Wetland Delineation and Assessment for the Proposed Exxaro Matla Coal Mine Stooping Project, Mpumalanga Province

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INDEMNITY AND CONDITIONS RELATING TO THIS REPORT

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1. BACKGROUND INFORMATION

Wetland Consulting Services (Pty.) Ltd. was appointed by GCS (Pty.) Ltd. to update the specialist wetland assessment report for proposed stooping activities at Matla Colliery as compiled in 2012 (Wetland Consulting Services, 2012, Report reference 687/2011). The update required four additional areas to be included in the wetland assessment (see Figure 1 below). All additional work undertaken as part of this update was limited to these four additional areas. All information and assessments pertaining to the areas surveyed in 2011 and 2012 has been kept as in the 2012 report, with the exception that an area proposed for opencast mining in 2012 has now been included as a stooping area.

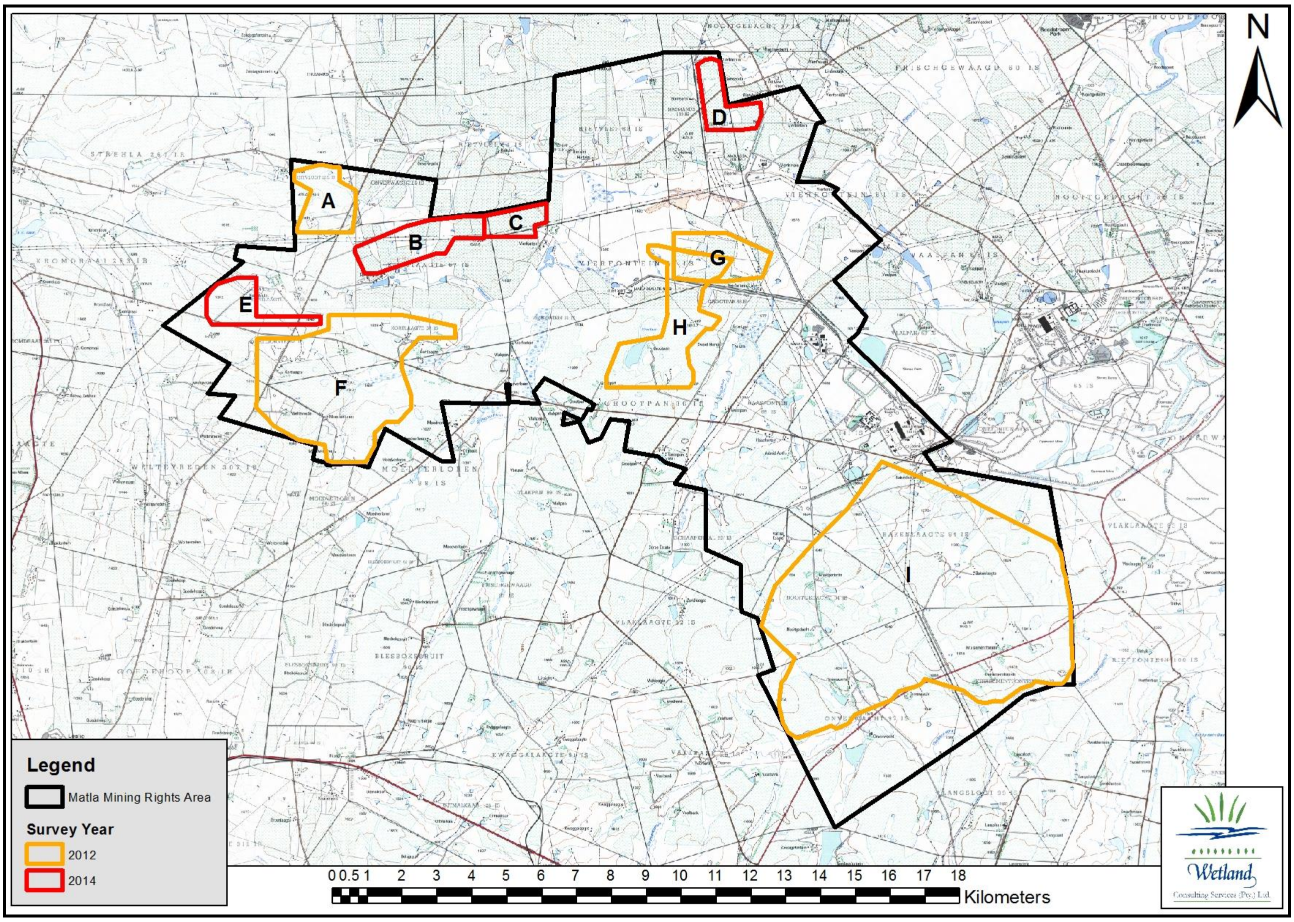

Figure 1. Map of the proposed Exxaro Matla Coal Mine Stooping Project areas surveyed as part of the wetland assessment. Field work and assessments were undertaken in 2014 (red outline) and 2011 & 2012 (orange outline).

The requirement to establish the existence and/or extent of wetlands on the property is based on the legal requirements contained in both the National Environmental Management Act (Act No. 107 of 1998) (NEMA, 1998) and the National Water Act (Act No. 36 of 1998) (NWA, 1998). Given the stringent legislation regarding developments within or near wetland areas, it is important that these areas are identified and developments planned sensitively around them to avoid and/or minimize any potential impacts.

The purpose of this document is to provide a baseline description of the wetlands within the Exxaro Matla Coal Mine's Stooping study area (refer to Figure 1 above).

2. SCOPE OF WORK

The project brief was to update the existing wetland report (WCS, 2012) to include the 4 additional areas as highlighted in Figure 1 above. No additional work was to be done on areas already surveyed and included in the 2012 report.

The following task formed part of the agreed upon scope of work for the WCS 2012 study:

- ⇒ Conduct a desktop and field investigation of the wetlands within the study area;
- ⇒ Assess, classify, delineate and map the identified wetlands;
- ⇒ Identify and describe the functions of the wetlands;
- ⇒ Determine the Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS) of the wetlands;
- ⇒ Review the proposed development plans;
- ⇒ Identify and assess all expected impacts to the wetlands using the provided impact assessment methodology;
- ⇒ Provide suitable recommendations to avoid, minimise, mitigate and manage all identified impacts; and
- ⇒ Provide a report detailing all the above information

The following tasks formed part of the agreed upon scope of work for the 4 additional areas:

- ⇒ Conduct a desktop and field investigation of the wetlands within the study area;
- ⇒ Assess, classify, delineate and map the identified wetlands;
- ⇒ Identify and describe the functions of the wetlands;
- ⇒ Determine the Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS) of the wetlands; and
- ⇒ Review the proposed development plans;
- ⇒ Identify and assess all expected impacts to the wetlands using the provided impact assessment methodology;
- ⇒ Provide suitable recommendations to avoid, minimise, mitigate and manage all identified impacts; and
- ⇒ Provide a report detailing all the above information

3. ASSUMPTIONS & LIMITATIONS

While an effort was made to visit every wetland within the 4 additional stooping areas as part of the current study, not every wetland boundary was walked. Extensive cultivation along and within the boundaries of certain wetlands, which results in complete removal of wetland vegetation and disturbs the soil profile, also presented obstacles to accurate delineation of some of the wetland boundaries on site.

The scale of the remote imagery used (1:10 000 aerial photographs and Google Earth Imagery), as well as the accuracy of the handheld GPS unit used to delineated wetlands in the field, result in the delineated wetland boundaries being accurate to about 15m on the ground. Should greater mapping accuracy be required, the wetlands would need to be pegged in the field and surveyed using conventional survey techniques.

Groundtruthing and field verification of wetland boundaries was limited to the study area (proposed stooping areas). Wetlands falling outside the study area boundary were not delineated in the field but are based on desktop mapping and existing information (WCS. 2012) where applicable.

Reference conditions of wetlands are unknown. This limits the confidence with which the present ecological category (PES) is assigned.

3.1.1 Adequacy of predictive measures

A number of generally accepted assessment methods were utilised within the current study for the assessment of the wetland and aquatic habitats on site:

- WET-Eco-Services (Kotze *et al*., 2009)
- WET-Health Level 1 (Macfarlane *et al*., 2008) – used for all wetlands excluding pans
- Modified version of the RDM Methods for Wetlands (DWAF, 1999), incorporating catchment characteristics (unpublished, WCS, 2013) – used for pan wetlands

Although there are limitations associated with each of these methods, the methods are generally accepted and widely applied within environmental impact assessments in South Africa and are deemed adequate for the purpose of this study.

4. STUDY AREA

For the purpose of the wetland study, and specifically for the detailed groundtruthing of the wetlands that was undertaken, the study area was defined as consisting of the proposed areas earmarked for stooping, and an approximate 500m buffer zone surrounding these areas. The study area can be divided into 8 distinct areas, detailed in the table below.

Table 1. Aerial extent (in hectares) of the study area (see Figure 2).

Label	Name	Area (ha)	Year surveyed
A	Uitvlugt Stooping Area	237.6	2012
B	Block B	291.1	2014
C	Block C	114.5	2014
D	Block D	173.0	2014
E	Block E	192.3	2014
F	3 Mine Stooping Area	1327.8	2012
G & H	Block G & H	783.4	2012
I	LOMP Stooping Area	4103.0	2012
	TOTAL	7222.6	

Although not limited to these areas (upstream and downstream reaches were also assessed), the field work undertaken as part of this study was focussed on these areas.

4.1 Location

The proposed Exxaro Matlo Coal Mine's Stooping Project study area (hereafter referred to as the study area) is located within the Mpumalanga Province in an area to the west of Kriel, north of Kinross, south of Ogies, south east of Delmas, and north east of Leandra. The Matla Power Station is located immediately adjacent to the site.

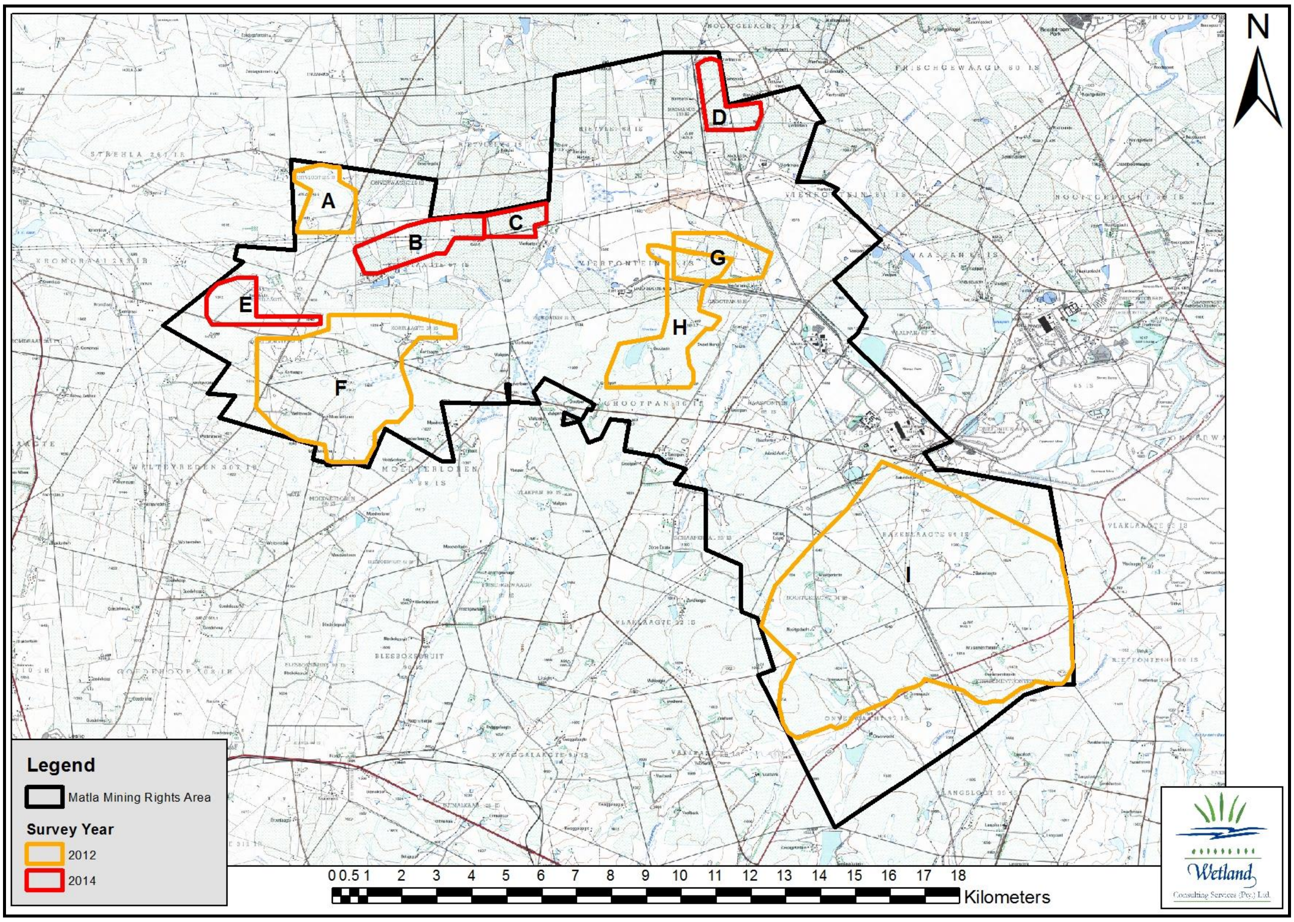

Figure 2. Map showing the location of the study area

4.2 Catchments

The study area is located within the Olifants River Catchment (Primary Catchment B), and more specifically within quaternary catchment B11E. The catchment is drained by the Rietspruit, a tributary of the Steenkoolspruit.

Information regarding catchment size, mean annual rainfall and runoff for the quaternary catchment is provided in the table below (Middleton, B.J., Midgley, D.C and Pitman, W.V., 1990). Figure 3 indicates the position of the various sites in relation to the affected quaternary catchments.

Table 2. Table showing the mean annual precipitation, run-off and potential evaporation per quaternary catchment (Middleton, B.J., Midgley, D.C and Pitman, W.V., 1990) (refer to Figure 3).

Quaternary Catchment	Catchment Surface Area (ha)	Mean Annual Rainfall (MAP) in mm	Mean Annual Run-off (MAR) in mm	MAR as a % of MAP
B11E	42 160	682.42	32.2	4.7 %
B11D	49 812	671.47	30.1	4.5 %
B20E	55 988	657.25	33.9	5.2 %

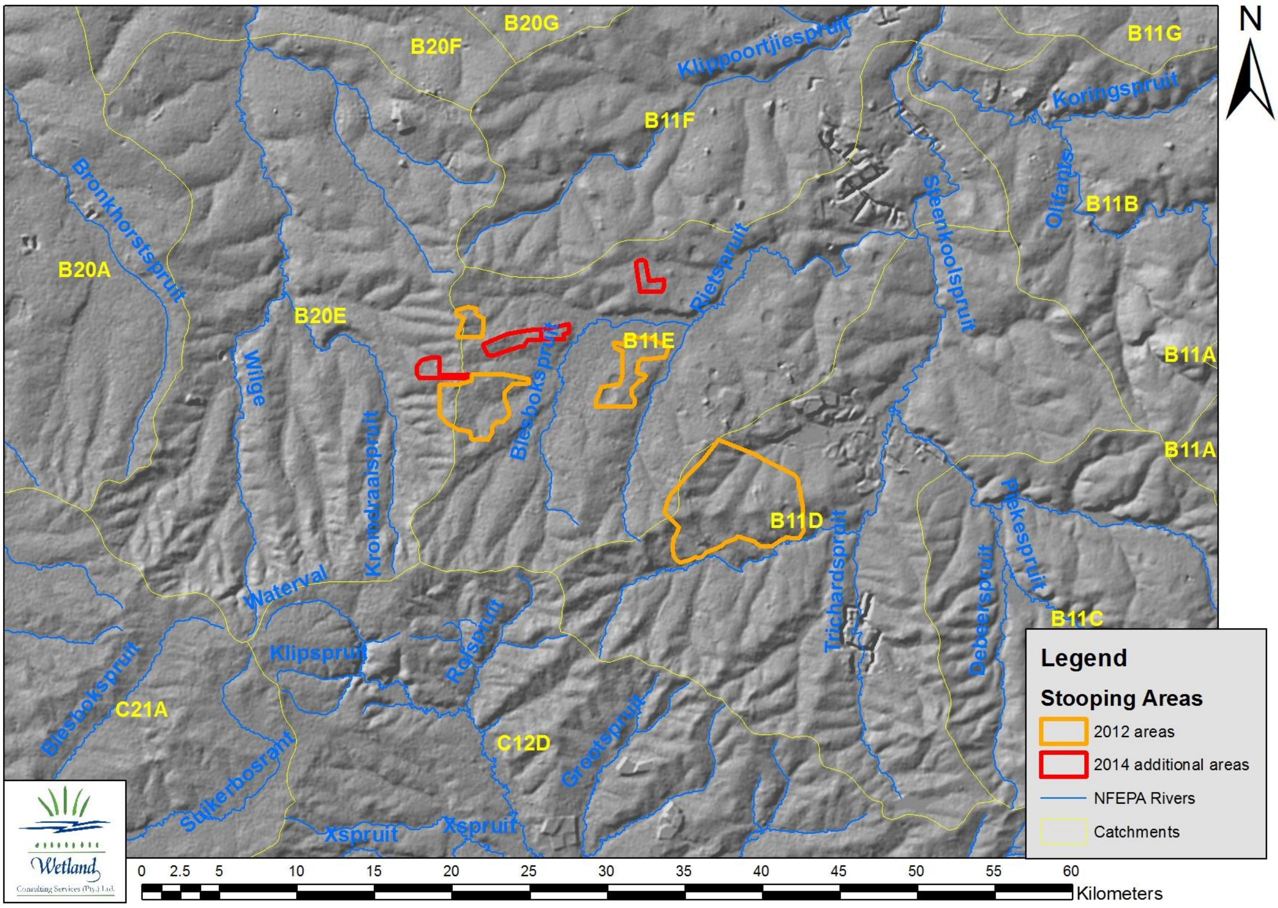

Figure 3. Map showing the study area in relation to the quaternary catchments

The watercourses that may receive impacts from the proposed Exxaro Matla Coal Mine's Stooping Project are listed below:

- Quaternary B20E is drained by the Wilge River. The receiving watercourse is the Kromdraaispruit.
- Quaternary B11D is drained by the Steenkoolspruit. The receiving watercourses are the Dwars-in-die-wegspruit and the Steenkoolspruit.
- Quaternary B11E is drained by the Steenkoolspruit. The receiving watercourses are the Rietspruit and Blesbokspruit.

As part of the Department of Water and Sanitation's (DWS) latest desktop update of PES and Ecological Sensitivity (ES) and Ecological Importance (EI) project, watercourses were divided into subquaternary reaches (Figure 4) and an assessment of the extent of different land-use activities in each sub-quaternary catchment was compiled (DWS 2014). The current activities and impacts on the sub-quaternary catchments of concern regarding this project are listed in Table 1. From the results in Table 1, it is evident that the streams in the vicinity (both up- and downstream) of the study area are currently highly impacted by various human activities. Critical impacts related to current activities are associated with mining and mining-related effluents and vegetation removal. Impacts of a serious nature include abstraction, canalization and presence of small farm dams. Other notable impacts (ranging from moderate to large in extent) include agricultural lands, low water crossings, erosion, inundation, industries, irrigation, urban runoff, sedimentation, trampling and urbanization. It is therefore evident that various human induced stresses are currently impacting on and contribute to the reduced state of the ecological integrity in the study area.

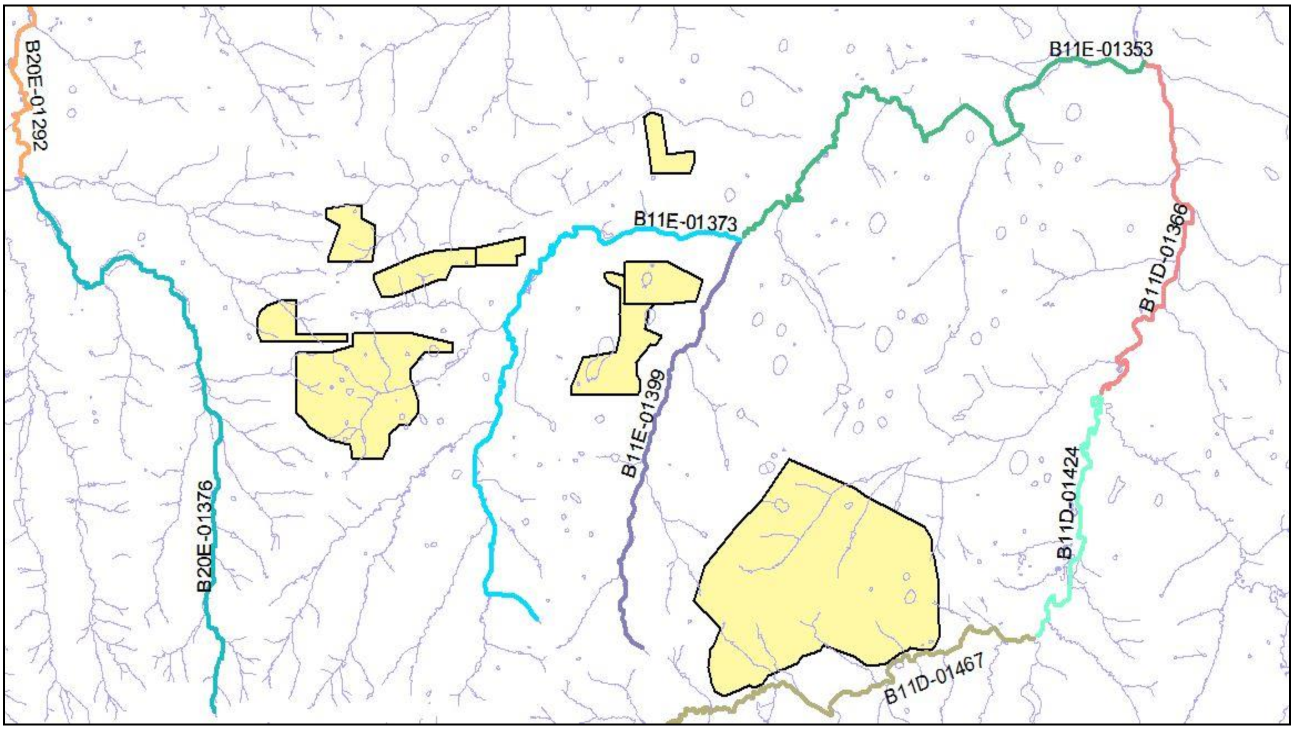

Figure 4. Sub-quaternary reaches of watercourses potentially affected by the proposed Exxaro Matla Coal Mine's Stooping Project (proposed stooping areas are highlighted in yellow).

4.3 Geology and Soils

According to the 1:250 000 geological maps of the area (Map Sheet 2628 East Rand, Department of Minerals and Energy Affairs, 1986), the geology of the area is typical of the Mpumalanga Coalfields, being characterised by sandstones of the Vryheid Formation, Karoo Sequence, and intrusive dolerites. Along the larger drainage lines of the area, most notably the Blesbokspruit, extensive alluvial deposits occur.

The soils of the area play a determining role in the way that water moves through the landscape and thus in the type of wetlands that form within an area. The soils in turn are derived from the weathering and differ markedly depending on the nature of the parent material. Sandstones tend to weather to form sandy soils that allow easy infiltration of rainwater into the soil and thus decreased surface run-off. Dolerites, in contrast, weather to form soils rich in clay, and often to vertic clay soils. Vertic soils are expansive in nature, implying that the soils expand when wet so as to become largely impermeable to water, resulting in increased surface run-off of rainfall and decreased infiltration. Given these characteristics, wetlands located on sandy soil areas underlain by sandstones tend to have a large subsurface component to their water inputs and outputs, whereas wetlands on vertic clay soils tend to be more surface water driven systems, though subsurface water does also occur, most significantly along the contact between the vertic soils and the underlying partially weathered parent rock.

4.4 National Freshwater Ecosystem Priority Areas (NFEPA)

The Atlas of Freshwater Ecosystem Priority Areas in South Africa (Nel *et al.*, 2011) (The Atlas) which represents the culmination of the National Freshwater Ecosystem Priority Areas project (NFEPA), provides a series of maps detailing strategic spatial priorities for conserving South Africa's freshwater ecosystems and supporting sustainable use of water resources. Freshwater Ecosystem Priority Areas (FEPA's) were identified through a systematic biodiversity planning approach that incorporated a range of biodiversity aspects such as ecoregion, current condition of habitat, presence of threatened vegetation, fish, frogs and birds, and importance in terms of maintaining downstream habitat. The Atlas incorporates the National Wetland Inventory (SANBI, 2011) to provide information on the distribution and extent of wetland areas. The wetland mapping was recently updated for the Mpumalanga Highveld region as part of a WRC funded project (Mbona *et al*., 2015). An extract of the updated NFEPA database as per Mbona *et al*. (2015) is illustrated in Figure 4 below.

Based on the Mbona *et al*. (2015) data, extensive wetland systems are indicated as occurring in the area, with most of these wetlands, specifically the Blesbokspruit and Rietspruit wetland systems, classified as FEPA (Freshwater Ecosystem Priority Area) wetlands.

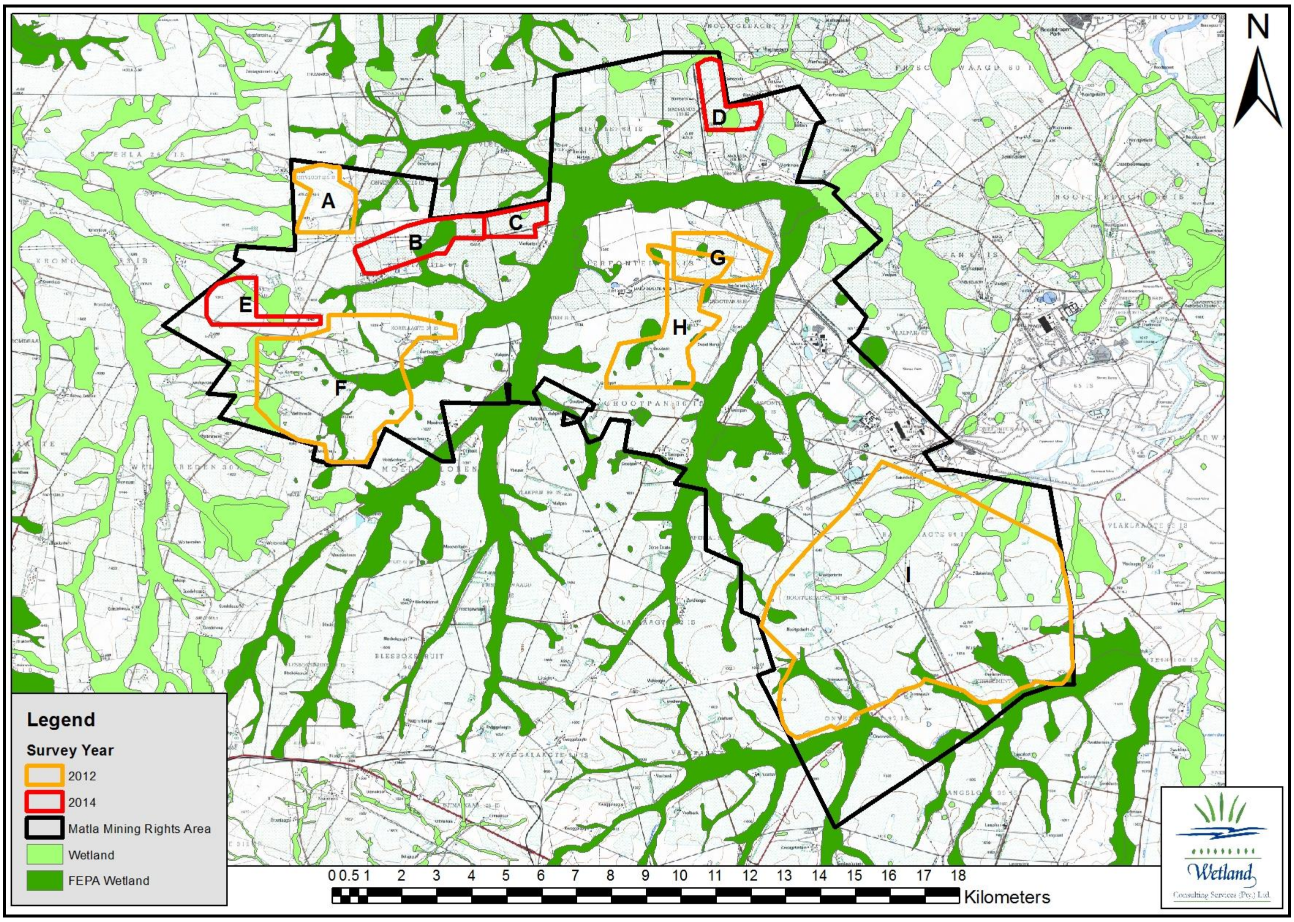

Figure 5. Extract of the distribution and location of FEPA wetlands within the mining right area of Exxaro Matla Coal Mine (Mbona et al., 2015).

4.5 Land-use and other human activities

Table 3. Extent of land-use activities impacting on the ecological integrity of the sub-quaternary catchments of concern (RFA, 2011).

SQ number:	B11D-01467	B11D-01424	B11D-01366	B11E-01373	B11E-01399	B11E-01353	B11E-01297	B11F-01274
Stream name:	Dwars-in-die-weg-spruit	Dwars-in-die-weg-spruit	Steenkoolspruit	Blesbokspruit	Rietspruit	Rietspruit	Steenkoolspruit	Olifants River
Abstraction (run-of river)/increased flows	Moderate	Moderate	Small	Large	Serious	Large	Large	Large
Agricultural lands	Small	Small	Moderate	Moderate	Large	Small	Small	None
Algal growth	None	Small	None	Small	None	Small	Small	None
Bed stabilisation	Small	Small	Small	None	None	None	None	None
Canalization	None	Small	Small	None	None	Serious	Serious	None
Chicken farms	None	None	None	None	None	None	None	None
Crossings low water	None	Small	Small	Small	Small	Moderate	Moderate	None
Erosion	Moderate	Large	Small	Moderate	Small	Large	Large	None
Exotic aquatic macrophytes	None	None	None	None	None	None	None	None
Exotic vegetation	Small	Moderate	Moderate	Small	Small	Small	Large	Moderate
Fire (rated if site is burnt)	None	Small	Small	Small	Small	None	None	None
Feedlots	None	None	None	None	None	None	None	None
Forestry	None	None	None	None	None	None	None	None
Inundation	None	None	None	None	Large	Small	None	None
Industries,	None	None	Moderate	None	Moderate	None	None	None
Interbasin transfers	None	None	None	None	None	None	None	None
Irrigation	Large	Large	None	None	None	None	None	None
Large dams	None	None	None	None	None	None	None	None
Mining	None	Serious	None	Large	None	Critical	Critical	Critical
Natural areas/nature reserves	None	None	None	None	None	None	None	None
Recreation	None	None	None	None	None	None	None	None
Roads	Small	Small	Small	Small	Small	Small	Small	Small
Runoff/effluent: Industries	None	None	None	None	None	None	None	None
Runoff/effluent: Irrigation	Small	None	None	None	None	None	None	None
Runoff/effluent: Mining	None	Serious	Small	Large	None	Critical	Critical	Critical
Runoff/effluent: Urban areas	Moderate	None	Large	None	None	None	Moderate	None
Sedimentation	Moderate	Moderate	Moderate	Moderate	Moderate	Large	Large	Large
Small dams (farm)	Large	Small	Moderate	Moderate	Serious	Large	None	None
trampling	Small	Small	Moderate	Moderate	Large	Moderate	Large	None
Urbanization	Small	None	Moderate	None	None	None	None	None
Vegetation removal	Small	Small	Small	Moderate	Large	Critical	Large	Large

4.6 Desktop Present Ecological Status (PES)

The PES desktop assessment per sub-quaternary catchment, as published in 2014 by DWS (DWS 2014) considered the following criteria:

- Potential instream and riparian/wetland habitat continuity modification;
- Potential instream and riparian/wetland zone habitat modification;
- Potential flow modification; and
- Potential physico-chemical modification.

Based on the desktop assessment of the Present Ecological Status (PES) (DWS 2014), most of the streams in the study area are presently in a modified state (Table 4). The reach that is currently estimated to be in the best ecological status is the upper reaches of the Blesbokspruit (B11E-1373), estimated to fall in a category B (largely natural). The upper Dwars-in-die-wegspruit (B11D-1467), Kromdraaispruit and Wilge River reaches are also presently in a good state, falling into a category C which reflects moderately modified conditions. The rest of the river reaches in the study area fall mostly within category D, reflecting largely modified conditions (Table 4). The exception is the downstream Rietspruit reach (B11E-1353) which is estimated to be in the worst ecological state at present, falling within a category E (seriously modified from natural conditions).

Table 4. Desktop evaluation the PES, EI and ES of each sub-quaternary (SQ) reach of concern. Refer to Figure 6.

SQ NAME	SQ REACH	PES CATEGORY BASED ON MEDIAN	PES CATEGORY DESCRIPTION	EI BASED ON MEAN FOR METRICS	MEAN EI CLASS	ES BASED ON MEAN FOR METRICS	MEAN ES CLASS
Dwars-in-die-wegspruit	B11D-01467	C	Moderately Modified	2.99	HIGH	3.54	HIGH
Dwars-in-die-wegspruit	B11D-01424	D	Largely Modified	2.41	MODERATE	3.27	HIGH
Steenkoolspruit	B11D-01366	D	Largely Modified	2.61	MODERATE	3.27	HIGH
Blesbokspruit	B11E-01373	B	Largely Natural	2.93	HIGH	3.69	HIGH
Rietspruit	B11E-01399	D	Largely Modified	2.51	MODERATE	3.40	HIGH
Rietspruit	B11E-01353	E	Seriously Modified	2.16	MODERATE	3.54	HIGH
Kromdraaispruit	B20E-01376	C	Moderately Modified	2.90	HIGH	3.40	HIGH
Wilge	B20E-01292	C	Moderately Modified	2.96	HIGH	3.59	HIGH

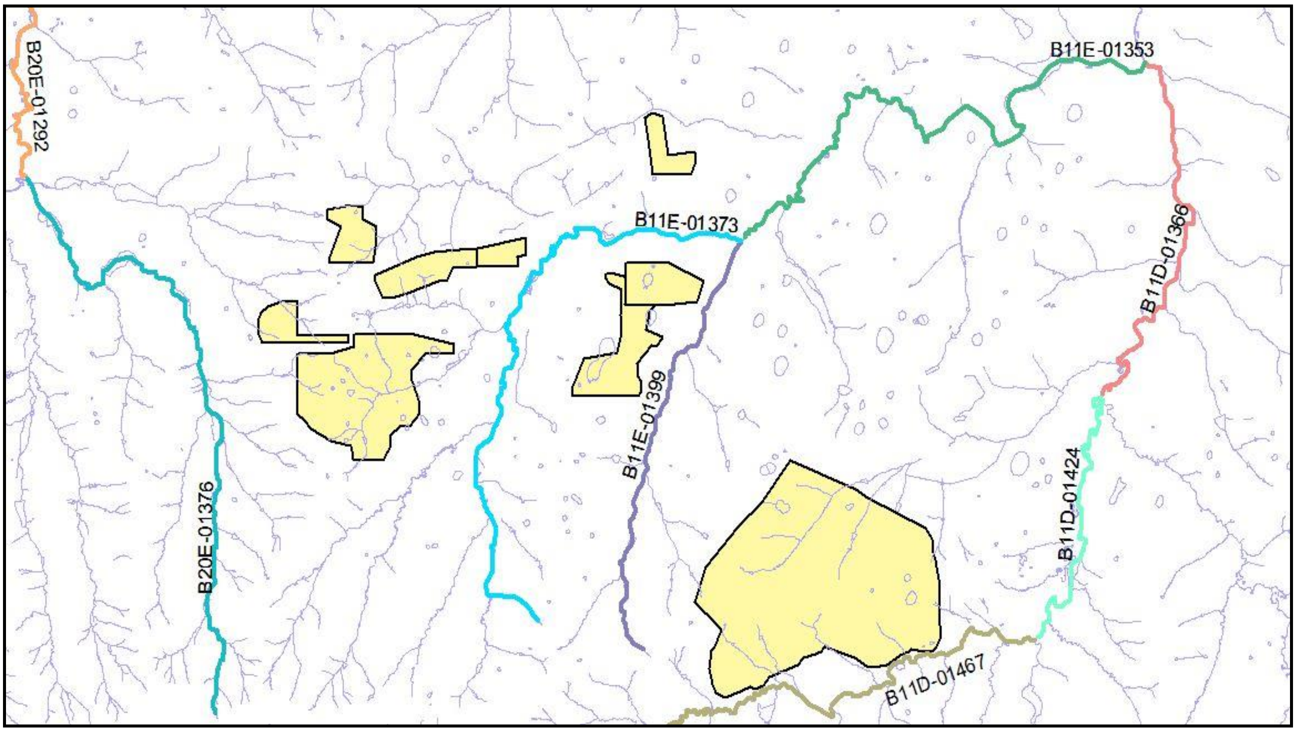

Figure 6. Map of the various sub-quaternary reaches (SQ reach) draining the area. (Refer to Table 4 above).

4.7 Desktop Ecological Importance (EI)

Ecological Importance (EI) of a river is an expression of its importance to the maintenance of ecological diversity and functioning on local and wider scales (Kleynhans 1999, Kleynhans & Louw 2008). Both abiotic and biotic components of the system are taken into consideration in the assessment of ecological importance (Kleynhans 1999). The desktop assessment of the EI of each sub-quaternary reach conducted in 2011 (DWS 2014) considered the following criteria:

- Fish and macroinvertebrate representivity and rarity;
- Riparian/Wetland/Instream vertebrates (excluding fish) importance;
- Riparian/Wetland natural vegetation in 500m zone;
- Riparian-Wetland vegetation importance;
- Habitat diversity;
- Habitat size (length);
- Instream and riparian-wetland zone migration link; and
- Instream and Riparian-Wetland zone habitat integrity.

Based on the desktop assessment of the sub-quaternary catchments (DWS 2014), the Ecological Importance (EI) of the affected reaches ranges between moderate to high importance (Table 4). The upper Blesbokspruit, upper Dwars-in-die-Wegspruit, Kromdraaispruit and the receiving reach of the Wilge River are all considered to be of high ecological importance (based on mean calculated importance), while the remaining sub-quaternary (SQ) reaches are considered to be of moderate importance (Table 4).

4.8 Desktop Ecological Sensitivity (ES)

Ecological Sensitivity (or fragility) (ES) refers to the system's ability to resist disturbance and its capability to recover from disturbance once it has occurred (resilience) (Resh et al. 1988; Milner 1994; Kleynhans 1999). Both abiotic and biotic components of the system are taken into consideration in the assessment of ecological sensitivity (Kleynhans, 1999). The desktop assessment of the ES of each sub-quaternary reach (DWS 2014) considered the following criteria:

- Fish and macroinvertebrates' intolerance level to physico-chemical modifications;
- Dependence on flow (velocity-depth) of fish and invertebrates;
- Riparian-Wetland-Instream vertebrates' (excl. fish) intolerance to water level/flow changes;
- Riparian-Wetland-Instream vegetation intolerance to water level/flow changes; and
- Stream size sensitivity to modified flow/water level changes.

Based on the desktop assessment of the Ecological Sensitivity (ES) of the sub-quaternary catchments of concern (DWS 2014), all the reaches in the study area are classified to be of high ecological sensitivity (Table 4).

5. APPROACH

5.1 Wetland Assessment

The National Water Act (Act No. 36 of 1998) defines wetlands as follows:

> *"Land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil."*

The presence of wetlands in the landscape can be linked to the presence of both surface water and perched groundwater. Wetland types are differentiated based on their hydro-geomorphic (HGM) characteristics; i.e. on the position of the wetland in the landscape, as well as the way in which water moves into, through and out of the wetland systems. A schematic diagram of how these wetland systems are positioned in the landscape is given in Figure 6 below.

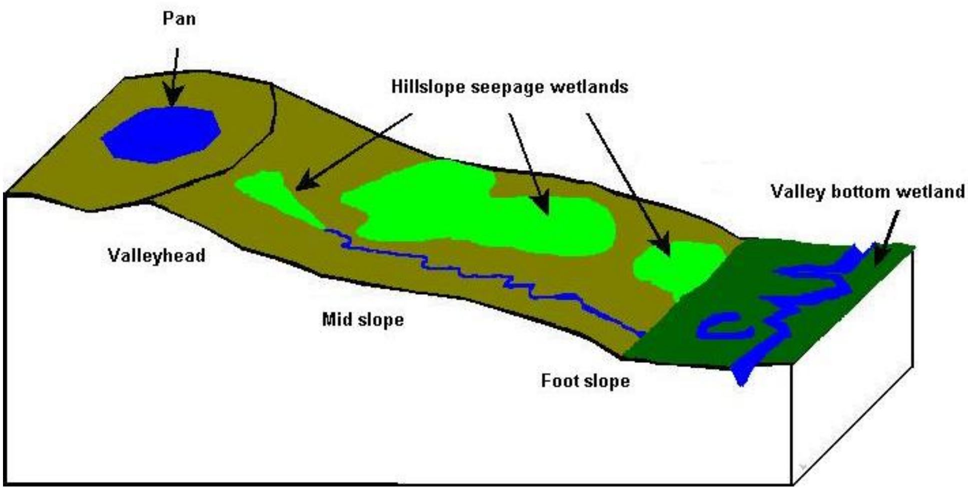

Figure 7. Diagram illustrating the position of the various wetland types within the landscape.

5.1.1 Wetland Delineation and Classification

Use was made of 1:50 000 topographical maps, 1:10 000 orthophotos and Google Earth Imagery to create digital base maps of the study area onto which the wetland boundaries could be delineated using ArcMap 9.0. A desktop delineation of suspected wetland areas was undertaken by identifying rivers and wetness signatures on the digital base maps. All identified areas suspected to be wetlands were then further investigated in the field.

Wetlands were identified and delineated according to the delineation procedure as set out by the "*A Practical Field Procedure for the Identification and Delineation of Wetlands and Riparian Areas*" document, as described by DWAF (2005) and Kotze and Marneweck (1999). Using this procedure, wetlands were identified and delineated using the Terrain Unit Indicator, the Soil Form Indicator, the Soil Wetness Indicator and the Vegetation Indicator.

For the purposes of delineating the actual wetland boundaries use is made of indirect indicators of prolonged saturation, namely wetland plants (hydrophytes) and wetland soils (hydromorphic soils), with particular emphasis on hydromorphic soils. It is important to note that under normal conditions hydromorphic soils must display signs of wetness (mottling and gleying) within 50cm of the soil surface for an area to be classified as a wetland (*A practical field procedure for identification and delineation of wetlands and riparian areas*, DWAF).

The delineated wetlands were then classified using a hydro-geomorphic classification system based on the system proposed by Brinson (1993), and modified for use in South African conditions by Marneweck and Batchelor (2002).

5.1.2 Functional Assessment – WET-EcoServices

A functional assessment of the wetlands on site will be undertaken using the level 2 assessment as described in "Wet-EcoServices" (Kotze *et al*., 2007). This method provides a scoring system for establishing wetland ecosystem services. It enables one to make relative comparisons of systems based on a logical framework that measures the likelihood that a wetland is able to perform certain functions.

5.1.3 Present Ecological State and Ecological Importance & Sensitivity

A Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS) assessment was conducted for every hydro-geomorphic wetland unit identified and delineated within the study area. This was done in order to establish a baseline of the current state of the wetlands and to provide an indication of the conservation value and sensitivity of the wetlands in the study area.

For the purpose of this study, the scoring system as described in the document "*Resource Directed Measures for Protection of Water Resources. Volume 4. Wetland Ecosystems*" (DWAF, 1999) was applied for the determination of the PES.

5.2 Aquatic Ecology Assessment

5.2.1 Habitat Integrity

Most aquatic ecosystems assessed on the site were also assessed in the Wetland Assessment Report. Therefore, habitats assessed within this report refer specifically to the habitats available to aquatic biota (fish, macroinvertebrates) on site. Instream and marginal habitats were assessed in terms a modified index of habitat integrity, which describes the broad habitat integrity or condition, based on the extent of different human activities. This approach is based on the assessment of physical habitat disturbance (Kleynhans, 1997). The following impacts were investigated, namely:

- Water abstraction;
- Flow modification (in valley bottom wetlands);
- Bed modification;

- Channel modification;
- Inundation;
- Exotic macrophytes;
- Solid waste disposal;
- Indigenous vegetation removal;
- Exotic vegetation encroachment; and
- Bank erosion.

5.2.2 Water Quality

- *Water quality*: On-site measurement of conductivity, TDS, pH and temperature. These were interpreted in terms of ecological responses only.
- *Diatoms*: Diatoms provide a rapid response to specific physico-chemical conditions in aquatic ecosystems and are often the first indication of change. The presence or absence of indicator taxa can be used to detect specific changes in environmental conditions such as eutrophication, organic enrichment, salinisation and changes in pH. Preparation of diatom slides followed the Hot HCl and KMnO4 method as outlined in Taylor *et al*. (2007a). A Nikon microscope with phase contrast optics (1000x) was used to identify 400 diatom valves per sample. Diatom analysis included measures of abundance so as to infer water quality based on species dominance.

5.2.3 Aquatic Macroinvertebrates

Aquatic macroinvertebrates were assessed using the SASS 5 (South African Scoring System) methodology. SASS5 is based on the presence or absence of sensitive aquatic macroinvertebrates collected and analysed according to the methods outlined in Dickens and Graham (2002). A high relative abundance and diversity of sensitive taxa present indicates a relatively healthy system with good water quality. Disturbance to water quality and habitat results in the loss of sensitive taxa. As this method was developed specifically for rivers, the methods of collection and analysis were modified for wetlands and pans. This meant sampling vegetation and substrate biotopes only, as no stone biotopes were available, and interpreting the PES for aquatic macroinvertebrates in terms of overall diversity and assemblage patterns, rather than according to guidelines derived from SASS5 scores in rivers (Dallas 2007). Table 5 summarises the categories used to classify sites according to both aquatic macroinvertebrates and fish.

Table 5: Descriptive categories used to describe the Present Ecological Status (PES) of biotic components (adapted from Kleynhans, 1999).

CATEGORY	BIOTIC INTEGRITY	DESCRIPTION OF GENERALLY EXPECTED CONDITIONS
A	Excellent	Unmodified, or approximates natural conditions closely. The biotic assemblages compares to that expected under natural, unperturbed conditions.
B	Good	Largely natural with few modifications. A change in community characteristics may have taken place but species richness and presence of intolerant species indicate little modifications. Most aspects of the biotic assemblage as expected under natural unperturbed conditions.
C	Fair	Moderately modified. A lower than expected species richness and presence of most intolerant species. Most of the characteristics of the biotic assemblages have been moderately modified from its naturally expected condition. Some impairment of health may be evident at the lower end of this class.
D	Poor	Largely modified. A clearly lower than expected species richness and absence or much lowered presence of intolerant and moderately intolerant species. Most characteristics of the biotic assemblages have been largely modified from its naturally expected condition. Impairment of health may become evident at the lower end of this class.
E	Very Poor	Seriously modified. A strikingly lower than expected species richness and general absence of intolerant and moderately tolerant species. Most of the characteristics of the biotic assemblages have been seriously modified from its naturally expected condition. Impairment of health may become very evident.
F	Critical	Critically modified. Extremely lowered species richness and an absence of intolerant and moderately tolerant species. Only intolerant species may be present with complete loss of species at the lower end of the class. Most of the characteristics of the biotic assemblages have been critically modified from its naturally expected conditions. Impairment of health generally very evident.

It must be emphasised that the A→F scale represents a continuum, and that the boundaries between categories are notional, artificially-defined points along the continuum (as presented below). This situation falls within the concept of a fuzzy boundary, where a particular entity may potentially have membership of both classes (Robertson *et al*. 2004). These boundary categories are denoted as B/C, C/D, etc.

5.2.4 Fish Assessments

5.2.4.1 Habitat composition

The aquatic habitats form the template of the biological composition of any system. If the habitat components are undisturbed, and in good condition, the biological composition of the system can be expected to be normal and one can expect a high biodiversity within the system (water quality permitting). If the habitat components are however degraded, due to human activities, the biota of the system will reflect this by a loss, firstly of the most intolerant species (Davies & Day, 1998).

An evaluation of habitat quality and availability to biota is therefore critical to any assessment of ecological integrity and should be conducted at each site at the time of biological sampling. On-site habitat assessments were conducted by using existing habitat evaluation indices. The general characteristics of the site and its immediate surroundings were described. The composition and ability of the habitats to meet the requirements of different fish species were broadly based on the Habitat Cover Rating method (Kleynhans, 1997). This approach was developed to assess habitats according to different attributes that are surmised to satisfy the habitat requirements of various fish species (Kleynhans, 1997). At each site, the following velocity-depth classes were identified, namely:

Slow (<0.3m/s);
Shallow (<0.5m) (SS) - Shallow pools and backwaters;
Slow, Deep (>0.5m) (SD) - Deep pools and backwaters;
Fast (>0.3m/s), Shallow (FS) - Riffles, rapids and runs; and
Fast, Deep (FD) - Usually rapids and runs.

The relative contribution of each of the above mentioned classes at a site is estimated and indicated as follows (adapted from Rankin, 1995):

Descriptor	Relative ecological value/abundance score	Occurrence (% of area covered)
None	0	0
Rare	1	0-5
Sparse	2	5-25
Common	3	25-75
Abundant	4	75-90
Very abundant	5	90-100

For each depth-flow class, the following cover features, considered to provide fish with the necessary cover to utilise a particular flow and depth class, were investigated and similarly rated as described above:

- Overhanging vegetation;
- Undercut banks and root wads;
- Stream substrate; and
- Aquatic macrophytes.

5.2.4.2 Fish Assessments

The study area was visited in October 2011, and representative sites were selected in the primary aquatic ecosystems (Olifants River System) in the study area. Fish sampling of representative sites and habitats was performed using a SAMUS battery operated electro-fisher by wading in shallow habitats and using a boat in deeper areas. All fish species were identified to species level and returned to their natural habitats. The latest version of the Fish Response Assessment Index (FRAI) (DWAF, 2008) was used to determine the present ecological status (PES) of the aquatic ecosystem in the study area.

6. FINDINGS – WETLAND ASSESSMENT

6.1 Wetland Delineation and Classification

A number of different wetland types were identified and delineated within the study area, with wetlands covering roughly 36.5 % (2 365 ha) of the study area. The most common wetland type was found to be hillslope seepage wetlands, which covered 32.5 % of the site and made up almost 90 % of the wetland area, followed by valley bottom wetlands (2.8 % of the wetland area), pan wetlands (2.7 %), and dams (2.7 %). The very high percentage of hillslope seepage wetlands and relatively low percentage of valley bottom wetlands is at least partly the result of the proposed mining sites being located away from the large valley bottom wetlands of the area. However, hillslope seepage wetlands do typically form the majority of wetland habitat within the Mpumalanga Highveld.

Figure 8 illustrates all of the wetlands delineated within the study area, while Tables 6 and 7 provide details on the wetland extent.

Each of the various sites within the overall study area is then discussed individually.

Table 6. Table showing the overall extent of the various wetland types delineated across the proposed Exxaro Matla Coal Mine's Stooping Project area within the mining right area of Exxaro Matla Coal Mine (see Figure 8).

Wetland Type	Area (ha)	% of wetland area	% of study area
Channelled valley bottom	75.0	2.8%	1.0%
Unchannelled valley bottom	46.2	1.8%	0.6%
Hillslope seepage	2350.7	89.2%	32.5%
Pan	72.0	2.7%	1.0%
Dam	71.3	2.7%	1.0%
River diversion	3.8	0.1%	0.1%
Quarry	8.1	0.3%	0.1%
Subsidence wetland	8.0	0.3%	0.1%
TOTAL	**2635.1**	**100.0%**	**36.5%**

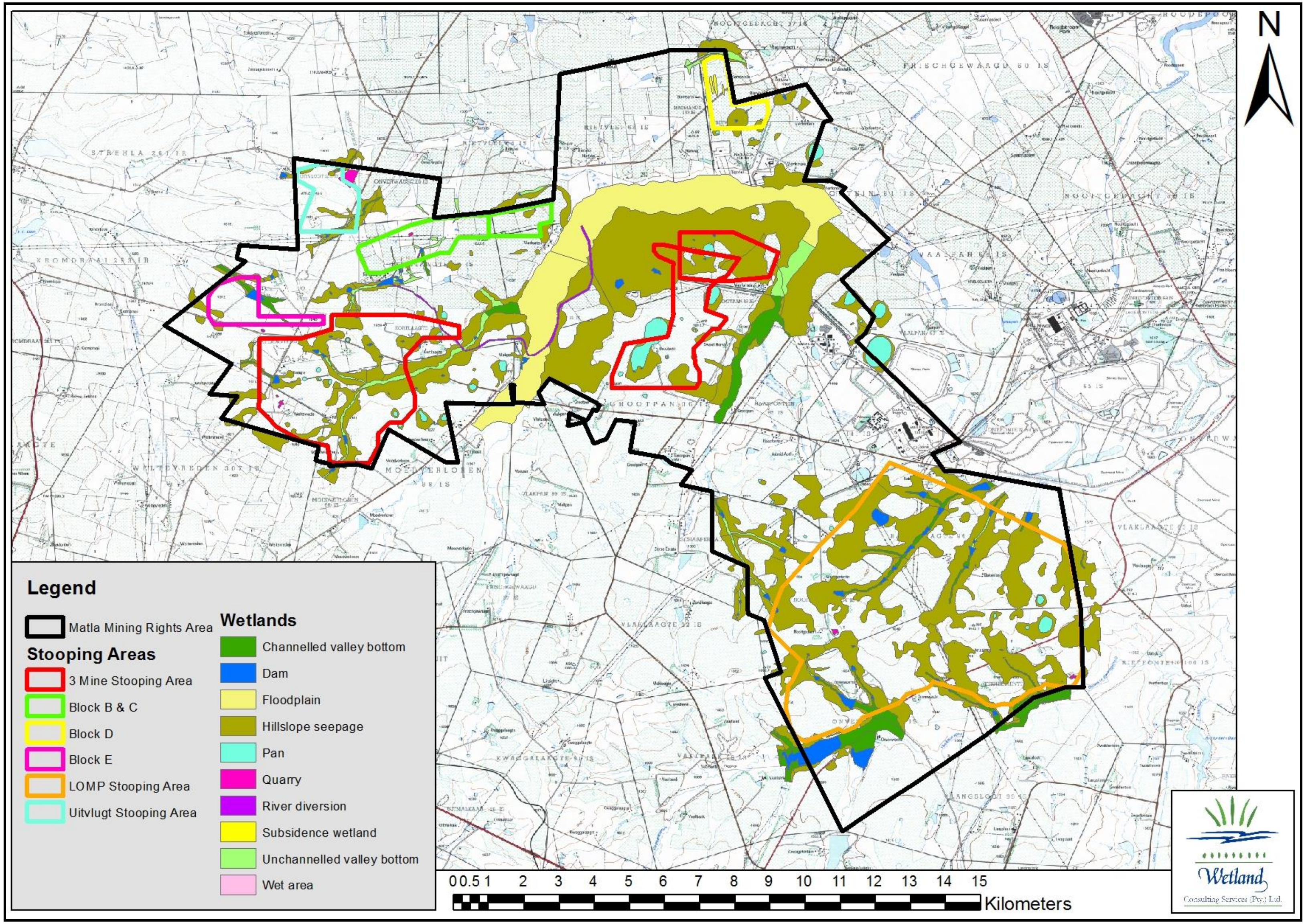

Figure 8. Map of the delineated wetlands within the entire Matla study area.

Table 7. Extent of wetlands delineated across the proposed Exxaro Matla Coal Mine's Stooping Project area within the mining right area of Exxaro Matla Coal Mine (see Figure 8).

Proposed Site	Size of site (ha)	Extent of wetlands on site (ha)	% of wetlands on site
Uitvlugt Stooping area (A)	237.6	39.2	16.5%
Block B & C	405.6	21.2	5.2%
Block D	173	36.9	21.3%
Block E	192.3	29.4	15.3%
3 Mine Stooping area (F, G & H)	2111.2	763.6	36.2%
LOMP Stooping area (I)	4103.3	1744.7	42.5%
TOTAL	**7222.6**	**2635.1**	**36.5%**

The highest wetland cover percentage, 42.5 %, was found to occur in the LOMP Stooping Area (Block I), which is also the largest of the proposed stooping areas at 4 103.3 ha. Next highest was the 3 Mine Stooping Area (Blocks F, G & H) at 36.2 % wetland cover, while the lowest wetland cover percentage was recorded in Blocks B & C at only 5.2 %.

Wetlands are the surface expression of water moving through the landscape and are influenced by the rainfall, geology, geomorphology and soil characteristics of the landscape and the resulting hydrology. Put simply, wetlands occur where water movement is slowed down and is retained within the landscape for a period sufficient to influence the soil and vegetation of the area. Wetlands can only form where water occurs near the surface, and are fully dependant on the quantity, velocity and quality of the water supporting them. In a natural, undisturbed landscape, the wetlands are in dynamic equilibrium with the driving hydrology and will persist in their state until the driving force, the hydrology, is changed. If any aspect of the water supporting the wetland is altered (i.e. the water quantity, velocity, periodicity or quality), the wetland itself will be changed as it attempts to reach a new equilibrium with the imposed drivers.

The maintenance of wetlands in their natural state is thus directly dependant on the maintenance of the drivers of the wetland – the water quantity, velocity and quality. Within the study area, wetland systems are dominated by numerous and extensive hillslope seepage wetlands. These wetlands are maintained by shallow sub-surface interflow, derived from rainwater. Rainfall infiltrates the soil profile, percolates through the soil until it reaches an impermeable layer (e.g. a plinthic horizon or the underlying sandstone), and then flows laterally through the soil profile along the aquitard (resulting in the formation of a perched water table), or remains within the soil profile until it is eventually lost to evapo-transpiration. Such perched water tables occur across large areas of the Mpumalanga Highveld, not only within hillslope seepage wetlands, but also within terrestrial areas, only at greater depth. In fact, given the deeper soils generally found within the terrestrial areas, these areas potentially store a far greater volume of water than is stored in the hillslope seepage wetlands themselves, and it is this water, temporarily stored within the landscape and slowly percolating through the soil, which supports the wetlands found on site. The hillslope seepage wetlands are merely the surface expression of this perched water table in those areas where a shallow soil profile results in the perched water table occurring within 50cm of the soil surface. Key here is the interconnectedness of the water movement through the landscape; the hillslope seepage wetlands are directly dependant on sub-surface interflow derived from the terrestrial areas, while the discharge of water from the hillslope seepage wetlands plays a major role in supporting valley bottom wetlands or pan wetlands, whichever the case may be. It can be said that wetlands are dependent on catchment-scale processes, not only on wetland-scale processes.

6.1.1 Uitvlugt Stooping Study Area – Block A

Two valley bottom wetland systems and associated hillslope seepage wetlands were delineated within the Uitvlugt Stooping study area. Both these wetland systems drain in an easterly direction towards an unnamed tributary of the Rietspruit. A number of small farm dams have also been constructed within the wetlands.

In total, wetlands cover roughly 16.5 % of the site, with this low percentage being attributed to the location of the site along the watershed between 2 quarternary catchments, with the wetlands on site forming the headwaters of two small, unnamed water courses.

A large quarry, covering over 12 hectares, was also identified extending partially onto site. Numerous wet areas and areas of surface water occur within the quarry where rainfall and run-off accumulates.

Table 8. Extent of the various wetlands types recorded within the Uitvlugt study area.

Wetland Type	Area (ha)	% of wetland area	% of study area
Channelled valley bottom	2.1	5.3%	0.9%
Unchannelled valley bottom	1.1	2.9%	0.5%
Hillslope seepage	32.9	83.8%	13.8%
Dam	0.4	0.9%	0.2%
Quarry	2.8	7.1%	1.2%
TOTAL	**39.2**	**100%**	**16.5%**

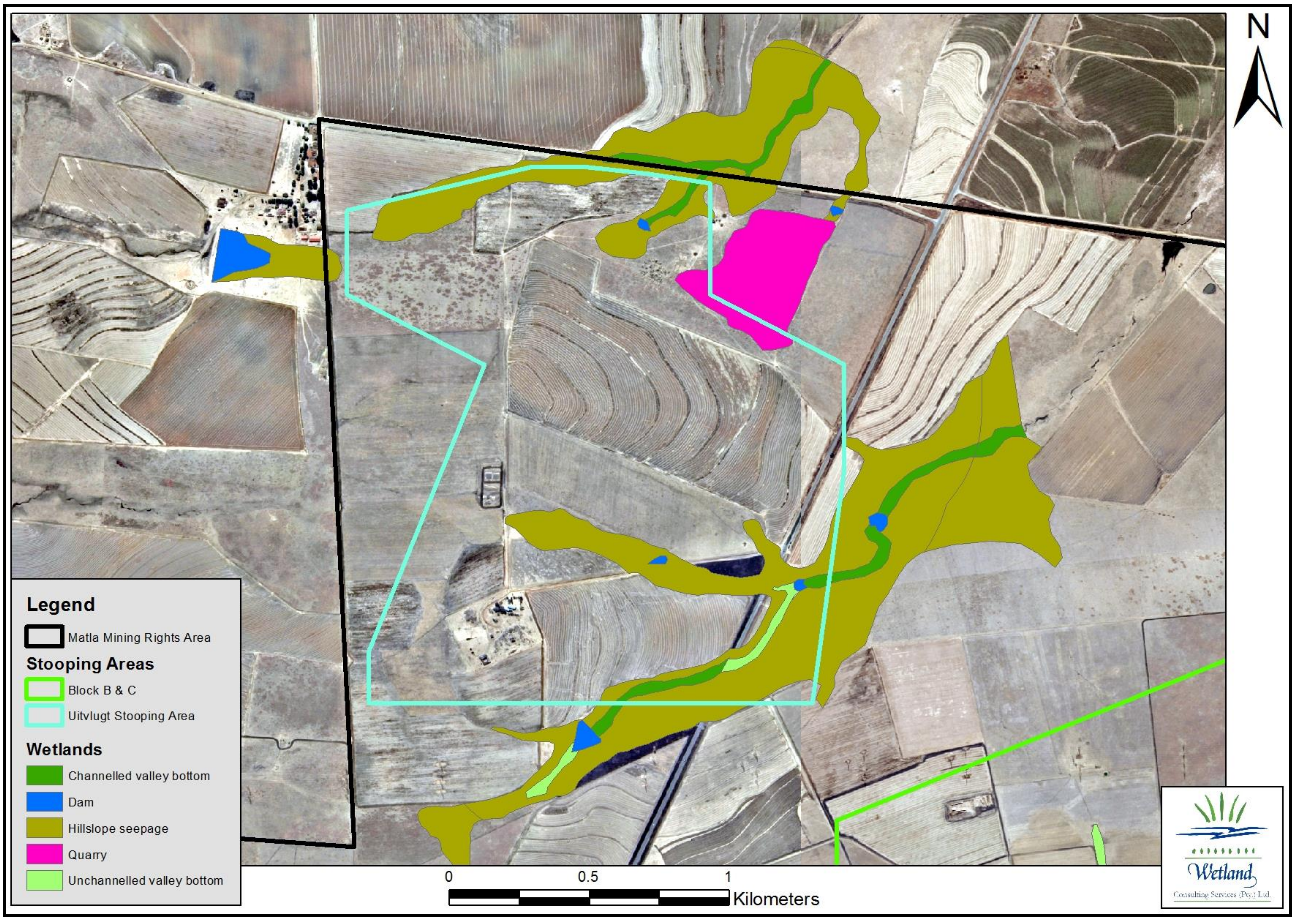

Figure 9. Map of the wetlands delineated within the Uitvlugt Stooping study area.

6.1.2 Block B & C

Block B and C form a longitudinal area approximately 5km long and 1km wide, aligned roughly along a crest in the landscape, with flows draining north and south off the site. The location of Block B and C along the crest in the landscape has as a consequence that no large watercourses traverse the area, and all wetlands located on site are generally small and form the extreme upper reaches of various small, unnamed tributaries to the Blesbokspruit.

Table 9. Table showing the extent of the wetland types recorded within the Block B and C area.

Wetland Type	Area (ha)	% of wetland area	% of study area
Channelled valley bottom	1.4	6.4%	0.3%
Unchannelled valley bottom	8.6	40.6%	2.1%
Hillslope seepage	7.4	35.0%	1.8%
Pan	0.5	2.5%	0.1%
Dam	1.1	5.3%	0.3%
River diversion	1.4	6.8%	0.4%
Quarry	0.7	3.1%	0.2%
TOTAL	**21.2**	**100%**	**5%**

The eastern section of the site, Block C, is characterised by more sandy soils with a number of hillslope seepage wetlands identified in this area, as well as a small pan. The sandy soils also allow extensive cultivation, which in most cases on site extends into the wetland areas. Significantly, a pair of **African Grass Owls (*Tyto capensis*), which are listed as Vulnerable on the Red Data List**, were observed within the large hillslope seepage wetland draining north east from Block C. Extensive stands of tall and dense *Imperata cylindrica* provide ideal roosting and nesting habitat for this species.

The western section of the site, Block B, is characterised by more clayey soils which are vertic in nature for large portions of the site. Seepage wetlands are largely absent from this area and only a number of small valley bottom wetlands were recorded, as well as a farm dam. A water discharge point was observed feeding into one of the valley bottom wetlands and eventually into the dam. The source of the water is not known, but it has resulted in the development of fairly extensive wetland habitat through increased water availability and soil saturation**.** Large numbers of birds were observed utilising this habitat, including at least 10 Marsh Owls. From the dam, flows enter the large Blesbokspruit river diversion.

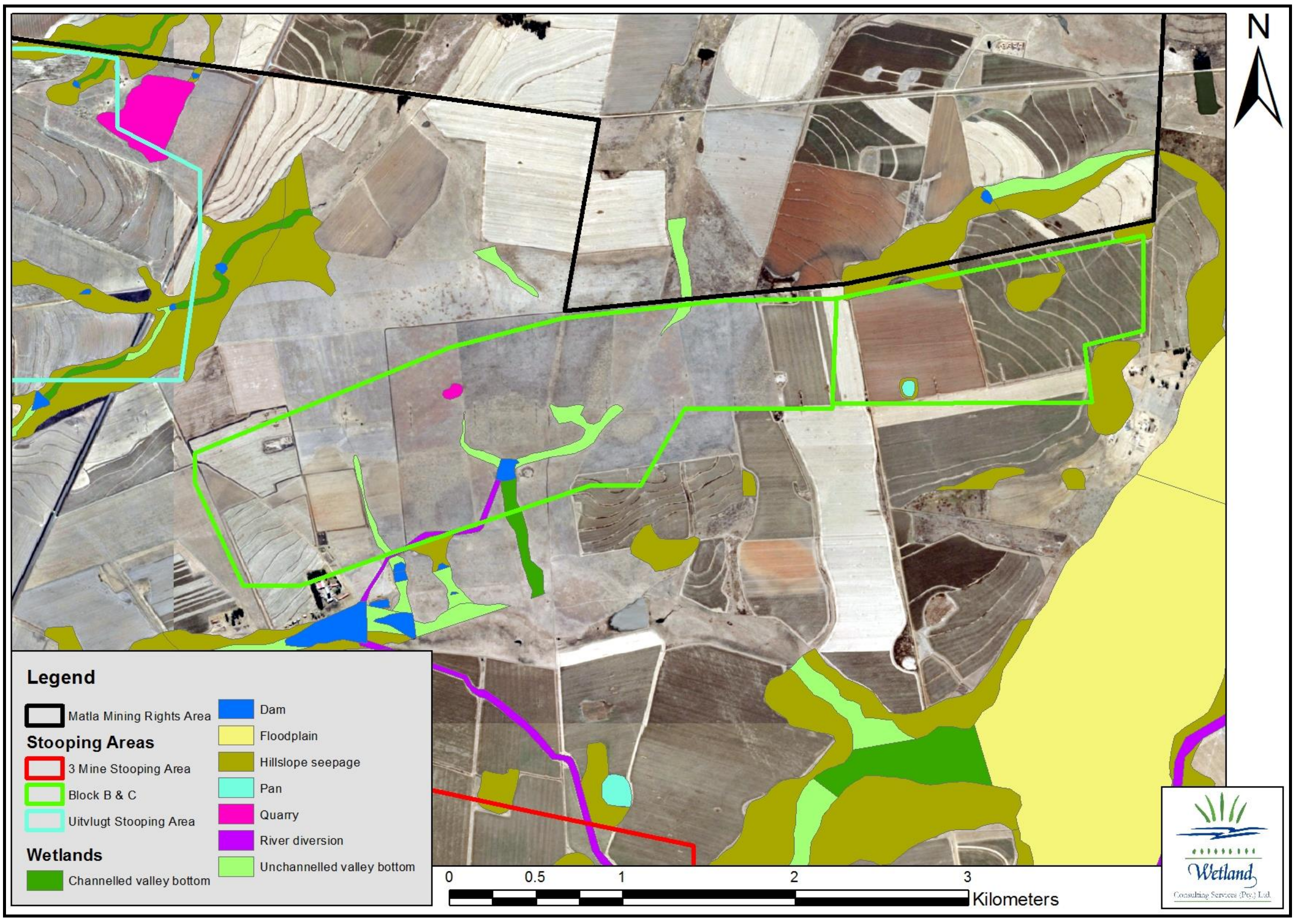

Figure 10. Map of the delineated wetland areas within the Block B and C area.

Figure 11. Photographs of the wetlands within the Block B and C area (clockwise from top left): water discharge point; wetland habitat below discharge point; wetland below discharge point feeding into farm dam; African Grass Owl observed within the north eastern hillslope seepage wetland.

6.1.3 Block D

21.3 % of the Block D area is covered by wetlands, though 4.6 % of the wetland area can be considered artificial wetland habitat that has formed as a result of surface subsidence. Surface subsidence has led to the formation of longitudinal depressions within the cultivated fields on site that retain water for extended periods and have become characterised by pioneer wetland indicator species such as *Imperata cylindrica*, as well as various ruderal species. Although these areas generally do not show signs of wetness in the soil, the vegetation has responded to increased wetness.

Immediately north of the Block D area a valley bottom wetland drains from west to east past the site. A large channel has been excavated through the length of this wetland to drain flows impounded in subsided areas to the west.

Within the southern portions of Block D, several large seemingly isolated hillslope seepage wetlands occur. These have for the most part been cultivated at some stage, with portions still currently under cultivation. Planted pastures also occur within the wetlands.

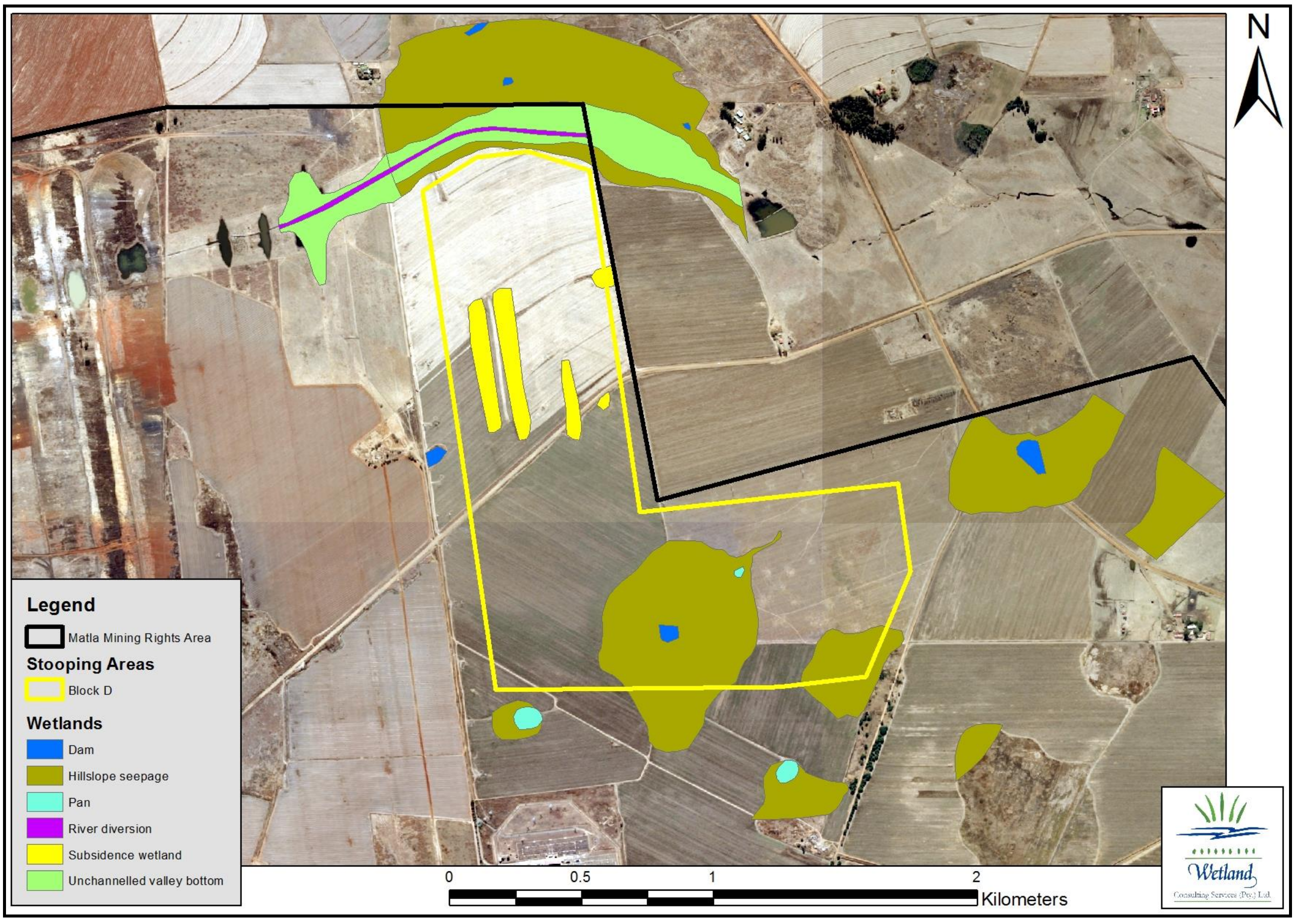

Figure 12. Map of the delineated wetland areas within the Block D area.

Table 10. Table showing the extent of the wetland types recorded within the Block D area.

Wetland Type	Area (ha)	% of wetland area	% of study area
Hillslope seepage	28.5	77.1%	16.5%
Pan	0.1	0.3%	0.1%
Dam	0.4	1.0%	0.2%
Subsidence wetland	8.0	21.7%	4.6%
TOTAL	**36.9**	**100%**	**21.3%**

Figure 13. Photographs of the wetlands within the Block D area (clockwise from top left): Excavated channel and subsided area.

6.1.4 Block E

Only 15.3 % of Block E has been classified as wetland habitat, consisting of valley bottom and hillslope seepage wetlands, as well as a large farm dam located within these wetlands.

The farm dam is feed by two channelled valley bottom wetlands originating within an area of natural grasslands on clayey soils of the Arcadia soil form. These systems are driven by surface runoff of rainfall and show significant signs of erosion and channel incision.

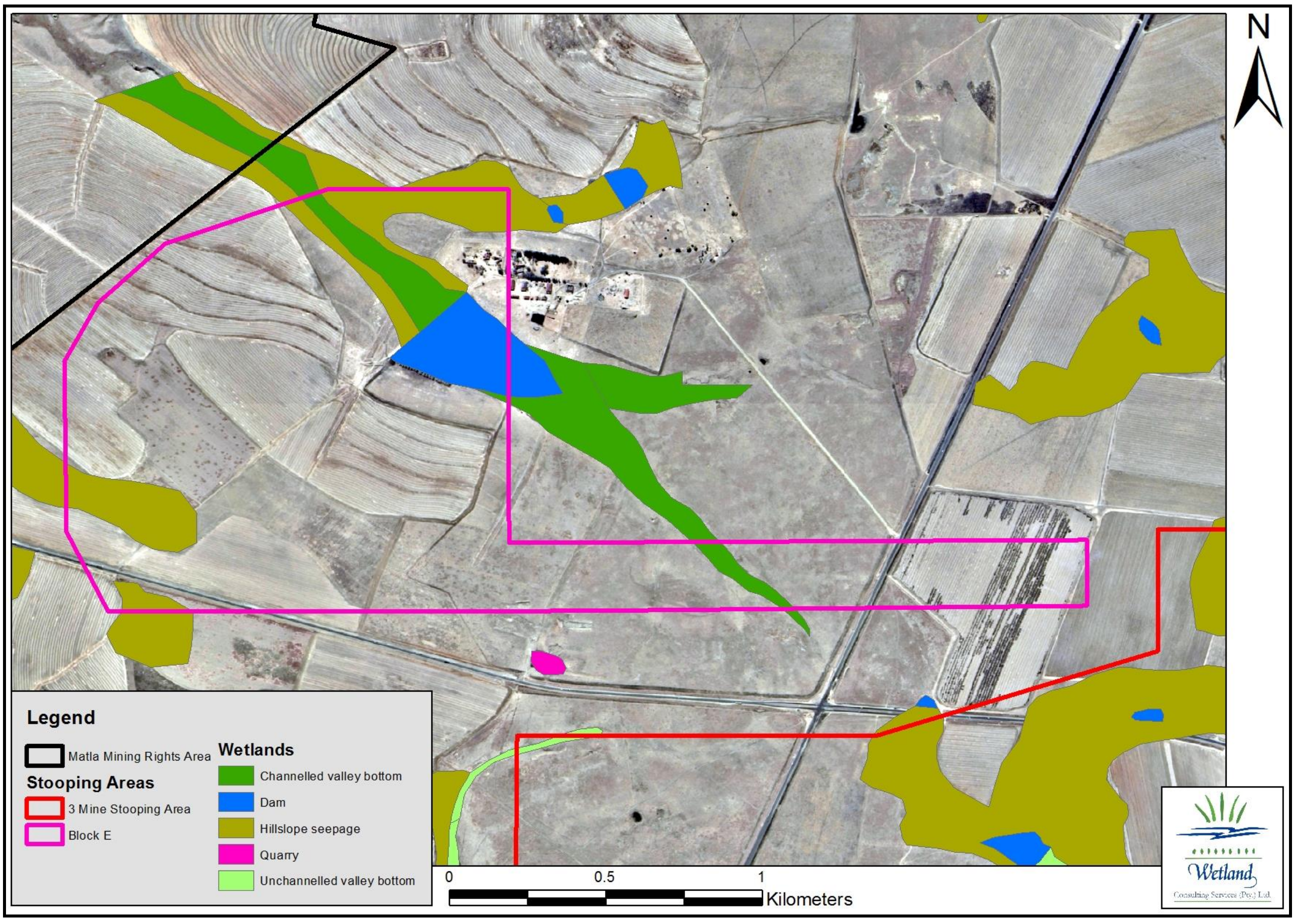

Figure 14. Map of the delineated wetland areas within the Block E area.

Table 11. Table showing the extent of the wetland types recorded within the Block E area.

Wetland Type	Area (ha)	% of wetland area	% of study area
Channelled valley bottom	6.4	21.8%	3.3%
Hillslope seepage	16.4	55.9%	8.5%
Dam	6.6	22.3%	3.4%
TOTAL	**29.4**	**100%**	**15.3%**

Downstream of the dam the valley bottom wetland is less incised, though the straight nature of the channel in this area suggests the channel is probably artificial in nature and likely an attempt to improve drainage away from the base of the dam wall. Large hillslope seepage wetlands feed into this valley bottom wetland.

A further seep was identified in the south western corner of the site – this seep had been previously cultivated and is characterised by secondary vegetation and hard-set soils.

Figure 15. Photographs of the wetlands within the Block E area (clockwise from top left): Upper reach of farm dam; view upstream of the farm dam; channelled valley bottom downstream of the farm dam – note straight channel; and erosion upstream of the farm dam associated with cattle trampling – note black clay soils.

6.1.5 3 Mine Stooping Area – Blocks F, G & H

Wetlands cover approximately 36 % of the 3 Mine study area, with the wetland area again dominated by extensive hillslope seepage wetlands, which make up 86.8 % of the wetlands on site.

Table 12. Extent of the various wetland types recorded within the 3 Mine study area.

Wetland Type	Area (ha)	% of wetland area	% of study area
Channelled valley bottom	1.8	0.2%	0.1%
Unchannelled valley bottom	30.4	4.0%	1.4%
Hillslope seepage	662.6	86.8%	31.4%
Pan	53.4	7.0%	2.5%
Dam	11.1	1.5%	0.5%
River diversion	2.3	0.3%	0.1%
Quarry	2.0	0.3%	0.1%
TOTAL	**763.6**	**100%**	**36%**

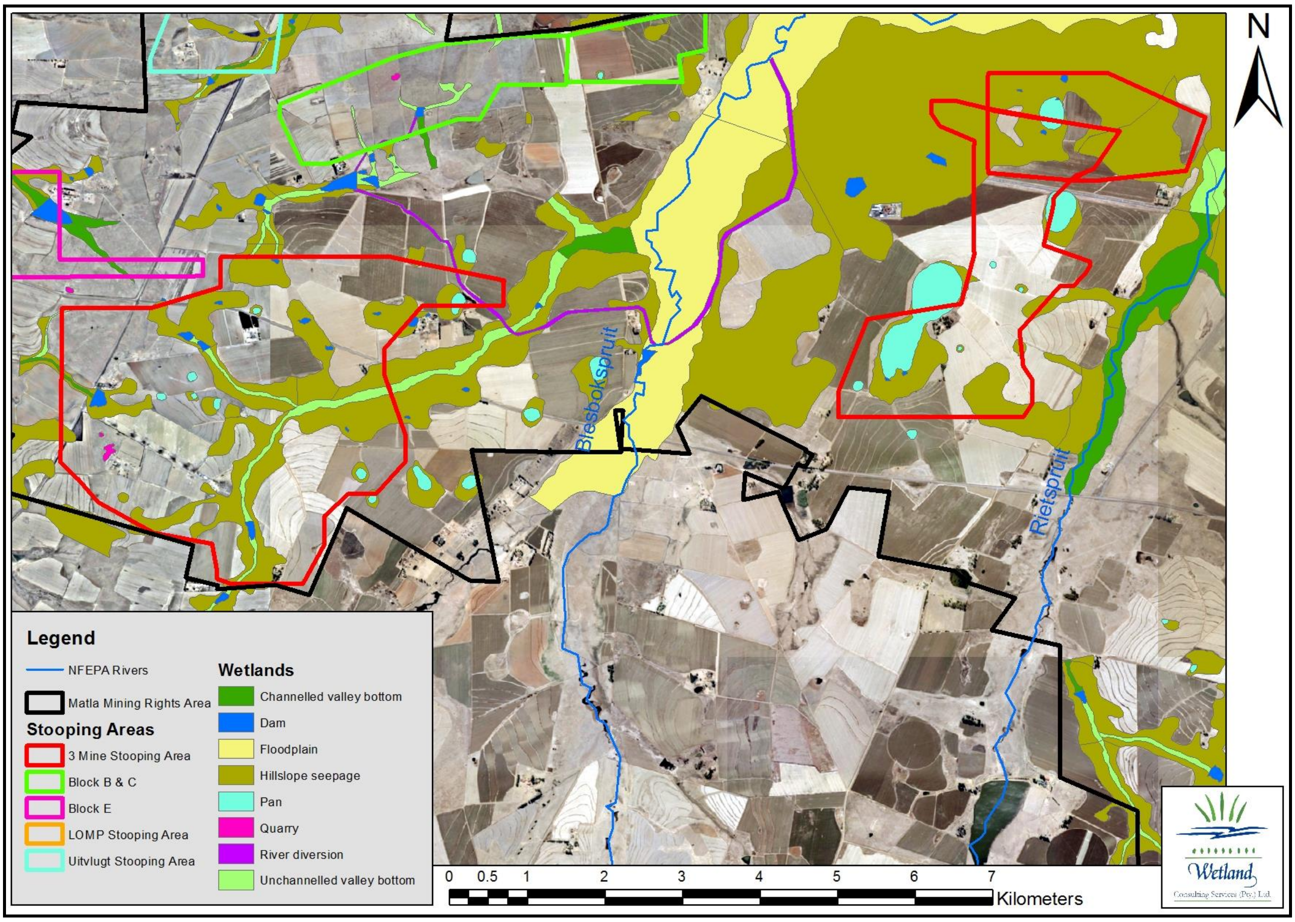

Figure 16. Map of the delineated wetlands within the 3 Mine study area.

The 3 Mine stooping area consists of two distinct sections, the eastern (Block F) and western (Block G & H) sections, which are separated by the large floodplain wetland associated with the Blesbokspruit. A large river diversion, in excess of 11 km in length, has in the past been constructed across the Blesbokspruit to allow for shortwall mining originally, and later stooping (due to safety reason) (Koos Smit, pers. comm.), underneath the floodplain wetland. The currently proposed stooping activities however avoid the Blesbokspruit floodplain.

The eastern section of the 3 Mine stooping area is characterised by a number of large hillslope seepage wetlands as well as a number of pans, which includes the Grootpan. The Grootpan is a large seasonal pan resembling two pans that have joined together, with the south western half of the pan being characterised by more extended saturation; at the time of the site visit the only remaining surface water was observed in this section of the pan. Two further large pans occur within this eastern section – the more northerly is characterised by a shallow, poorly defined basin and is considered a seasonal, grassed pan. The large central pan, which falls only partially within the proposed stooping area and which lies immediately adjacent to the existing conveyor, is considered a permanent pan. This pan was characterised by significant numbers of water birds during the site visit undettaken for the 2012 study, including at least 5 Greater Flamingo (Phoenicopterus roseus), which are listed as Near Threatened in the Eskom Red Data Book of Birds of South Africa, Lesotho and Swaziland (Taylor *et al*., 2015)

As the eastern section of the 3 Mine stooping area is located along a watershed, some of the hillslope seepage wetlands drain west towards the Blesbokspruit floodplain and the others east towards a tributary of the Rietspruit. Once again the hillslope seepage wetlands have formed on shallow sandy soils underlain by a plinthic horizon which forms an aquitard and prevents the deeper infiltration of water. A number of the hillslope seepage wetlands have been cultivated in the past, but recognition by the farmers that these areas are too wet for cultivation has resulted in many of these areas having been converted to planted pastures.

The western section of the 3 Mine stooping area makes up most of the upper catchment of an unnamed tributary to the Blesbokspruit, though the western most sections of the site fall within the adjacent catchment and drain west towards the Kromdraaispruit. A number of small pans were also identified.

6.1.6 LOMP Stooping Area – Block I

Wetlands cover approximately 43 % of the LOMP study area, with the wetland area again dominated by extensive hillslope seepage wetlands, which make up almost 92 % of the wetland extent on site.

Table 13. Extent of the various wetland types recorded within the LOMP study area.

Wetland Type	Area (ha)	% of wetland area	% of study area
Channelled valley bottom	63.3	3.6%	1.5%
Unchannelled valley bottom	6.0	0.3%	0.1%
Hillslope seepage	1602.9	91.9%	39.1%
Pan	18.0	1.0%	0.4%
Dam	51.8	3.0%	1.3%
Quarry	2.7	0.2%	0.1%
TOTAL	**1744.7**	**100%**	**43%**

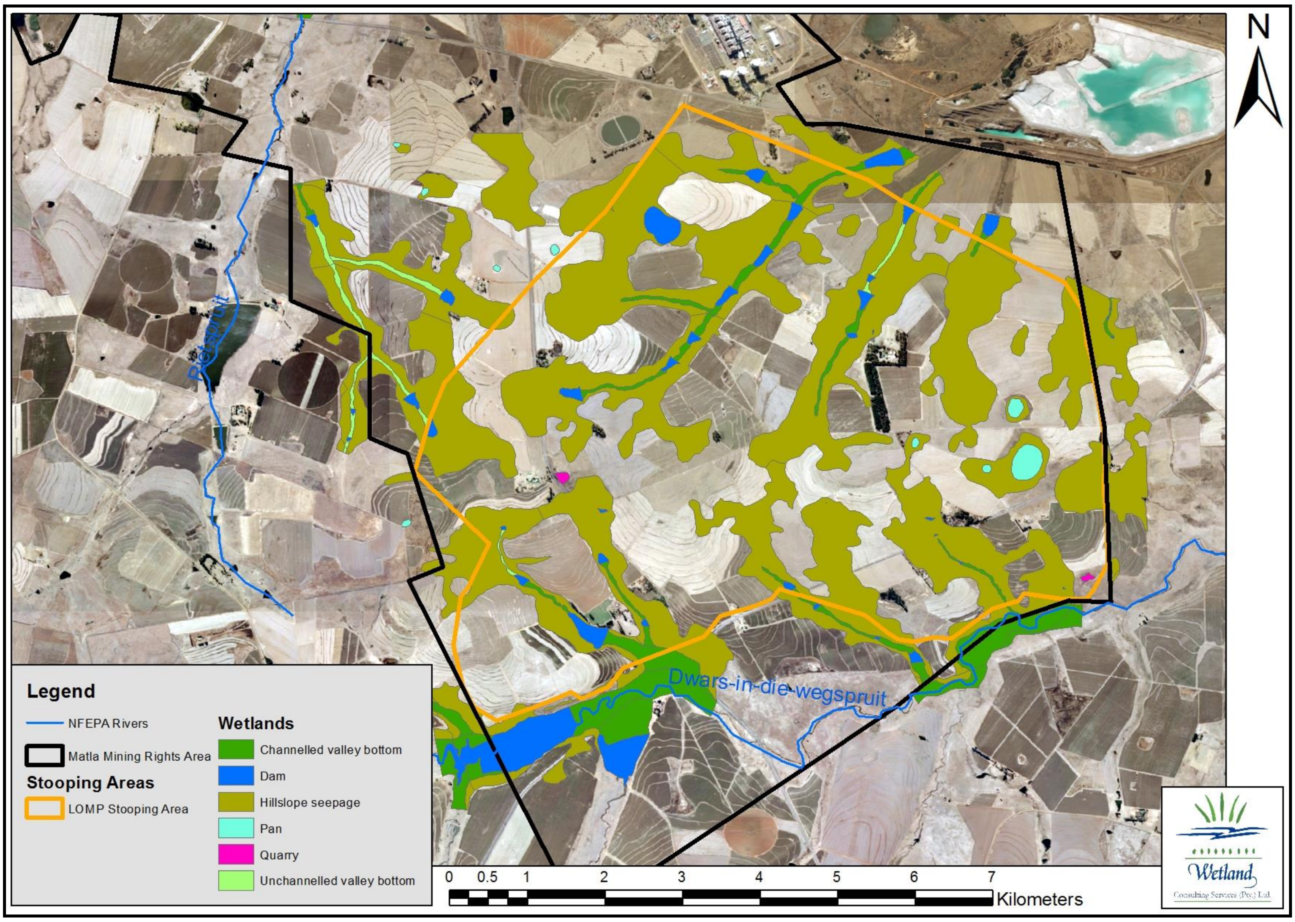

Figure 17. Map showing the delineated wetlands within the LOMP study area.

The LOMP stooping area is also located along a watershed. The Dwars-in-die-wegspruit flows roughly adjacent to the southern boundary of the LOMP stooping area, and the southern half of the study area drains towards the Dwars-in-die-wegspruit. The wetlands within this catchment consist mostly of extensive hillslope seepage wetlands that feed into a number of small channelled valley bottom wetlands, though a large channelled valley bottom that feeds into the Vaalbankspruit from the south was also identified. A number of large farm dams, the largest being over 56 ha, occur within these wetland systems.

Most of the north eastern part of the study area drains towards the ash dam associated with Matla Power Station where flows from the wetland are discharged into a river diversion around the dump, with flows eventually draining towards the Steenkoolspruit. Wetlands are again dominated by hillslope seepage wetlands associated with the headwaters of a number of small valley bottom wetlands, with many small farm dams constructed across the valley bottoms. This indicates that most of these systems are not characterised by the presence of surface water for extended periods, with the dams presumably constructed to ensure the presence of surface water for livestock watering.

The north western corner of the LOMP study area drains in a northerly direction to eventually feed into the Rietspruit.

6.2 Fauna and Flora

A brief discussion of wetland related fauna and flora is provided in this section, based on existing information and observations collected during the wetland delineation field work. For further information, the reader is referred to the specialist fauna and flora report compiled by Bathusi Environmental Consulting (2014).

6.2.1 Flora

A number of vegetation classification systems have been compiled for South Africa. According to Acocks (1953), the study area falls mostly within Themeda Veld (Turf Highveld), with a small portion in Bankenveld. Low and Rebelo (1996), the study area falls across two vegetation types, with the northern reaches (Uitvlugt study area and most of Mine 3 study area) classified as Moist Sandy Highveld Grassland and the southern reaches as Moist Clay Highveld Grassland (most of the LOMP study area).

According to the most recent vegetation classification of the country however, "*The Vegetation of South Africa, Lesotho and Swaziland*" (Mucina and Rutherford, 2006), the study area falls within the Grassland Biome, Mesic Highveld Grassland Bioregion. At a finer level, the study area is classed as Eastern Highveld Grassland (Mapping Unit Gm12, Mucina and Rutherford, 2006).

Eastern Highveld Grassland is mostly confined to Mpumalanga and western Swaziland, occurring marginally as well into Gauteng. The conservation status of this vegetation type is Endangered (Mucina & Rutherford, 2006), and whilst the conservation target is 24%, only a small fraction (<1%) is currently protected and 44% is considered to be transformed, mostly by cultivation, forestry, mines, dams and urbanisation. Typical Eastern Highveld Grassland is dominated by a variety of grass species, including *Aristida aequiglumis, Aristida congesta, Aristida junciformis, Brachiaria serrata, Cynodon dactylon, Digitaria monodactyla, Digitaria tricholaenoides, Elionurus muticus, Eragrostis chloromelas, Eragrostis curvula, Eragrostis plana, Eragrostis racemosa, Eragrostis sclerantha, Heteropogon contortus, Loudetia simplex, Michrochloa caffra, Monocymbium ceresiiforme, Setaria sphacelata, Sporobolus africanus, Sporobolus pectinatus, Themeda triandra, Trachypogon spicatus, Tristachya leucothrix* and *T. rehmannii*. A number of herbaceous plants may also be found, including *Berkheya setifera, Haplocarpha scaposa, Justicia anagalloides* and *Pelargonium luridum*. (Mucina & Rutherford, 2006).

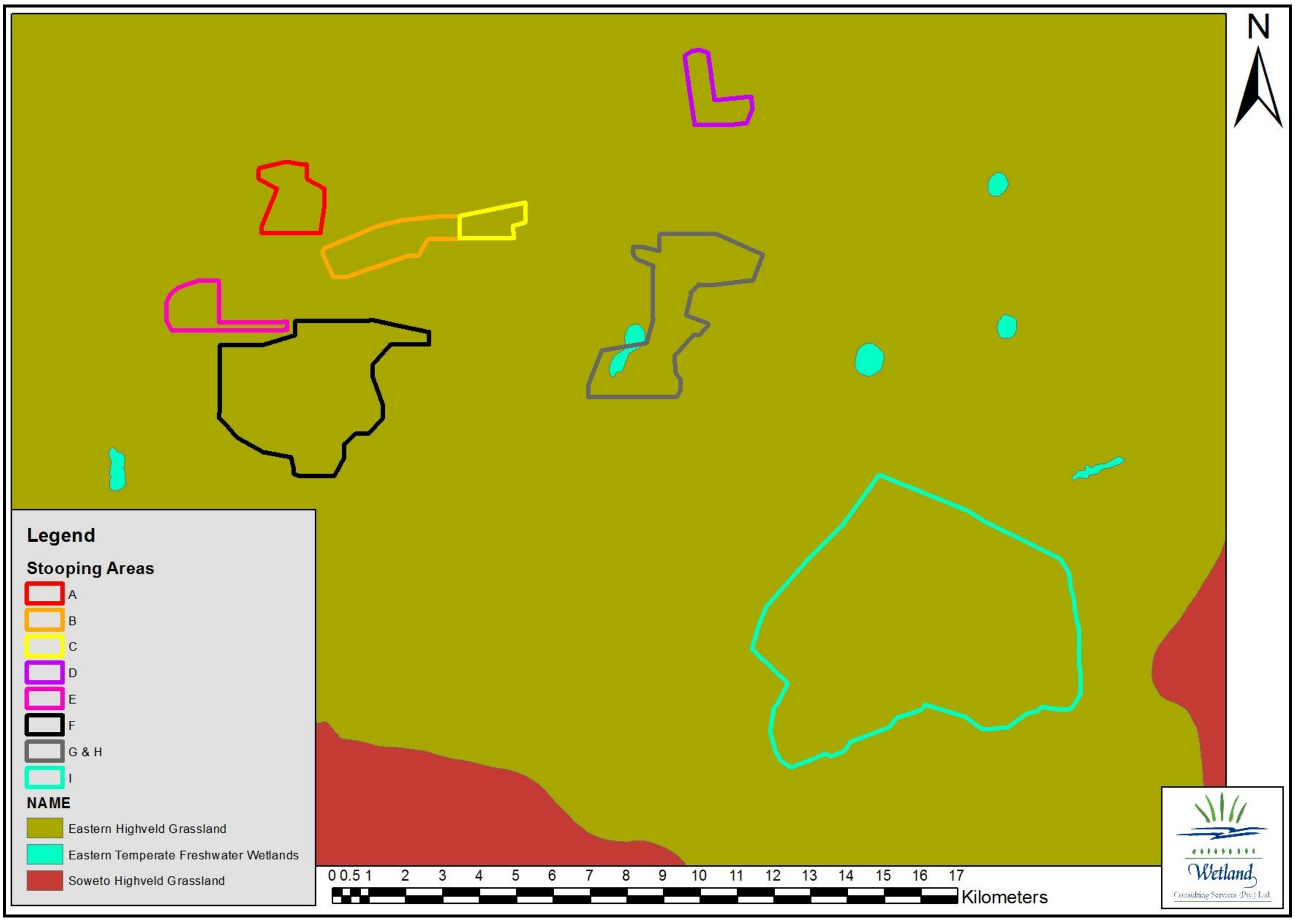

Figure 18. Map showing the vegetation types occurring within the study area, based on Mucina and Rutherford (2006).

The wetlands within the study area, though not labelled as such by Mucina and Rutherford (2006) most probably due to an issue of scale (with the exception of some of the larger pans), are considered to conform to the Eastern Temperate Freshwater Wetlands (Mapping AZf3, Mucina and Rutherford, 2006) vegetation type.

Eastern Temperate Freshwater Wetland vegetation occurs throughout South Africa except for the Western and Northern Cape Provinces. It is described as an intrazonal vegetation type occurring along water bodies with stagnant and slow flowing water and is embedded within the Grassland Biome of South Africa. It occurs on flat landscapes and within shallow depressions characterised by mostly temporary water bodies that support zoned systems of aquatic and hygrophilous vegetation. Dominant species listed by Mucina and Rutherford are as follows:

Megagraminoid: *Cyperus congestus, Phragmites australis, Schoenoplectus corymbosus, Typha capensis.*

Graminoids: *Agrostis lachnantha, Carex acutiformis, Eleocharis palustris, Eragrostis plana, E. planiculmis, Fuirena pubescens, Helictotrichon turgidulum, Hemarthria altissima, Imperata cylindrica, Leersia hexandra, Paspalum dilatatum, P. urvillei, Pennisetum thunbergii, Schoenoplectus decipiens, Scleria dieterlenii* and *Setaria sphacelata.*

Herbs: *Centella asiatica, Ranunculus multifidus.*

Within the study area the natural vegetation has been impacted and extensively transformed by agriculture. Most of the terrestrial areas of the site are currently under cultivation, while cultivation also extends significantly into temporary and seasonally wet areas. In many cases the extent of historical cultivation exceeds the current extent of cultivation as cultivation has over time been withdrawn from marginal soils; generally soils that are too wet for cultivation and that fall within the definition of a wetland. These areas are currently characterised by secondary vegetation or by planted pastures.

Further impacts to the vegetation have resulted as a consequence of heavy grazing pressure and trampling of vegetation by livestock within the wetlands (due to cultivation of virtually all terrestrial areas, livestock are forced to graze within wetland areas), as well as poorly managed and timed burning of the wetland areas.

Despite these impacts, the wetlands on site represent virtually the only remaining areas of indigenous vegetation on site and thus play a vitally important role in biodiversity support at the local and regional level.

The vegetation and species diversity within the various wetlands on site varied based on a number of factors. The greatest diversity was recorded within the hillslope seepage wetlands on site. This is to be expected given that hillslope seepage wetlands make up more than 80 % of the wetland area on site, but further factors also contribute. The variability in soil depth and characteristics as well as the associated differences in saturation of the soil profile between hillslope seepage wetlands and even within a hillslope seepage wetland result in a diverse range of microhabitats that lead to increased diversity. Conditions within the hillslope seepage wetlands ranged from permanent saturation through to near terrestrial, very temporary saturation, resulting in a mosaic of wetness zones that is reflect in the vegetation through differing species composition and structure.

In total, 83 plant species were recorded within the wetland habitats on site, with a list provided in Table 5. This list is by no means complete and is reproduced only to provide an indication of the more common and widespread species observed within the wetlands on site, as well as the different wetlands in which the species were observed. For further details on the flora of the study area, refer to the specialist vegetation report prepared by Bathusi as part of the EIA/EMP project.

Table 14. List of plant species recorded within the wetlands on site during the wetland survey field work.

Species	Hillslope seepage	Valley bottom	Pan
Agrostis lachnantha	1	1	
Andropogon appendiculatus	1		
Aristida congesta	1		
Aristida junciformis	1		
Berkheya africana	1		

Species	Hillslope seepage	Valley bottom	Pan
Berkheya radula	1		
*Bidens formosa**	1	1	
Chironia purparescens	1		
*Cirsium vulgare**	1	1	
*Conyza albida**	1		
Crinum bulbispermum		1	
Cycnium tubulosum	1		
Cynodon dactylon	1		1
Cyperus congestus	1	1	
Cyperus digitatus		1	
*Cyperus esculentus**	1		
Cyperus sp.		1	1
Echinochloa crus-galli	1		
Echinochloa sp.		1	
Eleocharis dregeana	1	1	1
Eragrostis chloromelas	1	1	
Eragrostis curvula	1		
Eragrostis gummiflua	1		
Eragrostis inamoena		1	1
Eragrostis plana	1	1	
Eucomis autumnalis	1		
Euphorbia striata	1		
Fimbrostylus complanata	1		1
Fimbrostylus dichotoma	1	1	
Fingerhuthia africana		1	
Fuirena pubescens	1		1
Gladiolus crassifolius	1		
Helichrysum aureonitens	1		
Helictotrichon turgidulum	1		
Hermathria altissima	1	1	1
Homeria pallida			
Hyparrhenia hirta	1	1	
Hypochaeris radicata	1		
Hypoxis acuminata	1		
Hypoxis sp.	1		
Imperata cylindrica	1	1	
Isolepis sp.	1		1
Juncus dregeanus		1	
Juncus effusus	1	1	
Juncus oxycarpus	1	1	1
Kniphofia sp.		1	

Species	Hillslope seepage	Valley bottom	Pan
Kyllinga erecta	1	1	
Kyllinga sp.		1	
Leersia hexandra	1	1	1
Limosella maior			1
Monopsis decipiens	1		
Moraea thomsonii	1		
*Oenothera rosea**	1	1	
Oxalis sp.	1	1	
Panicum coloratum		1	
Panicum hymeniochilum	1		
Paspalum dilatatum	1	1	1
Paspalum distichum	1	1	1
*Paspalum urvillei**	1	1	
*Pennisetum clandestinum**	1		
Pennisetum thunbergii	1	1	
Persicaria attenuata	1		
*Persicaria lapathifolia**		1	1
Persicaria sp.	1		
*Plantago lanceolata**	1		
Pseudognaphalium luteo-album	1		
Pycreus macranthus	1		
Ranunculus multifidus		1	
Rumex crispus	1	1	
Schizachyrium sanguineum	1		
Schoenoplectus corymbosus	1	1	1
Schoenoplectus decipiens	1	1	
Scirpoides burkei	1		
Senecio sp.	1		
Setaria nigrirostris	1		
Setaria pallide-fusca	1		
Sonchus dregeanus	1		
Stoebe vulgaris	1		
*Tagetes minuta**	1		
Themeda triandra	1	1	
Typha capensis	1	1	1
*Verbena bonariensis**	1		
Wahlenbergia caledonica	1		
Total species (83)	**69**	**38**	**16**

6.3 Functional Assessment

Within the study area the wetlands represent the virtually the only remaining areas of indigenous vegetation within a landscape largely altered by agriculture and mining, as well as infrastructure and activities associated with the Matla Power station. Most of the areas on site that were once characterised by terrestrial grassland have been cultivated and now provided limited habitat for faunal species, though a number of bird species do nonetheless utilise these cultivated areas for feeding purposes. Mining and the Matla Power Station further add to disturbances and habitat transformation within the area.

Only the wetland areas are still characterised by extensive areas of indigenous vegetation, even if many of the hillslope seepage wetlands have also been substantially impacted by cultivation in the past and are now characterised by secondary vegetation. Despite these disturbances, the wetlands play an important role at the local and regional scale in supporting biodiversity, not only wetland dependant and adapted species, but also terrestrial grassland species given the near complete transformation of terrestrial grassland habitat. Certain wetlands on site are also considered important at a national scale in biodiversity support as they support threatened species such as the African Grass Owl as well as Greater Flamingo.

In addition to biodiversity support, other functions typically attributed to wetlands include nutrient removal (and more specifically nitrate removal), sediment trapping (and associated with this is the trapping of phosphates bound to iron as a component of the sediment), stream flow augmentation, flood attenuation, trapping of pollutants and erosion control. Most of these functions can be described as indirect use functions – beneficial services which the wetlands provide through ecological process and functions. Many of these functions attributed to wetlands are wetland type specific and can be linked to the position of wetlands in the landscape as well as to the way in which water enters and flows through the wetland. Thus not all wetlands can be expected to perform all functions, or to perform these functions with the same efficiency.

However, based on the hydro-geomorphic wetland type which classifies wetlands on the way that water moves through the wetland as well as the position of the wetland within the landscape, certain assumptions on the functions supported by wetlands can be made.

Hillslope Seepage Wetlands:
Hillslope seepage wetlands make up 82 % of the wetlands on site and over 33 % of the land area. Hillslope seeps support conditions that facilitate both sulphate and nitrate reduction as interflow emerges through the organically rich wetland soil profile, and are thus thought to contribute to water quality improvement and/or the provision of high quality water. The greatest importance of the hillslope seepage wetlands on site is thus taken to be the movement of clean water through the hillslope seepage wetlands and into the adjacent valley bottom wetlands. Given the serious water quality concerns experienced in the upper Olifants River catchment, this provision of clean water assumes even greater importance. However, the seepage wetlands merely reflect the movement of this clean water through the landscape (in the sub-surface) and do not themselves produce the clean water.

As hillslope seepage wetlands, for the most part, are dependent on the presence of an aquiclude, either a hard or soft plinthic horizon, they are not generally regarded as significant sites for groundwater recharge (Parsons, 2004). However, by retaining water in the landscape and then slowly releasing this water into adjacent valley bottom or floodplain wetlands, hillslope seepage wetlands contribute to stream flow augmentation, especially during the rainy season and early dry season. From an overall water yield perspective there is evidence that they contribute to water loss. The longer the water is retained on or near the surface the more likely it is to be lost through evapo-transpiration (McCartney, 2000). Hillslope seepage wetlands are not generally considered to play an important role in flood attenuation, though early in the season, when still dry, the seeps have some capacity to retain water and thus reduce surface run-off. Later in the rainy season when the wetland soils are typically saturated, infiltration will decrease and surface run-off increase. Further flood attenuation can be provided by the roughness of the wetland vegetation; the greater the surface roughness of a wetland, the greater is the frictional resistance offered to the flow of water and the more effective the wetland will be in attenuating floods (Reppert *et al*., 1979). In terms of the hillslope seepage wetlands on site, the surface roughness is taken to be moderately low, given that the seepage wetlands are characterised by typical grassland vegetation offering only slight resistance to flow.

From a biodiversity perspective, hillslope seepage wetlands support plants in particular, and associated insects, birds and small mammals adapted to the seasonal moisture regime. The mosaic of moisture regimes within the hillslope seepage wetlands, ranging from temporary wetness in the rainy season to near permanent wetness in some areas results in a wide range of microhabitats within the hillslope seepage wetlands on site. Of all the wetland types on site, seepage wetlands displayed the highest species richness.

Valley Bottom Wetlands:
Valley bottom wetlands make up roughly 10.4 % of the wetland area on site, with channelled valley bottom wetlands, unchannelled valley bottom wetlands and a portion of the Rietspruit floodplain occurring on site.

Channelled valley bottom wetlands receive water typically from surface run-off in the upslope catchment and convey it via the channel to the downslope catchment. Under normal flow conditions water is confined to the channel, though flood flows can overtop the channel banks and spread across the wetland. Under these conditions the valley bottom wetlands can contribute to flood attenuation and sediment trapping as flows overtopping the channel banks are spread out and slowed down through the surface roughness provided by the vegetation, leading to sediment deposition. In instances where flow is confined to the channel, for example under normal flow conditions or in instances where a deeply incised channel prevents overtopping, sediment transport rather than sediment deposition is the dominant process, which is evidence by the erosion of a channel through the wetland. Channel erosion may be both vertical and/or lateral. Given the limited contact time between the water and the wetland soils as well as the limited deposition of sediments, the channelled valley bottom wetlands on site are not expected to perform important water quality functions.

By providing a habitat differing from the surrounding terrestrial grasslands and hillslope seepage wetlands, the channelled valley bottom wetlands play a role in maintaining biodiversity within the landscape.

Un-channelled valley bottom wetlands reflect conditions where surface flow velocities are such that they do not, under existing flow conditions, have sufficient energy to transport sediment to the extent that a channel is formed. In addition to the biodiversity associated with these systems it is expected that they play an important role in retaining water in the landscape as well as in contributing to influencing water quality through for example mineralisation of rain water. In general, these wetlands could be seen to play an important role in nutrient removal, including ammonia, through adsorption onto clay particles.

Pan Wetlands:
Pans account for around 3.7 % of the wetland area in the study site. Given the position of many pans within the landscape, which is usually isolated from any stream channels, the opportunity for pans to attenuate floods is fairly limited, though some run-off is stored in pans. In the cases where pans are linked to the drainage network via seep zones, the function of flood attenuation is somewhat elevated. Pans are also not considered important for sediment trapping, as many pans are formed through the removal of sediment by wind when the pan basins are dry. Some precipitation of minerals and de-nitrification is expected to take place within pans, which contributes to improving water quality. Some of the accumulated salts and nutrients can however be exported out of the system and deposited on the surrounding slopes by wind during dry periods.

Direct Use Benefits:
Direct uses of the wetlands on site include the use of water for livestock watering purposes (through the building of small dams within the wetlands), grazing and crop production (through cultivation within the wetland areas on site). As all of the wetlands are located on private land, access to the wetlands is limited and little use is made of the wetlands in terms of recreational activities such as fishing or bird watching, even though opportunities for such activities exist, most notably in the various large pans (in terms of bird watching) and the numerous farm dams (fishing).

No information regarding potential cultural value of the wetlands on site was available or could be found. However, given that all of the study has been privately owned for numerous years and that access to the land is thus limited, it is considered unlikely that the wetlands hold any significant cultural value.

6.4 Present Ecological Status (PES) Assessment

The present ecological state assessment (PES) was undertaken using the Level 1 WET-Health methodology (Mcfarlane et al., 2009) for all wetlands excluding pans, for which the PES was assessed using the 1999 RDM methods (DWAF, 1999). The rating scale for the assessment is provided in Table 6.

The study area was subdivided in small sub-catchments so as to identify individual wetland units for assessment. Each wetland unit was classified into the various hydro-geomorphic wetland types represented within the unit and each hydro-geomorphic wetland type was then assessed in terms of hydrology, geomorphology and vegetation. The identified wetland units are shown in Figures 19 and 20.

Hydrology is defined in this context as the distribution and movement of water through a wetland and its soils. This module focuses on changes in water inputs as a result of changes in catchment activities and characteristics that affect water supply and its timing (extrinsic), as well as on modifications within the wetland that alter the water distribution and retention patterns within the wetland, intrinsic factors.

Geomorphology is defined in this context as the distribution and retention patterns of sediment within the wetland. This module focuses on evaluating current geomorphic health through the presence of indicators of excessive sediment inputs and/or losses for clastic (minerogenic) and organic sediment (peat).

Vegetation is defined in this context as the vegetations' structural and compositional state. This module evaluates changes in vegetation composition and structure as a consequence of current and historic onsite disturbances.

Each of the various proposed mining areas is now discussed individually.

Table 15. Table showing the rating scale used for the PES assessment.

Description	Combined impact score	PES Category
Unmodified, natural.	0-0.9	A
Largely natural with few modifications. A slight change in ecosystem processes is discernable and a small loss of natural habitats and biota may have taken place.	1-1.9	B
Moderately modified. A moderate change in ecosystem processes and loss of natural habitats has taken place but the natural habitat remains predominantly intact	2-3.9	C
Largely modified. A large change in ecosystem processes and loss of natural habitat and biota and has occurred.	4-5.9	D
The change in ecosystem processes and loss of natural habitat and biota is great but some remaining natural habitat features are still recognizable.	6-7.9	E
Modifications have reached a critical level and the ecosystem processes have been modified completely with an almost complete loss of natural habitat and biota.	8 - 10	F

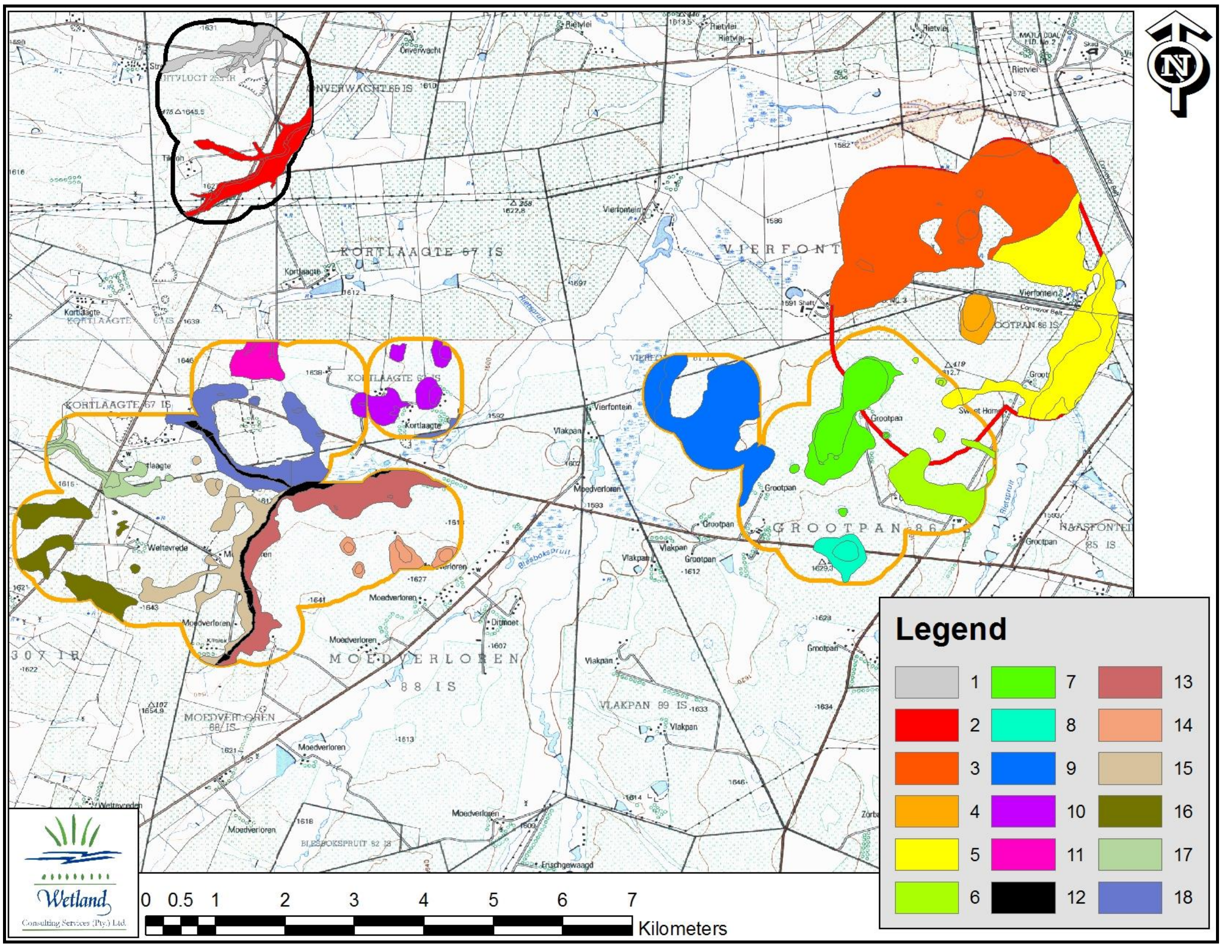

Figure 19. Map showing wetland units 1 to 18

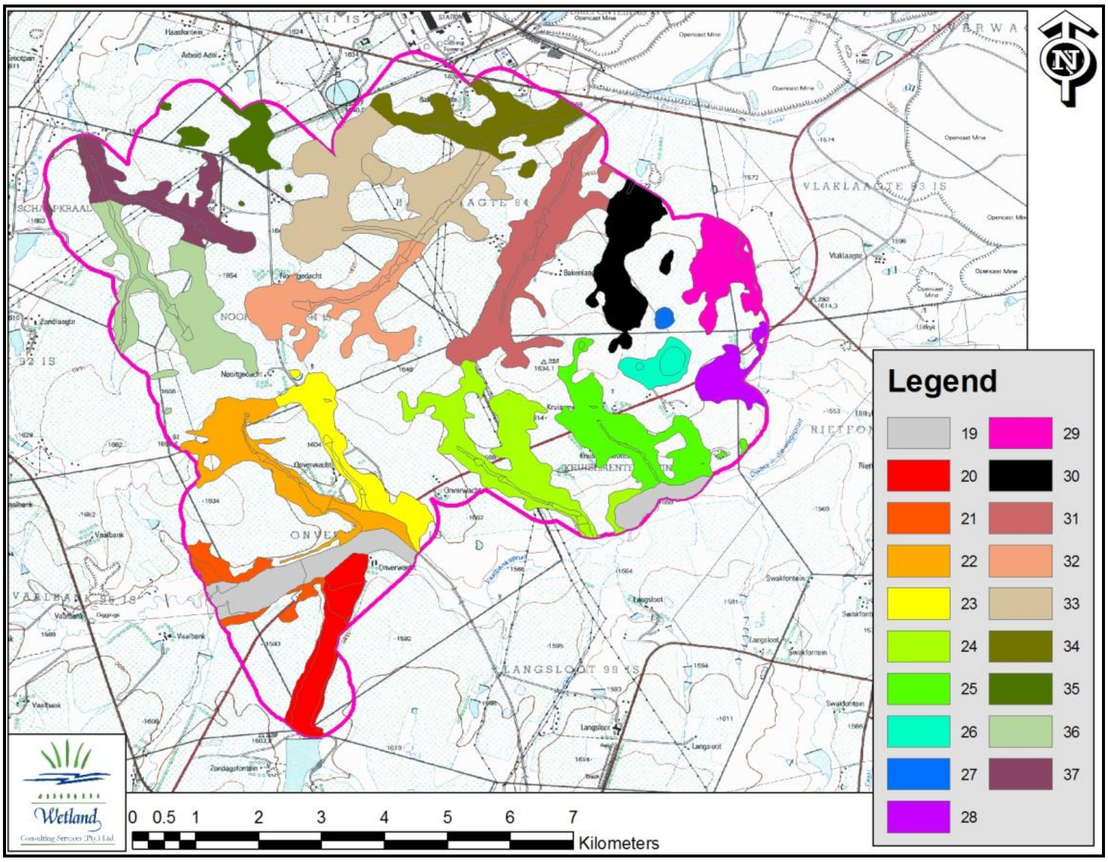

Figure 20. Map showing wetland units 19 to 37

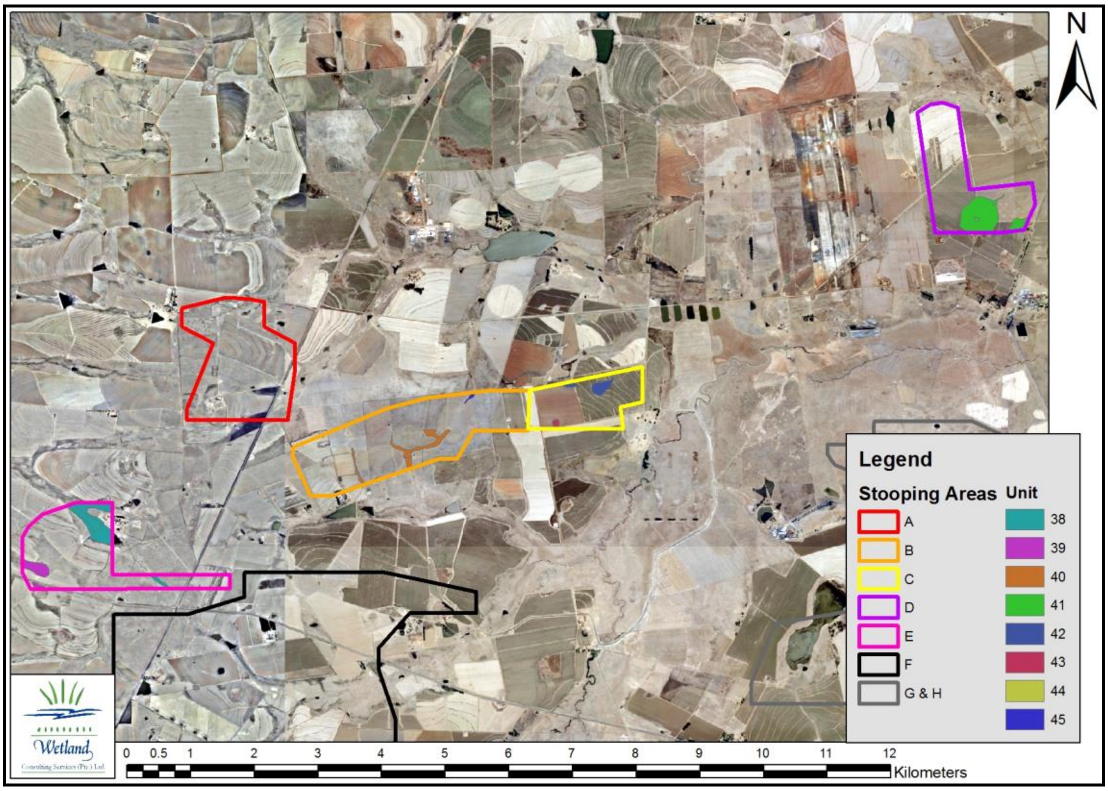

Figure 21. Wetland units within the additional mining areas - wetland units 38 to 45.

6.4.1 PES – Uitvlugt Study area

All of the wetlands within the proposed Uitvlugt stooping area were considered to be ***moderately modified (PES C)***. The modifications to the wetlands are mostly as a result of agricultural activities that have resulted in significant impact to the vegetation of the wetlands through cultivation within the wetland boundaries and conversion of parts of the hillslope seepage wetlands to planted pastures. Both the wetland systems are also crossed by public roads that concentrate flows through culverts and have resulted in channel incision within the wetlands. In the case of the northern wetland system, consistent leakage/overflow of a cattle drinking trough fed by a windmill has resulted in increased water inputs to the wetland and increased the wetland extent slightly.

Table 16. Results of the PES assessment for wetlands in the Uitvlugt Study Area

Unit	Area (ha)	Hydrology	Geomorphology	Vegetation	Combined score
Wetland Unit 1					
Valley Bottom	3.13	2	1.7	2.8	2.14
Hillslope Seepage	30.03	2	1.3	4.9	2.63
PES	**33.16**	**C**	**B**	**D**	**C**
Wetland Unit 2					
Valley Bottom	6.8	2	2.1	4.6	2.77
Hillslope Seepage	47.4	2	1.6	5.4	2.86
PES	**54.2**	**C**	**B**	**D**	**C**

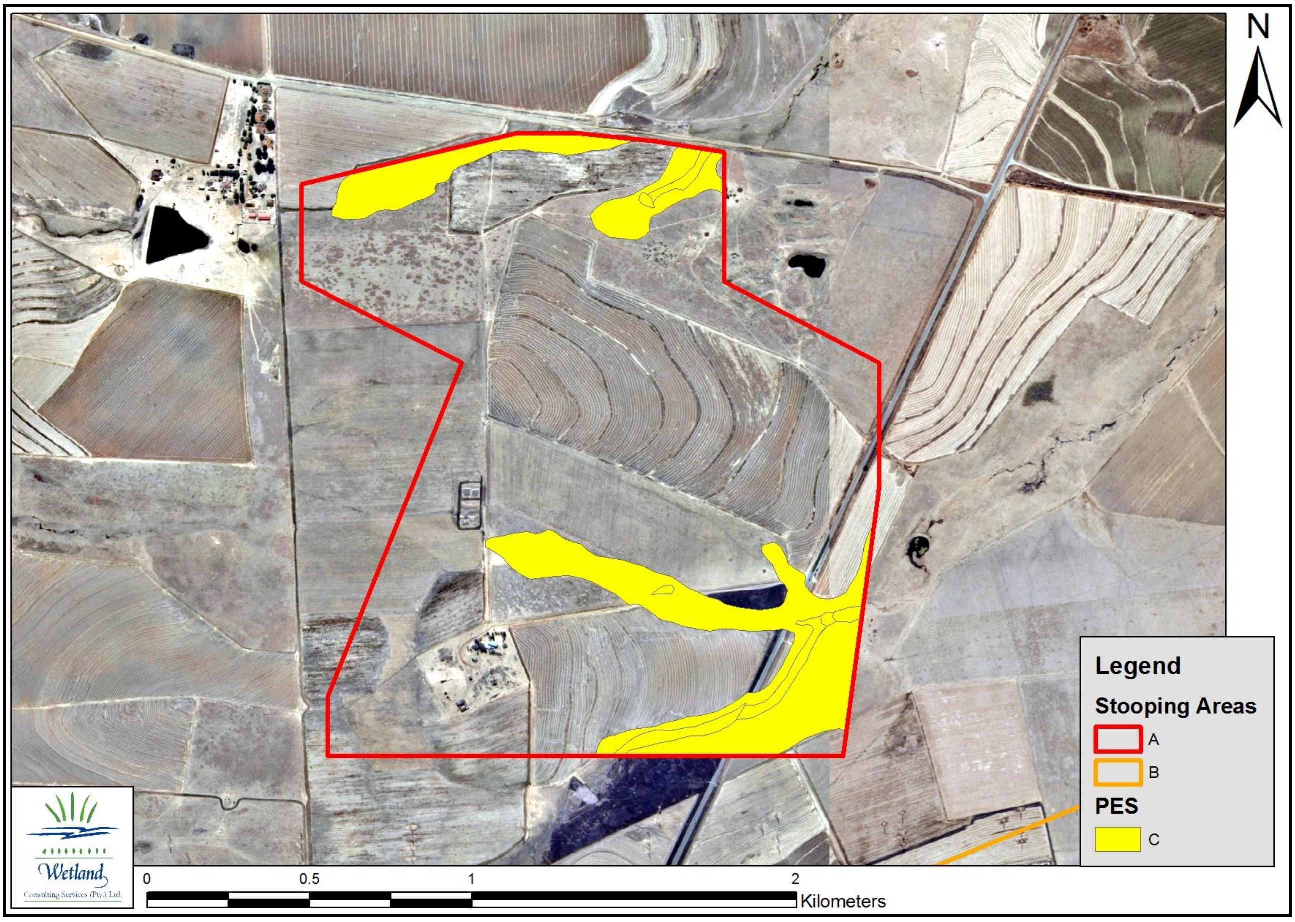

Figure 22. Map showing the results of the PES assessment for wetlands in the Uitvlugt Study Area

6.4.2 PES – Block B & C

Within the Block C and the east of Block B, the wetlands have been mostly impacted by agricultural activities. These have had a marked impact on the vegetation component of especially the hillslope seepage wetlands, which in most cases are now characterised by secondary vegetation. Cultivation would also have impacted on the runoff characteristics of the landscape through a likely marginal increase in surface runoff, as well as increase sediment transport into the wetlands.

Hydrological impacts have been more severe within the south draining wetlands of Block B. The large Blesbokspruit river diversion originates in this area and intercepts and diverts all flows from these wetlands, resulting in the remaining wetland habitat immediately downslope of the diversion being seriously modified due to decreased flows. Discharge of water into one of the wetland systems (the eastern unchannelled valley bottom wetland) has also largely altered the hydrology supporting this wetland.

Table 17. Results of the PES assessment for wetlands within the Block B and C area.

Unit	Area (ha)	Hydrology	Geomorphology	Vegetation	Combined score
Wetland Unit 40					
Unchannelled valley bottom (west)	1.21	2	0.4	1.2	1.3
Unchannelled valley bottom (far west)	1.49	6.5	1.95	4.6	4.7
Unchannelled valley bottom (east)	5.17	5.0	4.0	3.4	4.3
Channelled valley bottom	1.35	9.0	8.0	3.0	7
PES	**9.22**				**D**
Wetland Unit 42					
Hillslope Seepage (west)	1.56	1.0	0.65	5.0	2.0
Hillslope Seepage (east)	5.06	5.0	1.15	5.6	4.1
PES	**6.62**				**C**
Wetland Unit 43					
Hillslope Seepage	0.51	5.0	1.15	7.0	4.1
Pan	0.53	n/a	n/a	n/a	C
PES	**1.04**				**C**
Wetland Unit 44					
Hillslope Seepage	0.09	5.0	1.15	3.7	4.3
PES					**D**
Wetland Unit 45					
Unchannelled Valley Bottom	0.74	2.0	0.4	3.6	2.0
PES					**C**

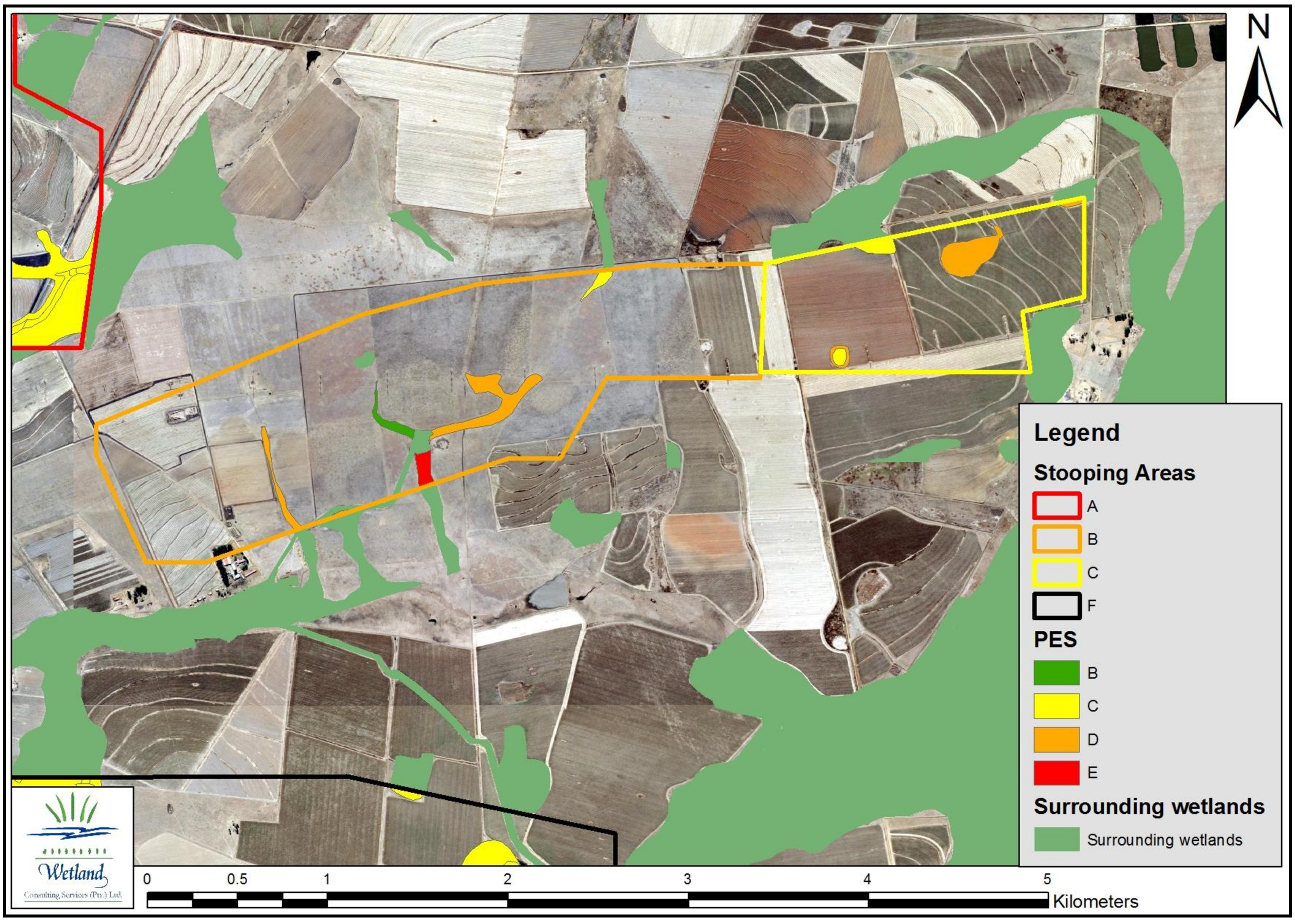

Figure 23. Map showing the results of the PES assessment for wetlands in the Block B and C area.

6.4.3 PES – Block D

Two large hillslope seepage wetlands and a very small depression/pan occur within Block D. These wetlands have been impacted by agricultural activities that extend into the wetland areas. Portions of these wetlands are currently under cultivation and were completely bare of vegetation at the time of the site visit. Large areas are characterised by planted pasture and were heavily grazed, with the remainder of the seepage wetlands characterised by secondary vegetation due to past cultivation. Flow through the wetlands has also been impacted by a small farm dam, a number of farm track crossings and several old drains. As a result, these wetlands were considered to be in a **largely modified condition (PES category D)**.

Table 18. Results of the PES assessment for wetlands within the Block D area.

Unit	Area (ha)	Hydrology	Geomorphology	Vegetation	Combined score
Wetland Unit 41					
Pan	0.09	n/a	n/a	n/a	C
Hillslope Seepage	28.47	3.5	2.0	7.1	4.1
PES	**28.56**				**D**

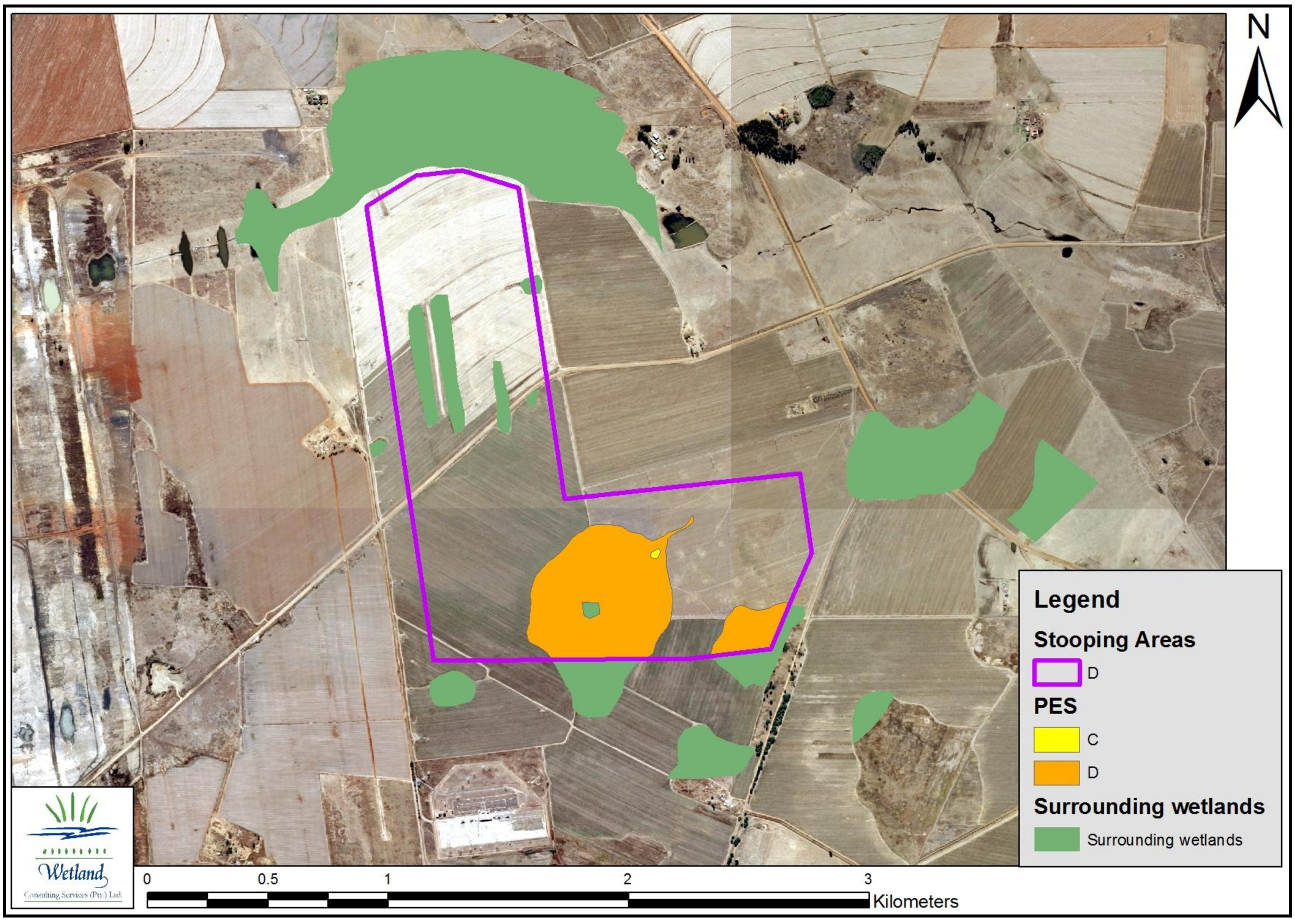

Figure 24. Map showing the results of the PES assessment for wetlands in the Block D area.

6.4.4 PES – Block E

The wetlands within Block E varied from moderately modified to largely modified (PES categories C – D). In general, the impacts to the hillslope seepage wetlands were most severe in terms of the vegetation component, with past cultivation of the temporary wetland areas resulting in large tracts of hillslope seepage wetland characterised by secondary vegetation and in parts still by current cultivation. The south western seepage wetlands were most impacted in this regard.

Hydrological impacts have been more important in the valley bottom wetland, were flow impoundment in the dam and artificial channelisation of the wetland downstream of the dam have altered both the water inputs, as well as the water retention and distribution within the wetland. Upstream of the dam significant erosion, exacerbated by cattle trampling, have impacted markedly on the geomorphology of the system.

Table 19. Results of the PES assessment for wetlands within the Block E area.

Unit	Area (ha)	Hydrology	Geomorphology	Vegetation	Combined score
Wetland Unit 38					
Valley Bottom (above dam)	1.61	2.0	0.4	3.6	2.0
Valley Bottom (below dam)	4.81	6.5	1.3	3.0	4.0
Hillslope Seepage	9.18	2.0	0.65	4.0	2.2
PES	**15.6**				**C**
Wetland Unit 39					
Hillslope Seepage	7.25	5.0	1.2	4.3	3.7
PES					**D**

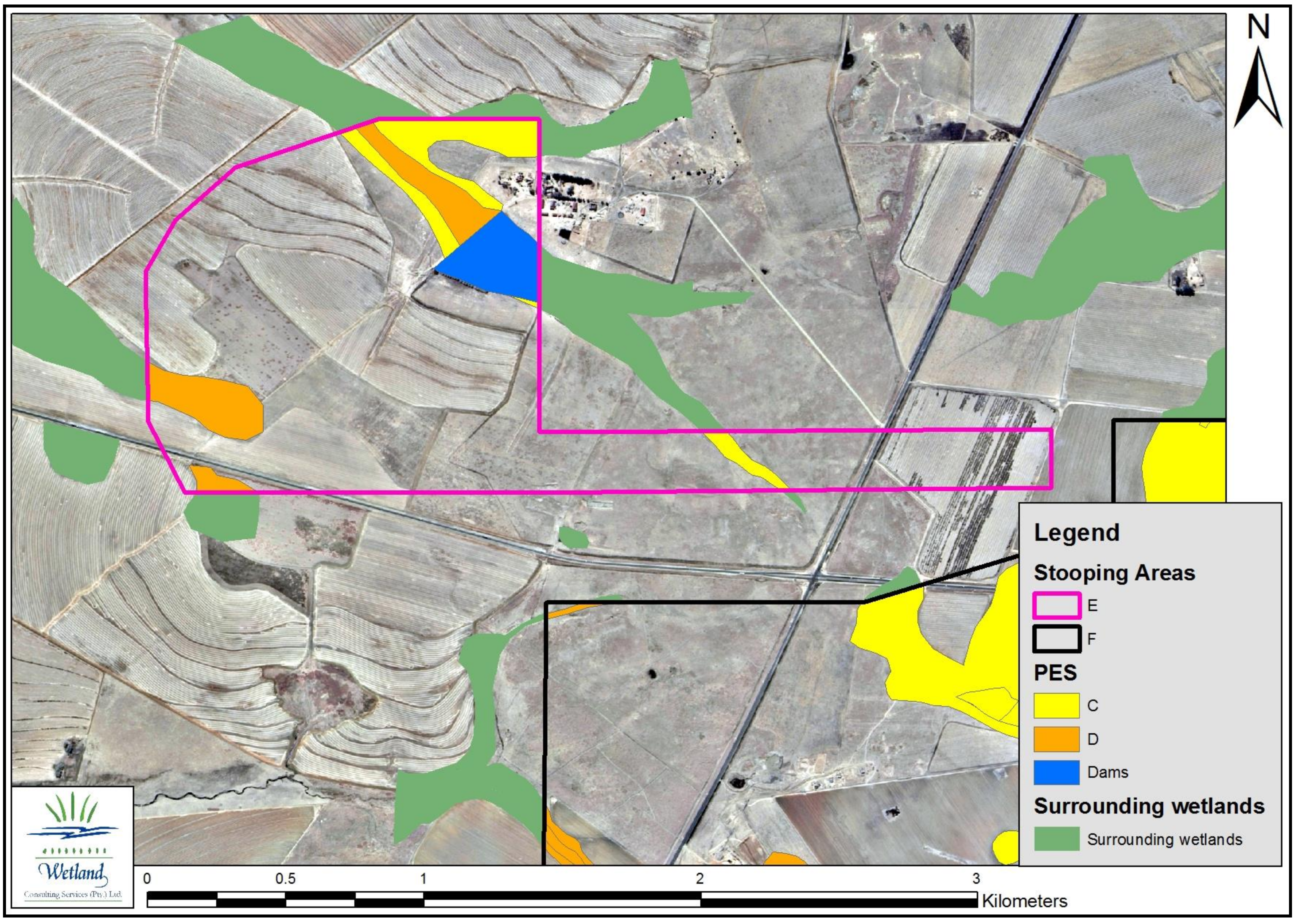

Figure 25. Map showing the results of the PES assessment for wetlands in the Block E area.

6.4.5 PES – 3 Mine Study Area – Blocks F, G & H

As is the case with the rest of the study sites, the 3 Mine study area has been subjected to extensive agricultural activities over many years. The impact of this land use on the wetlands is apparent in a number of changes that most of the wetland systems on site have undergone. In terms of the aspects considered in the PES assessment – hydrology, geomorphology and vegetation – both the hydrology and the geomorphology of the majority of wetlands were considered to be moderately modified, while the vegetation was in many cases considered largely to seriously modified.

The impacts to vegetation are mostly associated with a complete transformation of habitat due to cultivation within the wetland boundaries. Historically, the extent of cultivation on site was markedly more extensive than the currently actively cultivated areas. Recognition by farmers that planting maize within seasonally saturated soils provides limited yields has resulted in cultivation being withdrawn from these areas. Such previously cultivated areas were then either converted to planted pastures (generally *Eragrostis* pastures), or were left fallow and natural succession has resulted in these areas being characterised by secondary grassland.

Impacts to hydrology are again mostly related to changes in the distribution and retention of water within the wetlands as the water inputs to the wetlands are expected to have remained largely the same, with the exception of the Blesbokspruit floodplain wetland where the hydrology has been seriously modified through the construction of the river diversion and the surface subsidence due to underground mining that has completely altered the topography and water retention of the floodplain.

Extensive cultivation surrounding the wetlands provides considerable sediment sources to the wetlands that get transported by surface flow following heavy rain as well as wind deposition. In addition, the altered hydrology provides increased capacity for sediment transport out of the wetlands, resulting in the geomorphology of most of the wetlands being moderately modified.

Table 20. Results of the PES assessment for wetlands in the 3 Mine Study Area

Unit	Area (ha)	Hydrology	Geomorphology	Vegetation	Combined score
Wetland Unit 3					
Floodplain	9.8	3.5	3.2	3.8	3.50
Hillslope seepage	450.62	3	2.1	5.6	3.49
Pan	8.5	n/a	n/a	n/a	B
PES		**C**	**C**	**D**	**C**
Wetland Unit 4					
Pan	13.4	n/a	n/a	n/a	B
Hillslope seepage	9.5	2	1	3.1	2.03
PES	**22.9**	**B**	**B**	**C**	**B**

Unit	Area (ha)	Hydrology	Geomorphology	Vegetation	Combined score
Wetland Unit 5					
Valley Bottom	66.7	2	2.3	3.8	2.60
Hillslope seepage	501.6	3	3.4	6.8	4.20
PES	**568.3**	**B**	**C**	**E**	**D**
Wetland Unit 6					
Pan	12	n/a	n/a	n/a	C
Hillslope seepage	63.8	3	3.1	6.7	4.09
PES	**75.8**	**C**	**C**	**E**	**C**
Wetland Unit 7					
Pan	56.5	n/a	n/a	n/a	B
Hillslope seepage	40.7	2.5	1.8	5.5	3.16
PES	**97.2**	**C**	**B**	**D**	**C**
Wetland Unit 8					
Pan	6.7	n/a	n/a	n/a	D
Hillslope seepage	17.5	3.5	2.3	6.8	4.10
PES	**24.2**	**C**	**C**	**E**	**D**
Wetland Unit 9					
Floodplain	13.1	6	5.1	3.5	5.03
Hillslope seepage	133.7	3.5	2.1	7.2	4.16
PES	**146.8**	**C**	**C**	**E**	**D**
Wetland Unit 10					
Pan	5.1	n/a	n/a	n/a	C
Hillslope seepage	37.6	2	2.2	5.4	3.03
PES	**42.7**	**C**	**C**	**D**	**C**
Wetland Unit 11					
Hillslope seepage	26.2	2	3.5	5.8	3.51
Valley bottom	1.7	2.5	1.8	4.5	2.87
PES	**27.9**	**C**	**C**	**D**	**C**
Wetland Unit 12					
Valley bottom	27.7	2.5	3.8	2.2	2.79
PES	**27.7**	**C**	**C**	**C**	**C**

Unit	Area (ha)	Hydrology	Geomorphology	Vegetation	Combined score
Wetland Unit 13					
Hillslope seepage	94.9	3	2.3	5.6	3.54
PES	**94.9**	**C**	**C**	**D**	**C**
Wetland Unit 14					
Pan	8	n/a	n/a	n/a	C
Hillslope seepage	15.7	3	1.8	6.2	3.57
PES	**23.7**	**C**	**B**	**D**	**C**
Wetland Unit 15					
Hillslope seepage	87.4	3.5	3.1	7.1	4.41
Pan	2.3	n/a	n/a	n/a	C
PES	**89.7**	**C**	**C**	**E**	D
Wetland Unit 16					
Hillslope seepage	64.8	5	3.4	7.2	5.17
PES	**64.8**	**D**	**C**	**D**	D
Wetland Unit 17					
Hillslope seepage	25.4	3	4.1	5.8	4.11
Pan	0.8	n/a	n/a	n/a	C
Valley bottom	4.7	3.5	4.5	5.3	4.30
PES	**30.9**	**C**	**D**	**D**	**D**
Wetland Unit 18					
Pan	0.6	n/a	n/a	n/a	C
Hillslope seepage	202.8	3	2.1	4.9	3.29
PES	**203.4**	**C**	**C**	**D**	**C**

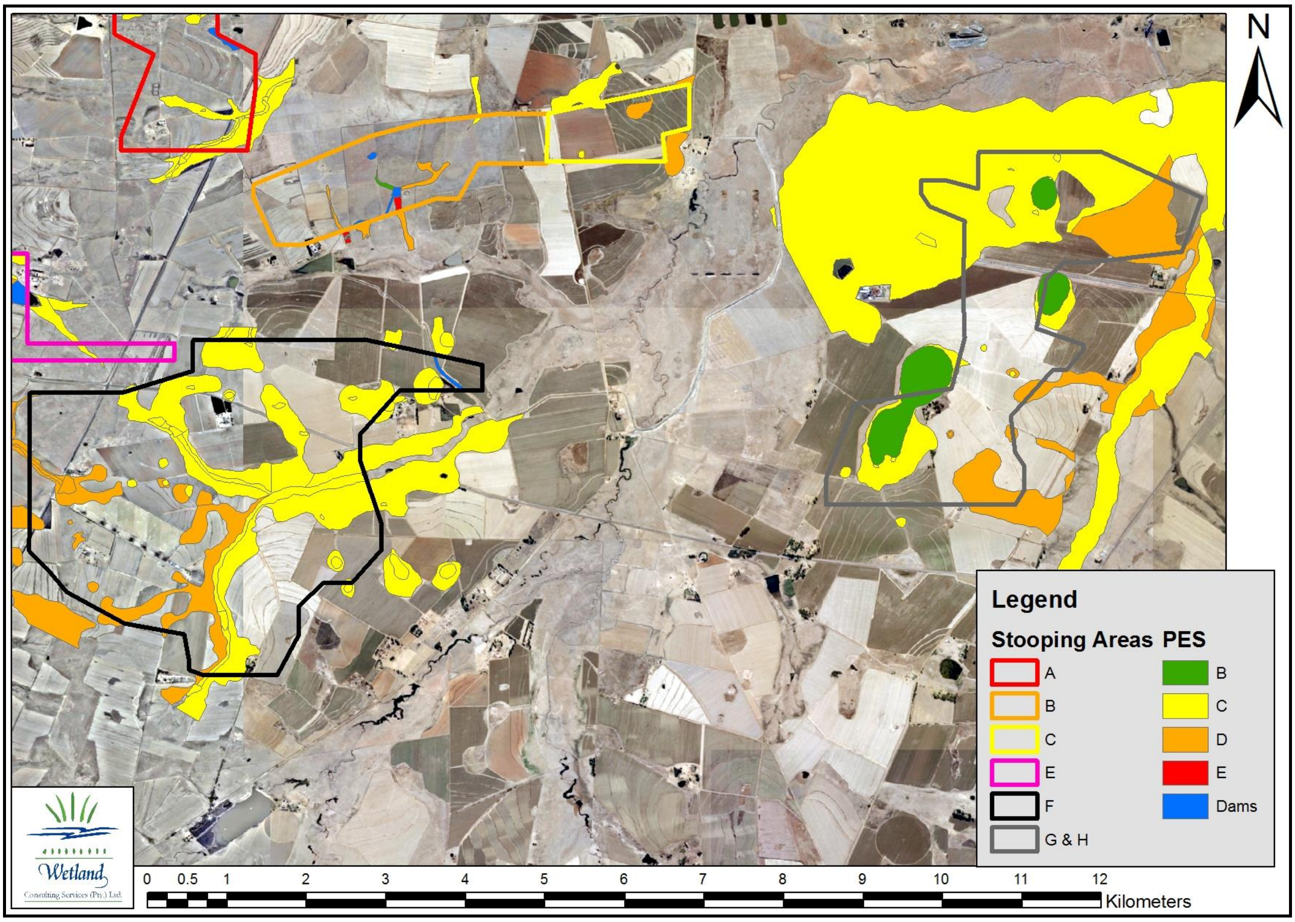

Figure 26. Map showing the results of the PES assessment for wetlands in the 3 Mine Study Area

6.4.6 PES - LOMP Study Area

Most of the wetlands within the LOMP study area are considered to be moderately modified (PES C), though a significant percentage is largely modified (PES D). Once again only the larger pans of the study area are still considered to be in a largely natural (PES B) condition.

Given that the general land use within the LOMP study area, agriculture, is the same as within the 3 Mine study area, the impacts to the wetlands are largely the same. For completeness however, the same discussion is included in this section again.

As is the case with the rest of the study sites, the LOMP study area has been subjected to extensive agricultural activities over many years. The impact of this land use on the wetlands is apparent in a number of changes that most of the wetland systems on site have undergone. In terms of the aspects considered in the PES assessment – hydrology, geomorphology and vegetation – both the hydrology and the geomorphology of the majority of wetlands were considered to be moderately modified, while the vegetation was in many cases considered largely to seriously modified.

The impacts to vegetation are mostly associated with a complete transformation of habitat due to cultivation within the wetland boundaries. Historically, the extent of cultivation on site was markedly more extensive than the currently actively cultivated areas. Recognition by farmers that planting maize within seasonally saturated soils provides limited yields has resulted in cultivation being withdrawn from these areas. Such previously cultivated areas were then either converted to planted pastures (generally *Eragrostis* pastures), or were left fallow and natural succession has resulted in these areas being characterised by secondary grassland.

Impacts to hydrology are again mostly related to changes in the distribution and retention of water within the wetlands as the water inputs to the wetlands are expected to have remained largely the same, with the exception of the Rietspruit floodplain wetland where the hydrology has been seriously modified through the construction of the river diversion and the surface subsidence due to underground mining that has completely altered the topography and water retention of the floodplain.

Extensive cultivation surrounding the wetlands provides considerable sediment sources to the wetlands that get transported by surface flow following heavy rain as well as wind deposition. In addition, the altered hydrology provides increased capacity for sediment transport out of the wetlands, resulting in the geomorphology of most of the wetlands being moderately modified.

Table 21. Results of the PES assessment for wetlands in the LOMP Study Area

Unit	Area (ha)	Hydrology	Geomorphology	Vegetation	Combined score
Wetland Unit 19					
Valley Bottom	146.4	4	3.5	3.5	3.71
PES	**146.4**	**D**	**C**	**C**	**C**
Wetland Unit 20					
Valley Bottom	94.2	4	3.6	3.1	3.63
Hillslope Seepage	14.7	1	2.8	3.9	2.34
PES	**108.9**	**C**	**C**	**C**	**C**
Wetland Unit 21					
Valley bottom	5.7	3.5	3.6	3.2	3.44
Hillslope seepage	45.2	3	3.6	6.1	4.06
PES	**50.9**	**C**	**C**	**D**	**C**
Wetland Unit 22					
Valley bottom	37.1	3.5	4.2	4.6	4.01
Hillslope seepage	120.7	3	2.2	3.9	3.03
PES	**157.8**	**C**	**C**	**D**	**C**
Wetland Unit 23					
Valley Bottom	6.5	4.5	4.2	5.1	4.59
Hillslope seepage	102.4	3.5	2.6	5.7	3.87

PES	**108.9**	**C**	**C**	**D**	**C**
Wetland Unit 24					
Valley bottom	13.7	4	3.8	4.2	4.00
Hillslope seepage	188.5	3	2.5	5.6	3.60
PES	**202.2**	**C**	**C**	**D**	**C**
Wetland Unit 25					
Pan	0.8	n/a	n/a	n/a	B
Valley bottom	3.8	3.5	4.4	3.4	3.73
Hillslope seepage	159.2	2.5	2.1	5.4	3.21
PES	**163.8**	**C**	**C**	**D**	**C**
Wetland Unit 26					
Pan	12.4	n/a	n/a	n/a	B
Hillslope seepage	30.8	3	2.5	3.4	2.97
PES	**43.2**	**C**	**C**	**C**	**C**
Wetland Unit 27					
Pan	3.2	n/a	n/a	n/a	B
Hillslope seepage	3.7	3	2.1	3.9	3.00
PES	**6.9**	**C**	**B**	**C**	**C**
Wetland Unit 28					
Hillslope seepage	55.8	6	4.3	5.8	5.46
PES	**55.8**	**E**	**D**	**D**	**D**
Wetland Unit 29					
Hillslope seepage	94.4	3	3.7	6.4	4.17
Valley bottom	1.3	3.5	4	3.3	3.59
PES	**95.7**	**C**	**C**	**E**	**D**
Wetland Unit 30					
Hillslope seepage	129.4	2	2.8	5.6	3.26
Valley bottom	0.9	1	1.6	3.4	1.86
PES	**129.4**	**C**	**C**	**D**	**C**
Wetland Unit 31					
Hillslope seepage	202.2	3	2.1	4.1	3.06
Valley bottom	17.4	4.5	4	5.6	4.67
PES	**202.2**	**C**	**C**	**D**	**C**

Wetland Unit 32					
Valley bottom	13.2	3.5	3	3.2	3.27
Hillslope seepage	151.2	2	2.1	4.5	2.74
PES	**164.4**	**C**	**C**	**D**	**C**
Wetland Unit 33					
Hillslope seepage	291.5	3.5	2.7	6.1	4.01
Valley bottom	18.8	4.5	4.4	3.2	4.10
PES	**310.3**	**C**	**C**	**E**	D
Wetland Unit 34					
Hillslope seepage	114.5	3.5	2.9	5.5	3.90
Valley bottom	21.8	4.5	4.1	3.4	4.07
PES	**136.3**	**C**	**C**	**D**	C
Wetland Unit 35					
Hillslope seepage	55.3	3.5	4.2	5.6	4.30
Pan	2.1	n/a	n/a	n/a	D
PES	**57.4**	**C**	**D**	**E**	**D**
Wetland Unit 36					
Valley bottom	16.7	2.5	2.7	3.2	2.76
Hillslope seepage	177.2	2	2.3	3.9	2.63
PES	**193.9**	**C**	**C**	**C**	**C**
Wetland Unit 37					
Valley bottom	14.8	3	2.7	3.2	2.97
Hillslope seepage	108.9	2.5	2.6	5.2	3.30
PES	**123.7**	**C**	**C**	**C**	**C**

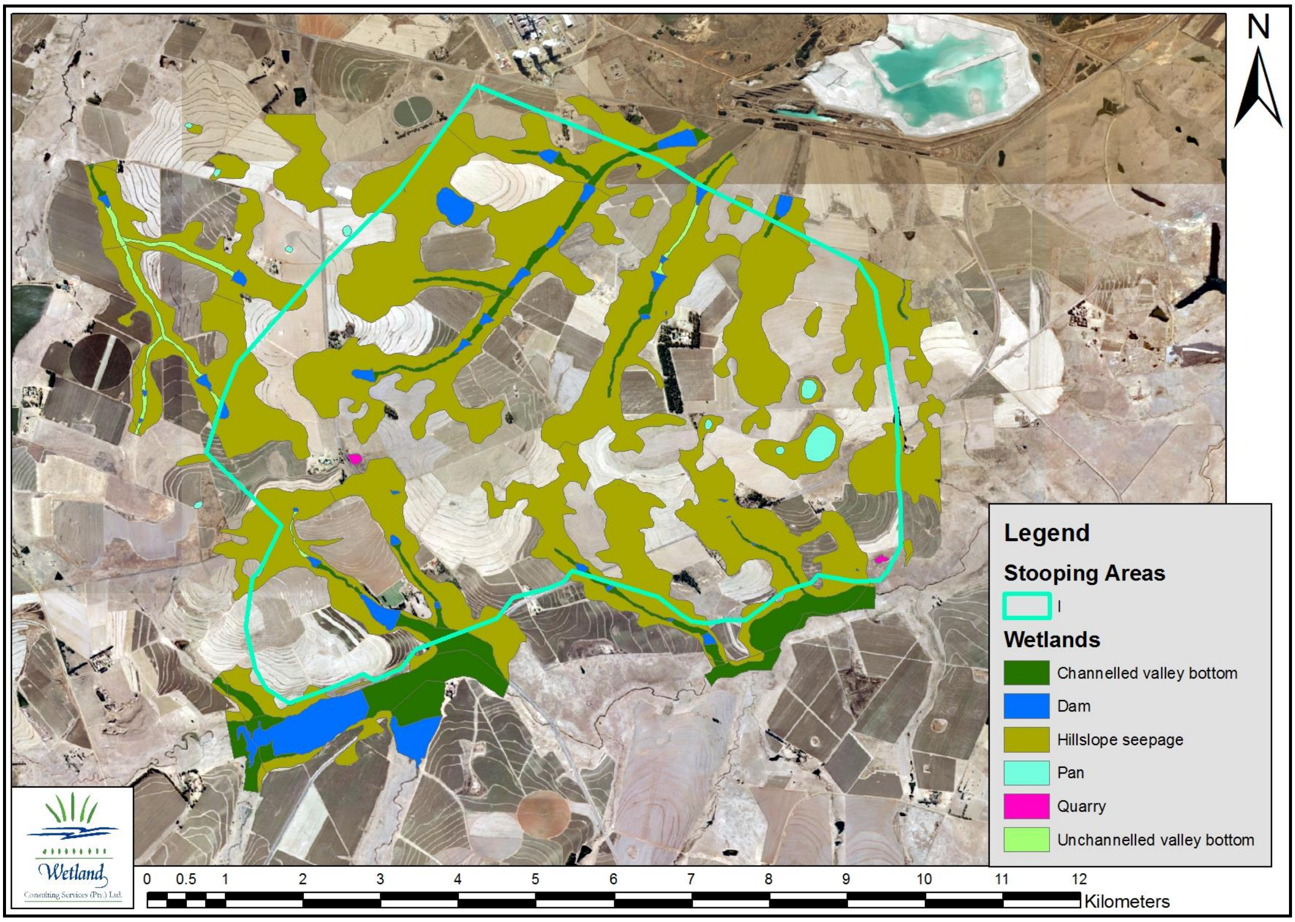

Figure 27. Map showing the results of the PES assessment in the LOMP study area

6.5 Ecological Importance and Sensitivity (EIS)

Ecological Importance and Sensitivity is a concept introduced in the reserve methodology to evaluate a wetland in terms of:

- Ecological Importance;
- Hydrological Functions; and
- Direct Human Benefits

The scoring assessments for these three aspects of wetland importance and sensitivity have been based on the requirements of the NWA, the original Ecological Importance and Sensitivity assessments developed for riverine assessments (DWAF, 1999), and the work conducted by Kotze et al (2008) on the assessment of wetland ecological goods and services (the WET-EcoServices tool). Based on this methodology, an EIS assessment was undertaken for all the delineated wetlands on site, with the results discussed and illustrated in the sections below.

The wetlands within the study area all form part of the Olifants River Primary catchment which is a heavily utilised and economically important catchment. Wetlands and rivers within the Olifants River Catchment upstream of Loskop Dam have been greatly impacted upon by various activities, which include mining, power stations, water abstraction, urbanization, agriculture etc. As a result of these impacts serious water quality concerns and also water quantity concerns have been raised within the sub-catchment, also specifically within the Steenkoolspruit sub-catchment, which is feed by the Steenkoolspruit River. Given this situation, and the fact that wetlands can support functions such as water purification and stream flow regulation, a high importance and conservation value is placed on all wetlands and rivers within the catchment that have as yet not been seriously modified. Within this context an EIS assessment was conducted for every hydro-geomorphic wetland unit identified within the study area. Further considerations that informed the EIS assessment include:

- The location of the study area within a vegetation type (Eastern Highveld Grassland) considered to be extensively transformed and threatened, and classed as ***Vulnerable.***
- The wetland ecosystem type of the area, Mesic Highveld Grassland Group 4 wetlands, is considered to be ***Critically Endangered.***
- The classification of the Blesbokspruit and Rietspruit wetland systems as FEPA wetlands.
- The extensive transformation of habitat that has occurred on site, as reflected in the Mpumalanga Biodiversity Sector Plan 2013 which classified only a very small area of the study area as a Critical Biodiversity Area – Irreplaceable, and some additional areas as Critical Biodiversity Area – Optimal, but most of the site as heavily modified.
- The results of the PES assessment of the wetlands on site which revealed most wetlands as being moderately modified, though a significant percentage also as heavily modified.
- The presence of Red Data species such as Greater Flamingo and African Grass Owl in some of the wetlands on site.

It is these considerations that have informed the scoring of the systems in terms of their ecological importance and sensitivity. The results of the assessment and rankings based on our current understanding of the wetlands is illustrated in Figures 28 and 29, and summarised in Table 22.

Just over 70% of the wetlands on site are considered of Moderate ecological importance and sensitivity, with only 3.7 % considered as High ecological importance and sensitivity. The wetlands that rated High consisted mostly of pan wetlands, but included the Blesbokspruit valley bottom upstream of the river diversion and one or two seepage wetlands known to support African Grass Owls.

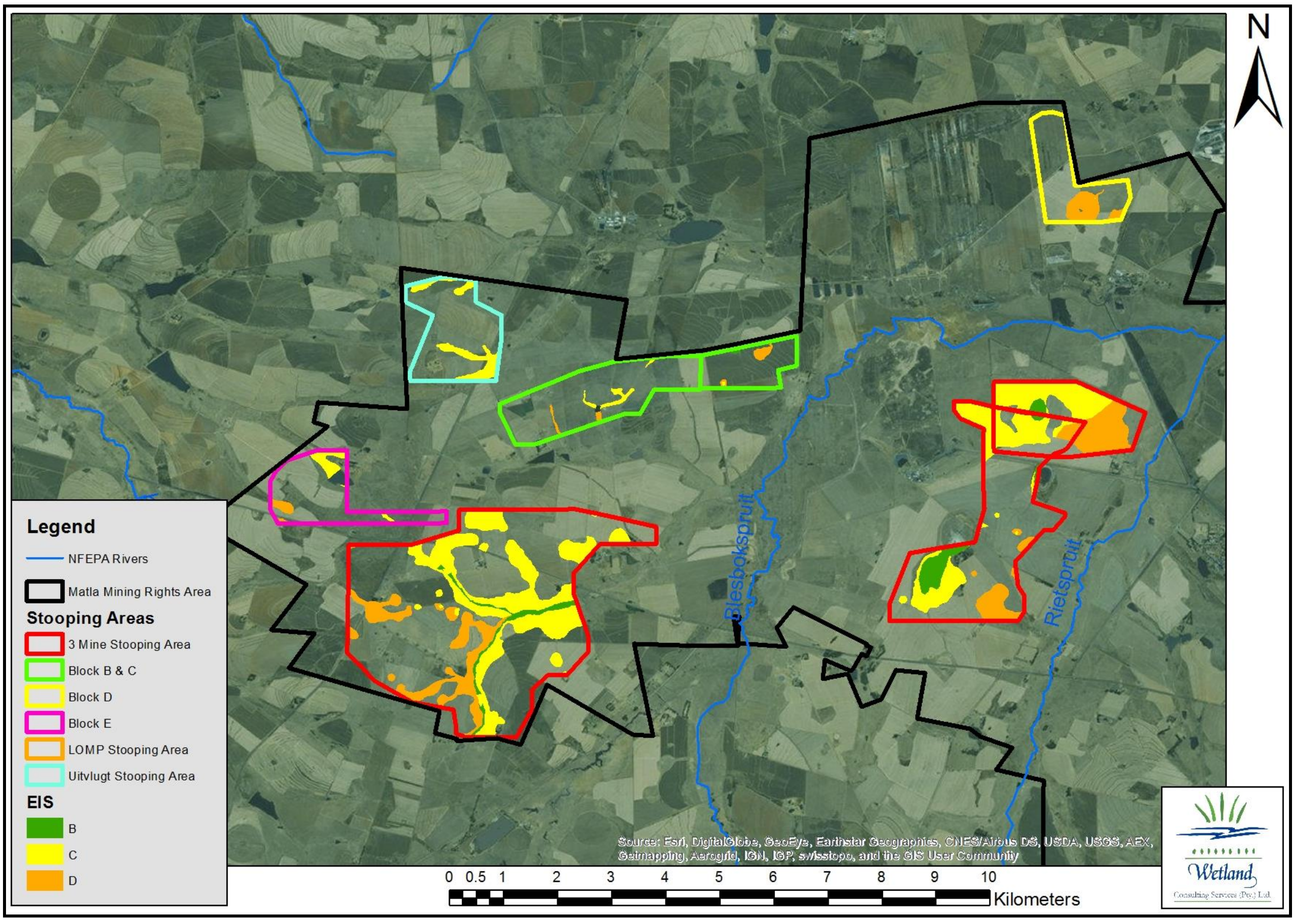

Figure 28. Results of the EIS assessment of wetlands in the 3 Mine study area and northern Blocks.

Table 22. Results of the EIS assessment.

Wetland Type	B	C	D	Total
Channelled valley bottom	1.1	50.8	23.1	75.0
Unchannelled valley bottom	29.8	12.8	3.5	46.2
Hillslope seepage	1.6	1723.5	625.6	2350.7
Pan	61.1	10.6	0.2	72.0
TOTAL	**93.6**	**1797.8**	**652.4**	**2543.8**
% of wetland area	**3.7%**	**70.7%**	**25.6%**	**100.0%**

Mining Block	B	C	D	Total
Uitvlugt Stooping area (A)		36.1		36.1
Block B & C	1.6	7.7	8.7	17.9
Block D		0.1	28.5	28.6
Block E		15.6	7.2	22.8
3 Mine Stooping area (F, G & H)	72.9	464.9	210.4	748.2
LOMP Stooping area (I)	19.1	1273.5	397.6	1690.2
TOTAL	**93.6**	**1797.8**	**652.4**	**2543.8**

The majority of wetlands on site are considered of moderate importance and sensitivity (EIS score of C), though a significant percentage are also considered to be of Low ecological importance and sensitivity. Approximately 6 % of the wetlands on site are considered of High ecological importance and sensitivity (EIS score of B), consisting mostly of pans and some larger valley bottom wetlands.

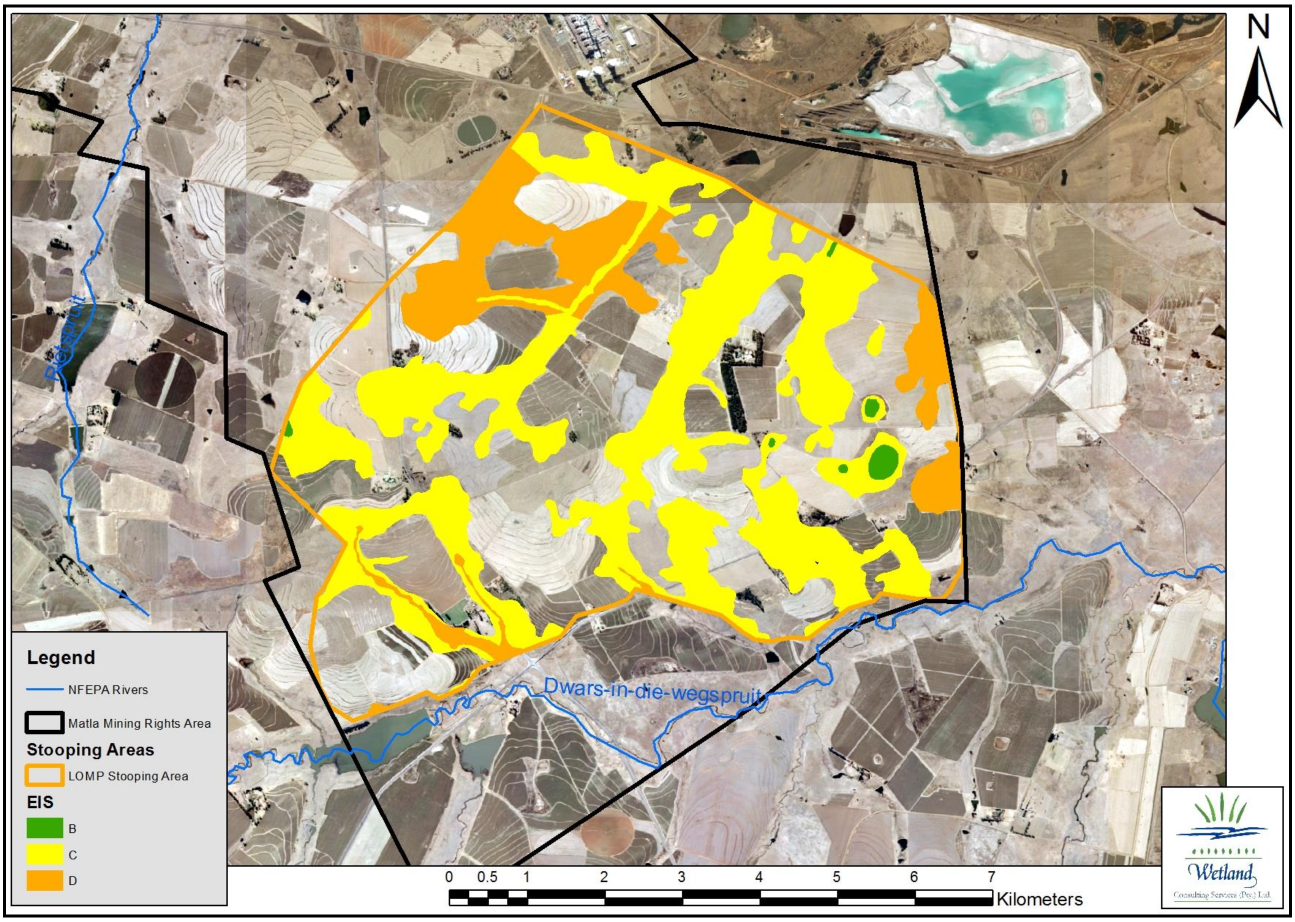

Figure 29. Results of the EIS assessment of wetlands within the LOMP study area.

7. FINDINGS – AQUATIC ECOLOGY ASSESSMENT

7.1 Sampling Sites

The aquatic sampling sites are illustrated in Figure 30 and summarised in Table 23.

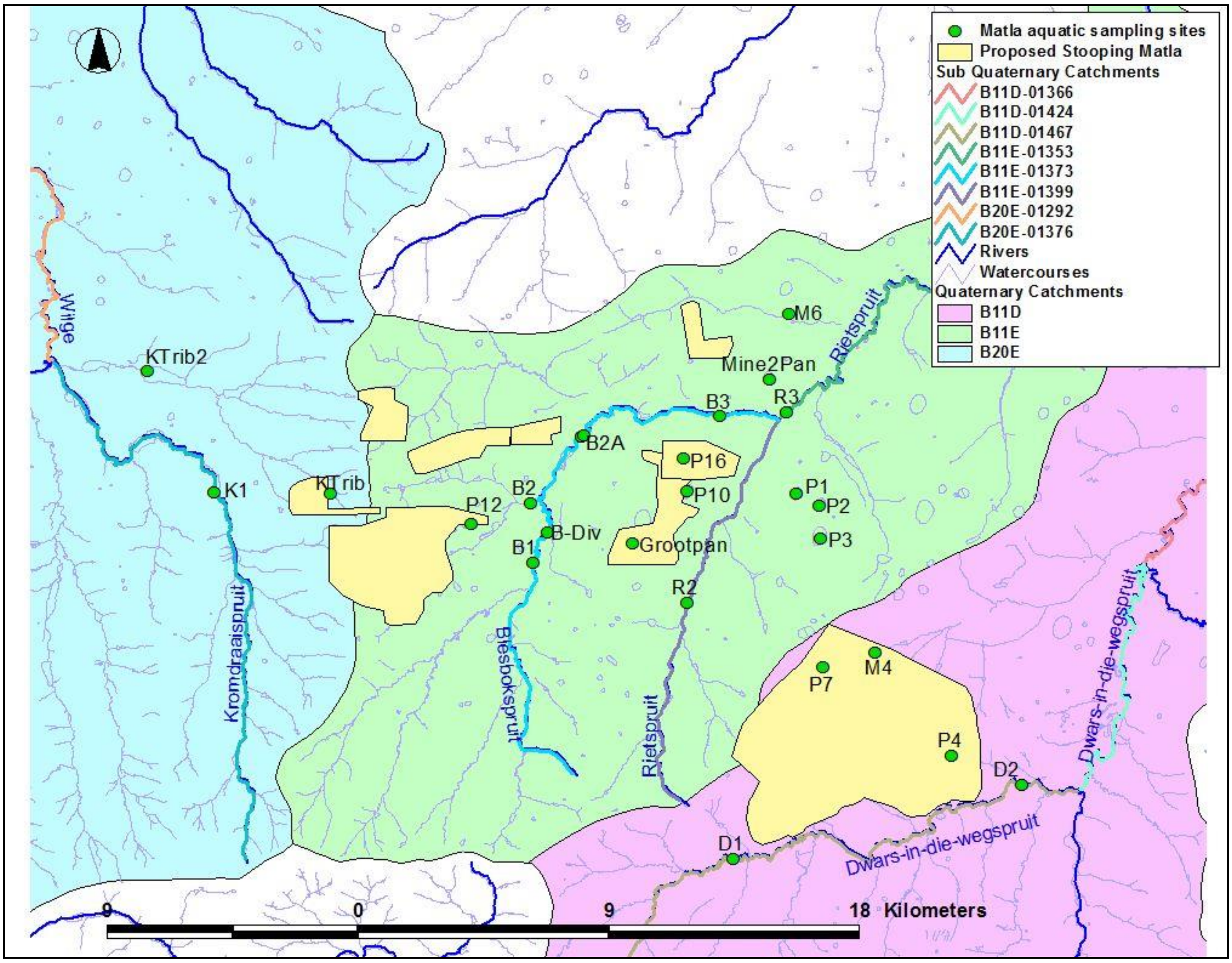

Figure 30. Aquatic sampling sites relative to the proposed mining expansions at Exxaro Matla.

Aquatic ecosystems sampled included permanent pans (Mine 2 Pan and Pan 3) and seasonal pans (P1, P2, P4, P7, P12, Grootpan, Pan 16 and P10), channelled valley bottom wetlands (M4, M7, Ktrib) and rivers (Rietspruit, Dwars-in-die-Wegspruit, Blesbokspruit and Kromdraaispruit). The Blesbokspruit is a seasonal tributary of the Rietspruit and essentially consisted of a series of pools at the time of sampling. The Blesbokspruit has also been diverted in its upper reaches, this diversion further decreasing flows within the main channel.

Grootpan will potentially be undermined, as it falls within the 3 mine stooping area. However, it was dry at the time of sampling. It is recommended that baseline aquatic survey be conducted of this pan, together with Pan 10 (also dry at the time of sampling), before the commencement of mining activities. Both pans were additionally assessed as part of the Wetland Assessment Report and were only assessed in terms of aquatic habitats in this report.

Table 23. Aquatic samplings sites for the Exxaro Matla mining expansion project.

Site	Components sampled	Rationale/Classification
PANS		
P1	Aquatic macroinvertebrates, diatoms, on-site water quality, habitat integrity	Included in the Water Treatment Plant Study and duplicated here for the sake of completeness
P2		
P3		
Mine 2 Pan		
P4	Aquatic macroinvertebrates, water quality, habitat integrity	Seasonal pan, within stooping area
P7	Aquatic macroinvertebrates, water quality, habitat integrity	Seasonal pan, within stooping area
Grootpan	Habitat integrity	Seasonal pan, within stooping area
P10	Habitat integrity	Seasonal pan, within stooping area
P12	Aquatic macroinvertebrates, habitat integrity	Seasonal Pan, within stooping area
P16	PES (assessed in Wetland Assessment Report only)	Seasonal Pan/Depression. This system functions mainly as a hillslope seepage wetland rather than an endorheic pan and was dry at the time of sampling.
WATERCOURSES		
R2	SASS5, water quality, fish, habitat integrity	Rietspruit, upstream of proposed open-cast mining but downstream of stooping
R3	SASS5, water quality, diatoms, fish, habitat integrity	Rietspruit, downstream of proposed mining
B1	SASS5, water quality, diatoms, fish, habitat integrity	Blesbokspruit, upstream of mining and the diversion
B-Div	SASS5, water quality, habitat integrity	Reach of the original Blesbokspruit excluded from the diversion (i.e. within the natural channel between the start and end of the diversion).
B2 (Trib)	SASS5, water quality, habitat integrity	Tributary of the Blesbokspruit, downstream of proposed stooping, flowing into the original Blesbokspruit (excluded from the diversion)
B2A	SASS5, habitat integrity	Blesbokspruit, immediately downstream of the diversion - downstream of stooping, upstream of proposed open-cast mining
B3	SASS5, water quality, diatoms, fish, habitat integrity	Blesbokspruit, downstream of present and proposed mining.
D1	SASS5, water quality, diatoms, fish, habitat integrity	Dwars-in-die-Wegspruit, upstream of proposed stooping
D2	SASS5, water quality, diatoms, fish, habitat integrity	Dwars-in-die-Wegspruit, downstream of proposed stooping
K1	SASS5, water quality, diatoms, habitat integrity	Kromdraaispruit, downstream of proposed stooping, within the Wilge River Catchment.
VALLEY BOTTOM WETLANDS		
M4	SASS5, diatoms, water quality, habitat integrity	Valley bottom wetland, downstream of stooping. This wetland drains past the Kriel Power Station and into the Steenkoolspruit.
M6	diatoms	Valley bottom wetland, downstream of stooping, draining into the Rietspruit. This is a mostly unchnnelled system unsuitable for aquatic sampling.
Ktrib	Water quality	Valley bottom wetland draining towards the Kromdraaispruit. Dry at the time of sampling (water quality sampled from a dam)
Ktrib2	Water quality	Valley bottom wetland draining towards the Kromdraaispruit. Dry at the time of sampling (water quality sampled from a dam)

7.2 Habitat Integrity

The following human activities have impacted on habitats at aquatic sampling sites (Table 23):

7.2.1 Pans:

Current impacts to pans within the study area were mainly due to agriculture – trampling and water quality impacts due to cattle grazing, as well as runoff containing pesticides and fertilizers from irrigated lands. Pan 3, Mine Pan 2 and Pan 10 were additionally impacted by mining.

- Pan 3 and Mine Pan 2 are both used for storage by the mine and were considered Largely Modified. Not only has water quality been seriously affected but the hydrological regimes have been modified from seasonal to permanent inundation.
- Pan 1 was a seasonal pan relatively unmodified with only minor impact from surrounding cultivated fields (receiving runoff containing sediment and possibly fertilizers or pesticides).
- Pan 2 was a seasonal pan that was considered naturally saline. This pan may have received limited water quality impacts from surrounding agricultural activities. The pan is surrounded by a considerable seepage wetland.
- Pan 4 was considered near-pristine with the only impacts evident being from cattle grazing. The seepage wetland surrounding this pan supported a large number of marsh owl. This seepage area also serves as a buffer against further agricultural impacts on the pan itself.
- Pan 7 was impacted by surrounding cultivated fields as well as cattle grazing. This has resulted in highly eutrophic water that supports prolific algal growth. Water birds and frogs (tadpoles) were abundant at this site. The low salinity of water in this pan suggests that it may have groundwater links and is near-permanent in its hydrology.
- Pan 10 was also highly eutrophic and similarly supported an abundant bird life and prolific algal growth. Water quality has been impacted by agricultural runoff, as well as by the adjacent conveyor.
- Pan 12 was impacted by grazing cattle but few other impacts were observed. The low volume of water within this seasonal pan, mean that water quality impacts are more concentrated.
- Grootpan has been impacted by cattle grazing but the extensive seepage wetland surrounding it has acted as an effective buffer.

Pans 1, 2, 4 and Grootpan all have a seasonal hydrology. As such they are likely to support aquatic invertebrate fauna that have become highly specialised as an adaptation to such variable conditions (e.g. ostracods, copepods, cladocerans, etc.). These, in turn, may support animals higher up in the food chain (such as flamingos and other water birds). Pan 7 is more permanent in nature, with possible groundwater links.

7.2.2 Watercourses:

Most aquatic sampling sites were classified as Moderately Modified (Category C) in terms of aquatic habitat integrity. The most notable present impacts on aquatic habitats were attributed to water abstraction, flow modification, bed modification, channel modification, inundation and bank erosion. These systems have become channelized and eroded as a result of dams, abstraction (lowering of the water table), overgrazing, trampling by cattle and road crossings.

Water abstraction results in reduced flows and a lowered water table, and hence, reduced habitat diversity and suitability for aquatic biota. Flow modification within the study area is attributable to dams, weirs, abstraction and diversions (the Blesbokspruit diversion). These have resulted in decreased flows, especially during the dry season, which may have a negative impact on some fish species (especially those with a preference for fast flowing habitats). Dams and weirs also create migration barriers for fish and provide suitable habitats for alien fish species.

The lower reach of the Rietspruit has been seriously impacted by mining. R3 was inundated upstream of the Kriel Colliery diversion. Considerable water quality impacts were evident at this site, together with the presence of aquatic weeds and algae which further compromise benthic and marginal habitats.

The upper section of the Blesbokspruit was considered Largely Natural in terms of aquatic habitat integrity. There was a gradual decline in integrity in a downstream direction. While there were impacts due to erosion, dams and diversions, water quality remained relatively unimpacted upstream of site B3. Site B3 was considered Largely to Seriously Modified in terms of aquatic habitat integrity, the main impacts being due to flow modification and water quality. Dams and diversions, as well as possible loss of surface water to groundwater, has resulted in lowered dry season flows, with longer no-flow periods.

Otter spoor were evident along the length of the Blesbokspruit as well as the Dwars-in-die-Wegspruit. It is important, therefore that habitat continuity be maintained for these animals, together with water quality levels that support their preferred prey (crabs).

Table 24. Summary of Habitat Integrity Assessed for aquatic sampling sites for the Matla Colliery Mining Survey. A: Rivers and Valley Bottom Wetlands, B: Pans

INSTREAM HABITAT INTEGRITY	K1	R 2	R 3	B1	B-Div	B2 (Trib)	B2A	B3	D1	D2	M4
WATER ABSTRACTION	11	18	8	3	6	8	5	8	8	8	8
FLOW/HYDROLOGICAL MODIFICATION	11	20	18	7	7	12	12	12	15	14	12
BED MODIFICATION /SEDIMENTATION	6	8	15	8	7	8	8	8	12	12	4
CHANNEL/STRUCTURAL MODIFICATION	10	5	16	8	8	2	7	12	3	5	3
WATER QUALITY	7	12	12	3	3	3	6	16	3	3	6
INUNDATION	0	5	17	3	0	0	0	0	0	0	0
EXOTIC MACROPHYTES	1	2	8	5	1	2	1	2	1	2	2
RUBBISH DUMPING	1	4	3	4	0	1	0	2	0	2	0
Total Score	**69**	**48**	**35**	**81**	**78**	**78**	**76**	**57**	**72**	**70**	**78**
RIPARIAN/MARGINAL INTEGRITY											
VEGETATION REMOVAL	2	2	1	0	3	0	0	0	0	0	2
EXOTIC VEGETATION	4	3	3	3	1	1	1	3	2	3	4
BANK EROSION	12	7	5	12	6	11	12	17	15	15	11
CHANNEL MODIFICATION	10	5	15	5	11	5	8	15	2	3	4
WATER ABSTRACTION	4	6	4	1	7	6	10	7	3	3	5
INUNDATION	0	4	15	0	0	0	0	0	0	0	0
FLOW/HYDROLOGICAL MODIFICATION	3	7	14	2	8	10	12	17	4	5	3
WATER QUALITY	2	3	3	1	4	1	3	6	0	3	2
Total Score	**71**	**81**	**48**	**77**	**72**	**73**	**60**	**36**	**75**	**72**	**75**
Estimated Overall PES	C	C	D/E	B/C	C	C	C	D/E	C	C	C

HABITAT INTEGRITY	P4	P7	Grootpan	P10	P12	Pan 1	Pan 2	Pan 3	Mine 2 Pan
WATER ABSTRACTION	0	4	0	0	0	0	0	0	0
FLOW/HYDROLOGICAL MODIFICATION	0	4	2	0	2	5	5	20	18
BED MODIFICATION /SEDIMENTATION	7	7	5	7	8	8	6	12	8
CHANNEL/STRUCTURAL MODIFICATION	0	2	2	8	2	2	2	5	3
WATER QUALITY	8	11	10	14	12	4	8	15	15
INUNDATION	0	0	0	0	0	0	0	16	15
EXOTIC MACROPHYTES	2	3	2	1	1	3	0	0	0
RUBBISH DUMPING	0	1	1	0	0	0	0	3	3
Total Score	**17**	**32**	**22**	**30**	**25**	**22**	**21**	**71**	**62**
Estimated Overall PES	A/B	B/C	B	B/C	B	B	B	D	D

Figure 31. Photographs of pans sampled at Matla. Fltr: P1 and 2, P4 and 7, Grootpan and P10, P 12.


R2

R3

Figure 32. Photographs of aquatic sampling sites within the Rietspruit Catchment (sites R2 and R3)


K1

K1

Figure 33. Photographs looking downstream and upstream of the aquatic sampling site within the Kromdraaispruit Catchment (K1)


B1


BDIV


B2A


B3


B2

Figure 34. Photographs of aquatic sites sampled within the Blesbokspruit catchment for the Matla Colliery Mining EIA: Site B1, BDiv and B2A are upstream, within (the original watercourse) and immediately downstream of the diversion. Site B3 is immediately upstream of the Rietspruit confluence. Site B2 is a tributary that joins the original watercourse downstream of BDiv.

Figure 35. Photographs of D1 and D2 (Dwars-in-die-Wegspruit) (top) and the Steelpoort tributary at site M4 (bottom).

7.3 Water Quality

It is important to note that the purpose of this section is not to provide a detailed surface water quality report of the study area, but purely to use the results of selected measurements obtained during the specialist assessment to assist in the interpretation of the biological data.

Electrical conductivity (EC) levels were the lowest in the upper Dwars-in-die-wegspruit (D1), and upper Rietspruit (Table 24). Salinity generally increased markedly towards the downstream sites and was highest within the lower Blesbokspruit (B3) upstream of its confluence with the Rietspruit. The Dwars-in-die-Wegspruit showed the lowest elevation in salinity, pointing to limited land use impacts on salinity between upstream and downstream sites.

The effects of increased salinities are difficult to predict but usually involves a change in community patterns as sensitive species are lost and tolerant species increase. An increase in salinity tends to improve the clarity of water, with consequent implications for increased algal production (associated with lower dissolved oxygen concentrations during the day) and algal species composition. Salinity levels exceeding 250mg/ℓ can change the algal species composition (Chutter and Walmsley 1994). Freshwater invertebrates are generally tolerant of elevated salinities of up to about 1000 mg/ℓ, providing the changes are not sudden (Chutter and Walmsley 1994). Fish are generally tolerant of salinities of up to 750mg/ℓ, although juveniles and eggs are significantly more sensitive (Chutter and Walmsley 1994). Water at site B3 (lower Blesbokspruit) is therefore likely to be limiting to fish and certain sensitive invertebrate species.

Sulphates, which are generally associated with coal mining, were high at site B3 within the Blesbokspruit, downstream of the diversion, but were low within the diversion itself and within tributaries draining into the diversion. Sulphates were also elevated within the Kromdraaispruit (although this was possibly due to coal dust entering the river from haul trucks crossing the bridge). Sulphates can form complex reactions that affect the pH, and therefore the solubility of metals and other substances. For example, under anaerobic conditions sulphate ions are reduced by bacteria to hydrogen sulphide, which is highly toxic to aquatic biota (Dallas and Day 1993).

Pans are often naturally saline so it is not always easy to detect contamination based on salinity alone. Therefore, where sulphate levels equal or exceeded chloride levels, this was taken as an indication of mining-related contamination. This was clearly the case in Pan 3, as well as Mine 2 Pan, to a lesser extent.

Results are summarized in Table 25 below.

Table 25. Water quality results for aquatic sampling sites for the Exxaro Matla mining expansion project.

	Kromdraaispruit		Rietspruit		Blesbokspruit					Dwars-in-die-Wegspruit		
	K1	Ktrib	R2	R3	B1	B-Div	B2	B2A	B3	D1	D2	M4
pH	8.67	8.88	8.04	7.00	7.97	8.30	7.15	8.73	6.65	7.89	8.26	7.02
Ec (mS/m)	95	93	54	103	90	74	77	100	138	56	84	118
Fluoride (1.5)	0.5	1.2	0.9	21.1	0.7	0.9	0.8	0.7	1.3	0.5	1.7	0.9
Nitrite (4.0)	0.1	0.1	0.0	2.3	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0
Nitrate (44.0)	0.2	0.2	0.6	4.8	0.0	0.2	0.0	0.2	4.6	1.6	1.6	0.0
Chloride (250)	50	77	61	181	22	146	128	142	119	43	37	224
Sulphate (500)	260	89	20	43	130	27	24	19	321	122	67	150
Phosphate	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0
Carbonate (20.0)	9.9	16.2	0.0	0.0	0.0	1.5	0.0	14.1	0.0	0.0	0.0	0.0
Bicarbonate	224	229	190	305	284	80	148	281	331	237	301	166
Sodium (400)	81	91	46	121	103	90	99	106	188	57	50	93
Potassium (400)	9.9	18.6	12.0	25.3	6.9	5.6	12.9	10.6	6.3	3.2	4.9	23.4
Calcium (200)	61.9	35.6	25.1	45.0	47.3	23.7	30.3	52.8	50.0	44.0	65.3	90.7
Magnesium (100)	50.9	42.5	19.3	26.6	31.5	20.7	24.1	40.1	40.5	23.3	56.8	43.9
Boron (1.5)	0.0	0.0	0.0	0.9	0.1	0.0	0.1	0.0	0.8	0.4	0.1	0.2
Total Dissolved Solids	657	508	281	623	482	365	393	558	896	413	436	709

	Pans					
	Pan 4	Pan 7	Mine Pan 2	Pan 1	Pan 2	Pan 3
pH	8.52	7.14	8.26	8.69	8.90	8.68
Ec (mS/m)	155	32	61	188	339	265
Fluoride (1.5)	1.1	0.1	0.7	40.2	7.8	1.0
Nitrite (4.0)	0.0	0.0	0.0	12.1	0.0	0.0
Nitrate (44.0)	0.0	0.0	4.0	44.0	3.7	2.9
Chloride (250)	91	23	43	396	657	176
Sulphate (500)	39	4	43	32	178	978
Phosphate	0.0	0.0	0.0	0.0	0.0	0.0
Carbonate (20.0)	16.2	0.0	0.0	24.6	36.3	0.0
Bicarbonate	694	159	262	532	828	125
Sodium (400)	347	19	51	401	770	276
Potassium (400)	21.9	17.7	15.9	30.6	13.3	51.8
Calcium (200)	21.0	38.0	39.8	21.7	24.7	210.8
Magnesium (100)	10.5	9.8	24.3	32.7	18.0	29.4
Boron (1.5)	0.6	0.1	0.2	0.2	0.8	9.7
Total Dissolved Solids	896	190	353	1301	2123	1797

7.4 Diatoms

The European numerical diatom index, the Specific Pollution Sensitivity Index (SPI) was used to interpret Diatom results.

Seasonal pans, which have naturally elevated salts and nutrient levels, were excluded from these analyses as the SPI was developed for flowing freshwater systems and may result in misleading interpretations for standing water and pans. Analyses of diatoms were therefore based on measures of relative abundance and species composition (i.e. assemblage patterns) to infer baseline water quality conditions at these sites.

Appendix A displays a list of species and abundances recorded for each site and Table 26 gives the diatom based ecological classification for water quality.

Table 26. Classification of sites based on diatoms sampled from Matla sampling sites: A: Generic diatom based ecological classification. B: Classification based on the Specific Pollution Sensitivity Index (SPI).

A. Ecological Classification

Site	pH	Salinity	Organic nitrogen	Oxygen levels	Trophic status
P1	Alkaline	Fresh-brackish	Needing periodically elevated concentrations of organically bound nitrogen	Low (>30% saturation)	Eutrophic
P2	Alkaline	Brackish-fresh	Tolerating elevated concentrations of organically bound nitrogen	Moderate (> 50% saturation)	Eutrophic
P3	Alkaline	Brackish-fresh	Tolerating elevated concentrations of organically bound nitrogen	Moderate (> 50% saturation)	Eutrophic
P7	Alkaline	Fresh-brackish	Tolerating elevated concentrations of organically bound nitrogen	Moderate (> 50% saturation)	Eutrophic
M4	Alkaline	Fresh-brackish	Tolerating very small concentrations of organically bound nitrogen	Moderate (> 50% saturation)	Eutrophic
B1	Alkaline	Fresh-brackish	Tolerating very small concentrations of organically bound nitrogen	Fairly High (> 75% saturation)	Eutrophic
B-Div	Alkaline	Fresh brackish	Elevated concentrations of organically bound nitrogen	Continuously high (~100% saturation)	Eutrophic
B2A	Alkaline	Fresh brackish	Elevated concentrations of organically bound nitrogen	Continuously high (~100% saturation)	Meso-eutrophic
B3	Alkaline	Fresh-brackish	Tolerating elevated concentrations of organically bound nitrogen	Low (>30% saturation)	Eutrophic
D1	Alkaline	Fresh-brackish	Tolerating very small concentrations of organically bound nitrogen	Fairly High (> 75% saturation)	Eutrophic
D2	Alkaline	Fresh-brackish	Tolerating elevated concentrations of organically bound nitrogen	Fairly High (> 75% saturation)	Eutrophic
R3	Circumneutral (pH of +/-7)	Fresh-brackish	Tolerating elevated concentrations of organically bound nitrogen	Moderate (> 50% saturation)	Eutrophic
K1	Alkaline	Fresh brackish	Elevated concentrations of organically bound nitrogen	Moderate (>50% saturation)	Eutrophic

B. SPI Classification

Site Name	NB spec.	%PTV	SPI	Ecological Category (EC)	Class	
P1	20	8	10.9	Inconclusive due to high salinity (possibly natural)		
P2	9	10	2.8			
P3	17	13.5	2.8			
M6	18	1	15.9	Good quality	B	
M4	30	3.3	15.9	Good quality	B	
B1	30	3.3	15.9	Good quality	B	
B1-Div	28	15.3	6,9	Moderate quality	C	
B2A	39	12	13	Moderate quality	C	
B3	38	26.8	8.9	Poor quality	D	
D1	24	2.3	13.6	Good quality	B/C	
D2	56	18.3	12.6	Moderate quality	C	
R 3	47	20.3	7.2	Poor quality	D/E	
K1	25	21.5	6.9	Poor quality	D/E	**organic pollution present

The results of the diatom analyses are described below. Species contributing 5% or more to the total count were classified as dominant species. A species list is provided in Appendix A:

- At sites P1, M6 and B1 *Achnanthidium minutissimum* is the prevalent taxon. At sites M4 and D2 *A. minutissimum* is relatively less prevalent. This taxon is often associated with clean, high oxygenated, freshwaters (Slàdecek, 1986; Leclercq and Maquet, 1987; Prygiel and Coste, 2000).

- Sites P2 and P3 are characterised by prevalent taxon *Amphora veneta*, a species found in electrolyte-rich waters often linked to mining and industrial effluent but can also occur in pans with natural high salinities. This taxon can also favour high nutrient concentrations.

- Site P3 has a significant number of taxa *Nitzschia amphibia*, *Navicula veneta* and *Nitzschia palea* indicating heavily eutrophic, electrolyte-rich conditions. These species are often linked to agricultural and industrially impacted waters.

- At site R3, the species composition is comprised of pollution tolerant species such as *Nitzschia palea*, *Sellaphora pupula*, *Mayamaea atomus* and *Navicula rostellata* indicative of electrolyte and nutrient inputs from anthropogenic activities. Water was classified as poor quality at this site.

- At sites D1, D2, B1, M6 and M4, the presence of *Epithemia adnata*, a pollution sensitive taxon found in slow flowing/standing alkaline waters with moderate to high electrolyte content, implies that the water quality is in relatively good condition.

- The diatom species composition at site M4 indicates reasonably good water quality. Taxa are characteristic of slow flowing/stagnant waters, tolerant of osmotic fluctuations, with moderate to high electrolyte content, such as *Rhopalodia gibba*, *Nitzschia liebetruthii* and *Nitzschia inconspicua*.

- Site B-Div was classified as having moderate water quality. At this site *Achnanthidium minutissimum* was the prevalent taxon. This taxon is often associated with clean, high oxygenated, freshwaters (Slàdecek, 1986; Leclercq and Maquet, 1987; Prygiel and Coste, 2000). However, studies have also revealed that *A. minutissimum* can be abundant at sites contaminated with sulphates and various metals often associated with mining effluent (e.g. Pb, Cd, Zn, Cu) (Deniseger et al., 1986; Genter et al., 1987; Medley and Clements, 1998; Ivorra et al., 1999, Gold et al., 2002, 2003, Cattaneo et al., 2004, Ferreira da Silva et al., 2009). Measurements of heavy metal concentrations are required to distinguish between the two responses. However, at site M-Div, the presence of *Epithemia adnata*, a pollution sensitive taxon found in slow flowing/standing alkaline waters with moderate to high electrolyte content, implies that the water quality is in relatively good condition at this site.

- Site B2A was classified as having moderate water quality. The prevalent taxon for this site was *Cymbella tumida*, which prefers oligo- to mesotrophic waters with moderate electrolyte content. The diatom species composition at site B2A indicated reasonably good water quality. The prevalent taxa were characteristic of weakly alkaline waters, tolerant of osmotic fluctuations, with moderate to high electrolyte content, such as *Fragilaria tenera* and *Gomphonema acuminatum.* The presence of *Nitzschia* species indicates slight nutrient and organic enrichment.

- Site K1 was considered to have poor water quality. Dominant species included *Navicula capitatoradiata, Fragilaria tenera, Nitzschia palea, Cyclotella meneghiniana, Stephanodiscus hantzschii, Nitzschia linearis, Nitzschia dissipata and Gomphonema truncatum*. These species all have preferences for poor water quality. *Navicula capitatoradiata* was the dominant species. This species prefers eutrophic, high electrolyte and as well brackish waters and is tolerant of critical levels of pollution. The dominance of *Cyclotella meneghiniana* and *Stephanodiscus hantzschii* point to elevated salinities. Indicator species for industrial related impacts (*Nitzschia palea*) occurred at high abundance.

It should be noted that diatom results give a snapshot view of conditions at a specific sampling site over a period of time (weeks to months) and therefore do not represent conditions over an entire subcatchment or river reach. Because flows were low or absent at most sites at the time of sampling (October), this effect was amplified, so that a single pollution source (e.g. a road crossing) would have had a greater impact on water quality than it would have under higher flow conditions (e.g. at site K1).

7.5 Aquatic Macroinvertebrates

It should be noted that conditions were extremely dry at the time of sampling (October) and flows were reduced to a trickle or altogether absent. Most watercourses, especially small tributaries, consisted of a series of pools. As such, the use of the SASS5 methodology, which is designed specifically for flowing systems, was limited. Analysis was therefore based largely on taxonomic diversity and the presence or absence of sensitive or specialized taxa. Aquatic macroinvertebrate results are given in Appendix B and summarised below. As taxon composition is expected to differ between pans and flowing water (watercourses), these ecosystems are discussed separately without direct comparison.

7.5.1 Watercourses

The Present Ecological State of sites, based on their aquatic macroinvertebrate fauna, was classified according to Dallas (2007), with responses to water quality, flow and habitat modifications also taken into consideration (based on Thirion, 2008). The PES categories are shown in Table 5. It should be noted that most of the watercourses on site were originally valley bottom wetlands that have become eroded to various degrees. For this reason, it is difficult to accurately determine reference conditions and, thus, the degree of modification.

Aquatic macroinvertebrate diversity was highest within the lower Dwars-in-die-Wegspruit (D2), Steelpoort tributary (site M4) and all upstream Blesbokspruit sites (all sites upstream of site B3). These sites also had the highest prevalence of sensitive taxa that are intolerant of changes in water quality. Sensitive taxa included atyid shrimps, lestid damselflies and dixid midges. The Dwars-in-die-Wegspruit sites had additional sensitive taxa, including two species of baetid mayfly, aeshnid dragonflies (at D1 and D2) and hydraenid beetles (at M4).

The upper Blesbokspruit (B1, D-Div, B2A), the lower Dwars-in-die-Wegspruit (D2) and Steelpoort tributary (M4) were considered to be ***Largely Natural to Moderately Modified*** (Category B/C) in terms of aquatic macroinvertebrates. The relatively high prevalence of sensitive taxa points to relatively good water quality. However, channelization has affected the availability of marginal habitats, while habitat modification due to reduced or altered flows (diversions, dams, road crossings) was also evident. This has affected the invertebrate assemblage to some extent. The Steelpoort tributary (site M4) was considered to be the least modified in terms of aquatic macroinvertebrates.

Diversity was low at the Kromdraaispruit site (K1), as well as at the lower Rietspruit and Blesbokspruit sites (sites R3 and B3). The downstream Blesbokspruit and Rietspruit sites (B3, and R3) were considered to be Category D-E (***Largely to Seriously Modified***) for aquatic macroinvertebrates. The low diversity of invertebrates within the Blesbokspruit and Kromdraaispruit was at least partly due to extreme low flows at the time of sampling and thus a dearth of suitable habitats (e.g. for atyid shrimps), while site K1 was affected by low flows and coal dust from haul trucks crossing the bridge adjacent to the site.

The upper Rietspruit site (R2) had a slightly higher prevalence of sensitive taxa (including dixid midges) than the downstream site (R3) and was considered ***Moderately Modified*** (Category C). The upper Dwars-in-die-Wegspruit site (D1) has a lower diversity and ASPT than the downstream site, pointing to a loss of sensitive taxa in response to water quality impacts. This site was also considered Category C.

Otter tracks and scats were observed along the entire Blesbokspruit, together with its primary prey item, crabs. As such, the ecological importance of this stream should consider ecosystem services and processes – i.e. the provision of migration corridors and aquatic invertebrate prey items for wetland mammals such as otter and water mongoose.

Table 27. Summarised SASS5 data for the aquatic sampling sites sampled for the Matla mining expansion project.

	Kromdraais pruit	Rietspruit		Blesbokspruit					Dwars-in-die-Wegspruit		
SITE	**K1**	**Riet 2**	**Riet 3**	**B1**	**BDIV**	**B2 (trib)**	**B2A**	**B3**	**D1**	**D2**	**M4**
Temp (°C):	22.9	25.0	20.8	25.0	21.0	24.6	21.3	24.3	23.5	24.2	20.0
pH:	8.69	8.04	8.03	7.97	8.43	7.15	7.85	8.1	7.89	8.26	7.03
Cond (mS/m):	99.3	54	90.5	90	74.7	77	107.9	133.1	56	84	103.4
Biotopes Rated 1-5: Stones	1	0	0	2	0	0	0	0	0	0	0
Biotopes Rated 1-5: Aquatic vege	0	1	2	2	1	1	1	0	1	1	2
Biotopes Rated 1-5: Marginal vege	2	3	3	2	3	2	3	2	2	2	3
Biotopes Rated 1-5: Gravel/ Sand /Mud	2	1	1	1	2	1	1	1	1	1	1
TOTAL No. SASS TAXA	11	13	10	14	15	9	14	9	14	17	22
SASS Score	44	64	45	73	80	37	78	35	67	89	110
Average Score per Taxon	4.0	4.9	4.5	5.2	5.3	4.1	5.2	3.9	4.8	5.2	5.0
PES	D	C	D	B/C	B/C	D	B/C	E	C	B/C	B

7.5.2 Pans

It should be noted that:

1. SASS5 was developed specifically for flowing systems (rivers and streams) and should be applied to pans with caution. For this reason, the biotic integrity of pans, based on aquatic macroinvertebrates, was analysed in terms of diversity and the presence of specialized, rare or sensitive taxa, and not according to SASS5 guidelines.
2. PES categories have been subjectively assigned, based on comparisons with over 20 pans sampled across the highveld. No published interpretation guidelines are available for aquatic macroinvertebrate fauna in pans.

Pan 7 had a far higher diversity of aquatic macroinvertebrates than any other pan. Sensitive hydraenid beetles were present within this pan. As such, it was estimated to be Category B (Largely Natural) in terms of aquatic macroinvertebrates. The higher diversity within this pan also reflects the prolific marginal vegetation (*Typha*, *Juncus* and grasses) and high productivity of this eutrophic ecosystem.

Pans 4 and 12 had a moderate diversity that reflected their seasonal hydrology and the low diversity of marginal vegetation. They were estimated to be Category B/C (Largely Natural to Moderately Modified). Seasonal pans have specialized taxa that are adapted to periods of temporary dryness, thus increasing the overall aquatic biodiversity of an area. These pan-adapted taxa (such as ostracods, copepods and cladocerans) are important food sources for water birds and amphibians, resulting in a higher abundance and diversity of water birds and amphibians associated with pans than with channeled watercourses.

Diversity was exceptionally low at the mine-impacted pans (Mine 2 Pan and Pan 3) – with only 6-8 recorded taxa and an absence of sensitive taxa.

Pan 2 also recorded a low diversity and sensitivity score (SASS5 score). However, unlike the mine impacted pans, Pan 2 had caenid mayflies, ostracods, and pleids and leeches, all of which were absent from Pan 3 and Mine 2 Pan. As such, it resembled Pan 1 more closely in terms of its invertebrate assemblage and its low diversity may be more related to an absence of available marginal habitats than to water quality impacts.

Table 28. Summarised results for aquatic macroinvertebrates sampled from pans for the Matla mining expansion project.

		Pans						
SITE		Mine Pan 2	1	2	3	Pan 4	Pan 7	Pan 12
Temp (°C):		24.1	24.6	24,3	25.3	23.6	22.8	
pH:		8.14	9.26	9.36	8.68	8.52	7.14	
Cond (mS/m):		320.6	167.5	278.8	228.8	155.0	32.0	
Biotopes Rated 1-5	Stones	0	0	0	0	0	0	0
	Aquatic vege	0	3	0	2	1	4	1
	Marginal vege	3	3	2	2	2	4	1
	Gravel/ Sand /Mud	1	1	1	1	1	1	1
TOTAL No. SASS TAXA		8	11	8	6	8	16	8
SASS Score		26	44	33	24	35	73	34
Average Score per Taxon		n/a	n/a	n/a	n/a	n/a	n/a	n/a

7.6 Fish

7.6.1 Habitat Composition

The habitat diversity or biotopes available for fish varied between the different sites. No fast habitats were available at the time of sampling, being representative of the end of dry season conditions. The lack of flow was however aggravated by impacts such as flow modification (as described above). The only velocity-depth classes available for fish was therefore slow-deep and slow-shallow (slow and deep pools). Cover features for fish were also generally limited, mostly being provided in the form of overhanging vegetation (reeds) with limited aquatic macrophytes and substrate (stones) also available at some sites (Table 29).

Table 29. Habitat composition and diversity for fish at different sampling sites.

Sites:	D1	D2	B1	B3	R2	R3
SLOW-DEEP (>0.5m; <0.3m/s)						
Abundance	4	3	3	2	1	3
Overhanging vegetation	4	4	2	1	1	1
Undercut banks and Root-wads	1	1	0	2	0	0
Substrate	0	0	3	0	0	0
Macrophytes	3	1	3	1	2	2
SLOW-SHALLOW (<0.5m; <0.3m/s)						
Abundance	1	3	3	3	3	3
Overhanging vegetation	3	4	3	2	3	2
Undercut banks and Root-wads	0	1	0	1	0	1
Substrate	0	0	2	0	0	0
Macrophytes	2	1	2	1	3	2
FAST-DEEP (>0.3m; >0.3m/s)						
Abundance	0	0	0	0	0	0
Overhanging vegetation	0	0	0	0	0	0
Undercut banks and Root-wads	0	0	0	0	0	0
Substrate	0	0	0	0	0	0
Macrophytes	0	0	0	0	0	0
FAST-SHALLOW (<0.3m; >0.3m/s)						
Abundance	0	0	0	0	0	0
Overhanging vegetation	0	0	0	0	0	0
Undercut banks and Root-wads	0	0	0	0	0	0
Substrate	0	0	0	0	0	0
Macrophytes	0	0	0	0	0	0

Abundance of velocity-depth classes and cover are estimated according to:
0 – absent; 1 – rare; 2 – sparse; 3 – common; 4 – very abundant

7.6.2 Fish Species Composition

During the October 2011 baseline fish survey performed in the study area, only three indigenous fish species were sampled (Table 30). These included the Chubbyhead barb (*Barbus anoplus*), Sharptooth catfish (*Clarias gariepinus*) and Southern mouthbrooder (*Pseudocrenilabrus philander*) (Table 30). *Pseudocrenilabrus philander* was the most widespread species, sampled at most sites (all three river systems). *Clarias gariepinus* was only sampled in the Dwars-in-die-wegspruit (site D1) and Rietspruit (site D3), while *Barbus anoplus* was only sampled in the Dwars-in-die-wegspruit (sites D1 and D2).

Two alien fish species were also sampled, namely Mosquito fish (*Gambussia affinis*) and Common carp (*Cyprinus carpio*) (Table 30). Mosquito fish were present with alarmingly high abundance, and it can be expected that the presence of this species in such high numbers is currently impacting negatively on the indigenous fish assemblages.

Table 30: Fish species (no. of individuals) sampled during October 2011 at the selected sampling sites.

SPECIES		LOCALITY					
ABBREVIATION	**SCIENTIFIC NAME**	**D1**	**D2**	**B1**	**B3**	**R2**	**R3**
BANO	*Barbus anoplus*	15	24				
CGAR	*Clarias gariepinus*	1					1
PPHI	*Pseudocrenilabrus philander*	6	10	2		1	
CCAR*	Cyprinus carpio		2				2
GAFF*	*Gambusia affinis*			>100	2	20	
Sampling effort (minutes electrofishing)		17	23	17	15	16	15

*Exotic (alien) alien species

To enable the determination of the biotic integrity (present state in relation to that expected under natural conditions) of the study area in terms of its fish assemblage, it is necessary to estimate which species would have occurred here under natural (pre-disturbance) conditions. No historic (pre-disturbance) information is known to exist, or has been published, for the exact study area covered by this study. The approach therefore used to determine which species could have occurred under reference conditions is based on all available fish information of the region together with an estimation of habitat composition under reference conditions.

Based on all available information, seven indigenous fish species have a known distribution range overlapping the Matla study area, or have been sampled previously or during the current survey in the rivers and streams flowing through the Matla study area (Table 31). One indigenous fish species, namely the Smallmouth yellowfish (*Labeobarbus aeneus*) has been translocated from the Vaal River system into the upper reaches of the Olifants River (Table 31). Three alien (exotic) species with natural occurrence outside of South Africa are also currently present within the study area. It must be noted that the presence of translocated/introduced indigenous fish species, as well as alien species, have a negative impact on the indigenous fish species through competition for food and habitat, as well as the possibility of hybridization. The presence of these species, both indigenous and exotic, is therefore seen as an impact on the indigenous fish assemblage of the study area, and interpreted and discussed as such.

As mentioned above, the presence of only three of the expected seven indigenous fish species was confirmed during the baseline survey in the study area. *Barbus neefi*, a moderately intolerant species, has a low to moderate probability of occurrence. The absence of this species during the baseline survey may be a reflection of poor biotic integrity, especially related to reduced water quality, flow and alien predatory fish species. The same goes for *Labeobarbus polylepis*, another moderately intolerant species that was not sampled during the baseline survey. This species has a preference for fast habitat, and therefore habitat limitations may have been a determining factor for its absence from the study area during the baseline survey. Flow modification, and to a lesser degree water quality deterioration, may contribute to the absence or scarcity of this species in this area. It is estimated that there is still a high probability that it occurs within and downstream of the Matla study area. *Barbus paludinosus* and *Tilapia sparrmanii* are both tolerant species, and although not sampled during the baseline survey, there is a high probability that these species still occur in the study area.

Table 31: Estimated probability of occurrence of fish species in the study area under natural and present conditions.

Abbreviation	SCIENTIFIC NAME	Dwars-in-die-weg-spruit		Blesbokspruit		Rietspruit		Downstream reaches (including Steenkoolspruit & Olifants River)	
		B11D-01467		B11E-01373		B11E-01399, B11E-01353		B11D-01424, B11D-01366, B11E-01297, B11F-01274	
		Natural	Present[1]	Natural	Present[1]	Natural	Present[1]	Natural	Present[1]
BANO	*BARBUS ANOPLUS* WEBER, 1897	High	Definite	High	Moderate	High	Moderate	High	High
BNEE	*BARBUS NEEFI* GREENWOOD, 1962	High	Low	High	Moderate	High	Moderate	High	Low
BPAU	*BARBUS PALUDINOSUS* PETERS, 1852	High	Low	Moderate	Moderate	High	High	High	Low
BPOL	*LABEOBARBUS POLYLEPIS* BOULENGER, 1907	High	Low	?	?	High	High	High	Moderate
CGAR	*CLARIAS GARIEPINUS* (BURCHELL, 1822)	High	Definite	High	Moderate	High	Definite	High	High
PPHI	*PSEUDOCRENILABRUS PHILANDER* (WEBER, 1897)	High	Definite	High	Definite	High	Definite	High	High
TSPA	*TILAPIA SPARRMANII* SMITH, 1840	High	Low	High	Moderate	High	High	High	High
BAEN#	*LABEOBARBUS AENEUS* (BURCHELL, 1822)	n/e	n/e	n/e	n/e	n/e	Moderate	n/e	Moderate
GAFF*	*GAMBUSIA AFFINIS* (BAIRD & GIRARD, 1853)	n/e	High	n/e	Definite	n/e	High	n/e	High
CCAR*	*CYPRINUS CARPIO* LINNAEUS, 1758	n/e	Definite	n/e	High	n/e	Definite	n/e	High
MSAL*	*MICROPTERUS SALMOIDES* (LACEPÈDE, 1802)	n/e	Low	n/e	Low	n/e	Low	n/e	Moderate

n/e not expected ? - uncertain
*Exotic (alien) alien species
- Introduced/translocated indigenous species.
1- Based on current survey and all other available information (including DWS 2014)

7.6.3 Habitat preference and intolerance to environmental degradation

The indigenous fish species of the study area differ in their preferences for different habitat types (Table 32). Most the fish species in the study area have a preference for slow habitats with overhanging vegetation, aquatic macrophytes and water column as cover (Table 32). One species, *Labeobarbus polylepis*, has a high preference and requirement for fast flowing water over substrate of good quality, as well as adequate depth in pools (water column) (Table 32). Examples of activities often responsible for degradation in different fish habitat features are given in Table 33 and caution should be taken with any of these activities, especially those that may influence the preferred habitats of the fish species known to occur in the study area.

Table 32: Habitat preferences (flow-depth and cover features) of the expected fish species (Kleynhans, 2003).

ABBREVIATION	SCIENTIFIC NAME	ENGLISH COMMON NAME	HABITAT PREFERENCE								
			SLOW-DEEP (<0.3 m/s; >0.5 m)	SLOW-SHALLOW (<0.3 m/s; <0.5 m)	FAST-DEEP (>0.3 m/s; >0.3 m)	FAST-SHALLOW (>0.3 m/s; <0.3 m)	OVERHANGING VEGETATION	BANK UNDERCUT	SUBSTRATE	AQUATIC MACROPHYTES	WATER COLUMN
BANO	*BARBUS ANOPLUS* WEBER, 1897	CHUBBYHEAD BARB	4.1	4.3	0.9	2.5	4	2.7	2.3	3.2	1.1
BNEE	*BARBUS NEEFI* GREENWOOD, 1962	SIDESPOT BARB	3.3	4.7	1	1.7	3.9	3.3	4.4	0.5	0.2
BPAU	*BARBUS PALUDINOSUS* PETERS, 1852	STRAIGHTFIN BARB	3.9	3.9	2.2	2.6	4.2	2.4	1.9	3.6	3.5
BPOL	*LABEOBARBUS POLYLEPIS* BOULENGER, 1907	SMALLSCALE YELLOWFISH	4.2	2.9	3.7	4.3	1	1.6	5	0	3.6
CGAR	*CLARIAS GARIEPINUS* (BURCHELL, 1822)	SHARPTOOTH CATFISH	4.3	3.4	1.2	0.8	2.8	2.9	2.8	3	2.6
PPHI	*PSEUDOCRENILABRUS PHILANDER* (WEBER, 1897)	SOUTHERN MOUTHBROODER	2.6	4.3	0.5	0.9	4.5	3.2	1.9	2.9	0.3
TSPA	*TILAPIA SPARRMANII* SMITH, 1840	BANDED TILAPIA	3	4.3	0.9	1.5	4.5	1.9	2.5	3.6	1.1

0 = NO PREFERENCE, IRRELEVANT; >0 -0.9 = VERY LOW PREFERENCE -COINCIDENTAL?
>1-1.9 = LOW PREFERENCE >2-2.9 =MODERATE PREFERENCE
>3-3.9 =HIGH PREFERENCE >4-5 =VERY HIGH PREFERENCE

Table 33: Human activities that are often responsible for degradation in specific fish habitat features (important habitats for fish in study area shaded)

Velocity depth class or Habitat feature	General impacts and activities.
Slow deep & slow shallow	Increased flows as result of regulation, water transfer schemes, irrigation releases. Sedimentation of pools as a result of catchment and bank erosion.
Fast deep and fast shallow	Decreased flows as a result of water abstraction (for agriculture, domestic, mining or industry), flow modification as a result of dams, weirs and channelization.
Overhanging vegetation	Clearing of vegetation on stream banks for the purpose of stream crossings (conveyer belts, roads, haul roads), clearing of riparian zones for construction activities, exotic vegetation encroachment replacing natural vegetation and also causing increased bank erosion, and to a lesser extent water quality deterioration (increased toxins could result in decreased availability of vegetation while increased nutrients could result in excessive growth or domination by single or a few species).
Undercut banks	Alteration of natural water levels (through water abstraction, flow alterations, etc.). Physical disturbance of banks through construction or agricultural activities.
Substrate	Increased sedimentation (related to erosion), excessive algal growth (especially associated with irrigation return flows and WWTW effluents), sand mining, trampling by livestock, disturbance by bottom-feeding alien species such as Common carp, etc.
Aquatic macrophytes	Altered flow regimes, use of herbicides, presence of alien Grass carp.
Water column	Decreased flows (through abstraction, constructions of dams, etc.)

7.6.4 Relative intolerance of fish to environmental change

The fish species of the study area also differ in their tolerance level to disturbance of the environment (Table 34). All the fish species expected or observed within the study area are classified as being overall tolerant, moderately tolerant or moderately intolerant to environmental change (Table 34). The most intolerant of all species are the Sidespot barb (*Barbus neefi*), which is intolerant to trophic, habitat and flow alterations and water quality deterioration (Table 34). The Smallscale yellowfish (*Labeobarbus polylepis*) is also classified as being overall moderately intolerant, being especially intolerant to habitat and flow modification. These two species, if still present within the study area under natural conditions, should be the most important indicator fish species to use in future to detect changes as a result of activities such as mining operations.

Table 34: Relative intolerance ratings of expected fish species (Kleynhans, 2003)

ABBREVIATION	SCIENTIFIC NAME	ENGLISH COMMON NAME	INTOLERANCE RATINGS				
			TROPHIC SPECIALIZATION	HABITAT SPECIALIZATION	FLOW REQUIREMENT	REQUIREMENT: UNMODIFIED WATER QUALITY	AVERAGE OVERALL INTOLERANCE RATING
BANO	*BARBUS ANOPLUS* WEBER, 1897	CHUBBYHEAD BARB	2.8	2.8	2.3	2.6	2.6
BNEE	*BARBUS NEEFI* GREENWOOD, 1962	SIDESPOT BARB	3.3	3.4	3.4	3.4	3.4
BPAU	*BARBUS PALUDINOSUS* PETERS, 1852	STRAIGHTFIN BARB	1.6	1.4	2.3	1.8	1.8
BPOL	*LABEOBARBUS POLYLEPIS* BOULENGER, 1907	SMALLSCALE YELLOWFISH	3	3.3	3.3	2.9	3.1
CGAR	*CLARIAS GARIEPINUS* (BURCHELL, 1822)	SHARPTOOTH CATFISH	1	1.2	1.7	1	1.2
PPHI	*PSEUDOCRENILABRUS PHILANDER* (WEBER, 1897)	SOUTHERN MOUTHBROODER	1.3	1.4	1	1.4	1.3
TSPA	*TILAPIA SPARRMANII* SMITH, 1840	BANDED TILAPIA	1.6	1.4	0.9	1.4	1.3

0-1.9 = TOLERANT; >2-2.9 = MODERATELY TOLERANT
>3-3.9 = MODERATELY INTOLERANT >4-5.0 = INTOLERANT

7.6.5 Conservation status

None of the fish species expected or observed in the study area are classified as threatened on any scale (international, national or regional) (Table 35). The Chubbyhead barb, Sharptooth catfish, Threespot barb, Southern mouthbrooder and Banded tilapia are all widespread and common species. The Sidespot barb is classified as least concern (does not currently qualify for threatened status), but is becoming scarcer in areas where it was previously common. Its trend of occurrence in South Africa and Mpumalanga are uncertain due to data deficiency. The Smallscale yellowfish was classified as "least concern" by Wolhuter & Impson (2007). As for most yellowfish in South Africa, their natural distribution range is shrinking, but they are however still widely distributed and relatively abundant in many rivers (Roux, F: in Wolhuter & Impson, 2007).

Table 35: Conservation status of indigenous fish species expected in the study area.

ABBREVIATION	SCIENTIFIC NAME	ENGLISH COMMON NAME	CONSERVATION STATUS / GENERAL COMMENTS
BANO	*BARBUS ANOPLUS* WEBER, 1897	CHUBBYHEAD BARB	Widespread and common
BNEE	*BARBUS NEEFI* GREENWOOD, 1962	SIDESPOT BARB	Least concern (Potentially more than one species).
BPAU	*BARBUS PALUDINOSUS* PETERS, 1852	STRAIGHTFIN BARB	Widespread and common
BPOL	*LABEOBARBUS POLYLEPIS* BOULENGER, 1907	SMALLSCALE YELLOWFISH	Least concern* (Natural distribution range however shrinking)
CGAR	*CLARIAS GARIEPINUS* (BURCHELL, 1822)	SHARPTOOTH CATFISH	Widespread and common
PPHI	*PSEUDOCRENILABRUS PHILANDER* (WEBER, 1897)	SOUTHERN MOUTHBROODER	Widespread and common
TSPA	*TILAPIA SPARRMANII* SMITH, 1840	BANDED TILAPIA	Widespread and common

*Wolhuter & Impson (2007)

7.6.6 Alien and introduced fish species

The Common carp (*Cyprinus carpio*) was sampled in the Dwars-in-die-wegspruit and Rietspruit during the current study. Common carp can be seen as equivocal, having a negative impact on the environment they occur in, but being valued by certain interest groups such as sport fishermen. They are widely regarded as a pest, and are held responsible for the introduction of numerous fish parasites. They compete with other fish for food, they eat the spawn of other fish and disrupt nest-building activities of some fish. Furthermore, they cause habitat degradation by their feeding behaviour of grubbing in the mud for food, which causes the destruction of vegetation, rooting up of marginal vegetation and disturbing of the bottom sediments which increases turbidity (de Moor & Bruton, 1988).

Gambusia affinis, the other alien species being very abundant in the study area, has been introduced to aquatic systems in South Africa as a biological control method for mosquitoes (de Moor, 1988). It feeds on living animals, including mosquito- and fish larvae. They may alter the ecosystem by reducing the population of zooplankton and aquatic insect larvae. They also feed on the eggs and larvae of other fish and have been known to nip at the fins of larger fish (de Moor & Bruton, 1988). The high abundance of this species in the study area is of concern and may have a significant impact on the indigenous fish assemblage.

Another alien fish species, namely the Largemouth bass (*Micropterus salmoides*) has a low to moderate probability of occurrence within this quaternary catchment. The potential presence of this species is always alarming and the expected impact can be detrimental, as this aggressive predator can have a large impact on the indigenous fish species, especially small species and juveniles of larger species. It should be encouraged to remove specimens of this species whenever caught by anglers to keep their numbers as low as possible. These species should also not be allowed to be stocked in the river or dams in tributaries of the rivers in the area.

7.6.7 Migration

Most of the fish species expected or observed in the study area are all classified as potadromous in terms of migratory life history. *Labeobarbus polylepis*, *Barbus anoplus*, *Barbus paludinosus*, *Barbus trimaculatus*, *Barbus neefi*, *Clarias gariepinus* and *Tilapia sparrmanii* all require movement between reaches, while *Pseudocrenilabrus philander* primarily migrates within a reach. Currently, migration of the fish in the study area is influenced by the presence of various existing dams, weirs and road crossings. Chemical migration barriers as a result of the poor water quality in some areas may also act as migration barriers to these fish species. It is recommended that all redundant dams should be removed from streams in the study area (and region where applicable) and no new instream dams should be constructed. An investigation should also be undertaken to determine the impact of migration barriers on fish movement, and recommendations should be made to mitigate these impacts. All new weirs, dams and road crossings should allow for the free movement of fish (through proper design and implementation of fishways, etc.).

7.6.8 Biotic integrity based on fish

The present ecological status (PES) or biotic integrity, based on fish, of the different river reaches of the study area was determined through the application of the Fish Response Assessment Index (FRAI) (Kleynhans, 2007). It provides an indication of the present status of the fish assemblage, in relation to what could be expected under natural or unmodified conditions.

1.1.1.1 Dwars-in-die-Wegspruit

According to the FRAI calculations, the present ecological status (PES) of the Dwars-in-die-wegspruit is in the best ecological status, in terms of fish assemblages, of the three river ecosystems in the study area. The Dwars-in-die-wegspruit is however still in a deteriorated state, with a FRAI score of 59% calculated for this reach, falling in a category C/D (moderately to largely modified from natural conditions (Table 36 and 37). Most aspects of the fish assemblage have been altered from its natural unperturbed state. In terms of the FRAI metrics, the primary impacts responsible for the present ecological state of the Dwars-in-die-wegspruit are as follows:

- Velocity-Depth metrics: Flow modification related to dams, weirs, abstraction, return flows have altered the natural flow regime. A loss of fast-habitats has resulted in alteration in especially fish species with a preference for this habitat type, such as the Smallscale yellowfish and to some extent also the Sidespot barb. Sedimentation of pools has reduced the presence of deep habitats in some cases.
- Cover metrics: Rocky substrates (cobbles, boulders, bedrock cracks) have been altered through sedimentation, embeddedness and algal growth. Vegetation as cover has been altered by the changed flow regime, alteration in floods, localised disturbance through vegetation removal for construction of bridges, dams, weirs, river crossings.
- Flow dependence metrics: No rheophilic species (species with requirement for flowing water during all stages of life cycle) are present in the study area, but the semi-rheophilic (moderately intolerant to no-flow conditions) are to some extent impacted by the altered flow regime.
- Reduced water quality (primarily associated with agricultural and livestock farming activities, formal and informal settlement runoff) may be responsible for some deterioration in water quality, impacting especially on species with moderate intolerance to water quality alteration (such as *Barbus neefi*).
- Migration metrics: Various dams, weirs and road crossings in the study area are creating physical migration barriers, limiting the natural movement of fish. Water quality deterioration in downstream river reaches may also create physico-chemical migration barriers to some species.
- Alien/introduced species: The presence of especially the habitat modifying alien fish species *Cyprinus carpio*, as well as possible presence of predatory alien *Gambussia affinis*, has a negative impact on the indigenous fish assemblages of this reach.

Table 36: Estimated frequency of occurrence of indigenous fish species under reference and present conditions in the Dwars-in-die-wegspruit reach.

ABBREVIATIONS: REFERENCE SPECIES	SCIENTIFIC NAMES: REFERENCE SPECIES	REFERENCE CONDITION (EXPECTED) FREQUENCY OF OCCURRENCE*	PRESENT FREQUENCY OF OCCURRENCE*: PES
BANO	***BARBUS ANOPLUS*** **WEBER, 1897**	3	3
BNEE	***BARBUS NEEFI*** **GREENWOOD, 1962**	3	1
BPAU	***BARBUS PALUDINOSUS*** **PETERS, 1852**	3	2
BPOL	***LABEOBARBUS POLYLEPIS*** **BOULENGER, 1907**	2	1
CGAR	***CLARIAS GARIEPINUS*** **(BURCHELL, 1822)**	3	3
PPHI	***PSEUDOCRENILABRUS PHILANDER*** **(WEBER, 1897)**	4	4
TSPA	***TILAPIA SPARRMANII*** **SMITH, 1840**	3	2

*0=ABSENT; 1=PRESENT AT VERY FEW SITES (<10%); 2=PRESENT AT FEW SITES (>10-25%); 3=PRESENT AT ABOUT >25-50 % OF SITES; 4=PRESENT AT MOST SITES (>50- 75%); 5=PRESENT AT ALMOST ALL SITES (>75%).

Table 37: Fish Response Assessment Index (FRAI) results for Dwars-in-die-Wegspruit Reach.

METRIC GROUP	METRIC	*RATING (CHANGE)	METRIC GROUP WEIGHT (%)
VELOCITY-DEPTH CLASSES METRICS	Response of species with high to very high preference for FAST-DEEP conditions	-3	95
	Response of species with high to very high preference for FAST-SHALLOW conditions	-3	
	Response of species with high to very high preference for SLOW-DEEP conditions	-1	
	Response of species with high to very high preference for SLOW-SHALLOW conditions	-1	
COVER METRICS	Response of species with a very high to high preference for overhanging vegetation	-1	100
	Response of species with a very high to high preference for undercut banks and root wads	-2	
	Response of species with a high to very high preference for a particular substrate type	-3	
	Response of species with a high to very high preference for instream vegetation	-1	
	Response of species with a very high to high preference for the water column	-2	
FLOW DEPENDANCE METRICS	Response of species intolerant of no-flow conditions	0	77
	Response of species moderately intolerant of no-flow conditions	-3	
	Response of species moderately tolerant of no-flow conditions	-1	
	Response of species tolerant of no-flow conditions	-1	
PHYSICO-CHEMICAL METRICS	Response of species intolerant of modified physico-chemical conditions	0	63
	Response of species moderately intolerant of modified physico-chemical conditions	-3	
	Response of species moderately tolerant of modified physico-chemical conditions	-1	
	Response of species tolerant of modified physico-chemical conditions	-1	
MIGRATION METRICS	Response in terms of distribution/abundance of spp with catchment scale movements		51
	Response in terms of distribution/abundance of spp with requirement for movement between reaches or fish habitat segments	2.0	
	Response in terms of distribution/abundance of spp with requirement for movement within reach or fish habitat segment	2.0	
INTRODUCED SPECIES METRICS	The impact/potential impact of introduced competing/predaceous spp?	0.5	64
	How widespread (frequency of occurrence) are introduced competing/predaceous spp?	0.5	
	The impact/potential impact of introduced habitat modifying spp?	3.0	
	How widespread (frequency of occurrence) are habitat modifying spp?	2.0	
FRAI SCORE (%)		**59**	
FRAI CATEGORY		**C/D**	
FRAI CATEGORY DESCRIPTION		**Moderately/Largely modified**	

*GUIDELINES FOR RATING/CHANGE (0-->5)
-5=Extreme loss from reference (absent); -4=Serious loss from reference; -3=Large loss from reference; -2=Moderate loss from reference, -1= Small loss from reference; 0=No change from reference; 1= Small increase from reference; 2=Moderate increase from reference; 3=Large increase from reference; 4=Serious increase from reference; 5=Extreme increase from reference (completely dominant).

1.1.1.2 Blesbokspruit

According to the FRAI calculations, the present ecological status (PES) of the Blesbokspruit reach is in the worst ecological status, in terms of fish assemblages, of the three river ecosystems in the study area. A FRAI score of only 48% was calculated for this reach, indicating largely modified conditions (category D) (Table 38 and 39). Most aspects of the fish assemblage have been altered from its natural unperturbed state. In terms of the FRAI metrics, the primary impacts responsible for the present ecological state of the Blesbokspruit are similar to those described for the Dwars-in-die-wegspruit above, although current mining activities further contribute to deterioration together with agricultural impacts. Flow modification related to dams, weirs and abstraction again impacted on both fast and also slow-deep habitats, while sedimentation in the lower section was especially significant (leading in loss of pool depth). Cover features have been altered and lost, with rocky substrates (cobbles, boulders, bedrock cracks) that have been altered through sedimentation, embeddedness and algal growth. Vegetation as cover has been altered by the changed flow regime, alteration in floods, localised disturbance through vegetation removal for construction as well as trampling and grazing by livestock. Reduced water quality (associated with agricultural and livestock farming activities, as well as current mining activities) may be responsible for deterioration in water quality, impacting most of the fish species to some extent. The condition of the fish assemblage is further impacted upon by physical and chemical migration barriers (also downstream reaches), as well as the presence of alien fish species.

Table 38: Estimated frequency of occurrence of indigenous fish species under reference and present conditions in the Blesbokspruit.

ABBREVIATIONS: REFERENCE SPECIES	SCIENTIFIC NAMES: REFERENCE SPECIES	REFERENCE CONDITION (EXPECTED) FREQUENCY OF OCCURRENCE*	PRESENT FREQUENCY OF OCCURRENCE*: PES
BANO	***BARBUS ANOPLUS*** **WEBER, 1897**	3	1
BNEE	***BARBUS NEEFI*** **GREENWOOD, 1962**	3	1
BPAU	***BARBUS PALUDINOSUS*** **PETERS, 1852**	3	1
BPOL	***LABEOBARBUS POLYLEPIS*** **BOULENGER, 1907**	1	1
CGAR	***CLARIAS GARIEPINUS*** **(BURCHELL, 1822)**	3	1
PPHI	***PSEUDOCRENILABRUS PHILANDER*** **(WEBER, 1897)**	4	3
TSPA	***TILAPIA SPARRMANII*** **SMITH, 1840**	3	1

*0=ABSENT; 1=PRESENT AT VERY FEW SITES (<10%); 2=PRESENT AT FEW SITES (>10-25%); 3=PRESENT AT ABOUT >25-50 % OF SITES; 4=PRESENT AT MOST SITES (>50- 75%); 5=PRESENT AT ALMOST ALL SITES (>75%).

Table 39: Fish Response Assessment Index (FRAI) results for Blesbokspruit Reach.

METRIC GROUP	METRIC	*RATING (CHANGE)	METRIC GROUP WEIGHT (%)
VELOCITY-DEPTH CLASSES METRICS	Response of species with high to very high preference for FAST-DEEP conditions	0	95
	Response of species with high to very high preference for FAST-SHALLOW conditions	0	
	Response of species with high to very high preference for SLOW-DEEP conditions	-3	
	Response of species with high to very high preference for SLOW-SHALLOW conditions	-3	
COVER METRICS	Response of species with a very high to high preference for overhanging vegetation	-3	100
	Response of species with a very high to high preference for undercut banks and root wads	-2	
	Response of species with a high to very high preference for a particular substrate type	-2	
	Response of species with a high to very high preference for instream vegetation	-3	
	Response of species with a very high to high preference for the water column	-3	
FLOW DEPENDANCE METRICS	Response of species intolerant of no-flow conditions	0	77
	Response of species moderately intolerant of no-flow conditions	-3	
	Response of species moderately tolerant of no-flow conditions	-3	
	Response of species tolerant of no-flow conditions	-3	
PHYSICO-CHEMICAL METRICS	Response of species intolerant of modified physico-chemical conditions	0	63
	Response of species moderately intolerant of modified physico-chemical conditions	-3	
	Response of species moderately tolerant of modified physico-chemical conditions	-2	
	Response of species tolerant of modified physico-chemical conditions	-3	
MIGRATION METRICS	Response in terms of distribution/abundance of spp with catchment scale movements		51
	Response in terms of distribution/abundance of spp with requirement for movement between reaches or fish habitat segments	2.0	
	Response in terms of distribution/abundance of spp with requirement for movement within reach or fish habitat segment	2.0	
INTRODUCED SPECIES METRICS	The impact/potential impact of introduced competing/predaceous spp?	4.0	64
	How widespread (frequency of occurrence) are introduced competing/predaceous spp?	4.0	
	The impact/potential impact of introduced habitat modifying spp?	1.0	
	How widespread (frequency of occurrence) are habitat modifying spp?	1.0	
FRAI SCORE (%)		**48**	
FRAI CATEGORY		**D**	
FRAI CATEGORY DESCRIPTION		**Largely modified**	

*GUIDELINES FOR RATING/CHANGE (0-->5)
-5=Extreme loss from reference (absent); -4=Serious loss from reference; -3=Large loss from reference; -2=Moderate loss from reference, -1= Small loss from reference; 0=No change from reference; 1= Small increase from reference; 2=Moderate increase from reference; 3=Large increase from reference; 4=Serious increase from reference; 5=Extreme increase from reference (completely dominant).

1.1.1.3 Rietspruit

According to the FRAI calculations, the present ecological status (PES) of the Rietspruit reach is in also in a deteriorated ecological status, in terms of fish assemblages, with a FRAI score of only 52% calculated for this reach. It therefore indicates that this reach falls in a category D, reflecting largely modified from natural condition (Table 40 and 41). In terms of the FRAI metrics, the primary impacts responsible for the present ecological state of the Rietspruit are similar to those described for the Blesbokspruit, with current mining activities, agricultural and livestock farming as well as urban areas contributing to the deterioration. Flow modification related to dams, weirs and abstraction again impacted on both fast and also slow-deep habitats, while sedimentation decreased pool depth and embedded substrate resulting in loss of cover for fish. Vegetation as cover has been altered by the changed flow regime, alteration in floods, localised disturbance through vegetation removal for construction river diversions, as well as trampling and grazing by livestock. Reduced water quality (associated with agricultural and livestock farming activities, as well as current mining activities) may be responsible for deterioration in water quality, impacting most of the fish species to some extent. The condition of the fish assemblage is further impact by physical and chemical migration barriers (also downstream reaches), as well as the presence of predatory and habitat-modifying alien fish species.

Table 40: Estimated frequency of occurrence of indigenous fish species under reference and present conditions in the Rietspruit reach.

ABBREVIATIONS: REFERENCE SPECIES	SCIENTIFIC NAMES: REFERENCE SPECIES	REFERENCE CONDITION (EXPECTED) FREQUENCY OF OCCURRENCE*	PRESENT FREQUENCY OF OCCURRENCE*: PES
BANO	*BARBUS ANOPLUS* WEBER, 1897	3	1
BNEE	*BARBUS NEEFI* GREENWOOD, 1962	3	1
BPAU	*BARBUS PALUDINOSUS* PETERS, 1852	3	1
BPOL	*LABEOBARBUS POLYLEPIS* BOULENGER, 1907	1	1
CGAR	*CLARIAS GARIEPINUS* (BURCHELL, 1822)	3	3
PPHI	*PSEUDOCRENILABRUS PHILANDER* (WEBER, 1897)	4	3
TSPA	*TILAPIA SPARRMANII* SMITH, 1840	3	1

*0=ABSENT; 1=PRESENT AT VERY FEW SITES (<10%); 2=PRESENT AT FEW SITES (>10-25%); 3=PRESENT AT ABOUT >25-50 % OF SITES; 4=PRESENT AT MOST SITES (>50- 75%); 5=PRESENT AT ALMOST ALL SITES (>75%).

Table 41: Fish Response Assessment Index (FRAI) results for Rietspruit Reach.

METRIC GROUP	METRIC	*RATING (CHANGE)	METRIC GROUP WEIGHT (%)
VELOCITY-DEPTH CLASSES METRICS	Response of species with high to very high preference for FAST-DEEP conditions	0	95
	Response of species with high to very high preference for FAST-SHALLOW conditions	0	
	Response of species with high to very high preference for SLOW-DEEP conditions	-2	
	Response of species with high to very high preference for SLOW-SHALLOW conditions	-2	
COVER METRICS	Response of species with a very high to high preference for overhanging vegetation	-3	100
	Response of species with a very high to high preference for undercut banks and root wads	-2	
	Response of species with a high to very high preference for a particular substrate type	-2	
	Response of species with a high to very high preference for instream vegetation	-3	
	Response of species with a very high to high preference for the water column	-3	
FLOW DEPENDANCE METRICS	Response of species intolerant of no-flow conditions	0	77
	Response of species moderately intolerant of no-flow conditions	-3	
	Response of species moderately tolerant of no-flow conditions	-3	
	Response of species tolerant of no-flow conditions	-1	
PHYSICO-CHEMICAL METRICS	Response of species intolerant of modified physico-chemical conditions	0	63
	Response of species moderately intolerant of modified physico-chemical conditions	-3	
	Response of species moderately tolerant of modified physico-chemical conditions	-2	
	Response of species tolerant of modified physico-chemical conditions	-2	
MIGRATION METRICS	Response in terms of distribution/abundance of spp with catchment scale movements		51
	Response in terms of distribution/abundance of spp with requirement for movement between reaches or fish habitat segments	2.0	
	Response in terms of distribution/abundance of spp with requirement for movement within reach or fish habitat segment	2.0	
INTRODUCED SPECIES METRICS	The impact/potential impact of introduced competing/predaceous spp?	4.0	64
	How widespread (frequency of occurrence) are introduced competing/predaceous spp?	3.0	
	The impact/potential impact of introduced habitat modifying spp?	3.0	
	How widespread (frequency of occurrence) are habitat modifying spp?	3.0	
FRAI SCORE (%)		**52**	
FRAI CATEGORY		**D**	
FRAI CATEGORY DESCRIPTION		**Largely modified**	

*GUIDELINES FOR RATING/CHANGE (0-->5)
-5=Extreme loss from reference (absent); -4=Serious loss from reference; -3=Large loss from reference; -2=Moderate loss from reference, -1= Small loss from reference; 0=No change from reference; 1= Small increase from reference; 2=Moderate increase from reference; 3=Large increase from reference; 4=Serious increase from reference; 5=Extreme increase from reference (completely dominant).

8. IMPACT ASSESSMENT

Matla Coal intends to stoop (or totally extract) pillars at previously underground mined areas with the intent to reclaim the remaining coal reserves. The proposed activities will occur only on farms and portions within the Matla Coal mining boundary currently owned by Eskom or Exxaro (see Figure 36 below). This has been termed Phase 1 of the stooping activities. The proposed stooping activities cover farms within Block B, Block D, Block F, Blocks G & H and Block I (the LOMP stooping area). Based on information provided (email from Estie Retief dated 25/08/2016), the absolute maximum subsidence that could be expected is 1.53m in the case of longwall mining. Where pillar extraction will take place, somewhat lower subsidence is expected.

The proposed stooping activities will utilise most of the existing current operations' infrastructure of Matla Coal viz. access roads, haul road, conveyor belts, water pipelines, power lines, etc., and no new surface infrastructures are proposed. The impact assessment is therefore limited to the Phase 1 stooping activities (see Figure 36 below).

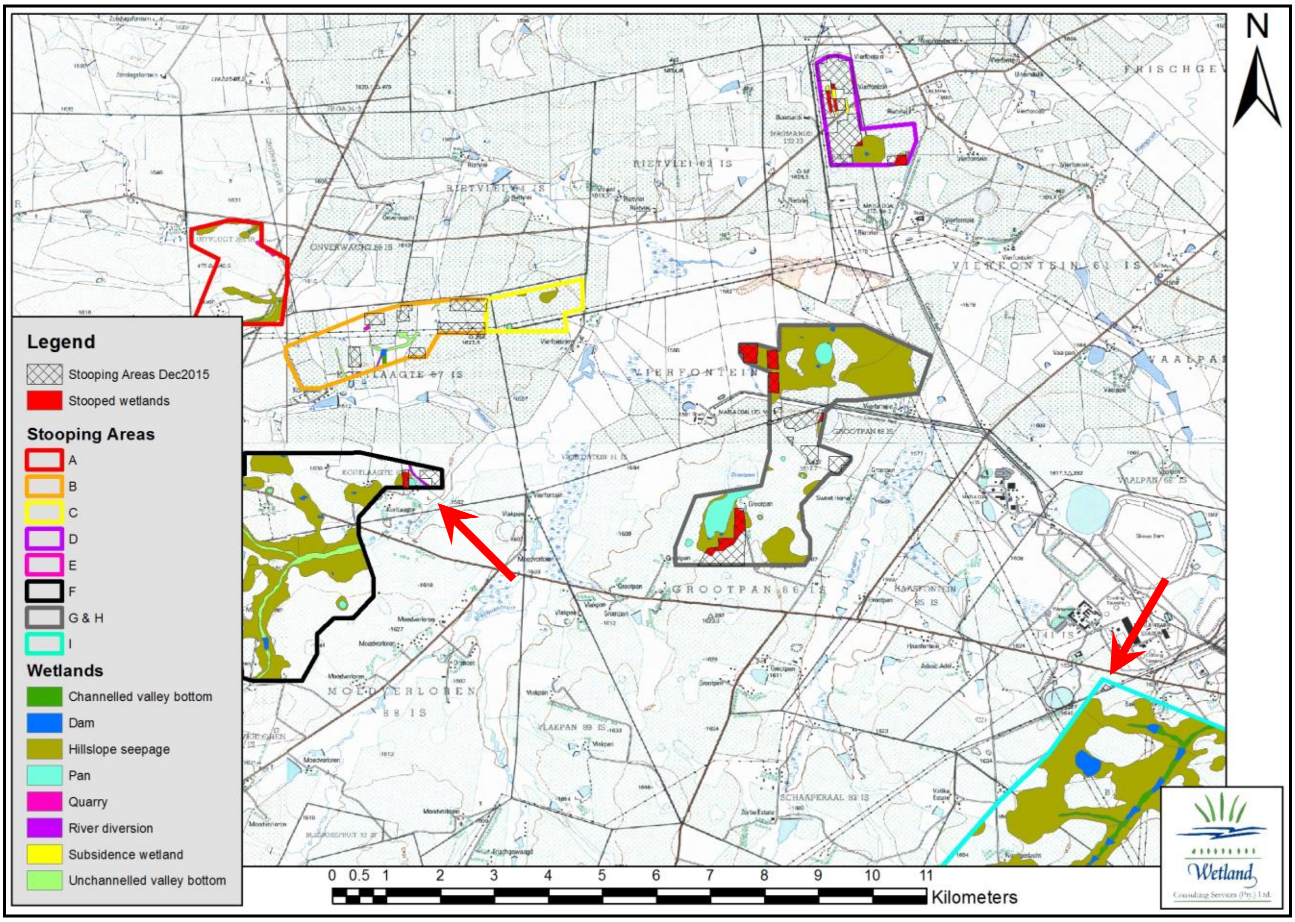

Figure 36. Map of the proposed stooping activities in relation to delineated wetlands. Wetlands that will be directly affected by stooping activities are highlighted in red. Red arrows indicate small stooping areas not readily visible at the scale of this map.

The proposed stooping activities will directly affect a total area of 251 hectares, of which 49 hectares (19.5 %) will take place underneath wetlands. Table 42 shows the affected wetland types and extent. The majority of wetlands affected are hillslope seepage wetlands, but significantly approximately 1.6 ha of pan habitat will also be directly affected. The affected pans are located within Blocks F and G. The affected pan within Block G was rated as being of High importance and sensitivity, while the seepage wetland feeding into the Grootpan (southern pan in Block G & H) will also be directly affected. Consideration should be given to excluding both these pans and their catchments from stooping activities.

Table 42. Table showing the type and extent of wetlands likely to be directly impacted by the proposed stooping activities.

Wetland Type	Area (ha)
Hillslope seepage	43.0
Pan	1.6
Subsidence wetland	4.5
TOTAL	49.1

The proposed stooping activities under wetlands are likely to result in a number of impacts to the wetlands due to surface subsidence. These impacts are identified and discussed below, as well as in Tables 43 & 44. Given that existing mining infrastructure will be utilized and that the stooping areas will be accessed from existing underground mining areas, there will be no construction phase as such, with expected impacts occurring during the operational and closure phases:

- **Wetland degradation and habitat alteration**: Subsidence within wetland areas due to stooping activities will alter the patterns of water retention and distribution within the wetlands, leading to habitat degradation (lowering of the wetland PES) and habitat alteration as the vegetation and fauna adapt to the new patterns of water movement. Subsidence areas within wetlands, particularly in valley bottom positions and areas of more clayey soils, will form depressions within increased water retention. Increased water retention in these areas implies decreased water retention in other areas of the wetland. These impacts are already observable in other wetlands within the area where stooping activities have taken place. Such changes can lead to habitat fragmentation and disruption of movement corridors through wetlands, especially where channels are interrupted, preventing the free movement of aquatic fauna.
- **Decreased flow in downstream wetlands**: This impact will materialize in two ways. Firstly, depressions formed within wetlands due to subsidence will increase water storage within the wetlands, reducing flow to downstream wetlands. Secondly, surface subsidence and the associated subsurface fracturing of the rock strata can lead to increased ingress of surface water into the underground mine workings, reducing flow in downstream wetlands. The consequence of the above is likely to be more severe and extended low flow periods. Reduced flow will lead to habitat degradation as vegetation adjusts to the new flow regime, with ruderal and alien species potentially colonizing affected areas.
- **Increase in alien vegetation**: Disturbance to wetland habitat could provide opportunities for establishment and spread of alien and pioneer species. This could lead to further knock-

on effects such as decreased flow within wetlands, increased erosion and exclusion of indigenous species.

- **Increased sediment movement into wetlands**: Rehabilitation activities undertaken on subsided areas will require the movement of soil and the exposure of bare soil areas to erosion. Eroded sediments are likely to enter wetlands and watercourses leading to increased turbidity and increased sediment deposition. Areas of sediment deposition are likely to be colonized by robust pioneer species such as *Typha capensis* that exclude other species.
- **Water quality deterioration**: Post mining the underground workings are expected to fill with water as groundwater levels rebound. As groundwater levels rise, decant of such contaminated water out of the mine workings is possible. Decant could occur through boreholes, subsided areas or other low points along the mined out coal seam. The expected decant quality is not known, but is expected to be of high salinity with high sulphate loads. The long-term deterioration in water quality due to contaminated mine drainage (AMD) is considered as probably the most significant impact of coal mining on aquatic resources. Acidification and salinisation of surface water as a result of decant/AMD will have a negative impact on especially biota intolerant to water quality alterations, but depending on the severity, may be detrimental to the entire aquatic ecosystem.

The above identified impacts have been assessed in Tables 43 and 44 below, as per the methodology provided by GCS (Pty) Ltd.

Table 43. Impact Assessment Table for the Operational Phase of proposed Phase 1 stooping activities.

POTENTIAL ENVIRONMENTAL IMPACT	ACTIVITY	ENVIRONMENTAL SIGNIFICANCE BEFORE MITIGATION						RECOMMENDED MITIGATION MEASURES	ENVIRONMENTAL SIGNIFICANCE AFTER MITIGATION					
		M	D	S	P	TOTAL	SP		M	D	S	P	TOTAL	SP
Operational Phase: Stooping of Coal (Underground mining)														
Issues related to WETLANDS														
Degradation and alteration of wetland habitat	stooping	8	5	2	5	75	H	Difficult to mitigate unless surface subsidence is prevented under wetlands. Consideration should be given to, as a minimum, exclude the pans within the Block G & H area (including Grootpan) and their catchments from stooping activities unless it can be shown that flow into the pans will not be negatively impacted by stooping. Means to prevent surface subsidence could be explored and possibly implemented at least at pilot scale. Other measures that should be implemented is the ploughing over of cracks appearing on the earth's surface where such cracks appear in cultivated areas. Should subsidence occur in wetland areas, the cracks should be closed by hand, as is the current practice for surface subsidence at Matla 3 mine. Where flow paths are disrupted by subsidence, these should be re-created in consultation with wetland and aquatic specialists.	6	5	3	5	70	H
Decreased flow in downstream wetlands	stooping	6	5	3	5	70	H	Difficult to mitigate unless surface subsidence is prevented under wetlands. Where flow paths are disrupted by subsidence, these should be re-created in consultation with wetland and aquatic specialists. Where impoundments are created by surface subsidence, the opportunities and desirability of reshaping such areas to again drain to downstream reaches should be investigated by suitable specialists, including specialists in the field of wetlands/aquatic ecology.	6	5	2	4	52	M
Increase in alien vegetation	stooping	6	5	2	3	39	M	An alien vegetation management plan must be drawn up for all surface areas under the control of Matla. Regular alien vegetation surveys should be undertaken to inform clearing and control activities. Special attention should be paid to areas disturbed by surface subsidence.	2	2	1	3	15	L

Increased sediment movement into wetlands	stooping	6	2	2	4	40	M	All sediment moving activities within wetlands should be undertaken during low flow periods. Rapid revegetation of disturbed soils is vital and must be insured. Regular follow up checks are required to ensure successful revegetation and to repair any observed erosion damage. Sediment control measures such as bidim fences, hay bales etc. should be installed to limit movement of sediment away from the disturbed area.	4	2	1	3	21	L

Table 44. Impact Assessment Table for the Decommissioning and Closure Phase of proposed Phase 1 stooping activities.

POTENTIAL ENVIRONMENTAL IMPACT	ACTIVITY	ENVIRONMENTAL SIGNIFICANCE BEFORE MITIGATION						RECOMMENDED MITIGATION MEASURES	ENVIRONMENTAL SIGNIFICANCE AFTER MITIGATION					
		M	D	S	P	TOTAL	SP		M	D	S	P	TOTAL	SP
Closure & Decommissioning: Rehabilitation														
Issues related to WETLANDS														
Increased sediment movement into wetlands	rehabilitation	6	2	2	4	40	M	All sediment moving activities within wetlands should be undertaken during low flow periods. Rapid revegetation of disturbed soils is vital and must be insured. Regular follow up checks are required to ensure successful revegetation and to repair any observed erosion damage. Sediment control measures such as bidim fences, hay bales etc. should be installed to limit movement of sediment away from the disturbed area.	4	2	1	3	21	L
Increase in alien vegetation	rehabilitation	6	5	2	3	39	M	An alien vegetation management plan must be drawn up for all surface areas under the control of Matla. Regular alien vegetation surveys should be undertaken to inform clearing and control activities. Special attention should be paid to areas disturbed by surface subsidence.	2	2	1	3	15	L
Closure & Decommissioning: Residual Impacts Post Closure														
Issues related to WETLANDS														

Water quality deterioration	residual impacts post closure	10	5	3	5	90	H	Decanting of polluted water from the underground mine should be avoided unless water is of an acceptable quality to meet the ecological requirements of the Olifants River as determined in the Olifants River Reserve Study. A water quality management plan must be compiled that will ensure no long-term degradation of water quality occurs within any of the watercourses draining the area. Water infiltrating into the underground mine will be pumped to the water treatment plant and used at the mine and power station. Selective release of treated water into some of the wetland systems on site could be considered to maintain/increase flows. Release of the water should mimic the natural hydrology. Use of treated water for irrigation should be explored in this regard.	6	5	3	3	42	M
Decreased flow in downstream wetlands	residual impacts post closure	8	5	3	5	80	H	The hydrology of the subsided areas has been permanently altered and a return to pre-mining conditions is impossible. Water infiltrating into the underground mine will be pumped to the water treatment plant and used at the mine and power station. Selective release of treated water into some of the wetland systems on site could be considered to maintain/increase flows. Release of the water should mimic the natural hydrology. Use of treated water for irrigation should be explored in this regard. Where flow paths are disrupted by subsidence, these should be re-created in consultation with wetland and aquatic specialists. Where impoundments are created by surface subsidence, the opportunities and desirability of reshaping such areas to again drain to downstream reaches should be investigated by suitable specialists, including specialists in the field of wetlands/aquatic ecology.	8	5	3	5	80	H

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