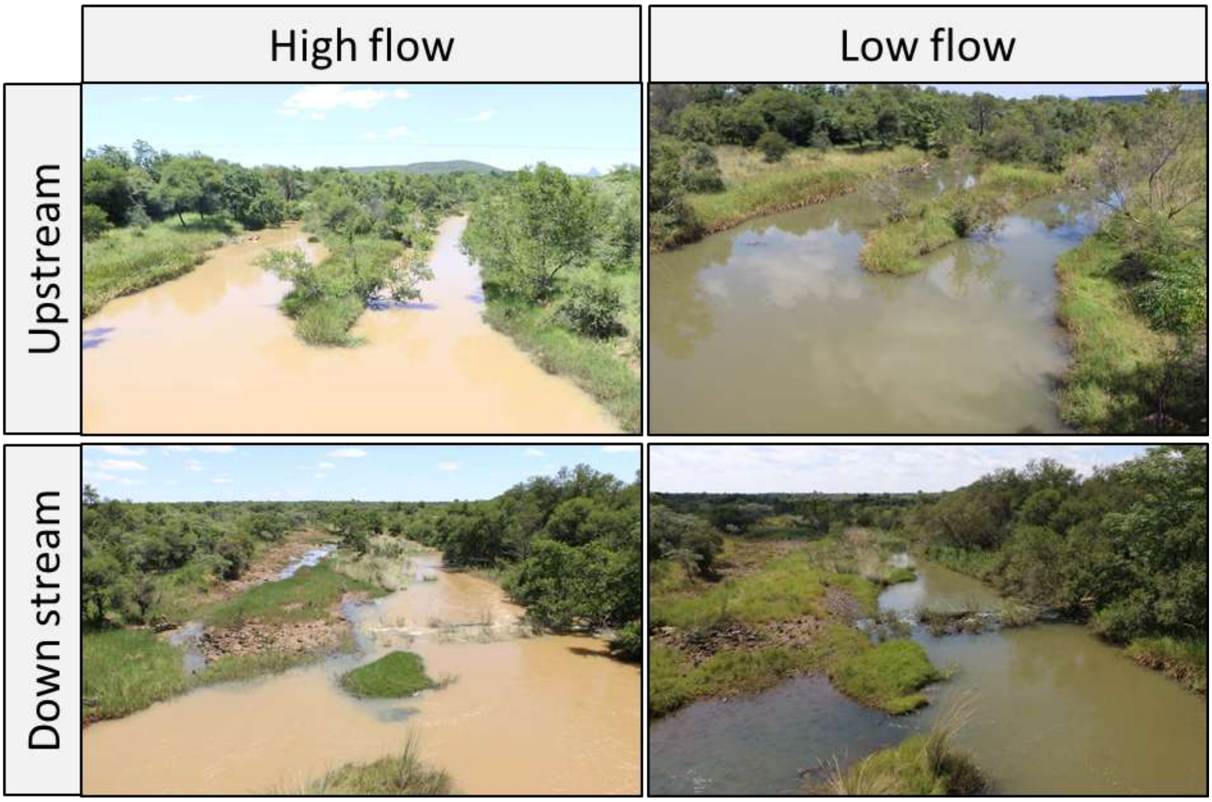

Figure 6-1: Depicting the Sterk River site during the High and Low Flow Survey

6.2.2 Mogalakwena River

The instream habitat as well as the vegetation habitat of the Mogalakwena River was assessed be in a moderately modified state achieving scores of 60.9% and 66% respectively. Within the Mogalakwena River habitat can only be said to be available when it is inundated. During the low flow survey areas upstream of the confluence with the Sterk River were found to be dry. This resulted in the loss of habitat during the dry season as well as a disruption to migration for the macroinvertebrate species (not capable of flight in different life stages), and fish. These low flows are likely the result of multiple dams upstream reducing the flows received downstream.

6.2.2.1 Flow

Figure 6-2 shows the flow rates during the high and low flow sampling surveys at the upstream site of the Mogalakwena.

Figure 6-2: A) High Flow Volumes, B) Low Flow Volumes at MAG1

6.3 Aquatic Invertebrate Assessment

The various aspects of the aquatic invertebrate assessment are detailed below per component.

6.3.1 SASS5

SASS5 scores were consistently high at all sites surveyed, ranging between class A (Natural) and class B (largely natural). These classifications are a result of three families which are sensitive to adequate flows (Leptophlebidea, Heptigeniidae, Perlidae) as well as good water quality (Oligoneuridae, diverse species of Baetidae and Hydropsychidae) being present in the systems.

SASS5 scores were strongly correlated to the available habitat (biotope) types. In sections with more sediment, SASS5 scores were seen to decline. However, in areas with a good balance between stones, vegetation and gravel, sand and mud (GSM) scores approached those thought to be characteristic of natural areas (reference data: Dallas 2007).

6.3.2 MIRAI

The MIRAI results correlate to the SASS5 findings for the Sterk River. The Sterk River was found to be in a largely natural state (class A/B), while the Mogalakwena was found to be in a moderately modified state (class C). The moderately modified score attained in the Mogalakwena River was likely largely a result of agricultural impacts within the catchment. Upstream impoundments also reduce the water quantity available to the river system. Reduced water quantity can allow for the concentration of solids within the system and thus raise the conductivity, and concentrate any pollutants within the water. From the survey it appeared that the Sterk River had strong flows during both site visits. The Mogalakwena was observed to have strong flows during the high flow, while flow volumes were observed to be greatly reduced in the dry season survey.

6.3.3 IHAS

The IHAS scores were found to range between fair and very good. Site MAG2 consistently scored the highest in terms of habitat quality during both the high and low flow site surveys. Of concern was the reduced flow during the low flow survey at MAG1. No water was recorded during either survey at MAG6.

6.4 Fish Assessment

The FRAI component was spilt into two distinct sections corresponding to the rivers assessed. The Sterk River received a FRAI score of class B/C placing it on the border between largely natural and moderately modified. It appears that the Sterk River may be a refuge site as water appears to be present here year round. This allows it to maintain aquatic communities even when other sections of associated rivers run dry, it appears to have a greater volume of water within in and more constant flows. These increased flows may be as a result of return agricultural flows. As seen above (Figure 6-2), the Mogalakwena River dries up in the early low flow. This is likely as a result of the system of impoundments upstream of the MAG1 which retain water and prevent flow during the low flow. The Mogalakwena River received a lower FRAI result (class C) primarily due to the absence of certain species such as Labeo molybdinus and the presence of exotic species such as Micropterus salmoides. Habitat quality appears to remain relatively constant between the two river systems with the same biotopes available, however, it is the impoundments, low water crossings reduced flows that negatively impacts on the migration of fish species within the reach.

6.5 Ecological Description

The final PES of the Sterk and Mogalakwena Rivers are class B and class C respectively. This implies that conditions are more favourable to aquatic biota (both micro and macro fauna) within the Sterk River system, due to the conditions within being closer to the natural reference conditions originally present in the catchment.

The Mogalakwena River has many impacts further upstream. Flows should be far higher within the river but are greatly reduced to multiple farm and some commercial scale dams. Sewage and urban effluent are also sources of major pollution. However, it does appear that much of the pollution is contained behind the dam walls and that water quality at the sites associated with the proposed project is better than what would be found upstream.

The Sterk River passes through large areas of game reserves and wilderness prior to reaching our sampling site and later it's confluence with the Mogalakwena River. It is for these reasons that the Sterk River site could be considered a good reference site for this study.

7 Impact Assessment

The following (Table 7-1) are a list of activities that the mine will need to carry out in the different stages within the life of the mine plan. Those that may impact upon the aquatic environment have been assessed to determine their impact rating pre and post mitigation respectively.

Table 7-1: List of Activities necessary during the Life of Mine

Construction	
1	Site clearance and vegetation removal;
2	Change of land-use from agriculture to mining;
3	Topsoil and softs removal and stockpiling;
4	Development of access and haul roads;
5	Surface infrastructure development such as storm water channels, bridges, dams, offices and workshops.
6	Water abstraction and use;
7	Waste generation, storage and disposal (hazardous and general);
8	Use of heavy machinery (Haul Trucks, FEL, Excavators etc.)
9	Employment and capital expenditure;
Operation	
10	Development of two open pits by drilling and blasting, truck and shovel methods;;
11	Development of one waste rock dump;
12	Concentrator plant including crushing, grinding and screening;
13	Conveyor belts at crushing and grinding sections and for concentrate product and tailings;
14	Hauling of waste rock;
15	Tailings Storage Facility (TSF) ;
16	Pollution control dam, water storage dam and associated pipelines;
17	Storm water diversion berms and channels;
18	Storage of fuels, process concentrate, maintenance/workshop oils, and explosive storage facilities;

19	Waste generation, storage and disposal (hazardous and general);
20	Product storage (magnetite concentrate);
21	Sewerage treatment plant;
22	Use of heavy machinery (Haul trucks, FEL, Excavators etc.)
23	Employment and operational expenditure;
Closure and Rehabilitation	
24	Dismantling and removal of major equipment and infrastructure
25	Waste generation, storage and disposal
26	Rehabilitation of disturbed areas including waste dumps
27	Backfilling of the open pits using waste rock only
28	Post-closure monitoring
* Greyed numbered blocks are those impacts which have been determined to be of potential impact to the aquatic ecosystems.	

7.1 Aquatic Ecological Impacts

All impacts within aquatic ecology fall broadly within three categories. These are:

- Water Quality Impacts
- Water Quantity Impacts, and
- Aquatic Habitat Impacts.

7.1.1 Water Quality Impacts

Water quality impacts encompass all activities that may have either a positive or negative impact on the chemistry of water within the aquatic ecosystem. Healthy wetlands, may have a positive effect on an aquatic ecosystem by trapping sediment and improving water quality by natural filtration. The removal of topsoil however may negatively impact on aquatic ecosystems by introducing increased sediment loads into the system and increasing the total dissolved solids (TDS) and turbidity of the stream.

7.1.2 Water Quantity Impacts

Interrupting the flow of a river by the addition of dams or poorly engineered low water crossings will have negative water quality effects by reducing the flow within the system. Alternatively removing such impoundments may have positive effects on flow and therefore improve water quantity making it a positive impact.

7.1.3 Aquatic Habitat Impacts

All forms of habitat disturbance are viewed as negative impacts within the aquatic environment. Usually these disturbances result in increased sedimentation which may impact on the natural distribution of available biotopes within a given river.

7.2 Current Land Use Conditions

Current land use within the affected catchments are as follows:

- Agriculture:
  - Livestock; and
  - Crop farming.
- Granite quarrying;
- Mining:
  - Platinum; and
  - Granite.
- Wild game farming;
- Dams and impoundments; and
- Effluent/urban runoff.

The current land use impacts (in Table 7-2) are rated without mitigation measures as it is unlikely that these practises will change without intervention. The effects of the impacts are discussed below in greater detail.

Table 7-2: Impact Table for Current Land Use

Activities	Intensity / Replace ability		Extent	Duration / reversibility	Probability	Rating
Water Quality Impacts						
1a, 1b, 2, 3a and 3b, 4 and 5		4	3	2	4	-36
3	3		3	3	4	+36
Water Quantity Impacts						
1b, 3b and 4		3	5	5	5	-65
3	+1		3	2	4	+32
Aquatic Habitat Impacts						
1b and 4		3	3	2	4	-32
3	+3		3	2	4	+32

7.2.1 Water Quality Impacts

All current water quality impacts range between -36 and +36. This places them within the banding of minor negative to minor positive respectively. Water quality impact currently occur due to trampling of the river banks and nutrient input from stock animals that are watered in the rivers.

The Mogalakwena River flows through the town of Mokopane where inputs include raw sewage and urban runoff. However due to the presence of many dams upstream these impacts appear to be constrained to higher in the catchment. Water quality was found to be acceptable at all of the project related sites, when compared against the national reference data (DWAF, 1996).

The passage of rivers through conserved or wilderness areas contributes to improved water quality where those rivers pass through natural wetlands which filter and enhance water quality.

Water quality is linked to water quantity, the greater the size of the water body the bigger it's potential to absorb chemical impacts. Larger water bodies have a greater dilution capacity however no capacity is infinite and should enough of a chemical impact be introduced it will have an effect on the biota within the ecosystem. As mentioned above (section 6.2.1.1) in the low flow upstream impacts in the form of dams greatly reduce the flow available within the Mogalakwena River reducing its dilution capacity and increasing the likelihood for water quality impacts.

7.2.2 Water Quantity Impacts

Very small scale abstraction (personal potable water) was witnessed during the survey. However upstream many small and large dams are visible from aerial imagery. These dams have a definite effect on the amount of water found within the river. In the low flow survey it is likely that these impoundments resulted in the dry sites found upstream of the project boundary (MAG1). As mentioned above the presence of dams in the upper catchment greatly affect the flows received to the SQRs associated with the project area resulting in the ranking of -65.

Within wilderness areas very few if any impoundments are constructed, this allows for the resumption or recovery of natural flow regimes improving the recharge of rivers via runoff or base flow.

7.2.3 Aquatic Habitat Impacts

Sedimentation and flow modification are serious impacts within the rivers. Mining and poor land use practises which allow the watering of animals in the rivers allows for trampling of the river banks by livestock, all these factors lead to increased sedimentation and destabilisation of banks. Informal low water crossing were also observed. Together these impacts contribute further to the increased transportation of sediment which is then deposited further downstream when energy levels decrease.

Un-impacted wilderness areas often contain undisturbed wetland systems as well as natural riparian vegetation. These serve to reduce return flow, anchor sediment and reduce erosion within the rivers that are associated with them. This allows for the deposition of sediment and for a recovery of the usually affect stones and vegetation biotopes.

7.3 Impacts Associated with the Proposed Project

The impacts associated with the proposed project are based on the list of activities above (Table 7-1). For ease of understanding the impacts have been divided into three distinct phases these are:

- Construction phase;
- Operation phase; and
- Closure and rehabilitation phase.

These are discussed in greater detail below.

7.3.1 Construction Phase

The construction phase impacts are rated below according to water quality, water quantity and aquatic habitat impacts (Table 7-3).

Table 7-3: Construction Phase Impacts

Dimension	Rating	Motivation	Significance
Construction activities will cause water quality impacts due to vegetation removal and soil stripping (Negative impact). (Numbers: 1, 3, 4, 5, 8, Table 7-1)			
Impact Description: Erosion and the transportation of the sediments down slope reduces water quality			
Prior to mitigation/ management			
Duration	2	Short duration of effect	-32 (Negligibly negative)
Extent	4	Due to the ability of rivers to transport sediments effects may exceed the project boundary	
Intensity	3	May affect some of the baseline organisms	
Probability	4	These effects have been witnessed at other open cast mines and are therefore probable.	
Mitigation/ Management actions			
▪ Limiting the area to be stripped will reduce surface area open to erosion; ▪ Temporary berms may be erected; and ▪ Silt screens could be utilised to capture small particles being washed down slope.			
Post- mitigation			
Duration	2	Short duration of effect	-24 (Negligibly

Extent	3	Reducing the run off would reduce the amount of sediment washed into the river	negative)
Intensity	3	Will still affect baseline organisms	
Probability	3	The use of mitigation measures will reduce the probability of water quality impacts.	

Dimension	Rating	Motivation	Significance
Construction activities will impact on water quantity by disturbing the flow regime. (Negative impact) (Number 6 and 7, Table 7-1)			
Impact Description: Soil erosion due to wind and surface water runoff; Loss of land capability due to erosion			
Prior to mitigation/ management			
Duration	4	The mining of the voids will impact on the ground water reducing the recharge to the river	-44 (Minor negative)
Extent	4	The reduced recharge will further decrease the amount of water entering the rivers	
Intensity	3	Reduced flow will reduce the overall biodiversity of the river as those organisms sensitive to higher flows decline	
Probability	4	These effects have been observed at other open cast mines	
Mitigation/ Management actions			
▪ Responsible and economic water use; and ▪ Discharging treated water that meets DWAS guidelines.			
Post management			
Duration	4	The mining of the voids will impact on the ground water reducing the recharge to the river	-33 (Negligibly negative)
Extent	3	It should be possible to reduce or mitigate the extent of the impact through sustainable economic water use.	
Intensity	2	Reducing the extent of the impact will reduce the intensity with which it is felt by the aquatic biota	
Probability	3	The proper integration and adherence to a surface water management plan will reduce the likelihood of water loss.	

Dimension	Rating	Motivation	Significance
Construction activities will cause habitat quality impacts (negative impact) (Number 1 and 3, Table 7-1)			
Impact Description: Erosion reduces water quality			
Prior to mitigation/ management			
Duration	4	Long term impacts of erosion could take many years for the river to rectify	-55 (Minor negative)
Extent	4	It is likely that the effects of erosion will be transported by the river further downstream affecting an area greater than the project boundary.	
Intensity	3	An increased sediment load will impact on the aquatic biota of the system	
Probability	5	It is likely that a degree of increased erosion and aeolian deposition will occur from the proposed construction activities	
Mitigation/ Management actions			
▪ Limiting the area to be stripped will reduce surface area open to erosion; ▪ Temporary berms may be erected; ▪ Silt screens could be utilised to capture small particles being washed down slope; and ▪ Dust suppression.			
Post- mitigation			
Duration	3	The impact lifespan may be reduce by the mitigation measures.	-36 (Minor negative)
Extent	3	Reducing the sediment transport into the aquatic systems would reduce the area the impact could affect.	
Intensity	3	An increased sediment load will impact on the aquatic biota of the system.	
Probability	4	With mitigation measures in place the risk of an uncontrollable event taking place is reduced.	

7.3.2 Water Quality Impacts

7.3.2.1 Pre-mitigation

Water quality impacts during the construction phase are largely related clearing of vegetation and the stripping of top soils as well as the transportation of top soils and other soft materials. These activities remove the above ground biomass currently anchoring the soil in place and preventing erosion. Should erosion be allowed to occur large amounts of topsoil may be transported downslope and into the river. If this occurs the TDS within the river will increase which may result in the loss of sensitive aquatic fauna and a reduction in overall biodiversity. Another water quality impact of concern is seepage from the Tailings storage facility (TSF). The Geochemistry and Waste Classification Report (Digby Wells 2015) suggests that there is a minor threat of waste rock and tailings becoming acid generating and these finding have contributed to the lowered risk profile in the impact ranking.

7.3.2.2 Post-mitigation

Mitigation measures include increasing the distance between the vegetation removal and soils stripping and the river by use of buffers (refer to Figure 3-2). The implementation of temporary berms and silt screens will reduce the amount of sediment transport during rain events. Selective stripping of areas that are designated for infrastructure, i.e. avoiding unnecessary vegetation removal will also reduce the amount of opportunity for sediment transport. This mitigation measure will also tie in with the promotion or natural corridors as discussed in the flora and fauna report.

Any and all waste must be confined to within the boundaries of the dirty surface water trenches. Hazardous waste such as petrochemicals and blasting materials must be stored in bunded areas. Spill kits should be readily available, and training should be carried out so that all personnel are aware of how to contain spills and notify those responsible for clean-up.

7.3.3 Water Quantity Impacts

7.3.3.1 Pre-mitigation

Of primary concern during the construction phase is the impact to the river due to water abstraction. As mentioned previously during the low flow due to upstream impoundments the Mogalakwena River begins to dry up. It is likely that any collection of rain water by the proposed mine will reduce surface water runoff that reaches the river, of particular concern is the storm water management infrastructure which may reduce the amount of run-off that the aquatic ecosystems receive.

7.3.3.2 Post-mitigation

Responsible water use is essential to reduce the impact that is posed by the surface water runoff regime. Only what is needed should be stored. The option of releasing treated water that meets the guidelines set by the competent authority, and does not negatively impact on the management class outlined by the Department of Water Affairs and Sanitation (DWAS) should be investigated as a measure to reduce undue stress on the ecological reserve.

7.3.4 Aquatic Habitat Impacts

7.3.4.1 Pre-mitigation

Aquatic habitat impacts are related to the clearing of vegetation and the stripping of top soils as well as the transportation of top soils and other softs. These activities disturb vegetation that anchors the soil in place and preventing erosion. Should erosion be allowed to occur large amounts of topsoil will be transported downslope and into the river. Increased sediment loads will cause deposition over other biotopes reducing the amount of available habitat to those species which require stones or certain types of vegetation. This can result in changes in community structures and a loss of biodiversity throughout the trophic levels.

7.3.4.2 Post-mitigation

Mitigation measures include increasing the distance between the vegetation removal and soils stripping and the river by use of buffers (Figure 3-2). The implementation of temporary berms may also reduce the amount of sediment transport during rain events. Selective stripping of areas that are designated for infrastructure, i.e. avoiding unnecessary vegetation removal will also reduce the amount of opportunity for sediment transport.

7.4 Operation Phase

The operation phase impacts are rated below according to water quality, water quantity and aquatic habitat impacts (Table 7-4).

Table 7-4: Operation Phase Impacts

Dimension	Rating	Motivation	Significance
Operations will impact on water quality through erosion, sediment transport and atmospheric deposition. (negative impact) (Numbers:10, 11, 13, 15, 16, 18, 19, 20, 21, 22, Table 7-1)			
Impact Description: Soil erosion due to wind and surface water runoff; Loss of land capability due to erosion			
Prior to mitigation/ management			
Duration	5	The potential exists for long term water quality impacts if management measures are not put in place	-65 (Minor negative)
Extent	4	Aquatic systems are excellent mechanisms of natural transportation. Upstream impacts will be conveyed downstream beyond the project boundary.	
Intensity	4	Should prolonged water quality impacts occur the aquatic biodiversity will be suppressed and deteriorate.	
Probability	5	Mining is synonymous with water quality impacts. It is very likely that there will be a degree of water quality impact from the operations.	
Mitigation/ Management actions			
▪ Correct surface water management ▪ Reducing the contact time of water with deep soils, rock dumps or other contaminated material			
Post management			
Duration	4	The duration of the impact can be reduced by the correct implementation of a project wide water management plan.	-50 (Minor negative)

Extent	3	With adequate surface water clean and dirty water separation the water quality impact could be confined to the project area.	
Intensity	3	The intensity of the impact could be constrained with mitigation measures	
Probability	5	The likelihood of water quality impacts remains unchanged, only the above factors can be mitigated against.	

Dimension	**Rating**	**Motivation**	**Significance**
Operational water quantity impacts will result from the disruption of established flow regimes (negative impact) (Numbers: 17 and 22, Table 7-1)			
Impact Description: Soil erosion due to wind and surface water runoff; Loss of land capability due to erosion			
Prior to mitigation/ management			
Duration	5	The construction of the open cast pits will not adversely affect the ground water flow to the river systems.	-44 (Minor negative)
Extent	3	The extent of the ground water disruption is likely to be limited to the project area according to the ground water report (digby wells 2015).	
Intensity	3	Moderate loss of biological diversity.	
Probability	4	The development of the pits will definitely impacts on subsurface flows however will have a limited impact on the rivers associated with the site.	
Mitigation/ Management actions			
▪ The efficient use of water resources is very important ▪ Separation of clean and dirty water on site will allow for the discharge of un-impacted rain water back into the system			
Post- mitigation			
Duration	5	The duration of the disruption of the water flows, surface and ground water will be for the entire life of mine.	-40 (Minor negative)
Extent	3	The extent of the ground water disruption is likely to be limited to the project area according to the ground water report (digby wells 2015).	
Intensity	2	Through the return of clean water the intensity of the impact can be reduced	

Probability	4	The development of the pits will definitely impacts on subsurface flows however will have a limited impact on the rivers associated with the site.	

Dimension	Rating	Motivation	Significance
Operational habitat quantity will be impacted by sedimentation of the rivers. (negative impact) (Numbers: 14 and 22 Table 7-1)			
Impact Description: Soil erosion due to wind and surface water runoff; Loss of land capability due to erosion			
Prior to mitigation/ management			
Duration	4	Impacts from the operations phase could impact on aquatic habitats for a long period of time	-44 (Minor negative)
Extent	4	It is likely that such habitat impacts largely thought to be related to increased sediment loads and flow alteration would extend beyond the project boundary,	
Intensity	3	Moderate impacts are anticipated on the associated systems	
Probability	4	These impacts have occurred elsewhere and are likely to occur to some degree on this project.	
Mitigation/ Management actions			
▪ The use of erosion prevention measures ▪ Sediment traps ▪ Use of buffers between operations and the aquatic ecosystems			
Post management			
Duration	4	Duration remains the same as the activities remain the same	-27 (Negligibly negative)
Extent	3	The extent of the impact can be reduced with mitigation measures	
Intensity	2	The intensity can be reduced by reducing the transport of sediment downslope	
Probability	3	With the correct mitigation measures the likelihood of the impact occurring can be reduced.	

7.4.1 Water Quality Impacts

7.4.1.1 Pre-mitigation

The disturbance of deep soils and rocks as well as the associated ingress of water and oxygen to areas previously not exposed to such chemicals may result in the formation of new mineral salts that are able to be transported via ground or surface water into aquatic ecosystems. These chemicals previously unknown in these environments have the capacity to greatly reduce water quality by the addition of salts, heavy metals and other toxics such as sulfur. Salts in high concentrations can affect the osmotic functioning within aquatic organisms resulting in the loss of species not capable of tolerating the increased strain on kidney functions. Heavy metals and toxic chemicals can result in the poisoning of sensitive species resulting in reduced recruitment during sensitive lifecycle stages and ultimately the loss of that species within the affected reach of the river.

These impacts have the potential to be transported far beyond the boundary of the project area.

7.4.1.2 Post-mitigation

Mitigation measures include adequate clean and dirty water separation. Water should not be allowed to accumulate in the pit or ingress into the dumps. The thrust of these measures is to reduce the time available for these chemicals to dissolve into the water. No water should be released from the site unless it has been adequately treated and meets or exceeds the guideline physio-chemical water parameters as defined by the competent authority, the Department of Water Affairs and Sanitation (DWAS).

Any and all waste must be confined to within the boundaries of the dirty surface water trenches. Hazardous waste such as petrochemicals and blasting materials must be stored in bunded areas. Spill kits should be readily available, and training should be carried out so that all personnel are aware of how to contain spills and notify those responsible for clean-up.

7.4.2 Water Quantity Impacts

7.4.2.1 Pre-mitigation

Disruption of ground water recharge and the retention of water in the storm water and pollution control dams may result in lower flows within the associated aquatic ecosystems, however the ground water report found that it is unlikely that the proposed pit at the proposed maximum depth of 80m will negatively impact on the ground water recharge of the rivers. However the size of the infrastructure and the area encompassed by the surface water management scheme will retain water from rainfall events and prevent some of it returning to the aquatic systems.

7.4.2.2 Post-mitigation

Efficient water use by storing only what water is necessary for operations and reusing dirty water may allow for the return of clean water (water which meets discharge quality guidelines, which will need to be set by DWAS) back into the system.

7.4.3 Aquatic Habitat Impacts

7.4.3.1 Pre-mitigation

Heavy vehicles entering the aquatic ecosystems such as rivers can cause large scale habitat modification.

7.4.3.2 Post-mitigation

The use of buffers (Figure 3-2) in constraining and isolating river systems, infrastructure and mine vehicles cannot be overstated. All vehicles should observe a minimum of 100m distance from the rivers during all phases of the proposed project.

7.4.4 Closure and Rehabilitation Phase

The closure and rehabilitation phase impacts are rated below according to water quality, water quantity and aquatic habitat impacts (Table 7-5).

Table 7-5: Closure and Rehabilitation Phase

Dimension	Rating	Motivation	Significance
Closure activities will cause water quality impacts due to vegetation removal and soil stripping (Negative impact) (Numbers: 25, 26, 27, Table 7-1)			
Impact Description: Erosion reduces water quality			
Prior to mitigation/ management			
Duration	6	Often in mining the scale of water quality impacts is only fully realised during closure, this is due to water accumulating in old voids and dissolving previously isolated metals and toxicants	-65 (Minor negative)
Extent	4	It is very likely that these impacts will expand beyond the project boundary	
Intensity	3	From the ground water report it was found that the rock has only minimal to moderate acid generating capacity. Of chief concern is then the TDS of the final water exiting the site.	
Probability	5	Water quality effects such as these are common place are likely to occur	
Mitigation/ Management actions			
▪ TSF should be capped, isolated by lining and rehabilitated.			

▪ Waste rock dumps need to be rehabilitated and be designed in such a way as to reduce the ingress of water. ▪ Where possible water should not be allowed to accumulate in voids to reduce the opportunity for the dissolution of metals and contaminants into the water. ▪ Isolation of voids form surface water inflow by means of a berm. ▪ Maintain enough freeboard to prevent overflow of contaminated water.			
Post- mitigation			
Duration	5	With correct rehabilitation the duration of water quality impacts may be reversible	-48 (Minor negative)
Extent	4	Due to the rivers ability to transport dissolved contaminants if contaminated water enters the aquatic system it will be transported beyond the boundaries of the project area	
Intensity	2	With correct rehabilitation the intensity of the impact will be reduced and contaminated material is isolated from water ingress.	
Probability	4	Good rehabilitation design would reduce the probability of the water quality event from taking place (reduce frequency).	

Dimension	Rating	Motivation	Significance
Closure activities will cause water quality impacts due to vegetation removal and soil stripping (Negative to positive impact). (Numbers: 26, Table 7-1**)**			
Impact Description: Erosion reduces water quality			
Prior to mitigation/ management			
Duration	3	Often in mining the scale of water quality impacts is only fully realised during closure, this is due to water accumulating in old voids and dissolving previously isolated metals and toxicants	-32 (Negligibly negative)
Extent	3	It is very likely that these impacts will expand beyond the project boundary	
Intensity	2	From the ground water report it was found that the rock has only minimal to moderate acid generating capacity. Of chief concern is then the TDS of the final water exiting the site.	
Probability	4	Water quality effects such as these are common place are likely to occur	
Mitigation/ Management actions			
▪ TSF should be capped, isolated by lining and rehabilitated; ▪ Waste rock dumps need to be rehabilitated and be designed in such a way as to reduce the			

ingress of water; ▪ Where possible water should not be allowed to accumulate in voids to reduce the opportunity for the dissolution of metals and contaminants into the water; ▪ Isolation of voids form surface water inflow by means of a berm; and ▪ Maintain enough freeboard to prevent overflow of contaminated water.			
Post- mitigation			
Duration	6	With correct rehabilitation the duration of water quality impacts may be reversible	+44 (Minor positive)
Extent	3	Due to the rivers ability to transport dissolved contaminants if contaminated water enters the aquatic system it will be transported beyond the boundaries of the project area	
Intensity	2	With correct rehabilitation the intensity of the impact will be reduced and contaminated material is isolated from water ingress.	
Probability	4	Good rehabilitation design would reduce the probability of the water quality event from taking place (reduce frequency).	

Dimension	Rating	Motivation	Significance
Closure activities will impact on water quantity by disturbing the flow regime. (Negative impact) (Number: 27, Table 7-1)			
Impact Description: Disturbance of the flow regime will reduce the amount of water available to the associated rivers.			
Prior to mitigation/ management			
Duration	5	The current plan speaks of leaving voids, these will collect surface water flow reducing the recharge to the river during rainfall events	-36 (Minor negative)
Extent	2	The extent will be limited to the project area	
Intensity	2	There will be a small to moderate effect on the river systems flow	
Probability	4	It is likely this will occur	
Mitigation/ Management actions			
▪ Implementation of a berm to reduce surface water inflow.			
Post management			
Duration	5	The current plan speaks of leaving voids, these will collect surface water flow reducing the recharge to the river during rainfall events	-28 (Negligibly negative)

Extent	1	The extent can be limited further if these voids are isolated from surface water inflow	
Intensity	1	There will be a small effect on the river systems flow if the only loss of flow is due to the reduced catchment area of the voids. (no surface water inflows)	
Probability	4	It is likely that this will occur post closure	

Dimension	**Rating**	**Motivation**	**Significance**
Closure activities will cause aquatic habitat impacts due to vegetation removal and soil stripping (Negative impact). Number: 26, Table 7-1**)**			
Impact Description: Deposition of soil within aquatic habitats impacts on available biotopes			
Prior to mitigation/ management			
Duration	3	As the vegetation establishes itself erosion is likely to occur as the system stabilises	-36 (Minor negative)
Extent	3	The extent of the impact is likely to be local as large sediment volumes are not anticipated	
Intensity	3	When the sediment reaches the river it will reduce the available habitat types and thus impact on the specialist organisms that require the biotopes to survive	
Probability	4	This has occurred elsewhere and could potentially happen here	
Mitigation/ Management actions			
▪ Use of buffer to prevent heavy vehicles entering or disturbing the riparian or aquatic ecosystems (positive impact); and ▪ Maintain sufficient freeboard to account for heavy rain fall events.			
Post- mitigation (positive)			
Duration	2	With careful planning the rehabilitation could become a positive impact	+21 (Negligibly positive)
Extent	3	It is unlikely that the impact will extend beyond the project boundary	
Intensity	2	The intensity of the impact can be reduce via the recommended mitigation measures, to such a degree that the negative impact is reversed.	
Probability	3	The probability of the negative impact occurring could be reduced with planning and best practise rehabilitation.	

7.4.5 Water Quality Impacts

7.4.5.1 Pre-mitigation

The removal of infrastructure as well as earth moving involved with rehabilitation all have the potential impact of increasing the surface areas that is capable of being eroded. Sediment transported into the rivers will decrease the water quality by increasing the TDS of the Mogalakwena River.

7.4.5.2 Post-mitigation

All possible measures must be made to reduce erosion potential. It is highly recommended that the surface water management system is the last remaining infrastructure to be dismantled. This system must also be maintained so that during closure and rehabilitation any unforeseen spill or erosion events are captured and prevented from spreading down slope.

Any and all waste must be confined to within the boundaries of the dirty surface water trenches. Hazardous waste such as petrochemicals and blasting materials must be stored in bunded areas. Spill kits should be readily available, and training should be carried out so that all personnel are aware of how to contain spills and notify those responsible for clean-up.

If rehabilitation is carried out correctly so that the final land use maintains or improves the vegetation cover it may have a potential positive effect on the river system by reducing erosion and filtering runoff.

7.4.6 Water Quantity Impacts

7.4.6.1 Pre-mitigation

The backfilling of the pit with only waste rock will result in a void being created as less material will be available to fill the pit than was extracted. These voids can disrupt the natural flow regime by acting as sinks for water to flow into and become trapped. Or isolated from the surface water systems.

7.4.6.2 Post-mitigation

The construction of berms above and around the voids will reduce the surface water inflow possible and result in more water being available to feed back into the natural drainage features.

7.4.7 Aquatic Habitat Impacts

7.4.7.1 Pre-mitigation

If topsoil stock piles are poorly maintained so that when they are applied to the area to be rehabilitated they are nutrient poor, very little vegetation cover is likely to result which may increase the treat of erosion and increased sedimentation within the rivers.

7.4.7.2 Post-mitigation

If rehabilitation succeeds in the establishment of good ground cover that is capable of anchoring sediment in place during high rainfall events it may contribute to improved habitat conditions within the associated river systems. Monitoring of potential waste and pollution causing infrastructure such as the TSF will need to be conducted to ensure it remains in a stable condition. Ground water, surface water, aquatic ecology as well as geotechnical monitoring should be carried out after closure.

7.5 Cumulative Impacts

The current no-go effects were found to be negligibly negative with regard to impacts on water quality. This is largely due to the effect of numerous upstream impoundments which greatly reduce the possibility of the transport of impacts from the upstream mine (Anglo American Platinum's facility as well as the numerous granite mining sites within the proposed project boundary). However, during the low flow the threat of water quality deterioration will be greater due to the low flows experienced in the region and rivers and the loss of dilution potential within the rivers.

It is therefore thought that any further degradation to the system will likely be due to the additional strain the caused by proposed mine. Known mining impacts are numerous and include but are not limited to sedimentation, changes in water quality, introduction of pollutants and toxicants. However, if mitigation measures are put in place the impacts were seen to decrease from minor negative in certain circumstances to negligible negative.

The cumulative impact of the mine contributed pollution and the urban and other effluents resulting from the surrounding community may become a large issue if more people migrate to the area looking for work, the secondary impact of human migration and settlement could produce large negative impacts.

The most serious threat of cumulative impacts is to the quantity of water within the Mogalakwena River. As was mentioned above, section 6.2.1.1, prior to the confluence with the Sterk River the Mogalakwena during the low flow survey was found to be dry in sections. If the proposed mine goes ahead monitoring of its effect on the water levels of the Mogalakwena River will be necessary. Although no ground water abstraction is planned the disruption in the surface flow will impact on the quantity of water reaching the Mogalakwena River.

Habitat impacts may be reduced due to the large distance between the current mine plan and the aquatic ecosystems approximately 3 km. This area will provide a buffer that may reduce the threat of habitat disturbance.

8 Project Risks

Risks differ from impacts in that impact are a result of planned activities while risks are occur as a result of unplanned activities.

8.1 Risks Identified

The following risks were identified as part of the proposed project:

- Hydrocarbon spills;
- Additional pipelines; and
- Accidental release of effluent such as,
  - Sewage
  - Dirty water from the pollution control dams

8.2 Risk Mitigations

8.2.1 Hydrocarbon Spills

Hydrocarbon spills are common risks in all forms of mining. However, they are unintentional consequences and the scale of such events varies widely from small isolated fuel spills to much larger more damaging events like damage to fuel containers. It is essential that spill kits and emergency response procedures are well documented and personal responsible for mitigation and clean-up are well trained and equipped to handle such events. Keeping within prescribed buffers and maintaining clean and dirty water separation infrastructure will allow for these events to be kept away from sensitive aquatic ecosystems and will do a great deal to prevent the contamination of these environments.

8.2.2 Infrastructure Spanning Rivers

The construction of infrastructure spanning river systems such as pipelines (should these be necessary) should have full and complete environmental investigations into their potential impact.

8.2.3 Release of Effluent

Should spills reach the rivers it could result in a huge loss of biodiversity potentially reducing the current largely natural SASS5 scores to largely modified scores, this in turn will have other effects on fish biodiversity. Should spills be severe or toxic enough large fish kills could result.

9 Recommendations

The following recommendations are made with regard to the proposed project and are proposed in order to avoid and mitigate and detect undue impact to the aquatic systems associated with the project.

The recommendations are as follows:

- An aquatic biomonitoring program is required to be implemented at the beginning during construction to monitor the state of the rivers, for this study the site utilised for this study should be sufficient, as well as detect trends in deteriorating water quality in order for appropriate mitigation measures to be put in place.
  - Measurable metrics (such as a change is the SASS5 or FRAI score of X%) should be set with the guidance of the competent authority to ensure that issues that are identified are swiftly rectified. It is thought a decrease in the SASS5 or FRAI scores of 10% from the baseline conditions should warrant a detailed investigation into the cause of the decline.
- A buffer of 100m needs (Figure 3-2) be in place around the associated water systems of the site. This buffer will serve to reduce the impacts that may occur due to the removal of topsoil.
- No water should be released unless it meets or exceeds the water quality guidelines defined by the catchment management objectives defined by the competent authority, DWAS.

10 Comments and Responses

No comments were received on the Aquatic Impact Assessment

11 Conclusion

The discrepancy between the SASS5 and the FRAI model may be due to increased flows within the catchments associated with the sites. It stands to reason that the invertebrates would react to improving conditions faster than the slower to spawning fish species. The Eco Status of the rivers was determined to be class B and class C for the Sterk and Mogalakwena Rivers respectively. This was based on the various components of the RHP methodologies, such as good habitat which contributed to high SASS5 scores. FRAI scores were rated class B and class C and can be viewed as a good longer term indication of the state of the rivers. The class B and class C ratings imply that the Sterk River is in a largely natural state, while the Mogalakwena in moderately modified. Although impacts, predominantly impoundments, sewage and urban runoff are present upstream of the current sampling sites, the water quality is not overly impacted and sensitive species particularly macroinvertebrates were found in both rivers.

The impacts of most concern relate to water quality and water quantity. Any water quantity restriction occurring from the proposed project will likely have knock on water quality impacts, as the dilution and transport potential of the system is reduced. Reducing flows will also reduce the amount of habitat inundated and may contribute to a reduction in the biodiversity of the systems.

From the Geochemistry and Waste Classification Report (Digby Wells 2015) the acid generating potential of the ore appears to be low to negligible however there are many other potential aquatic ecology impacts associated with mining and as such the use of adequate buffers and biomonitoring throughout the life of mine as well as during closure should be carried out.

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