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ILISO CONSULTING (PTY) LTD

Aquatic Assessment for the Kusile Ash Dump and Aquatic Impact Assessment

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REPORT

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Golder Associates

Executive Summary

Golder Associates Africa (Pty) Ltd (Golder) was commissioned by Iliso Consulting (Pty) Ltd to conduct an aquatic baseline assessment and impact assessment for the proposed Kusile ash disposal facility and associated activities as supportive documentation for the Waste Management License (WML) application.

The assessment conducted in August/September 2013 aimed to quantify the potential impacts emanating from the proposed project on the biotic ecosystem in the Klipfonteinspruit and adjoining tributaries of the Wilge River, and to further identify potential problems and recommend suitable mitigation measures.

As assessment of the *in situ* water quality illustrated that Dissolved Oxygen (DO) concentration and percentage saturation was a limiting factor of aquatic biodiversity at certain sites. Both of these parameters were below the TWQR guidelines at sites TRI1 and KUS15. Low DO concentrations may be attributed to the large amount of decaying organic matter on the stream beds and limited flow conditions at the time of the survey. The remainder of the *in situ* water quality parameters were within the guideline values and thus not considered to be limiting factors to the aquatic ecosystem

Habitat availability was a limiting factor of aquatic macroinvertebrate diversity at all sites except KUS4 and KUS9. The limited habitat availability was due to the absence of the stones biotope.

Based on the aquatic macroinvertebrate assessment biotic integrity in the project area ranged from slightly to critically modified (Class B to F) and comprised primarily of tolerant taxa. This was primarily attributed to limited habitat availability and low flow conditions.

An assessment of the ichthyofauna within the study area showed that the fish species diversity in the Klipfonteinspruit and adjoining tributaries was low. Based on the fish results biotic integrity in the project area ranged from largely to critically modified. The low biotic integrity was primarily attributed to limited habitat availability and low flow conditions. No fish species were recorded at sites KUS7, KUS8 and TRI1.

Based on the risk assessment four potential impacts on aquatic ecosystems were identified, namely:

- Degradation of aquatic ecosystems due to increased sedimentation;
- Change to natural flow regime; and
- Loss of indigenous species and biodiversity due to declines in water quality and habitats.

Majority of the above impacts were rated as low, should mitigation measures be implemented. Although their severity was primarily high, the probability of the impacts taking place was low, duration was short term over a regional scale. However, should mitigation measures not be implemented, the significance of the impacts would be moderate. The only impact rated high prior to mitigation measures was degradation of aquatic ecosystems due to increased sedimentation. The high significance will be as a result of no adequate sediment control measures installed into the aquatic systems in order to evade large sediment plumes migrating downstream from the project site. However, the significance of this impact will be reduced to moderate, following the implementation of mitigation measures.

However, not only are there site specific impacts, but further cumulative impacts. The existing construction footprint of the Kusile Power Station, surrounding agricultural activities, industrial activities (waste rock crushing plant), and surrounding mining activities, all contribute to the cumulative impacts on the receiving environment.

It was recommended that appropriate mitigation measures concerning the aquatic environment should be implemented during both the construction and operational phase of the project. The following were recommended for the proposed project:

- Silt traps should be placed down-slope of where vegetation stripping will take place to minimise siltation in rivers and wetlands. These silt traps need to be regularly maintained to ensure effective drainage;
- The runoff should be routinely monitored for acidity/alkalinity and TDS as an early warning for potential increases in discharge water. The water in these pollution control dams should be reused at the Kusile Power Station if possible; and
- Water quality and biotic integrity should be routinely monitored in the Klipfonteinspruit and adjoining tributaries of the Wilge Rivers to assess and quantify the potential impact on the receiving environment.

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1.0 INTRODUCTION

Golder Associates Africa (Pty) Ltd (Golder) was commissioned by Iliso Consulting (Pty) Ltd (Iliso) to conduct an aquatic assessment for the proposed Kusile ash disposal facility and associated activities as supportive documentation for the Waste Management License (WML) application.

In 2006, Eskom Holdings embarked on an Environmental Impact Assessment (EIA) for the construction of the 4 800 MW Kusile coal-fired power station and associated infrastructure near Ogies, Mpumalanga. A positive environmental authorisation was received from the Department of Environmental Affairs in 2007, for the construction of the power station and to operate ash disposal systems. However, at the time of the EIA, Eskom's intention was to dispose of ash only at the ash disposal facility but subsequently initiated an investigation to determine existing potential opportunities in the market which would result in the use of gypsum. Since gypsum is considered to be a hazardous waste, a WML was required as per the National Environmental Waste Act (No. 59 of 008). This specialist study forms part of several other specialist studies required for the mentioned authorisation.

In addition, the aquatic impact assessment further took into account the following facilities located adjacent to the Kusile ash dump:

- Station dirty dam settling tank;
- Station dirty dam;
- Ash dump silt retention dams;
- Ash dump dirty water dam; and
- K4 area.

The Kusile construction footprint, where the mentioned facilities are located, is near to Emalahleni in the Mpumalanga Highveld. The Kusile study area is situated within quaternary drainage region B20F in the Wilge River catchment in the Olifants Water Management Area (WMA4). It falls within the Highveld (11) – Lower Level 1 Ecoregion and the Grassland Biome (Mucina & Rutherford, 2006; Dallas, 2007).

This report presents the dry season (August/September 2013) results. Included is an assessment of the *in situ* water quality, habitat availability for aquatic macroinvertebrates, aquatic macroinvertebrate and ichthyofauna diversity. A comparison of previous data from the study area has been included.

1.1 Objectives

The objectives of this assessment included the following:

- Characterization of the biotic integrity of aquatic ecosystems in the project area as per the scope of work;
- Assessment of impacts emanating from the proposed Kusile ash dump and associated facilities, taking into account the surrounding land uses on the biotic ecosystem in the catchment area;
- Evaluation of the extent of site-related effects in terms of selected ecological indicators;
- Identification of listed aquatic biota based on the latest IUCN rankings, or other pertinent conservation ranking bodies;
- Identification of sensitive or unique aquatic habitats which could suffer irreplaceable loss; and
- Identification of potential impacts and recommendation of suitable mitigation measures.

1.2 Experience in the Project Area

Golders' ecological team has previously been involved in numerous specialist studies for a variety of mining and industrial organisations within and around the Ogies area in Mpumalanga. In particular, our team conducted the baseline aquatic and impact assessment for the original Kusile Environmental Impact Assessment (EIA). Furthermore, our team has been involved in the quarterly aquatic biomonitoring of aquatic macroinvertebrates and ichthyofauna for the construction phase of Kusile as well as the ash dumps at Kendal and Kusile. We have extensive knowledge of the aquatic ecosystem of the project area, coupled with a large historical database for the study area. This historical database has been used for this report in order to gain a better understanding of the health and integrity of the rivers and streams for this proposed project.

2.0 AQUATIC ASSESSMENT APPROACH

In order to enable adequate descriptions of the aquatic environment, it is recommended that indicators be selected to represent each of the stressor, habitat and response components involved in the aquatic environment. Broad methodologies to characterise these components are described below. These proposed methodologies are generally applied and accepted (DWAF & USEPA) and are as follows:

2.1 Stressor Indicators

- *In situ* water quality parameters.
  - Electrical Conductivity (EC), Total Dissolved Salts (TDS), pH, Dissolved Oxygen (DO), percentage saturation (DO%), water temperature and turbidity.

2.2 Habitat Indicators

- General habitat assessment; and
- Integrated Habitat Assessment System (IHAS, *Version 2*).

2.3 Response Indicators

- Aquatic macroinvertebrates (South African Scoring System, *Version 5*); and
- Ichthyofauna (Fish Assemblage Integrity Index, FAII).

3.0 STUDY AREA

The main drainage feature of the Kusile study area is the Wilge River which flows northwards to the west of the Power Station construction site. The Holfonteinspruit, Klipfonteinspruit and an unnamed tributary, drain in a north westerly direction from the Kusile site towards the Wilge River.

The topography of the region is a gently undulating to moderately undulating landscape of the Highveld plateau. Some small scattered wetlands and pans occur in the area, rocky outcrops and ridges also form part of significant landscape features in the wider area. The altitude ranges between 1 260 – 1 620 metres above mean sea level.

3.1 Sampling Points

A total of eight (8) sites were monitored within the watercourses associated with the Kusile Power Station construction site. Sites KUS4, KUS15, KUS7 to KUS9 form part of our monitoring sites for the Kusile's quarterly aquatic monitoring events. Furthermore, the sites have been selected to represent the receiving environment associated with the development as well as potential impacts on the larger Wilge River.

The GPS co-ordinates of sampling sites were determined using a Garmin GPS 60CSx and are listed in Table 1 along with descriptions of the sites. A map of the study area showing the location of aquatic sampling sites is presented in Figure 1. Photographs of sampling sites are presented in APPENDIX A.

Table 1: Descriptions and locations of aquatic and wetland monitoring sites

Site	Latitude	Longitude	River	Description
KUS4	-25.94279	28.93998	Klipfonteinspruit	*Existing site.* This site has been selected as an upstream point on the Klipfonteinspruit, which may be impacted upon by the ash dump
KUS15	-25.95740	28.90733	Holfonteinspruit	*Existing site.* This site is located in the Holfonteinspruit, just before it enters into the Klipfonteinspruit upstream of site KUS07
KLI1	-25.947033	28.909867	Klipfonteinspruit	Additional site. This site is located south of the proposed Kusile ash dump on the Klipfonteinspruit within the Kusile construction footprint.
TRI1	-28.907083	28.907083	Unnamed tributary of the Klipfonteinspruit	Additional site. This site is located north of the proposed Kusile ash dump within the Kusile construction footprint and forms part of the river diversion
KUS7	-25.93887	28.89471	Klipfonteinspruit	*Existing site.* This site has been selected as a downstream point on the Klipfonteinspruit, which may be impacted upon by the ash dump. Associated infrastructure also crosses the river at this point
KUS8	-25.92462	28.90022	Unnamed tributary of the Klipfonteinspruit	*Existing site.* This site has been selected as a downstream point for the diversion. Associated infrastructure also crosses the river at this point. This point will also represent any impacts from the Power Station upstream. This site will hereafter be referred to in the report as the Kusile tributary
KUS9	-25.91424	28.88064	Klipfonteinspruit	*Existing site.* This point is located below the confluence of the two tributaries draining the Power Station and ash dump area. This point will monitor the combined effect on the river system
KLI2	-28.866033	28.866033	Klipfonteinspruit	Additional site. This site is located downstream of the Kusile construction footprint on the Klipfonteinspruit approximately 960m from the confluence of the Wilge River

WGS_84 Datum co-ordinate system represented in decimal degrees

Figure 1: Map of aquatic monitoring sites

4.0 METHODS AND MATERIALS

4.1 *In Situ* Water Quality

During the August/September 2013 dry season survey, compact field instruments were used to measure the following parameters:

- pH (Eutech pH Tester);
- Electrical Conductivity (EC) (Eutech ECTester11 Dual Range);
- Dissolved Oxygen (DO) (Eutech CyberScan DO300);
- Temperature (Eutech CyberScan DO300); and
- Clarity (Secchi Disk).

Water quality has a direct influence on aquatic life forms. Although these measurements only provide a "snapshot", they can provide valuable insight into the characteristics and interpretation of a specific sample site at the time of the survey.

It should be noted that this does not constitute the general water quality state of the sites or streams and does not include chemical water quality analysis, metal or organic contaminants, nutrient analysis or pesticide analysis.

In 1996 the Department of Water Affairs and Forestry (DWAF) published the South African Water Quality Guidelines for Aquatic Ecosystems (Volume 7). These guidelines provide target ranges in terms of water quality for the protection of aquatic ecosystems. All measured parameters for the sites should be within the target water quality range (TWQR). It is these benchmarks that are used to assess the present condition of the river systems and the extent of degradations. Dissolved Oxygen (DO) however is measured against the guideline provided from Kempster *et al.* 1980.

4.2 Habitat Assessment

Habitat assessment can be defined as the evaluation of the structure of the surrounding physical habitat that influences the quality of the water resource and the condition of the resident aquatic community (Barbour *et al*., 1996). Habitat quality and availability plays a critical role in the occurrence of aquatic biota. For this reason habitat evaluation is conducted simultaneously with biological evaluations in order to facilitate the interpretation of results.

4.2.1 Integrated Habitat Assessment System

The Integrated Habitat Assessment System (IHAS, V*ersion 2*) was applied at each of the sampling sites in order to assess the availability of habitat biotopes for macroinvertebrates. The IHAS was developed specifically for use with the SASS5 index and rapid biological assessment protocols in South Africa (McMillan, 1998). The index considers sampling habitat and stream characteristics. The sampling habitat is broken down into categories, these being stones-in-current, vegetation and other habitat/ general. All of these add up to a possible 100 points (or percentage). It is presently thought that a total IHAS score of over 65% represents good habitat conditions, a score over 55% indicates adequate/fair habitat conditions and anything below 55% is poor (McMillan, 2002) (Table 2).

Table 2: Integrated Habitat Assessment System Scoring Guidelines (Version 2)

IHAS Score	Description
> 65%	Good
55-65%	Adequate/Fair
< 55%	Poor

4.3 Aquatic Macroinvertebrates

The monitoring of benthic macroinvertebrates forms an integral part of the monitoring of the health of an aquatic ecosystem as they are relatively sedentary and enable the detection of localised disturbances. Their relatively long life histories (±1 year) allow for the integration of pollution effects over time.

Field sampling is easy and since the communities are heterogeneous and several phyla are usually represented, response to environmental impacts is normally detectable in terms of the community as a whole (Hellawell, 1977).

Aquatic macroinvertebrates were sampled using the qualitative kick sampling method called SASS5 (South African Scoring System, *version 5*) (Dickens & Graham, 2002). The SASS5 protocol is a biotic index of the condition of a river or stream, based on the resident macroinvertebrate community, whereby each taxon is allocated a score according to its level of tolerance to river health degradation (Dallas, 1997). This method relies on churning up the substrate with your feet and sweeping a finely meshed SASS net (mesh size of 1000 micron), over the churned up area. It must be noted that the SASS5 index was designed specifically for the assessment of perennial streams and rivers and is not suitable for assessment of impoundments, isolated pools, wetlands or pans (Dickens & Graham, 2002).

In the Stones-In-Current (SIC) biotope the net is rested on the substrate and the area immediately upstream of the net disturbed by kicking the stones over and against each other to dislodge benthic invertebrates. The net is also swept under the edge of marginal and aquatic vegetation (VEG). Kick samples are collected from areas with gravel, sand and mud (GSM) substrates. Identification of the organisms is made to family level (Thirion *et al*., 1995; Davies & Day, 1998; Dickens & Graham, 2002; Gerber & Gabriel, 2002).

The endpoint of any biological or ecosystem assessment is a value expressed either in the form of measurements (data collected) or in a more meaningful format by summarising these measurements into one or several index values (Cyrus *et al*., 2000). The indices used for this study were, SASS5 Total Score and Average Score per Taxon (ASPT).

4.3.1 Biotic Integrity Based on SASS5 Results

Reference conditions reflect the best conditions that can be expected in rivers and streams within a specific area and also reflect natural variation over time. These reference conditions are used as a benchmark against which field data can be compared. Modelled reference conditions for the Highveld Ecoregion were obtained from Dallas (2007) (Table 3).

Table 3: Modelled reference conditions for the Highveld Ecoregion (11) based on SASS5 and ASPT scores (adapted from (Dallas, 2007), (Kleynhans, 1999) and (Kleynhans, *et al.,* 2005)

SASS Score	ASPT	Class	Description
>124	>5.6	A	Unmodified; community structures and functions comparable to the best situation to be expected. Optimum community structure for stream size and habitat quality.
83-124	4.8-5.6	B	Largely natural with few modifications; A small change in community structure may have taken place but ecosystem functions are essentially unchanged
60-82	4.6-4.8	C	Moderately modified; community structure and function less than the reference condition. Community composition lower than expected due to loss of some sensitive forms. Basic ecosystem functions are still predominantly unchanged.
52-59	4.2-4.6	D	Largely modified; fewer families present than expected, due to loss of most intolerant forms. An extensive loss of basic ecosystem function has occurred.
30-51	Variable <4.2	E	Seriously modified; few aquatic families present, due to loss of most intolerant forms.
<30	Variable	F	Critically or extremely modified; An extensive loss of basic

SASS Score	ASPT	Class	Description
			ecosystem function has occurred.

4.4 Ichthyofauna

Fish are used as indicators of river condition as they are relatively long-lived and mobile, and indicate long-term influences and general habitat conditions integrate effects of lower trophic levels and are consumed by humans (Uys *et al*., 1996).

Fish samples were collected using a battery operated electro-fishing device (Smith-Root LR24). This method relies on an immersed anode and cathode to temporarily stun fish in the water column; the stunned fish can then be scooped out of the water with a net for identification. The responses of fish to electricity are determined largely by the type of electrical current and its wave form. These responses include avoidance, electrotaxis (forced swimming), electrotetanus (muscle contraction), electronarcosis (muscle relaxation or stunning) and death (USGS, 2004). Electrofishing is regarded as the most effective single method for sampling fish communities in wadeable streams (Plafkin *et al.,* 1989). All fish were identified in the field using the guide Freshwater Fishes of Southern Africa (Skelton, 2001). Reference specimens were preserved for laboratory confirmation of field identifications and the remainder of the fish released at the point of capture.

Expected fish species list

Based on a desktop review of available literature an expected species list was compiled for the Kusile ash dump project (Kleynhans *et al.,* 2007).

Based on this assessment, a total of 10 indigenous fish species are expected to occur within the area (7 to 10 indigenous species per site), although some of the smaller “AD” sites may only expect to have a total of 4 indigenous fish species occurring (Table 4). In addition the introduced species *Cyprinus carpio (Carp), Gambusia affinis* (Mosquito fish) and *Micropterus salmoides* (Largemouth Bass) are also expected to occur in the area (Table 4).

Table 4: Fish species expected to occur in the Kusile project area (IUCN, 2013 and Kleynhans, 1999).

Species	Common Name	Habitat Preference		IUCN Status	Intolerance Rating
Barbus anoplus	Chubbyhead barb	SD/SS	Wide variety of habitats	Least Concern	2.6
Barbus paludinosus	Straightfin barb	SD/SS	Wide variety of habitats	Least Concern	1.8
Barbus trimaculatus	Threespot barb	SD	Wide variety of habitats	Least Concern	2.2
**Cyprinus carpio*	Carp (Exotic)	SD	Wide variety of habitats	Vulnerable	1.4
Chiloglanis pretoriae	Shortspine Suckermouth	FS	Flowing water over cobbles and in shoots	Least Concern	4.6
Clarias gariepinus	Sharptooth catfish	SD	Wide variety of habitats	Unlisted	1.2
**Gambusia affinis*	Mosquito fish (Exotic)	SD	Wide variety of habitats	Unlisted	2.0
Labeo cylindricus	Redeye labeo	FS	Prefers clear flowing water in rocky habitat	Least Concern	3.1
Labeobarbus marequensis	Lowveld Largescale yellow	FS/SD	Flowing water of larger rivers	Least Concern	2.6
Labeobarbus polylepis	Bushveld Smallscale yellowfish	FS/SD	Flowing water of larger rivers	Least Concern	3.1
**Micropterus salmoides*	Largemouth Bass (Exotic)	SD	Clear standing or slow flowing water	Unlisted	2.2
Pseudocrenilabrus philander	Southern mouthbrooder	SS	Wide variety of habitats	Unlisted	1.3
Tilapia sparrmanii	Banded tilapia	SS	Wide variety of habitats	Least Concern	1.3

**Red highlighted species are those that are classed as exotic in South Africa.*

SS: slow shallow, SD: slow, deep, FS: fast shallow

Presence of Red Data species

In order to assess the Red Data Book status of the expected fish assemblage, the IUCN Red List of Threatened Species was consulted (IUCN, 2012). The result of the IUCN Red List assessment is presented in Table 4

Of the 13 fish species expected to occur in the sampling area:

- Four are currently unlisted on the IUCN Red List of which two of them are exotic in South Africa;
- Eight are currently listed as Least Concern (LC) on the IUCN Red List. Species in this category are considered to be widespread and abundant (IUCN, 2012); and
- One is Vulnerable (V) on the IUCN Red List although *Cyprinus carpio* is classed as an exotic species in South Africa.

Based on the IUCN Red List no rare threatened or endangered fish species are expected to occur in the project area.

Fish Assemblage Integrity Index (FAII)

The Fish Assemblage Integrity Index (FAII) was applied to sites associated with the Kusile ash dump alternatives. The FAII index uses the diversity and composition of fish populations, their relative tolerance/intolerance to disturbance, frequency of occurrence and health, to assess biotic integrity. This index measures the current integrity of the fish community relative to what is derived to have been present under natural/unimpaired conditions. The integrity of the fish assemblages is considered to provide a perspective on the broad biological integrity status of a river/stream.

Procedures used in the application of the FAII are described below:

Species Intolerance Ratings

Intolerance refers to the degree to which an indigenous species is unable to withstand changes in the environmental conditions at which it occurs (Kleynhans, 1999). Four components were considered in estimating the intolerance of fish species, i.e. habitat preferences and specialization (HS), food preferences and specialisation (TS), requirement for flowing water during different life stages (FW) and association with habitats with unmodified water quality (WQ). Each of these aspects was scored for a species according to low requirements/specialization (rating = 1), moderate requirement/specialization (rating = 3) and high requirement/specialization (rating = 5) (Table 5). The total intolerance (IT) of fish species is estimated as follows:

$$IT = (HS + TS + FW + WQ)/4$$

Table 5: Species intolerance ratings

Score	Class
1 - 1.9	Tolerant
>2 - 2.9	Moderately Tolerant
>3 - 3.9	Moderately Intolerant
>4 - 5.0	Intolerant

The expected fish species were ranked into classes based on their intolerance rating (Table 5). Based on that assessment one intolerant species, *Chiloglanis pretoriae* may potentially occur within the project area (Table 4).

Fish Health Assessment

The assessment is conducted in such a way as to derive numeric values, which reflect the status of fish health. The percentage of fish with externally evident disease or other anomalies was used in the scoring of this metric (Kleynhans, 1999; Kilian *et al.*, 1997). The following procedures were followed to score the health of individual species at site:

- Frequency of affected fish >5%. Score = 1;
- Frequency of affected fish 2 – 5%. Score = 3; and
- Frequency of affected fish < 2%. Score = 5.

This approach is based in the principle that even under unimpaired conditions a small percentage of individuals can be expected to exhibit some anomalies (Kleynhans, 1999).

Calculation of FAII Score:

The FAII consists of the calculation of an expected value, which serves as the baseline or reference, the calculation of an observed value and the comparison of the expected and observed scores that provide a relative FAII score. The expected FAII rating for a fish habitat segment is calculated as follows (Kleynhans, 1999):

FAII value (Exp) = ΣIT x ((F + H)/2)

Where:

- Exp = expected for a fish segment;
- IT = Intolerance rating for individual species expected to be present in a fish habitat segment and in habitats that were sampled; and
- H = Expected health rating for a species expected to be present.

The observed observation is calculated on a similar basis, but is based on information collected during the survey:

FAII value (Obs) = ΣIT x ((F + H)/2)

Where:

- Obs: = observed for a fish habitat segment

The relative FAII score is calculated by:

Relative FAII score = FAII value (Obs)/FAII value (exp) x 100

Interpretation of the FAII score

Interpretation of the relative FAII values is based on the habitat integrity classes of Kleynhans (1996) (Table 6).

Table 6: FAII Assessment Classes (Kleynhans, 1996; 1999)

Class	Description of generally expected conditions for integrity classes	FAII score (% of total)
A	Unmodified, or approximate natural conditions closely.	90 - 100
B	Largely natural with few modifications. A change in community characteristics may have taken place but species richness and	80 - 89

Class	Description of generally expected conditions for integrity classes	FAII score (% of total)
	presence of intolerant species indicate little modification	
C	Moderately modified. A lower than expected species richness and presence of most intolerant species. Some impairment of health may be evident at the lower limit of this class	60 - 79
D	Largely modified. Clearly lower than expected species richness and presence of most intolerant species. Some impairment of health may be evident at the lower limit of this class	40 - 59
E	Seriously modified. A strikingly lower than expected species richness and general absence of intolerant and moderately intolerant species. Impairment of health may become evident.	20 - 39
F	Critically modified. Extremely lowered species richness and an absence of intolerant and moderately intolerant species. Only tolerant species may be present with a complete loss of species at the lower limit of the class. Impairment of health generally very evident.	0 - 19

4.4.1 Fish Health

The fish health assessment was confined to external examination of the skin, fins, eyes, gills, opercula (the hard, bony flap covering the gill slits) and the presence of ectoparasites. This approach ensured the minimization of stress due to handling and allowed the fish to be released unharmed. This approach is based in the principle that even under unimpaired conditions, a small percentage of individuals can be expected to exhibit some anomalies (Kleynhans, 1999).

4.5 Risk Assessment

A quantitative risk assessment methodology will be used for the risk assessment as per Illiiso risk assessment methodology. This method makes use of the basic risk assessment approach of deriving an expression for risk from the product of likelihood and consequences. It works by attributing absolute values to likelihood (probability) and consequences. The methodology is described in Figure 2.

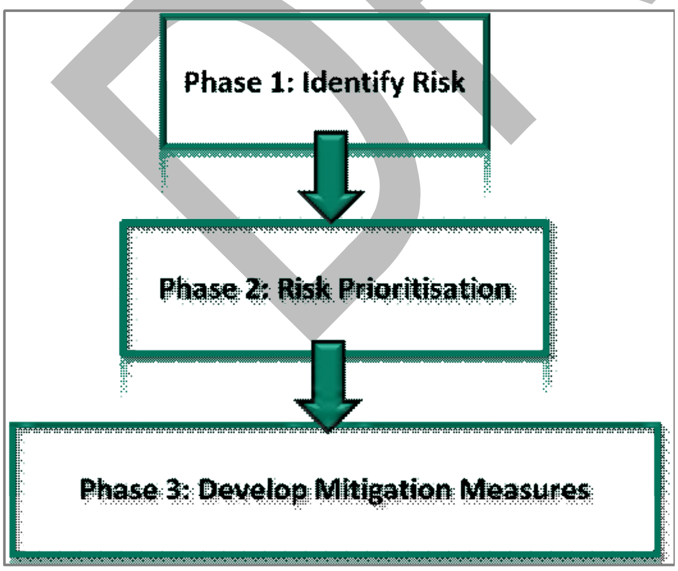

Figure 2: Summary of quantitative risk assessment methodology (adapted from Illiso risk assessment methodology)

4.5.1 Phase 1: Identify the Risks

The aquatic assessment will identify all the risks associated with the proposed project (positive, negative and cumulative).

4.5.2 Phase 2: Quantitative Risk Assessment (Risk Prioritisation)

The risk assessment will involve the quantification of the risks associated with the project. The potential significance of potential environmental risks identified should be determined using the significance rating as described below. The terminology has been taken from the Guideline Documentation on EIA Regulations as follows:

- Severity / magnitude;
- Reversibility;
- Duration of impact; and
- Spatial extent.

Refer to Table 7 for the consequence and probability ranking.

Table 7: Consequence and probability ranking

Severity/magnitude (S)	Reversibility (R)	Duration (D)	Spatial Extent (E)	Probability (P)
(5) Very high / don't know	(1) Reversible (regenerates naturally)	(5) Permanent	(5) International	(5) Definite / don't know
(4) High		(4) Long term (impact ceases after operational life)	(4) National	(4) High probability
(3) Moderate	(3) Recoverable (needs human input)	(3) Medium term (5 – 15 years)	(3) Regional	(3) Medium probability
(2) Low		(2) Short term (0 – 5 years)	(2) Local	(2) Low probability negligible
(1) Minor	(5) Irreversible	(1) Immediate	(1) Site only	(1) Improbable
(0) None				(0) None

The maximum value which can be obtained is 100 significance points. The risks will be rated as High, Moderate or Low significance by combining the consequence of the impact and the probability of occurrence. Refer to Table 8 for the levels of significance.

Consequence = Severity + Reversibility + Duration + Spatial Scale

Consequence X Probability = Significance

Table 8: Significance Levels

Significant Points	Environmental Significance
>60	High
30 – 60	Moderate
<30	Low

4.5.3 Phase 3: Mitigation Measures

Specialists will be required to include mitigation measures in the assessments and to quantify the changes in the significance of the risk after the implementation of the mitigation measures. The measures will include;

- Ways to avoid the identified risks (if possible);
- Where it is not possible to avoid the risks, ways to minimise the risks (mitigation measures); and
- Ways to maximise the positive risks.

4.5.4 Cumulative Impacts

It is a requirement that the impact assessments take cognisance of cumulative impacts. In fulfilment of this requirement the impact assessment will take cognisance of any existing impact sustained by the operations, any mitigation measures already in place, any additional impact to environment through continued and proposed future activities, and the residual impact after mitigation measures.

It is important to note that cumulative impacts at the national or provincial level will not be considered in this assessment, as the total quantification of external companies on resources is not possible at the project level due to the lack of information and research documenting the effects of existing activities. Such cumulative impacts that may occur across industry boundaries can also only be effectively addressed at Provincial and National Government levels.

5.0 STATE OF THE ENVIRONMENT: RESULTS AND DISCUSSION

5.1 Flow Conditions

At the time of the survey (August/September 2013), flow conditions within the project area were considered to be normal for a dry season survey. Although, flow was low and varied between sites, none of the sampling sites were dry during the time of the survey.

The Ogies area in which the project area is located normally receives about 578 mm of rain per year, with most rainfall occurring during summer, peaking in January (109 mm). Low flow conditions are experienced during June and July with no rain expected during this period (SA explorer, 2011).

5.2 *In Situ* Water Quality

In situ water quality measurements were recorded using field instruments and the results presented in Table 9.

The Target Water Quality Range (TWQR) as provided by DWAF (1996) is shown for the *in situ* parameters measured. The guideline for DO was obtained from Kempster *et al.,* 1980.

Table 9: *In situ* water quality results recorded during the August/September 2013 survey

Site	pH	EC (mS/m)	TDS (mg/ℓ)	DO (mg/ℓ)	DO Saturation (%)	Temp (˚C)	Clarity (cm)
TWQR	6.5 – 9.0	<154	<1000	>5.00	80 – 120	5 – 30	>25
KUS4	8.4	4.0	26.0	5.0	84.4	15.0	>20
KUS15	8.0	10.0	65.0	3.9	74.5	20.6	>23
KLI1	8.3	97.0	630.5	4.5	90.4	27.1	>24
TRI1	8.2	2.0	13.0	1.7	29.6	18.3	>12
KUS7	7.4	37.0	240.5	7.1	98.4	5.7	>20
KUS8	7.8	16.0	104.0	7.2	100.2	6.1	>70
KUS9	7.9	29.0	188.5	7.4	113.6	10.2	>31

Site	pH	EC (mS/m)	TDS (mg/ℓ)	DO (mg/ℓ)	DO Saturation (%)	Temp (˚C)	Clarity (cm)
KLI2	8.4	93	604.5	5.6	111.7	22	13

(Red highlighted text indicate exceedances of the guideline values detailed in the report; [1]EC - Electrical Conductivity; [2]TDS - Total Dissolved Solids; [3]DO - Dissolved Oxygen; mS/m – milliSiemens per metre; mg/l – milligrams per litre; % Sat – percentage saturation. Clarity figures that display a ">" indicates the maximum depth of the river where the secchi disk could still be seen, and thus an accurate clarity measurement could not be recorded as the water was either too shallow or clear.

5.2.1 pH

Most fresh waters are usually relatively well buffered and more or less neutral, with a pH range from 6.5 to 8.5, and most are slightly alkaline due to the presence of bicarbonates of the alkali and alkaline earth metals (Bath, 1989). The pH target for fish health is presented as ranging between 6.5 and 9.0, as most species will tolerate and reproduce successfully within this pH range (Alabaster and Lloyd, 1982). In addition, pH values should not be allowed to vary from the range of historical data for a specific site and time of day, by > 0.5 of a pH unit, or by > 5 % (whichever is the more conservative) (DWAF, 1996). The pH of natural waters is determined by geological influences and biotic activities.

During the August/September 2013 survey, the pH values were alkaline but within the South African Fresh Water Quality Guidelines for Aquatic Ecosystems (DWAF, 1996; Volume 7). The values ranged from 7.4 at site KUS7 to 8.4 at sites KUS4 and KLI2 (Table 9 and Figure 3).

Historical pH results were assessed from March 2010 to present for sites that have been previously monitored. The trend indicated both spatial and temporal fluctuations in the pH values within the tributaries that drain towards the Wilge River (Figure 4). Historically pH values have been mostly alkaline throughout the catchment. Based on comparison with long term results, recent pH values were considered to be largely natural and were not regarded as having a limiting effect on aquatic biota. There is high variation in the pH values at all the sites, with sites KUS4, KUS7 and KUS15 indicating minimum outliers below the TWQR guidelines (Figure 4). This may have been attributed to various runoff events from the surrounding agricultural activities at the time of those surveys.

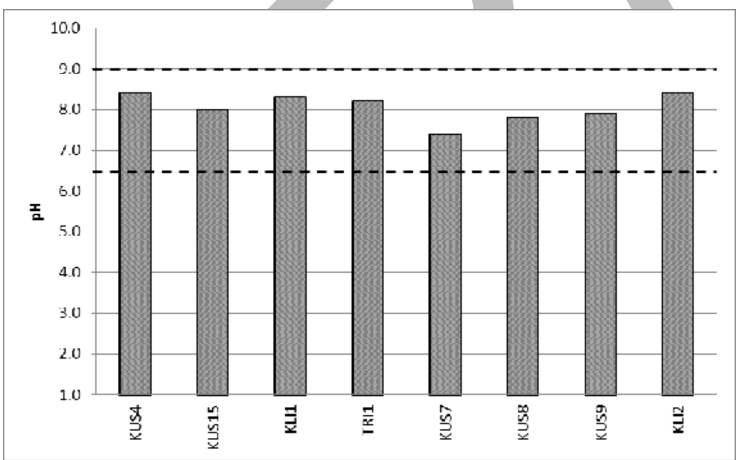

Figure 3: pH values observed in August/September 2013 (dashed lines indicate guideline values)

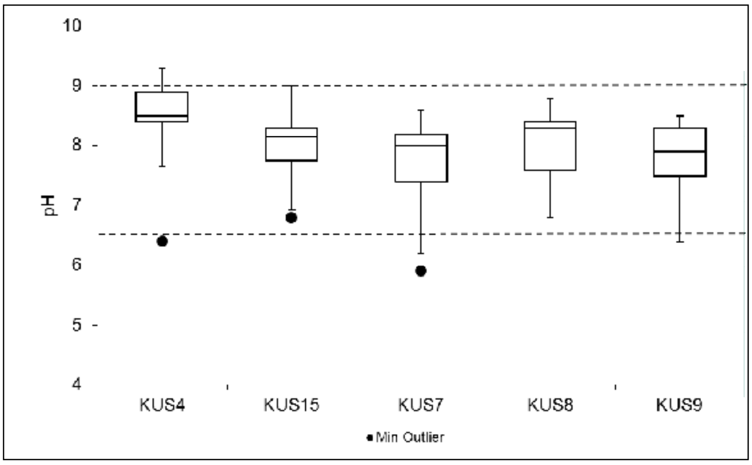

Figure 4: Historical pH values observed in the project area (excluding the three additional sites) from March 2010 to August 2013 (dashed lines indicate guideline values. ● Minimum Outlier)

5.2.2 Total Dissolved Salts / Electrical Conductivity

The EC is a measure of the ability of water to conduct an electrical current (DWAF, 1996). This ability is a result of the presence in water of ions such as carbonate, bicarbonate, chloride, sulphate, nitrate, sodium, potassium, calcium and magnesium, all of which carry an electrical charge (DWAF, 1996). Many organic compounds dissolved in water do not dissociate into ions (ionise), and consequently they do not affect the EC (DWAF, 1996). The EC is a rapid and useful surrogate measure of the TDS concentration of waters with a low organic content (DWAF, 1996). For the purpose of interpretation of the biological results collected during the August 2013 survey the TDS concentrations were calculated by means of the EC using the following generic equation (DWAF, 1996):

TDS (mg/ℓ) = EC (^{m}S/m at 25 °C) x 6.5

If more accurate estimates of the TDS concentration from EC measurements are required then the conversion factor should be experimentally determined for each specific site and for specific runoff events (DWAF, 1996). According to Davies and Day (1998), freshwater organisms usually occur at TDS values less than 3000 mg/ℓ. According to the South African Water Quality Guidelines for Aquatic Ecosystems (DWAF, 1996) the rate of change of the TDS concentration, and the duration of the change is more important than absolute changes in the TDS concentration. Most of the macroinvertebrate taxa that occur in streams and rivers are sensitive to salinity, with toxic effects likely to occur in sensitive species at salinities > 1000 mg/ℓ (DWAF, 1996). According to the South African Water Quality Guidelines for Aquatic Ecosystems (DWAF, 1996; Volume 7) TDS concentrations in South African inland waters should not be changed by > 15% from the natural background values.

During the August/September 2013 survey, the TDS concentrations at all the sites were with the TWQR guidelines (DWAF, 1996) and thus not considered a limiting factor for aquatic biota (Table 9 and Figure 5). The highest TDS concentrations were recorded at sites KLI1 and KLI2 in the Klipfonteinspruit, measuring 630.5 mg/ℓ and 604.5 mg/ℓ respectively (Figure 5). The elevated TDS concentrations measured at these sites may be a consequence of agricultural activities in the area. Sedimentation input from the construction site may further have contributed to the TDS concentrations. However, the TDS concentrations measured at sites KUS7 (240 mg/ℓ) and KUS9 (188.5 mg/ℓ), located directly downstream of the construction footprint, were not as high as site KLI2 (Figure 5). Therefore, another unidentified factor may have contributed to the TDS concentrations at these sites.

Historical results assessed from March 2010 to present, have illustrated that the TDS concentrations at the sites have remained below the guideline values since March 2010. Large variations in the TDS concentrations were noted at sites KUS7 and KUS9 along the Klipfonteinspruit (Figure 6), while the lowest TDS concentrations were recorded at the most upstream site (KUS4) (Figure 6).

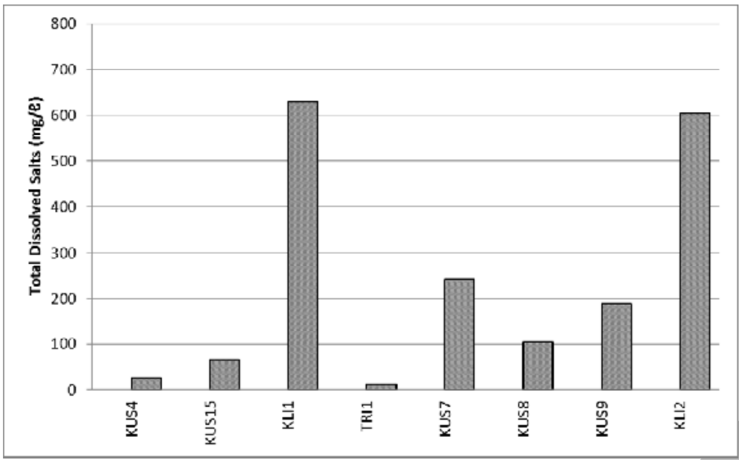

Figure 5: Total Dissolved Salts concentrations measured in August/September 2013

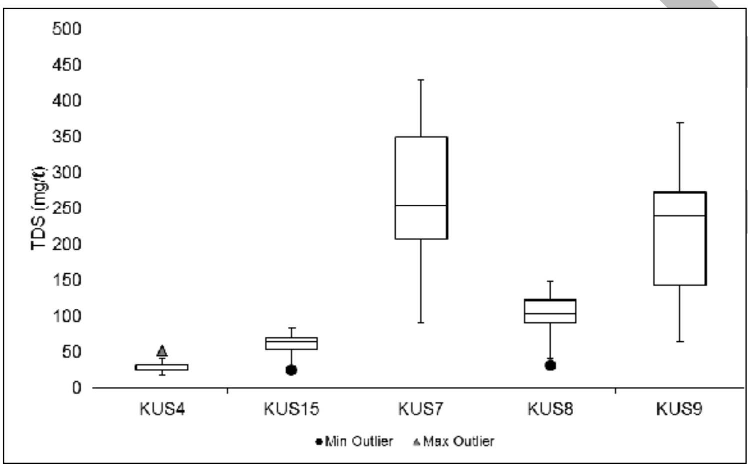

Figure 6: Historical TDS values observed in the project area (excluding the three additional sites) from March 2010 to August 2013 (●Minimum Outlier, ▵ Maximum Outlier)

5.2.3 Dissolved Oxygen

The maintenance of adequate DO concentrations is critical for the survival and functioning of the aquatic biota as it is required for the respiration of all aerobic organisms (DWAF, 1996). Therefore, DO concentration provides a useful measure of the health of an ecosystem (DWAF, 1996). The median guideline for DO for the protection of aquatic biota is > 5 mg/ℓ (Kempster *et al.,* 1980).

The DO concentrations exceeded the guideline concentration of 5 mg/ℓ at most sites, with the exception of sites KUS15, KLI1 and TRI1 (Table 9 and Figure 7). Sites KUS15 and TRI1 were of particular concern as the DO concentrations recorded were below the lower limit for the protection of fish. This may clarify why only one *Barbus anoplus* was recorded at the former site and no fish were recorded at the latter site (Table 18). These low concentrations may be attributed to a lack of flow conditions at both sites and a large amount of decaying organic matter on the stream bed at site KUS15, contributing to low DO concentrations (Figure 7). The decaying process consumes dissolved oxygen in the water column, resulting in hypoxic conditions (USEPA, 2012). Low DO concentrations in aquatic ecosystems may result in increased respiratory stress, changes in behaviour and consequently elevated mortality rates amongst aquatic biota (USEPA, 2012). Furthermore, DO levels fluctuate seasonally and diurnally over a 24-hour period and vary with water temperature and altitude (DWAF, 1996).

Historical data was compared spatially and temporally along the tributaries in the study area and indicated high variation in the data (Figure 8). The graph further illustrates that low DO concentrations are not uncommon in the project area (Figure 8). This trend is likely associated with these tributaries being located in the upper region of the Highveld where the gradient is generally flat and thus are not characterised by typical rocky riffle or cascade habitats. Low water levels and limited to no flow conditions is the general characteristic of these tributaries in the study area, contributing to low DO concentrations. Furthermore, these tributaries often contain large quantities of algal blooms, a sign of eutrophication associated with nutrient enrichment which also contributes to low DO concentrations throughout the catchment.

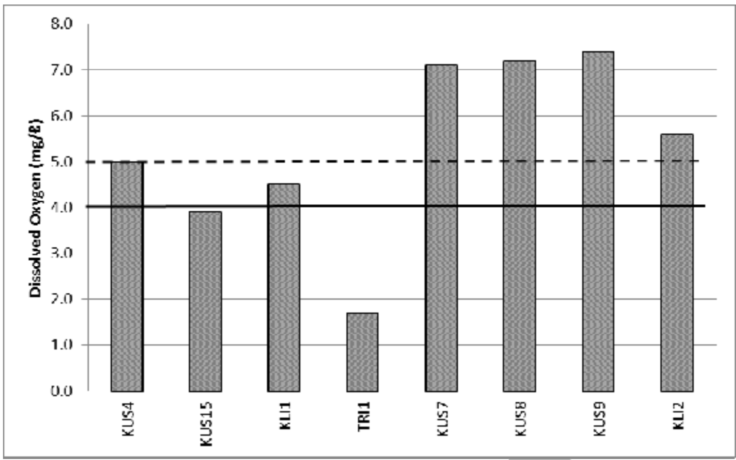

Figure 7: Dissolved Oxygen concentrations measured during the August/September 2013 survey (dashed line indicates guideline limit, solid line indicates lower limit for the protection of fish)

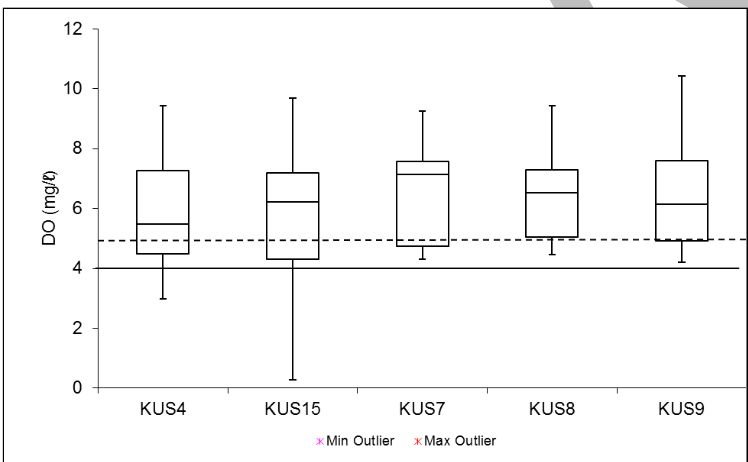

Figure 8: Historical DO concentration values observed in the project area (excluding the three additional sites) from March 2010 to August 2013 (dashed line indicates guideline limit, solid line indicates lower limit for the protection of fish)

5.2.4 Percentage Saturation (DO%)

Percentage saturation (DO%) is the amount of oxygen (O_2) dissolved in a litre of water relative to the total amount of oxygen that the water can hold at that temperature. DO% levels fluctuate seasonally and diurnally over a 24-hour period and vary with water temperature and altitude (DWAF, 1996). The South African Water Quality Guidelines (1996), state that the TWQR for DO% to protect aquatic biota through most life stagers is 80% - 120%, and that DO% levels below 40% would be lethal.

During the August/September 2013 survey DO% levels exceeded the TWQR guideline, with the exception of sites KUS15 and TRI1 (Table 9 and Figure 9). Similarly to the above, this may be attributed to a range of conditions namely, observed algal blooms, limited flow conditions and large quantities of decaying organic matter on the stream beds. Although no fish kills were observed at these sites, the low saturation levels observed may explain the low to no fish species diversity and abundance recorded.

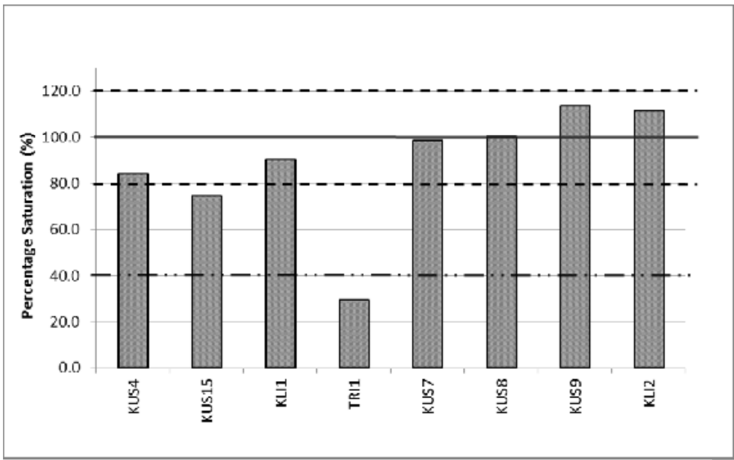

Figure 9: Percentage saturation (DO%) recorded during the August/September 2013 survey (dashed lines indicates target values, solid line indicates saturation and dot-dash line indicates lethal limit)

5.2.5 Water Temperature

Water temperature plays an important role in aquatic ecosystems by affecting the rates of chemical reactions and therefore also the metabolic rates of organisms (DWAF, 1996). Temperature affects the rate of development, reproductive periods and emergence time of organisms (DWAF, 2005). Temperature varies with season and the life cycles of many aquatic macroinvertebrates are cued to temperature (DWAF, 2005). The temperatures of inland waters generally range from 5 to 30 degrees Celsius (˚C) (DWAF, 1996).

The water temperatures measured during the August/September 2013 survey were considered to be normal for these systems at that time of the year and were not expected to have had a limiting effect on aquatic biota (Table 9 and Figure 10). Furthermore, the variability across the sites is primarily attributed to water depth and exposed surfaces. Site KLI1 recorded the highest temperature in the study area, primarily attributed to standing pools and low water levels observed at this site (Figure 10).

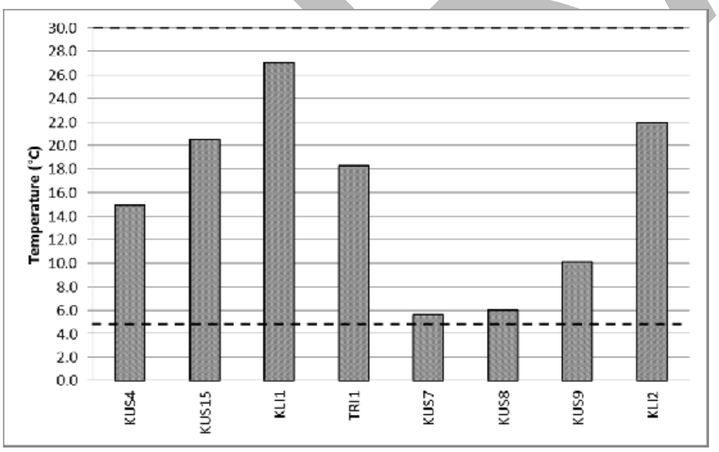

Figure 10: Water temperatures recorded during the August/September 2013 survey (dashed lines indicate guideline values)

5.2.6 Turbidity

Turbidity occurs as a result of 'suspensoids' in the water column. This suspended matter, which may include clay, silt, dissolved organic and inorganic matter, plankton and other microscopic organisms, causes the water to appear turbid (Davies and Day, 1998). Suspended matter causes light to be scattered and absorbed rather than transmitted in straight lines through a water sample and may reduce light penetration, smothers in-stream habitats, interferes with the feeding mechanisms of filter-feeding organisms such as certain macroinvertebrates and reduces visibility, thus leading to a reduction in biodiversity and a system which is dominated by a few tolerant species (Davies and Day, 1998).

During the August/September 2013 survey, the water levels at majority of the sites were comparatively low, resulting in shallow water that was low in turbidity (Figure 11). The low turbidity is attributed to a lack of run-off during the dry season, coupled with limited flow deposition transferring sediment downstream. Site KLI2 was the only site which recorded high turbidity during this survey (Figure 11). This may attributed to the recent veld fire that took place along the banks of the stream, presenting exposed soils and potentially contributing to the turbidity of the stream. In comparison, turbidity during the wet season is typically high, with cumulative impacts within the catchment contributing to elevated suspensoids.

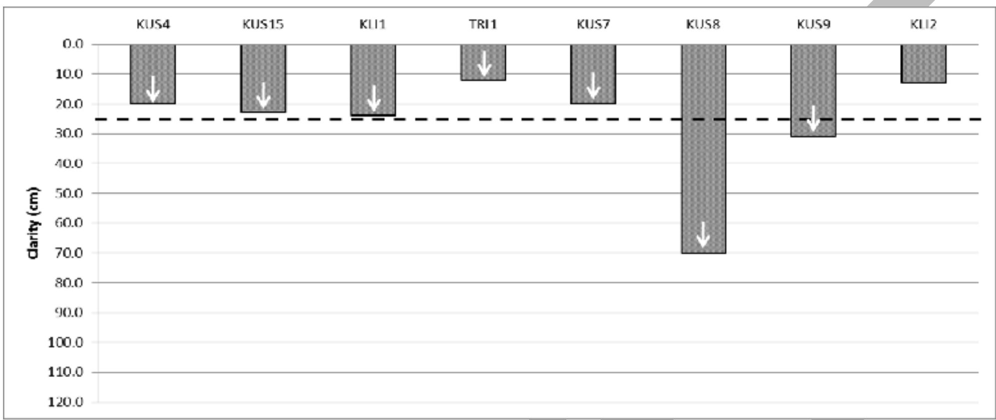

Figure 11: Secchi Disk Depths recorded during the August/September 2013 survey as an indication of clarity (dashed line indicates low turbidity, arrows indicate 'more than' values)

5.3 Habitat Assessment

5.3.1 Resource Utilization and Site Specific Impacts

Whilst on site, surrounding impacts and utilisation of resources were noted. As the study area falls within an economic hub for agricultural activities, there are a range of anthropogenic impacts on the tributaries within the study area. Impacts noted along the rivers are associated with agricultural, mining and power generation activities.

Overgrazing and trampling was evident throughout the project area and surrounds. The overgrazing of the ground cover results in higher runoff velocities that transport particulates and result in erosion (Figure 12 and Figure 13).

Figure 12: Cattle roaming around site KUS4

Figure 13: Deceased cow within the tributary at site KUS7

A further concern is the level of nutrient input into the river systems due to the high level of agricultural activities within the project area. High nutrient levels are contributing to algal bloom formations at various sites, a clear sign of eutrophic conditions (Figure 14).

Site KUS7

Site KUS8

Figure 14: Nutrient input resulting in filamentous algal blooms in the river systems

Overgrazing coupled with the construction of road and bridges (Figure 15) has contributed to the considerable amount of bank and head cut erosion at various sites in the project area (Figure 16).

Site KUS7

Site KUS8

Figure 15: Constructed bridges continue to contribute to high sedimentation levels, particularly during the wet season

Site KUS7

Figure 16: Bank and head cut erosion observations

5.3.2 General Habitat Characterization

In addition to taking note of site specific impacts, habitat characteristics were documented, as species composition is largely driven by the habitat and thus influences the biological results collected.

The substrate of a river is defined by the biological and inorganic materials making up the river bed. The inorganics include a range of sizes, from fine silts/sands, through gravels and pebbles to boulders and bedrocks. The biological materials are dominated by leaf litter, aquatic plants and wooded debris. The velocity of the water, determined by gradient erodes and deposits the different materials to form a heterogenic substrate or habitat.

Substrate heterogeneity is an important factor in determining both abundance and diversity of biota, with more stable substrate showing higher diversity and abundances (CBD, 2012). As particle size increase, so does physical complexity, so clay or sandy substrates would be considered poor due to their instability, whereas cobbles and rocks would be more stable. A mixed substrate would obviously be the optimal with a variety of habitats and microflow patterns available for different biota.

Table 10 provides an illustration of the habitats types present at each site that would contribute to the findings in the subsequent sections. It must be noted that habitat types vary seasonally and thus this table illustrates those for this survey (dry season).

Table 10: Habitat descriptions

Characteristics	KUS4	KUS15	KLI1	TRI1	KUS7	KUS8	KUS9	KLI2
Width (m)	1	1	~5	1	2-4	1-2	1-2	1-2
Depth (m)	½	¼	½	½	1	½	½	1
Flow characteristics	None to moderate	None	None	None	None	None	Moderate	None to moderate
GSM	√	√	√	√	√	√	√	√
Vegetation	√	√	√	√	√	x	√	√
Stones	√	x	x	√	x	x	√	x
Riparian vegetation	Grasses (I)	Grasses (I)	Grasses (I)	Grasses (I)	Grasses (I)	Grasses (I)	Shrubs and grasses (I)	Burnt grass (I)

The width and depths are approximations
[1] Indigenous vegetation; [2] Exotic vegetation

5.3.3 Integrated Habitat Assessment System

The IHAS was developed by McMillan (1998) for use in conjunction with the SASS5 protocol. The August/September 2013 IHAS results are provided in Table 11. Based on the IHAS results habitat availability during the August/September 2013 survey ranged from **Adequate** to **Poor**. The IHAS index considers sampling habitat and stream characteristics. Table 11 shows the scores calculated in obtaining the final IHAS score as well as a bar graph of the normalised percentage contribution per biotope. This allows one to breakdown the IHAS score into what biotopes were the most and least prominent as well as look between sites at what contribution the biotopes added to the final score.

Results showed that vegetation (VEG) and gravel, sand and mud (GSM) were strong drivers for higher IHAS scores within the Kusile ash dump area (Table 11). Stream bed composition is one of the most important physical factors controlling the structure of a freshwater invertebrate community (Mackay and Eastburn, 1990). Physical stream condition and other habitats / general biotopes are also important factors to consider.

The **Poor** habitat availability observed during the August/September 2013 survey was largely attributed to the absence of the SIC habitats, and the presence of incised banks and the homogenous habitats at the sampling points (Table 11). It was further attributed to the low flow conditions at the time of the survey and winter die-back of vegetation.

Table 11: Integrated Habitat Assessment System Evaluation for the August/September 2013 survey

Site	Sampling Habitat				IHAS	
	Stones-in-Current	Vegetation	Other Habitat / General	Physical Stream Condition	Score	Description
KUS4	10	13	9	25	57	Adequate
KUS15	0	13	7	17	37	Poor
KLI1	0	10	9	14	33	Poor
TRI1	6	11	15	15	47	Poor
KUS7	0	11	9	20	40	Poor
KUS8	0	0	7	18	25	Poor
KUS9	13	12	16	22	63	Adequate
KLI2	0	8	7	16	31	Poor

Bar graphs within cells indicate the normalized percentage contribution per biotope

n/a SASS5 not applicable due to site being dry or lack of flow

5.3.4 Long-Term Trends in Habitat Availability

The long term trends in habitat availability are presented inTable 12 and Table 13 for sites where previous monitoring has been conducted. Habitat availability in the tributaries of the Wilge River decreases during the high flow surveys (Table 12). Habitat availability during the high flow season is primarily **poor** at all the sites, with the exception of site KUS9 which improved from **poor** to **good** during the December 2012 survey, although subsequently reduced to **adequate** during the February 2013 survey. During the dry season surveys (Table 13), habitat availability was also predominantly **poor** although sites KUS4 and KUS9 were **adequate** during the August/September 2013 survey (Table 13). The poor habitat availability displayed temporally may be attributed to these sites located within smaller tributaries of the Wilge River, of which some of the sites have been directly associated and impacted by the infrastructure of the Kusile Power Station (newly constructed road and pipeline at sites KUS7 and KUS9).

Table 12: Historical IHAS scores - high flow surveys

Site	Mar '09	Mar '10	Dec '10	Mar '11	Nov '11	Dec'12	Feb'13
KUS4	44	43	51	58	38	60	53
KUS7	59	45	42	41	41	42	29
KUS8	40	34	39	35	33	53	40
KUS9	49	34	36	32	51	65	60
KUS15		44	44		42	43	Dry

Table 13: Historical IHAS scores - low flow surveys

Site	Jul '09	Jun '10	Sep '10	Jun '11	Sep '11	Aug'12	May'13	Aug'13
KUS4	40	50	52	48	44	Dry	48	57
KUS7	54	56	37	40	46	25	32	40
KUS8	48	45	34	35	39	39	40	25
KUS9	40	44	31	47	48	38	60	63
KUS15		50	55	44	37	Dry	32	37

5.4 Aquatic Macroinvertebrates

A total of 33 aquatic macroinvertebrate taxa were recorded in the sample area during the August/September 2013 survey (4 to 19 taxa per site) (Table 14). Refer to APPENDIX B for the detailed aquatic macroinvertebrate datasheets.

The SASS5 scores ranged from 17 at site KUS7 to 92 at site KUS4 (Table 14). The Average Score per Taxa (ASPT) values ranged from 3.5 at site KLI1 to 5.5 at sites KUS8 and KUS9 (Table 14). The ASPT scores provide an indication of the average tolerance/ intolerance of the aquatic macroinvertebrate community at each site. In this case ASPT scores indicated that the macroinvertebrate communities at the majority of the sites are composed primarily of tolerant (1 - 5) taxa (Dickens & Graham, 2002). However ASPT scores are considered to be unreliable when the total number of taxa at a site is low (<5) and should be interpreted with caution. Further explanations are provided below.

Table 14: SASS5 scores recorded during the August/September 2013 survey

Site	Total number of taxa	SASS Score	ASPT
KUS4	19	92	4.8
KUS15	12	54	4.5
KLI1	8	28	3.5
TRI1	18	83	4.6
KUS7	4	17	4.3
KUS8	11	61	5.5
KUS9	15	82	5.5
KLI2	14	64	4.6

As habitat availability affects the structure of a freshwater invertebrate community, there is value in assessing the ASPT of each biotope sampled in isolation. In this way you can avoid bias in your results at sites with different habitat types. Some taxa, such as Plecoptera (Stoneflies) and Trichoptera (Caddisflies), are associated with SIC, whilst some Odonata (Dragonflies) and Hemiptera (Bugs) are associated with VEG (Gerber and Gabriel, 2002). This is important to note as different taxa have been assigned different tolerance scores, which are based on their susceptibility or resistance to pollution and perturbations (Dickens & Graham, 2002). As a result the biotopes and ASPT scores are presented below in Figure 17.

The VEG and GSM were the most abundant biotopes sampled at all the sites (Figure 17). Although the SIC biotope was sampled at three of the sites, this biotope recorded the highest ASPT scores at site KUS9. This may be attributed to more sensitive taxa such as Heptageniidae (quality value (QV) score: 13) and Leptophlebiidae (QV score: 9) being recorded in this biotope (Figure 17). The VEG biotope at sites KUS4 and KUS7 recorded an ASPT score of greater than 5.0 while site KUS8, which only had the GSM biotope also recorded a high ASPT score, although this may be contributed to the low number of taxa recorded.

Although the GSM biotope recorded an average ASPT score of 5.0, this primarily comprised high abundances of highly tolerant taxa such as Oligochaeta (QV score: 1), Chironomidae (QV score: 2), Simulidae (QV score: 5) and Corixidae (QV score: 3). Tolerant species with low quality value scores are typically associated with the GSM, and as the availability of this specific habitat decreases, so does the likelihood of recording these species.

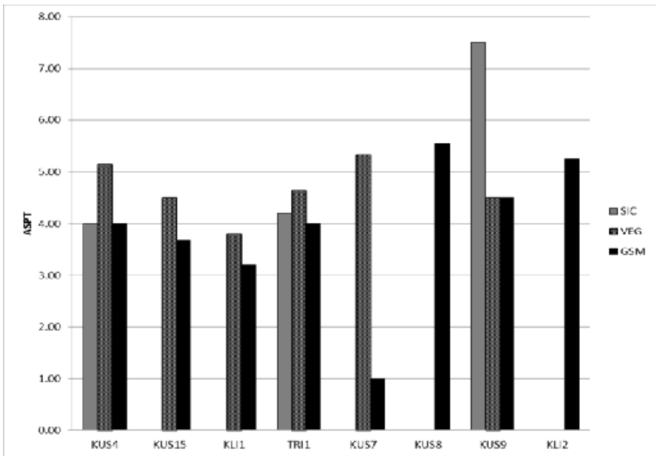

Figure 17: ASPT score for the SIC, VEG and GSM biotope, August/September 2013. (Dashed line indicates the reference point between biotope graphs)

The number of taxa, SASS5 scores and ASPT scores were variable in the tributaries with the lowest number of taxa and SASS5 scores recorded at site KUS7 (Figure 18 and Figure 20). This is further indicated in terms of the historical number of taxa and SASS5 scores and number of taxa data (Figure 19 and Figure 21 respectively). The habitat at this site is poor with eroded banks and limited VEG in which to sample. Typically, sensitive taxa populate the SIC biotope and with site KUS7 lacking this biotope/habitat, these taxa are not recorded and consequently result in a lower number of taxa and SASS5 scores. The ASPT scores fluctuated spatially during this survey with no real trend identified (Figure 20). The highest ASPT scores were recorded at sites KUS8 and KUS9, of which the score decreases at site KLI2, prior to reaching the confluence of the Wilge River (Figure 20).

Historically, there has been a large degree of variation in the number of taxa and SASS5 scores at sites KUS4, KUS8 and KUS9 (Figure 19 and Figure 21). This may be attributed to seasonal fluctuations and thus the presence or absence of certain biotopes at the sites, consequently influencing the type of aquatic biota recorded. Overall, the ASPT scores in the tributaries generally do not exceed an ASPT score of 5.0, indicating that these tributaries are historically characterised by tolerant taxa.

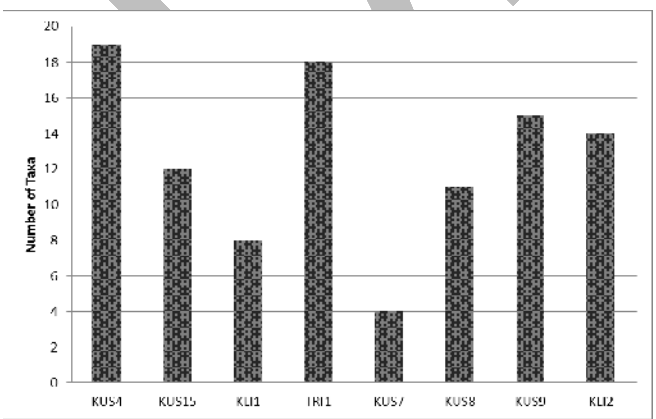

Figure 18: Total number of taxa recorded in the tributaries during the August/September 2013 survey

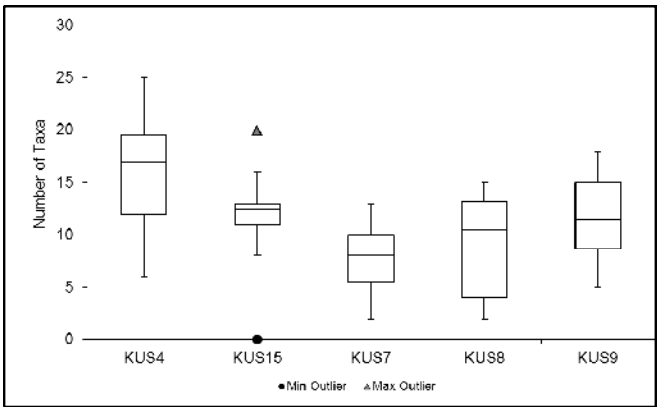

Figure 19: Historical total number of taxa recorded in the tributaries (●Minimum Outlier, ▲Maximum Outlier)

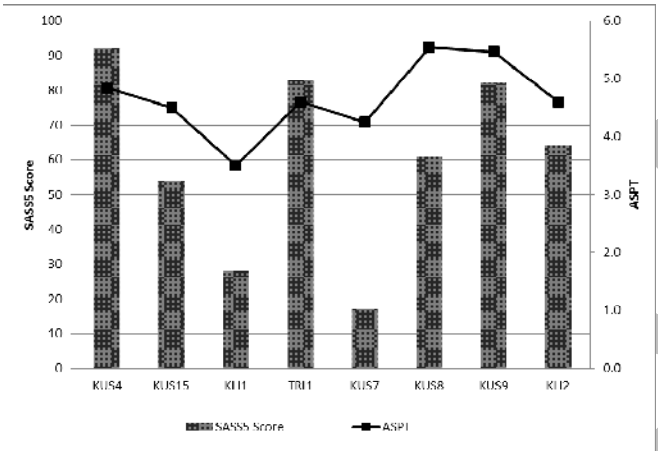

Figure 20: SASS5 scores and ASPT score recorded in the tributaries during the August/September 2013 survey

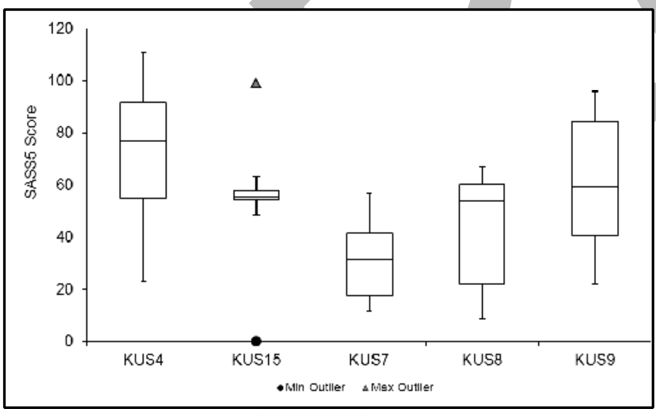

Figure 21: Historical SASS5 score recorded in the tributaries (●Minimum Outlier, ▲Maximum Outlier)

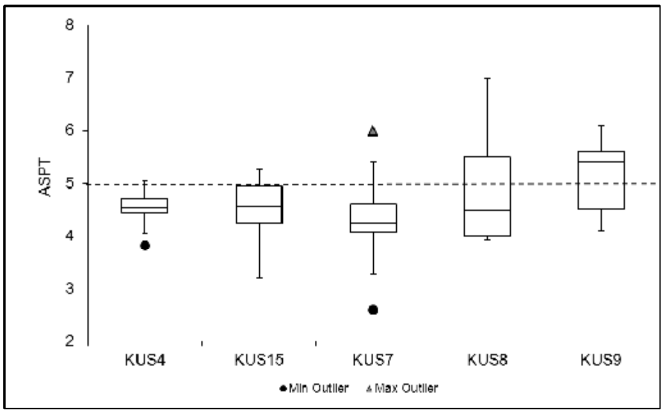

Figure 22: Historical ASPT score recorded in the tributaries (●Minimum Outlier, ▲Maximum Outlier)

5.4.1 Biotic Integrity based on SASS5 Results

The Present Ecological State (PES) classes and descriptions of each of the classes are presented in Table 15. Based on the August/September 2013 results, biotic integrity ranged from slightly modified (PES Class B) as the majority of the sites to critically modified (PES Class F) at site KUS7. This may be attributed to the extensive agricultural activities in close proximity to the site, as well as direct impacts from Kusile.

Table 15: Present Ecological State (PES) classes based on SASS5 results obtained during the August/September 2013 survey

Site	Reach		PES Class
KUS4	Klipfonteinspruit	B	Slightly modified
KUS15	Holfonteinspruit	D	Considerably modified
KLI1	Klipfonteinspruit	E	Seriously modified
TRI1	Unknown tributary of the Wilge River	B	Slightly modified
KUS7	Lower Klipfonteinspruit	F	Critically modified
KUS8	Lower Klipfonteinspruit	B	Slightly modified
KUS9	Lower Klipfonteinspruit	B	Slightly modified
KLI2	Klipfonteinspruit	D	Considerably modified

Long term SASS5 results illustrate the changes in biotic integrity over time. During the high flow surveys, biotic integrity at the upstream site (KUS4) has remained slightly modified since December 2012 (Table 16), whilst biotic integrity at sites KUS7 and KUS8, downstream of the Kusile ash dump, has decreased in integrity over the past three years (Table 16). Biotic integrity at site KUS9 has improved from slightly modified in December 2012 to unmodified in the February 2013 survey.

A comparison of long term results illustrated that biotic integrity tends to decrease during the low flow season (Table 17). This is likely due to reduced flow and habitat availability. During previous dry seasons, biotic integrity in the majority of the tributaries in the project area ranged from slightly to critically modified (PES Class B to F). Biotic integrity at site KUS7 has continued to decrease further since the May 2013 survey. This site is directly impacted by the newly constructed Kusile road and bridge and the lack of river bank rehabilitation, which may be contributing to the already impacted state of the river reach. Site KUS9 has maintained its biotic integrity since September 2011 while sites KUS4 and KUS8 have improved to slightly modified in this recent survey (August 2013) (Table 17).

Table 16: Historical PES classes based on SASS5 results – high flow surveys

Site	Mar'09	Mar'10	Dec'10	Mar'11	Dec'12	Feb'13
KUS4	E	E	B	C	B	B
KUS7	F	E	F	E	E	E
KUS8	F	E	C	F	B	E
KUS9	C	D	E	E	B	A
KUS15		D	B	*Dry*	D	*Dry*

Table 17: Historical PES classes based on SASS5 results – low flow surveys

Site	Jul'09	Jun'10	Sep'10	Jun'11	Sep'11	Aug'12	May'13	Aug'13
KUS4	E	D	B	D	E	*Dry*	C	B
KUS7	E	B	E	F	D	D	E	F
KUS8	D	D	D	F	C	D	D	B
KUS9	D	D	E	D	B	B	B	B
KUS15		D	D	D	C	*Dry*	B	D

5.5 Ichthyofauna

5.5.1 Observed Fish Species List

Two of the 10 expected indigenous fish species were recorded in the project area during the August/September 2013 survey, namely *B. anoplus* and *Pseudocrenilabrus philander* (1 to 2 species per site) (Table 18). No exotic species were recorded within the tributaries surveyed (Table 18). The highest combined fish abundance (n = 130) was recorded at site KLI1, of which 71 and 59 were *B. anoplus* and *P. philander* respectively (Table 18, Figure 23 and Figure 24). No fish species were recorded at sites TRI1, KUS7 and KUS8, while *B. anoplus* was the only species at sites KUS4 and KUS15. Only 1 individual *B. anoplus* was recorded at site KUS15 *(*Figure 7 and Figure 9). The low fish diversity and abundance at some sites may be attributed to fish seeking out deeper pools or moving downstream during the low flow conditions. The remainder of the expected fish species (Table 4) were not recorded during the August/September 2013 survey (Table 18).

Table 18: Fish species recorded in the Kusile ash dump project area during the August/September 2013 survey

Site	*Barbus anoplus*	*Pseudocrenilabrus philander*		**Diversity**	**Abundance**
KUS4	17			**1**	**17**
KUS15	1			**1**	**1**
KLI1	71	59		**2**	**130**
TRI1				**0**	**0**
KUS7				**0**	**0**
KUS8				**0**	**0**
KUS9	16	2		**2**	**18**
KLI2	23	1		**2**	**24**
Total Individuals	**128**	**62**			

Introduced species are highlighted in red
 # Site not sampled

Figure 23: Barbus anoplus, one of the most abundant fish species sampled in the project area. The golden colour indicates a reproductive male.

Figure 24: Pseudocrenilabrus philander, one of the most abundant fish species sampled in the project area. This individual further illustrates trematode cysts embedded in the fish's tissue

5.5.2 Presence of Red Data Species

Based on the IUCN Red List no rare, threatened or endangered fish species are expected to occur in the project area and none were recorded during the August/September 2013 survey (IUCN, 2013).

5.5.3 Fish Health Assessment

A large number of the individuals sampled during the August/September 2013 survey, showed signs of abnormalities and heavy parasite loads. The prevalence was considerably higher in *B. anoplus which* showed the highest infection rates (Figure 24 and Figure 25*)*.

Barbus anoplus

Figure 25: Trematode cysts embedded in the fish's tissue

5.5.4 Fish Assemblage Integrity Index (FAII)

The interpretation of the FAII scores follows a descriptive procedure into which the FAII score is allocated into a particular class (Table 19). The PES classes for each of the sites are presented in Table 19.

Table 19: Present Ecological State (PES) Classes recorded during the August/September 2013 survey

Site	River Reach	Relative FAII Score	Class Rating	Description
KUS4	Klipfonteinspruit	22	E	Seriously Modified
KUS15	Holfonteinspruit	22	E	Seriously Modified
KLI1	Klipfonteinspruit	24	E	Seriously Modified
TRI1	Unknown tributary of the Wilge River	0	F	Critically Modified
KUS7	Lower Klipfonteinspruit	0	F	Critically Modified
KUS8	Lower Klipfonteinspruit	0	F	Critically Modified
KUS9	Lower Klipfonteinspruit	44	D	Largely Modified
KLI2	Klipfonteinspruit	24	E	Seriously Modified

Based on the FAII results biotic integrity throughout the entire project area ranged from *Largely* to *Critically Modified* (PES Class D to F) (Table 19). Sites TRI1, KUS7, KUS8 were critically modified as no fish were recorded. Site TRI1 recorded low DO and percentage saturation, a potential contributing factor to the absence of fish from the site. However, these parameters were within the guidelines at the latter two sites. The low biotic integrity recorded at the rest of the sampling sites during the survey may be attributed to limited habitat availability and low flow conditions.

5.6 Summary of aquatic assessment results

A summary of the habitat and biological indices per site is displayed in Figure 26. The habitat and biological indices are rated as per the indices described in this report. The water quality was based on a professional opinion where the four *in situ* parameters (pH, DO ,DO%, EC/TDS and Temperature) were evaluated according to whether they met the South African water quality guideline values or not. Additional visual observations in terms of algal blooms, flow or observed pollutant sources were also included to give an overall professional opinion on the baseline state of the *in situ* water quality. The ratings were made according to Table 20.

Table 20: In situ water quality baseline state interpretation classes

Interpretation of *in situ* water quality parameters	
Class	**Class description**
Natural	As close to natural conditions as possible
Good	Above or within guideline values/ranges - optimal
Fair	Close to or at the limit of guideline values/ranges, but sub-optimal
Poor	Below or exceeding guideline values or ranges – non optimal

A summary of the *in situ* water quality baseline state of the aquatic ecosystems is shown in Table 21.

Table 21: Summarized *in situ* water quality baseline state of the in-stream sites, based on individual *in situ* water quality parameters as well as additional water quality impacts observed at the sites

Site	***In situ* parameter baseline state**						**General site baseline state for *in situ* water quality**
	pH	**DO**	**DO%**	**TDS**	**Temp.**	**Additional Impacts**	
KUS4	Natural	Fair	Good	Natural	Natural	Fair	Fair
KUS15	Natural	Poor	Poor	Natural	Natural	Fair	Fair
KLI1	Natural	Poor	Good	Natural	Natural	Fair	Fair
TRI1	Natural	Poor	Poor	Natural	Natural	Poor	Poor
KUS7	Natural	Good	Good	Natural	Natural	Poor	Fair
KUS8	Natural	Good	Good	Natural	Natural	Poor	Fair
KUS9	Natural	Good	Good	Natural	Natural	Fair	Fair
KLI1	Natural	Good	Good	Natural	Natural	Fair	Good

DO: Dissolved Oxygen; DO%: Saturation Percentage; TDS: Total dissolved solids; Temp.: Temperature

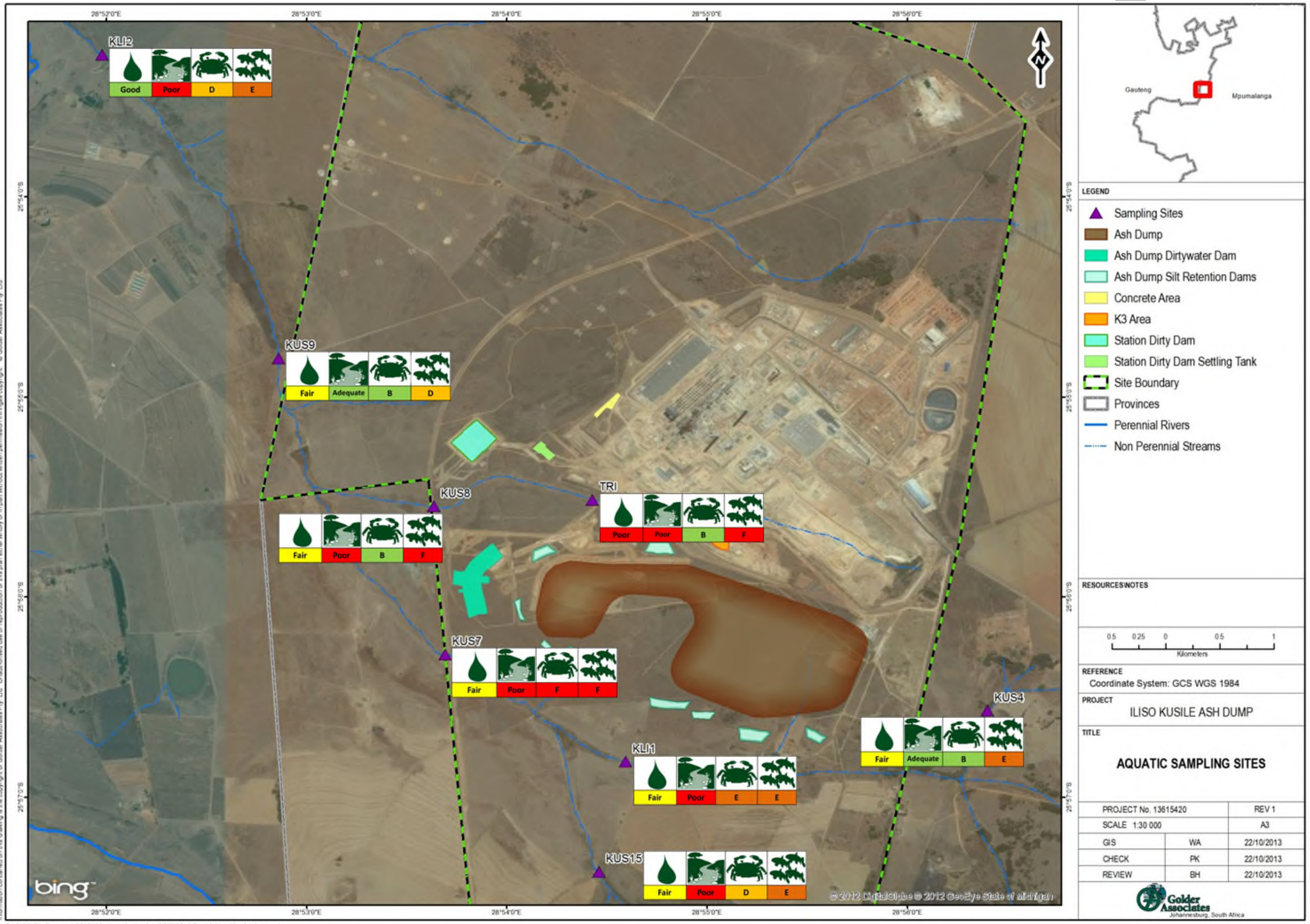

Figure 26: Summary of the habitat and biological indices per site

6.0 IMPACT RISK ASSESSMENT

6.1 Existing Impacts

Prior to determining the potential impacts of the proposed Kusile ash dump and associated facilities an assessment of the existing impacts was conducted (Table 22). The study area encompasses the existing construction footprint of the Kusile Power Station, coal washing plant, waste rock crushing plant, surrounding ash storage facilities, New Largo Mine, Leeufontein Coal Mine, Kendal Power Station as well as extensive agricultural activities. All of these activities are currently placing stress on the aquatic environment. As the Klipfonteinspruit and other tributaries in the study area drain into the Wilge River, the significance of the impacts are considered to be *HIGH at a Regional scale (*Table 22).

6.2 Potential Impacts associated with the Project

Impact 1: Degradation of aquatic ecosystems due to increased sedimentation

Habitat quality and quantity are major determinants of aquatic community structure. Changes in the biological community in a river may be linked to changes in water quality, habitat availability, habitat integrity or a combination of these. When naturally vegetated landscapes are transformed to industrial uses, physical and biological relationships with adjacent streams are affected resulting in impacts such as stream bank erosion, increased sedimentation which will in turn result in changes to the aquatic community structure.

Clearance of existing vegetation will increase the potential for soil erosion. Runoff after rain can result in erosion and sedimentation. The land that is cleared for the ash storage facility will be susceptible to erosion if not managed correctly. Aside from sediments a variety of pollutants may also be transported into water courses by runoff.

Sediment loading in the water column results in increased turbidity. This suspended matter, which may include clay, silt, dissolved organic and inorganic matter, plankton and other microscopic organisms, causes the water to appear turbid (Davies and Day, 1998). Suspended matter can result in harmful impacts to aquatic biota and their habitats. These impacts include *inter alia* as per Larkin *et al.,* 1998:

- Clogging and abrasion of the gills of fish. The clogging of fish gills impedes oxygen exchange;
- Behavioral changes such as limited movement and migration;
- Decreased resistance to disease;
- Habitat smothering and destruction for bottom dwelling aquatic macroinvertebrates which fish rely on for food;
- The turbidity interferes with the feeding habits of fish species who rely visually on finding their food source; and
- Poor egg development.

These impacts may lead to a reduction in fish species diversity and result in a system dominated by tolerant species (Davies and Day, 1998). The majority of the monitoring sites around the Kusile construction footprint already have increased turbidity due to the cumulative impacts in the catchment. The site selected for the proposed ash disposal facility, is situated between sites TRI1 and KLI1. Therefore, any runoff or seepage from the ash dump may further increase the already high turbidity levels within these tributaries with potential knock on effects on the Wilge River.

Prior to implementation of adequate sediment control measures the significance of this impact was rated as *high* (Table 23). Implementation of the recommended mitigation measures will reduce the significance of the impact to *moderate* (Table 23). This impact is only expected during the construction phase of the project when the site is being cleared for the construction of the ash disposal facility. However, as there are a number of activities taking place already on the Kusile construction footprint and no excessive siltation was noted, the probability (*definite*) of serious sedimentation would be confined to mismanagement

Impact 2: Change to natural flow regime

The alteration of flow regimes is often claimed to be the most serious and continuing threat to ecological sustainability of rivers and their associated floodplain wetlands (Bunn and Arthington, 2002). Flow modifications within a river may have several effects on the aquatic biota found within these systems. Firstly, flow is a major determinant of physical habitat, which in turn is a major determinant of biotic community structure. Secondly, aquatic species have evolved life history strategies primarily in direct response to the natural flow regimes; thirdly, the invasion and success of exotic species in rivers is facilitated by the alteration of flow regimes (Poff and Ward, 1990; Bunn and Arthington, 2002).

There are several impacts related to the change in the hydrological regime. These impacts include: reduced surface runoff and changes in groundwater recharge. Surface runoff is reduced as rainfall collects in collapsed areas after heavy summer rains. However, the increased speed of runoff due to impermeable structures and drains could cause extensive erosion and scouring of the aquatic ecosystems if not designed adequately.

The footprint of the proposed ash disposal facility is small in comparison to the rest of the catchment area. Furthermore, as there will be no discharge from the ash disposal facility into the aquatic ecosystem, there will be no change to the natural flow regime of the water resources. For this reason the impact of the facility on the aquatic ecosystems flow regime has been rated as *low* during both the construction and operational phase (Table 23).

Impact 3: Loss of indigenous species and biodiversity due to decreased water quality and habitats

Potential run-off from the Kusile ash disposal facility may result in a decline in water quality and consequently detrimental impacts to the functioning, ecology and integrity of the surrounding water courses. Previous surveys in this study area, recorded the sensitive species, *Chiloglanis pretoriae*, in the lower reaches of the Wilge River and thus the deterioration in water quality may result in the loss of this species. Impacts on water quality may further result in the increase in abundance of organisms that are tolerant to environmental changes.

During the operational phase and without mitigation measures, the probability of the above impact occurring as a result of proposed runoff from the ash disposal facility will be *low* (Table 23). Standard engineering designs for a facility of this nature will include return water dams and appropriate stormwater management structures. Furthermore, the duration of this impact taking place, should there be runoff from the ash disposal facility due to an unusually high rainfall event or a potential failure of the engineering design, will be *short* as the runoff would enter into the aquatic ecosystem and be flushed downstream. Based on the above, the significance will be moderate. Should mitigation measures be implemented, the significance would be *low* as similarly, the probability will be *low* and duration *immediate* (Table 23).

Table 22: Existing Impacts in the project area

EXISTING IMPACTS									
Risk	**Description**	**Severity**	**Reversibility**	**Duration**	**Spatial Extent**	**Consequence**	**Probability**	**Significance C*P**	**Description**
Existing impacts on aquatic ecosystem	Existing construction footprint of the Kusile Power Station, surrounding agricultural activities, industrial activities (waste rock crushing plant), and surrounding mining activities within the study area impacting the receiving aquatic environment.	5	5	5	3	18	4	72	High

Table 23: Impacts for the construction and operational Phase in the project area

Risk	**Description**		**Severity**	**Reversibility**	**Duration**	**Spatial Extent**	**Consequence**	**Probability**	**Significance C*P**	**Description**
CONSTRUCTION PHASE										
Degradation of aquatic ecosystems due to increased sedimentation	Prior to construction of the ash disposal facility, vegetation will need to be cleared increasing the potential for run-off into rivers and the sedimentation of instream habitats.	Rating before Mitigation Measures	5	3	2	4	14	5	70	High
		Rating after Mitigation Measures	4	3	2	3	12	3	36	Moderate
Change to natural flow regime	The current proposed footprint of the ash disposal facility will be located between two	Rating without Mitigation	2	1	2	2	7	2	14	Low

Risk	Description		Severity	Reversibility	Duration	Spatial Extent	Consequence	Probability	Significance C*P	Description
	tributaries that drain the Kusile construction footprint.	Measures								
		Rating with Mitigation Measures	1	1	2	2	6	2	12	Low
OPERATIONAL PHASE										
Change to natural flow regime	The current proposed footprint of the ash disposal facility will be located between two tributaries that drain the Kusile construction footprint.	Rating without Mitigation Measures	0	1	1	1	3	2	6	Low
		Rating with Mitigation Measures	0	1	1	1	3	1	3	Low
Loss of indigenous species and biodiversity due to declines in water quality and habitats	The ichthyofauna within the study area showed that the Klipfonteinspruit and other adjoining tributaries of the Wilge River had low species diversity. Therefore, the construction of the ash disposal facility may potentially increase the sedimentation loads within the systems thus contributing to habitat smothering, destruction and loss of indigenous species.	Rating without Mitigation Measures	5	5	2	3	15	2	30	Moderate
		Rating with Mitigation Measures	4	3	1	2	10	1	10	Low

6.3 Cumulative Impacts

The Olifants River has a catchment (Water Management Area 4) of approximately 54 400 km^2 in size. The river originates in the Mpumalanga Highveld and flows through industrial, agricultural and mining areas such as Emalahleni (Witbank), Middelburg, Steelpoort and Phalaborwa on its way towards the Kruger National Park (Van Zyl *et al.,* 2001; De Villiers and Mkwelo, 2009). Flowing through these economic hubs of mining and industry, combined with extensive agricultural activity within the catchment, the Olifants River has been classified as stressed with the overall condition of the river ecosystems being regarded as Fair to Poor (DWAF, 2000; WRC, 2001). Associated with these activities are high surface run-off, water contamination and biotic community alteration. The Wilge River a tributary of the Olifants River flows roughly northwards until it is joined by its main tributary, the Bronkhorstspruit River. The river then it flows in a north-easterly direction until it joins the Olifants River about 12 km upstream of Loskop Dam.

With the existing land-use in the Wilge River catchment, agriculture, mining and Waste Water Treatment Works (WWTW's), the river already is under pressure from nutrients and sulphate inputs (De Villiers and Mkwelo, 2009). This being said, sites within the Wilge River catchment show relatively good water quality in comparison to those in the Olifants River catchment (CSIR, 2010). It is therefore important to maintain the ecological integrity of the Wilge River and strive to improve it.

A concern is that the rivers and streams in the area already contain high sediment loads (turbidity). This is due to the land use in the area. Any further increase in sedimentation and erosion may cause a further loss in habitat diversity and quality that will further contribute to impacts on biological communities. Additionally the increase in development with mining (New Largo) and the new Kusile Power Station, cumulative impacts will be present.

6.4 Mitigation and Management Measures

It is imperative that the appropriate mitigation measures concerning the aquatic environment be implemented. The major impact of the proposed ash disposal facility is the potential run-off from the ash disposal facility. Therefore, a stormwater management plan is a vital component to consider with bare land and exposed ash present. The following must be considered:

- Runoff water from the ash disposal facility should be channelled into pollution control dams to avoid effects on the aquatic ecosystem;
  - Silt traps should be placed down-slope of where vegetation stripping will take place to minimise siltation in rivers and wetlands. These silt traps need to be regularly maintained to ensure effective drainage.
- The runoff should be routinely monitored for acidity/alkalinity and TDS as an early warning for potential increases in discharge water. The water in these pollution control dams should be reused at the Kusile Power Station if possible.

Water quality and biotic integrity should be routinely monitored in the Klipfonteinspruit and adjoining tributaries of the Wilge Rivers to assess and quantify the potential impact on the receiving environment.

It is important that rehabilitation and re-vegetation of the exposed areas be undertaken on a continual basis and should not be left for the closure phase. If erosion has taken place, rehabilitation should be implemented as soon as possible.

7.0 CONCLUSIONS

The following conclusions were reached based on the results of the August/September 2013 survey:

- Dissolved Oxygen (DO) concentration and percentage saturation was a limiting factor of aquatic biodiversity at certain sites. Both of these parameters were below the TWQR guidelines at sites TRI1 and KUS15. Low DO concentrations may be attributed to the large amount of decaying organic matter on the stream beds and limited flow conditions at the time of the survey. The remainder of the *in situ* water quality parameters were within the guideline values and thus not considered to be limiting factors to the aquatic ecosystem.

- Habitat availability was a limiting factor of aquatic macroinvertebrate diversity at all sites except KUS4 and KUS9. The limited habitat availability was due to the absence of the stones biotope.

- Based on the aquatic macroinvertebrate assessment biotic integrity in the project area ranged from slightly to critically modified (Class B to F) and comprised primarily of tolerant taxa. This was primarily attributed to limited habitat availability and low flow conditions.

- Fish species diversity in the Klipfonteinspruit and adjoining tributaries was low. Based on the fish results biotic integrity in the project area ranged from largely to critically modified. The low biotic integrity was primarily attributed to limited habitat availability and low flow conditions. No fish species were recorded at sites KUS7, KUS8 and TRI1;

- Based on the risk assessment four potential impacts on aquatic ecosystems were identified, namely:
  - Degradation of aquatic ecosystems due to increased sedimentation;
  - Change to natural flow regime; and
  - Loss of indigenous species and biodiversity due to declines in water quality and habitats.

- Majority of the above impacts were rated as low, should mitigation measures be implemented. Although their severity was primarily high, the probability of the impacts taking place was low, duration was short term over a regional scale. However, should mitigation measures not be implemented, the significance of the impacts would be moderate. The only impact rated high prior to mitigation measures was degradation of aquatic ecosystems due to increased sedimentation. The high significance will be as a result of no adequate sediment control measures installed into the aquatic systems in order to evade large sediment plumes migrating downstream from the project site. However, the significance of this impact will be reduced to moderate, following the implementation of mitigation measures.

- However, not only are there site specific impacts, but further cumulative impacts. The existing construction footprint of the Kusile Power Station, surrounding agricultural activities, industrial activities (waste rock crushing plant), and surrounding mining activities, all contribute to the cumulative impacts on the receiving environment.

7.1 Recommendations

Appropriate mitigation measures should be implemented during both the construction and operational phase of the project. The following mitigation measures are recommended for the proposed project:

- Silt traps should be placed down-slope of where vegetation stripping will take place to minimise siltation in rivers and wetlands. These silt traps need to be regularly maintained to ensure effective drainage;

- The runoff should be routinely monitored for acidity/alkalinity and TDS as an early warning for potential increases in discharge water. The water in these pollution control dams should be reused at the Kusile Power Station if possible; and

- Water quality and biotic integrity should be routinely monitored in the Klipfonteinspruit and adjoining tributaries of the Wilge Rivers to assess and quantify the potential impact on the receiving environment.

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APPENDIX A

Site Photos

KUS4: Upstream *(taken by K. Farrell 08/2013)*

KUS4: Downstream *(taken by K. Farrell 08/2013)*

KUS15: Upstream *(taken by K. Farrell 08/2013)*

KUS15: Downstream *(taken by K. Farrell 08/2013)*

KLI1: Upstream *(taken by K. Farrell 08/2013)*

KLI 1: Downstream *(taken by K. Farrell 08/2013)*

TRI1 No photo's were allowed to be taken on the Kusile construction footprint	**TRI1** No photo's were allowed to be taken on the Kusile construction footprint

KUS7: Upstream *(taken by K. Farrell 08/2013)*

KUS7: Downstream *(taken by K. Farrell 08/2013)*

KUS8: Upstream *(taken by K. Farrell 08/2013)*

KUS8: Downstream *(taken by K. Farrell 08/2013)*

KUS9: Upstream *(taken by K. Farrell 08/2013)*

KUS9: Downstream *(taken by K. Farrell 08/2013)*

KLI2: Upstream *(taken by K. Farrell 08/2013)*

KLI2: Downstream *(taken by K. Farrell 08/2013)*

APPENDIX B

Aquatic Macroinvertebrate Data

Taxon	QV	KUS4			KUS15			KLI1			TRI1			KUS7			KUS8			KUS9			KLI2		
		SIC	VEG	GSM	SIC	VEG	GSM	SIC	VEG	GSM	SIC	VEG	GSM	SIC	VEG	GSM	SIC	VEG	GSM	SIC	VEG	GSM	SIC	VEG	GSM
TURBELLARIA (Flatworms)	3	B	B	B							A								1						
ANNELIDA																									
Oligochaeta (Earthworms)	1			A			A			A		1				1			A						
CRUSTACEA																									
Potamonautidae* (Crabs)	3									OBS	A	1												1	
Atyidae (Freshwater Shrimps)	8																							A	
HYDRACARINA (Mites)	8		A	1		A					A														
EPHEMEROPTERA (Mayflies)																									
Baetidae 1sp	4																								
Baetidae 2 sp	6										B											A			
Baetidae > 2 sp	12																		B	B	B				
Caenidae (Squaregills/Cainfles)	6										B	A	A						A	A	A			1	
Heptageniidae (Flatheaded mayflies)	13																		1	A					
Leptophlebiidae (Prongills)	9																			B					
ODONATA (Dragonflies & Damselflies)																									
Coenagrionidae (Sprites and blues)	4		A			A															B			A	
Lestidae (Emerald Damselflies/Spreadwings)	8		B																						
Aeshnidae (Hawkers & Emperors)	8		A				1					1													
Corduliidae (Cruisers)	8		1																						
Gomphidae (Clubtails)	6	1										1							1	1		A			A
Libellulidae (Darters/Skimmers)	4					A																		A	
HEMIPTERA (Bugs)																									
Belostomatidae* (Giant water bugs)	3																							A	
Corixidae* (Water boatmen)	3	1		A		A					A	1							A		A			A	
Gerridae* (Pond skaters/Water striders)	5			OBS						OBS															
Nepidae* (Water scorpions)	3											1													
Notonectidae* (Backswimmers)	3								B			1									1	A			
Pleidae* (Pygmy backswimmers)	4		B						B												A				
TRICHOPTERA (Caddisflies)																									
Hydropsychidae 1 sp	4																			1					
COLEOPTERA (Beetles)																									
Dytiscidae/Noteridae* (Diving beetles)	5		A			A			A			B			1				A		A	A			A
Gyrinidae* (Whirligig beetles)	5	A	B	B								A			A				1					A	
Hydraenidae* (Minute moss beetles)	8		1			1																			
Hydrophilidae* (Water scavenger beetles)	5					1			A	1															1
DIPTERA (Flies)																									
Ceratopogonidae (Biting midges)	5		A			A					A	A								1	A	1		1	
Chironomidae (Midges)	2	C	B	B		A	B		B	C	B	A	A						A		A	A		1	
Culicidae* (Mosquitoes)	1		1			1					1										A				
Dixidae* (Dixid midge)	10											1													
Simuliidae (Blackflies)	5	C	A	B							B	1							A	A					
Tipulidae (Crane flies)	5																								1
GASTROPODA (Snails)																									
Ancylidae (Limpets)	6														1										
Lymnaeidae* (Pond snails)	3		A																						
SASS Score		24	77	32	0	45	11	0	19	16	42	65	8	0	16	1	0	0	61	60	45	27	0	43	21
No. of Taxa		6	15	8	0	10	3	0	5	5	10	14	2	0	3	1	0	0	11	8	10	6	0	10	4
ASPT		4.00	5.13	4.00	0.00	4.50	3.67	0.00	3.80	3.20	4.20	4.64	4.00	0.00	5.33	1.00	0.00	0.00	5.55	7.50	4.50	4.50	0.00	0.00	5.25
Total SASS Score		**96**			**58**			**32**			**87**			**21**			**65**			**82**			**68**		
Total No. Of Taxa		**19**			**12**			**8**			**18**			**4**			**11**			**14**			**14**		
Total ASPT		**5.05**			**4.83**			**4.00**			**4.83**			**5.25**			**5.91**			**5.86**			**4.86**		

APPENDIX C

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