FAUNAL, FLORAL, WETLAND AND AQUATIC ASSESSMENT AS PART OF THE ENVIRONMENTAL ASSESSMENT AND AUTHORISATION PROCESS FOR THE PROPOSED THARISA MINE DEVELOPMENT PROJECT, NORTH WEST PROVINCE

Prepared for

SLR Consulting (Africa) (Pty) Ltd.

2013

SECTION D – Wetland Assessment

Prepared by:	**Scientific Aquatic Services**
Report author	**S. van Staden (Pr. Sci. Nat)**
	A. Mileson
Report Reference:	**SAS 213199**
Date:	**November 2013**

Scientific Aquatic Services CC
CC Reg No 2003/078943/23
Vat Reg. No. 4020235273
91 Geldenhuis Rd
Malvern East, Ext 1

Tel: 011 616 7893
Fax: 011 615 6240
E-mail: admin@sasenvironmental.co.za

Table of Contents

List of Figures

List of Tables

1 INTRODUCTION

1.1 *Background*

Scientific Aquatic Services (SAS) was appointed to conduct a faunal, floral, wetland and aquatic ecological assessment as part of the environmental assessment and authorisation process for the proposed mine developments related to Tharisa Mine, hereafter referred to as the "subject property" (Section A: Figures 2 & 3). The subject property is situated immediately to the north of the N4 roadway within the North West Province. The town of Marikana is situated approximately 3km to the north, and the towns of Lapologang, Tsilong Village and Silver City (formerly Mmaditlhokwa Village) are located approximately 3km to the west, while Rustenburg is located 30km to the northwest. Existing infrastructure within the Tharisa Mining Rights Area (MRA) include two open pit areas, various waste rock dumps, a plant and office area, return and raw water dams, a storm water dam, a Sewage Treatment Plant (STP) and a Run-of-Mine (ROM) pad, while proposed development, which forms the focus of this study, includes the expansion of open pit and waste rock dump areas.

1.2 *Legislative requirements*

1.2.1 National Environmental Management Act, 1998

- The National Environmental Management Act (Act 107 of 1998) and the associated Regulations (Listing No R. 544, No R. 545 and R. 546) as amended in June 2010, states that prior to any development taking place within a wetland or riparian area, an environmental authorisation process needs to be followed. This could follow either the Basic Assessment process or the Environmental Impact Assessment (EIA) process depending on the nature of the activity and scale of the impact.

1.2.2 National Water Act, 1998

- The National Water Act (Act 36 of 1998) recognises that the entire ecosystem and not just the water itself in any given water resource constitutes the resource and as such needs to be conserved.
- According to GN199 of the National Water Act all activities within 500m of a wetland must be authorised in terms of Section 21c and 21l of the National Water Act (Act 36 of 1998).
- No activity may therefore take place within a water course unless it is authorised by the Department of Water Affairs (DWA).

- Any area within a wetland or riparian zone is therefore excluded from development unless authorisation is obtained from DWA in terms of Section 21.

1.2.3 GN 704 – Regulations on use of water for mining and related activities aimed at the protection of water resources, 1999

- These regulations, forming part of the National Water Act, were put in place in order to prevent the pollution of water resources and protect water resources in areas where mining activity is taking place from impacts generally associated with mining.

2 METHOD OF ASSESSMENT

2.1 *Desktop Study*

Wetland specific information resources taken into consideration during the desktop assessment of the subject property included:

- National Freshwater Ecosystem Priority Areas (NFEPAs), 2011
  - NFEPA water management area (WMA)
  - NFEPA wetlands/ National wetlands map
  - Wetland and estuary FEPA
  - FEPA (sub)WMA % area
  - Sub water catchment area FEPAs
  - Water management area FEPAs
  - Fish sanctuaries
  - Wetland ecosystem types
- The North West Database was consulted to ascertain the presence of Aquatic Critical Biodiversity Areas in relation to the subject property.

2.2 *Classification System for Wetlands and other Aquatic Ecosystems in South Africa*

All wetland features encountered within the subject property were assessed using the Classification System for Wetlands (hereafter referred to as the 'Classification System') and other Aquatic Ecosystems in South Africa. User Manual: Inland systems (Ollis *et al*., 2013).

A summary of Levels 1 to 4 of the Classification System for Inland Systems are presented in Table 1 and 2 below.

Table 1: Classification structure for Inland Systems, up to Level 3.

WETLAND / AQUATIC ECOSYSTEM CONTEXT		
LEVEL 1: SYSTEM	**LEVEL 2: REGIONAL SETTING**	**LEVEL 3: LANDSCAPE UNIT**
Inland Systems	DWA Level 1 Ecoregions OR NFEPA WetVeg Groups OR Other special framework	Valley Floor
		Slope
		Plain
		Bench (Hilltop / Saddle / Shelf)

Table 2: Hydrogeomorphic (HGM) Units for Inland Systems, showing the primary HGM Types at Level 4A and the subcategories at Level 4B to 4C.

FUNCTIONAL UNIT		
LEVEL 4: HYDROGEOMORPHIC (HGM) UNIT		
HGM type	Longitudinal zonation/ Landform / Outflow drainage	Landform / Inflow drainage
A	**B**	**C**
River (Channel)	Mountain headwater stream	Active channel
		Riparian zone
	Mountain stream	Active channel
		Riparian zone
	Transitional stream	Active channel
		Riparian zone
	Upper foothill rivers	Active channel
		Riparian zone
	Lower foothill rivers	Active channel
		Riparian zone
	Lowland river	Active channel
		Riparian zone
	Rejuvenated bedrock fall	Active channel
		Riparian zone
	Rejuvenated foothill rivers	Active channel
		Riparian zone
	Upland floodplain rivers	Active channel
		Riparian zone
Channelled valley-bottom wetland	(not applicable)	(not applicable)
Unchannelled valley-bottom wetland	(not applicable)	(not applicable)
Floodplain wetland	Floodplain depression	(not applicable)
	Floodplain flat	(not applicable)
Depression	Exorheic	With channelled inflow
		Without channelled inflow
	Endorheic	With channelled inflow
		Without channelled inflow
	Dammed	With channelled inflow

		Without channelled inflow
Seep	With channelled outflow	(not applicable)
	Without channelled outflow	(not applicable)
Wetland flat	(not applicable)	(not applicable)

2.3 *Inland systems*

For the purposes of the Classification System, Inland Systems are defined as an aquatic ecosystem that have no existing connection to the ocean[1] (i.e. characterised by the complete absence of marine exchange and/or tidal influence) but which are inundated or saturated with water, either permanently or periodically.

It is important to bear in mind, however, that certain Inland Systems may have had a historical connection to the ocean, which in some cases may have been relatively recent.

2.3.1 Level 1: Ecoregions

For Inland Systems, the regional spatial framework that has been included at Level 2 of the Classification System is that of DWA's Level 1 Ecoregions for aquatic ecosystems (Kleynhans *et al.,* 2005). There are a total of 31 Ecoregions across South Africa, including Lesotho and Swaziland (Figure 1). DWA Ecoregions have most commonly been used to categorise the regional setting for national and regional water resource management applications, especially in relation to rivers.

2.3.2 Level 2: NFEPA Wet Veg Groups

The Vegetation Map of South Africa, Swaziland and Lesotho (Mucina & Rutherford, 2006) groups vegetation types across the country according to Biomes, which are then divided into Bioregions – composite spatial terrestrial units defined on the basis of similar biotic and physical features and processes at the regional scale (Mucina and Rutherford, 2006).

To categorise the regional setting for the wetland component of the NFEPA project, wetland vegetation groups (referred to as WetVeg Groups) were derived by further splitting Bioregions into smaller groups through expert input (Nel *et al*., 2011). There are currently 133 NFEPA WetVeg Groups, and it is envisaged that these groups could be used as a special framework for the classification of wetlands in national- and regional-scale conservation planning and wetland management initiatives.

[1] Most rivers are indirectly connected to the ocean via an estuary at the downstream end, but where marine exchange (i.e. the presence of seawater) or tidal fluctuations are detectable in a river channel that is permanently or periodically connected to the ocean, it is defined as part of the estuary.

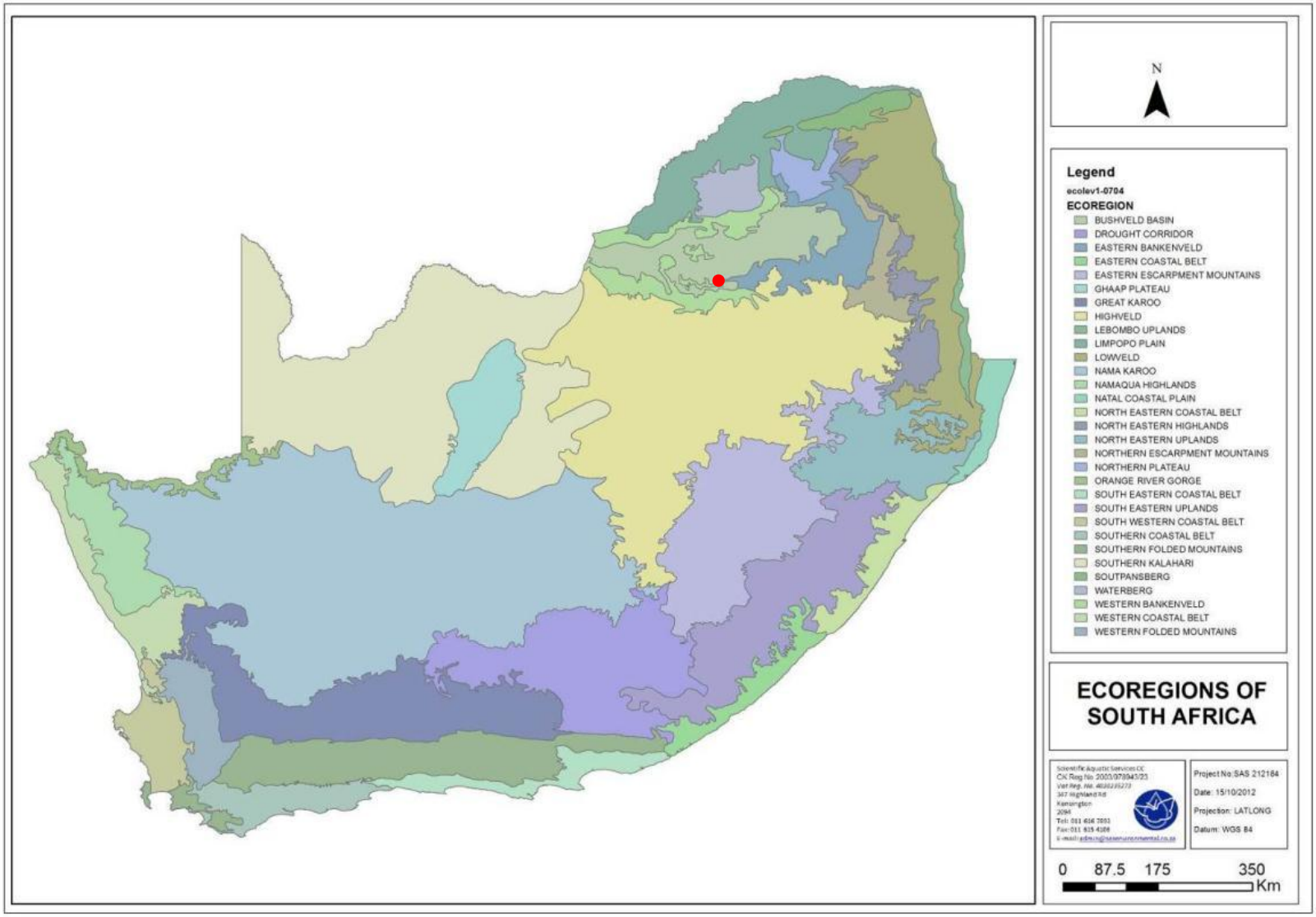

Figure 1: Map of Level 1 Aquatic Ecoregions of South Africa (approximate location of subject property indicated in red).

At Level 3 of the Classification System for Inland Systems, a distinction is made between four Landscape Units (Table 1) on the basis of the landscape setting (i.e. topographical position) within which a Hydrogeomorphic (HGM) Unit is situated, as follows (Ollis *et al.,* 2013):

- Slope: an inclined stretch of ground that is not part of a valley floor, which is typically located on the side of a mountain, hill or valley.
- Valley floor: The base of a valley, situated between two distinct valley side-slopes.
- Plain: an extensive area of low relief characterised by relatively level, gently undulating or uniformly sloping land.
- Bench (hilltop/saddle/shelf): an area of mostly level or nearly level high ground (relative to the broad surroundings), including hilltops/crests (areas at the top of a mountain or hill flanked by down-slopes in all directions), saddles (relatively high-lying areas flanked by down-slopes on two sides in one direction and up-slopes on two sides in an approximately perpendicular direction), and shelves/terraces/ledges (relatively high-lying, localised flat areas along a slope, representing a break in slope with an up-slope one side and a down-slope on the other side in the same direction).

2.3.3 Level 4: Hydrogeomorphic Units

Eight primary HGM Types are recognised for Inland Systems at Level 4A of the Classification System (Table 2), on the basis of hydrology and geomorphology (Ollis *et al*., 2013), namely:

- Channel (River): a linear landform with clearly discernible bed and banks, which permanently or periodically carries a concentrated flow of water.
- Channelled valley-bottom wetland: a valley-bottom wetland with a river channel running through it.
- Unchannelled valley-bottom wetland: a valley-bottom wetland without a river channel running through it.
- Floodplain wetland: the mostly flat or gently sloping land adjacent to and formed by an alluvial river channel, under its present climate and sediment load, which is subject to periodic inundation by over-topping of the channel bank.
- Depression: a landform with closed elevation contours that increases in depth from the perimeter to a central area of greatest depth, and within which water typically accumulates.
- Wetland Flat: a level or near-level wetland area that is not fed by water from a river channel, and which is typically situated on a plain or a bench. Closed elevation contours are not evident around the edge of a wetland flat.

- Seep: a wetland area located on (gently to steeply) sloping land, which is dominated by the colluvial (i.e. gravity-driven), unidirectional movement of material down-slope. Seeps are often located on the side-slopes of a valley but they do not, typically, extend into a valley floor.

The above terms have been used for the primary HGM Units in the Classification System to try and ensure consistency with the wetland classification terms currently in common usage in South Africa. Similar terminology (but excluding categories for "channel", "flat" and "valleyhead seep") is used, for example, in the tools developed as part of the Wetland Management Series including WET-Health (Macfarlane *et al.,* 2008) and WET-EcoServices (Kotze *et al.,* 2009).

Healthy wetlands are known to provide important habitats for wildlife and to deliver a range of important goods and services to society. Management of these systems is therefore essential if these attributes are to be retained within an ever changing landscape. The primary purpose of this assessment is to evaluate the ecophysical health of wetlands, and in so doing promote their conservation and wise management.

At Level 4B of the classification system, certain of the primary HGM Units can further be divided into sub-categories on the basis of longitudinal geomorphological zonation or localised landform, as follows:

- Channels (including their banks) are divided into six primary longitudinal zones and three zones associated with a rejuvenated longitudinal profile, according to the geomorphological zonation scheme of Rowntree & Wadeson (2000). The sub-categories are *Mountain Headwater Stream, Mountain Stream, Transitional River, Upper Foothill River, Lower Foothill River,* and *Lowland River* (i.e. the primary zones); and *Rejuvenated Bedrock Fall, Rejuvenated Foothill River,* and *Upland Floodplain River* (i.e. the zones associated with a rejuvenated long profile).
- Channelled and unchannelled valley-bottom wetlands are divided into '*valley-bottom flats'* and *'valley-bottom depressions'*.
- Floodplain wetlands are divided into *'floodplain depressions'* and *'floodplain flats'*.

2.4 *Riparian Vegetation Response Assessment Index (VEGRAI)*

Riparian vegetation is described in the NWA (Act No 36 of 1998) as follows: 'riparian habitat' includes the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterised by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent land areas.

The Riparian Vegetation Response Assessment Index (VEGRAI) is designed for qualitative assessment of the response of riparian vegetation to impacts in such a way that qualitative ratings translate into quantitative and defensible results[2]. Results are defensible because their generation can be traced through an outlined process (a suite of rules that convert assessor estimates into ratings and convert multiple ratings into an Ecological Category).

Table 3: Descriptions of the A-F ecological categories.

Ecological category	Description	Score (% of total)
A	Unmodified, natural.	90-100
B	Largely natural with few modifications. A small change in natural habitat and biota may have taken place but the ecosystem functions are essentially unchanged.	80-89
C	Moderately modified. Loss and change of natural habitat have occurred, but the basic ecosystem functions are still predominately unchanged.	60-79
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.	40-59
E	Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive.	20-39
F	Critically modified. Modifications have reached a critical level and the lotic system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible	0-19

2.5 *Index of Habitat Integrity (IHI)*

To assess the Present Ecological State (PES) of the various drainage features, the Index of Habitat Integrity (IHI) for South African floodplain, channelled and channelled valley bottom wetland types (Department of Water Affairs; DWAF, Resource Quality Services, 2007) were used.

[2] Kleynhans et al, 2007

The WETLAND-IHI is a tool developed for use in the National Aquatic Ecosystem Health Monitoring Programme (NAEHMP), formerly known as the River Health Programme (RHP). The WETLAND-IHI has been developed to allow the NAEHMP to include floodplain and channelled valley bottom wetland types to be assessed. The output scores from the WETLAND-IHI model are presented in A – F ecological categories (Table 4 below), and provide a score of the PES of the habitat integrity of the wetland system being examined.

Table 4: Descriptions of the A – F ecological categories (after Kleynhans, 1996, 1999).

Ecological Category	PES % Score	Description
A	90-100%	Unmodified, natural.
B	80-90%	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.
C	60-80%	Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.
D	40-60%	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred. E 20-40% Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive.
E	20-40%	Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive.
F	0-20%	Critically / Extremely modified. Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.

2.6 *Wetland Function Assessment*

"The importance of a water resource, in ecological social or economic terms, acts as a modifying or motivating determinant in the selection of the management class".[3] The assessment of the ecosystem services supplied by the identified wetlands was conducted according to the guidelines as described by Kotze *et al.* (2008). An assessment was undertaken that examines and rates the following services according to their degree of importance and the degree to which the service is provided:

- Flood attenuation
- Stream flow regulation
- Sediment trapping
- Phosphate trapping
- Nitrate removal

[3] Department of Water Affairs and Forestry, South Africa Version 1.0 of Resource Directed Measures for Protection of Water Resources, 1999

- Toxicant removal
- Erosion control
- Carbon storage
- Maintenance of biodiversity
- Water supply for human use
- Natural resources
- Cultivated foods
- Cultural significance
- Tourism and recreation
- Education and research

The characteristics were used to quantitatively determine the value, and by extension sensitivity, of the wetlands. Each characteristic was scored to give the likelihood that the service is being provided. The scores for each service were then averaged to give an overall score to the wetland.

Table 5: Classes for determining the likely extent to which a benefit is being supplied.

Score	Rating of the likely extent to which the benefit is being supplied
<0.5	Low
0.6-1.2	Moderately low
1.3-2	Intermediate
2.1-3	Moderately high
>3	High

2.7 *WET-Health*

2.7.1 Level of Evaluation

Two levels of assessment are provided by WET-Health:

- Level 1: Desktop evaluation, with limited field verification. This is generally applicable to situations where a large number of wetlands need to be assessed at a very low resolution;
- Level 2: On-site evaluation. This involves structured sampling and data collection in a single wetland and its surrounding catchment.

Due to the limited time spent on site, limited accessibility to some areas, with specific reference to active mining areas, and the large number of wetlands to be assessed, this study was undertaken as a Level 1 assessment.

2.7.2 Framework for the Assessment

A set of three modules has been synthesised from the set of processes, interactions and interventions that take place in wetland systems and their catchments: hydrology (water inputs, distribution and retention and outputs), geomorphology (sediment inputs, retention and outputs) and vegetation (transformation and presence of introduced alien species).

2.7.3 Units of Assessment

Central to WET-Health is the characterisation of HGM Units, which have been defined based on geomorphic setting (e.g. hillslope or valley-bottom; whether drainage is open or closed), water source (surface water dominated or sub-surface water dominated) and pattern of water flow through the wetland unit (diffusely or channelled) as described under the Classification System for Wetlands and other Aquatic Ecosystems in Section 2.2.

2.7.4 Quantification of Present State of a Wetland

The overall approach is to quantify the impacts of human activity or clearly visible impacts on wetland health, and then to convert the impact scores to a Present State score. This takes the form of assessing the spatial *extent* of impact of individual activities and then separately assessing the *intensity* of impact of each activity in the affected area. The extent and intensity are then combined to determine an overall *magnitude* of impact. The impact scores and Present State categories are provided in Table 6.

Table 6: Impact scores and categories of Present State used by WET-Health for describing the integrity of wetlands.

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

2.7.5 Assessing the Anticipated Trajectory of Change

As is the case with the Present State, future threats to the state of the wetland may arise from activities in the catchment upstream of the unit or within the wetland itself or from processes downstream of the wetland. In each of the individual sections for hydrology, geomorphology and vegetation, five potential situations exist depending upon the direction and likely extent of change (Table 7).

Table 7: Trajectory of Change classes and scores used to evaluate likely future changes to the present state of the wetland.

Change Class	Description	HGM change score	Symbol
Substantial improvement	State is likely to improve substantially over the next 5 years	2	↑↑
Slight improvement	State is likely to improve slightly over the next 5 years	1	↑
Remain stable	State is likely to remain stable over the next 5 years	0	→
Slight deterioration	State is likely to deteriorate slightly over the next 5 years	-1	↓
Substantial deterioration	State is expected to deteriorate substantially over the next 5 years	-2	↓↓

2.7.6 Overall health of the wetland

Once all HGM Units have been assessed, a summary of health for the wetland as a whole needs to be calculated. This is achieved by calculating a combined score for each component by area-weighting the scores calculated for each HGM Unit. Recording the health assessments for the hydrology, geomorphology and vegetation components provides a summary of impacts, Present State, Trajectory of Change and Health for individual HGM Units and for the entire wetland.

2.8 *Ecological Importance and Sensitivity (EIS) Method of assessment*

The method used for the Ecological Importance and Sensitivity (EIS) determination was adapted from the method as provided by DWA (1999) for floodplains. The method takes into consideration PES scores obtained for WET-Health as well as function and service provision to enable the assessor to determine the most representative EIS category for the wetland feature or group being assessed.

A series of determinants for EIS are assessed on a scale of 0 to 4, where 0 indicates no importance and 4 indicates very high importance. The median of the determinants is used to assign the EIS category as listed in Table 8 below:

Table 8: EIS Category definitions

EIS Category	Range of Median	Recommended Ecological Category
Very high	>3 and <=4	A
High	>2 and <=3	B
Moderate	>1 and <=2	C
Low/marginal	>0 and <=1	D

2.9 *Recommended Ecological Category*

"A high management class relates to the flow that will ensure a high degree of sustainability and a low risk of ecosystem failure. A low management class will ensure marginal maintenance of sustainability, but carries a higher risk of ecosystem failure." [4]

The Recommended Ecological Category (REC) was determined based on the results obtained from the VEGRAI, Wet-IHI, WET-Health calculations, reference conditions and Ecological Importance and Sensitivity (EIS) of the resource; followed by realistic recommendations, mitigation, and rehabilitation measures to achieve the desired REC.

[4] Department of Water Affairs and Forestry, South Africa Version 1.0 of Resource Directed Measures for Protection of Water Resources 1999

A wetland may receive the same category for the REC as the Present Ecological State (PES), if the wetland is deemed in good condition, and it must therefore remain in good condition. Otherwise, an appropriate REC should be assigned in order to prevent any further degradation as well as to enhance the PES of the wetland feature.

Table 9: Description of REC classes.

Category	Description
A	Unmodified, natural
B	Largely natural with few modifications
C	Moderately modified
D	Largely modified

2.10 *Wetland delineation*

For the purposes of this investigation, a wetland habitat is defined in the National Water Act (1998) as including the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterised by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent areas.

The wetland zone delineation took place according to the method presented in the final draft of “A practical field procedure for identification and delineation of wetlands and riparian areas” published by the DWA in February 2005. The foundation of the method is based on the fact that wetlands and riparian zones have several distinguishing factors including the following:

- The presence of water at or near the ground surface;
- Distinctive hydromorphic soils;
- Vegetation adapted to saturated soils and
- The presence of alluvial soils in stream systems.

By observing the evidence of these features, in the form of indicators, wetlands and riparian zones can be delineated and identified. If the use of these indicators and the interpretation of the findings are applied correctly, then the resulting delineation can be considered accurate (DWAF, 2005).

Riparian and wetland zones can be divided into three zones (DWAF, 2005). The permanent zone of wetness is nearly always saturated. The seasonal zone is saturated for a significant part of the rainy season and the temporary zone surrounds the seasonal zone and is only saturated for a short period of the year, but is saturated for a sufficient period, under normal circumstances, to allow for the formation of hydromorphic soils and the growth of wetland vegetation. The object of this study was to identify the outer boundary of the temporary zone and then to identify a suitable buffer zone around the wetland area.

3 RESULTS

3.1 *Ecoregions*

When assessing the ecology of any area (aquatic or terrestrial), it is important to know which ecoregion the study area is located within. This knowledge allows for improved interpretation of data to be made, since reference information and representative species lists are often available on this level of assessment, which aids in guiding the assessment.

The subject property falls within the Bushveld Basin Aquatic Ecoregion and is located within the A21K quaternary catchment as presented in Figure 2.

The main attributes of the Bushveld Basin Ecoregion, and the A21K quaternary catchment, are presented in Table 10 and Table 11 below:

Table 10: Main attributes of the Bushveld Basin Ecoregion

MAIN ATTRIBUTES	BUSHVELD BASIN
Terrain Morphology: Broad division (dominant types in bold) (Primary)	**Plains; Low Relief**; Plains; Moderate Relief; Lowlands; Hills and Mountains: Moderate and High Relief; Open Hills; Lowlands; Mountains: Moderate to High Relief; Closed Hills; Mountains: Moderate and High Relief (limited)
Vegetation types (dominant types in bold) (Primary)	**Mixed Bushveld;** Clay Thorn Bushveld; Waterberg Moist Mountain Bushveld (limited)
Altitude (m a.m.s.l) (modifying)	700-1700 (1700-1900 very limited)
MAP (mm) (Secondary)	400 to 600
Coefficient of Variation (% of annual precipitation)	25 to 35
Rainfall concentration index	55 to >65
Rainfall seasonality	Early to mid summer
Mean annual temp. (°C)	14 to 22
Mean daily max. temp. (°C): February	22 to 32
Mean daily max. temp. (°C): July	14 to 24
Mean daily min. temp. (°C): February	12 to 20
Mean daily min temp. (°C): July	0 to 6
Median annual simulated runoff (mm) for quaternary catchment	20 to 100

Table 11: Quaternary Catchment information

Catchment	Resource	EIS	PESC	DEMC
A21K	Sterkstroom	Moderate	Class C	C: Moderately sensitive system

QUATERNARY CATCHMENT A21K

According to the ecological importance classification for the quaternary catchment, the system can be classified as a Moderately Sensitive System which, in its present state, can be considered a Class C (Moderately modified) stream.

The points below summarise the current impacts on the aquatic resources in the quaternary catchment A21K (Kleynhans 1999):

- The aquatic resources within this quaternary catchment have been moderately affected by bed modification.

- Flow modifications were assessed mainly downstream from Buffelspoort Dam and were found to have a marginal effect on the system.
- Impacts on the system as a result of the introduced aquatic biota with special mention of *Micropterus salmoides* (Largemouth bass) and *Cyprinus carpio* (Carp) are low.
- Impact due to inundation as a result of the Buffelspoort Dam is considered moderate.
- Riparian zones and stream bank conditions are considered to be moderately impacted as a result of exotics and cultivated land.
- Impacts as a result of water quality modification are at a moderate level.

In terms of ecological functions, importance and sensitivity, the following points summarise the current conditions in this catchment:

- The riverine systems in this catchment have a high diversity of habitat types.
- The quaternary catchment has a moderate importance in terms of conservation and natural areas.
- The quaternary catchment has a high intolerance to flow and flow related water quality with special mention of A*mphilius uranoscopus* (Mountain catfish).
- The quaternary catchment is regarded as having no importance for rare and endangered species conservation.
- The quaternary catchment is considered of low importance in terms of provision of migration routes for faunal species in the instream and riparian environments.
- The quaternary catchment has a moderate importance in terms of providing refugia for aquatic community members.
- The quaternary catchment can be considered to have a moderate sensitivity to changes in water quality and flow.
- The quaternary catchment is of moderate importance in terms of species richness.
- The quaternary catchment is of high importance in terms of endemic and isolated species with special mention of A*mphilius uranoscopus* (Mountain catfish) and *Barbus motebensis* (Marico barb).

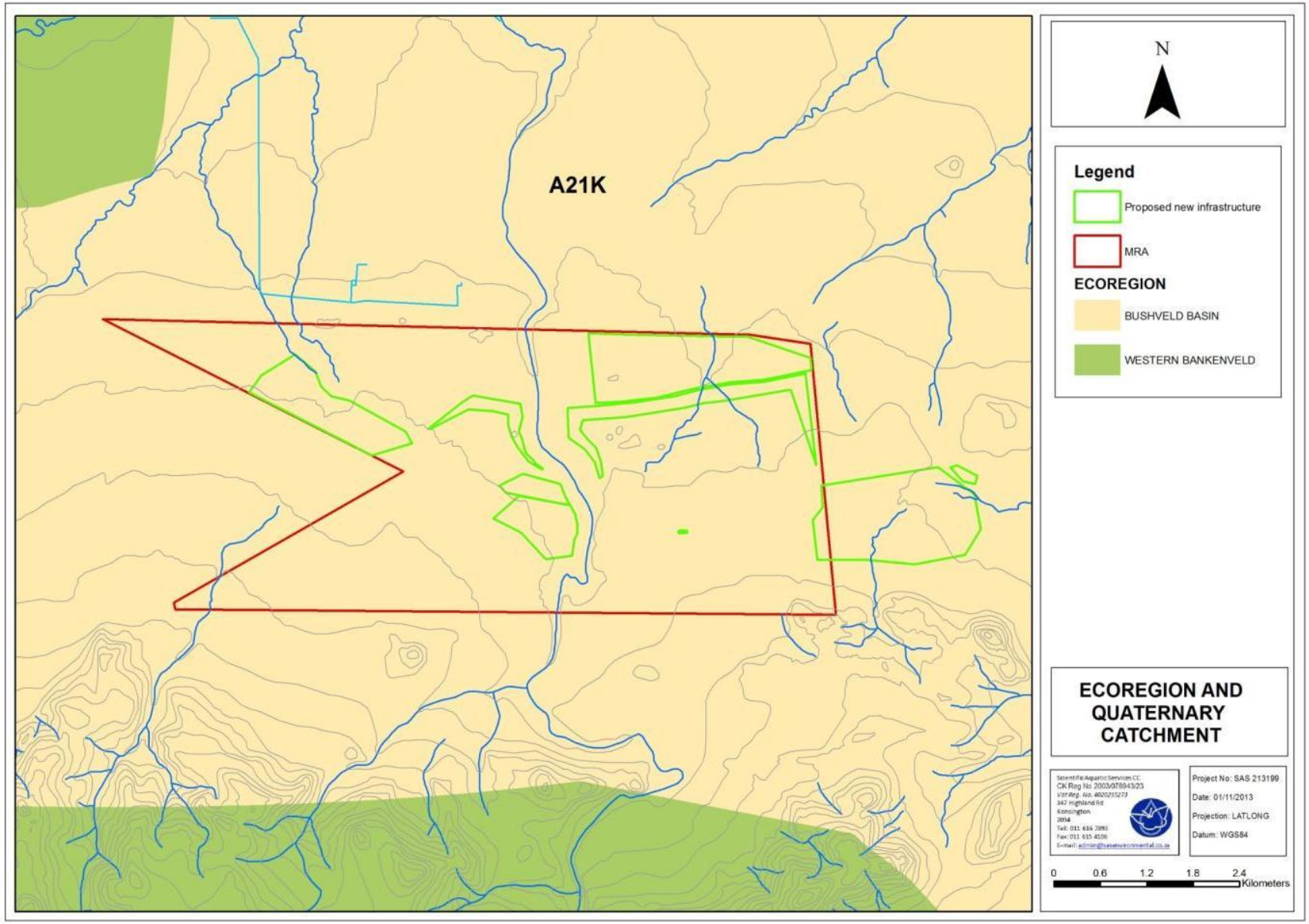

Figure 2: **The Ecoregion and Quaternary Catchment applicable to the subject property within the larger Mineral Rights Area (MRA).**

3.2 *General importance of the subject property with regards to watercourse conservation*

- The North West Province Database layer indicates an aquatic Critical Biodiversity Area (CBA) to the south of the subject property as presented in Section A.

3.2.1.1 Importance according to the National Freshwater Ecosystems Priority Areas database (2011)

The National Freshwater Ecosystem Priority Areas (NFEPA) (2011) database was consulted to define the aquatic ecology of the wetlands and river systems close to and within the subject property that may be of ecological importance. Aspects applicable to the subject property and surroundings are discussed below:

- The subject property falls within the Crocodile (West) and Marico Water Management Area (WMA). Each WMA is divided into several sub-Water Management Areas (subWMAs), where catchment or watershed is defined as a topographically defined area which is drained by a stream or river network. The sub-Water management unit indicated for the subject property is the Upper Crocodile subWMA.
- The subWMA is not regarded important in terms of fish sanctuaries, rehabilitation or corridors.
- The subWMA is not considered important in terms of translocation and relocation zones for fish.
- The subWMA is not listed as a fish Freshwater Ecosystem Priority Area (FEPA).
- The Sterkstroom River is the major river draining through the centre of the subject property, flowing in a northern direction and is indicated as a Class C (Moderately modified) system.
- The NFEPA database indicates that at Level 4A of the Classification System (Table 2), wetlands within the subject property are categorised as flat, unchannelled valley-bottom and valley-head seep (Figure3).
- No wetlands within the subject property are considered important with regards to the conservation of biodiversity (Figure 4).
    - Expertid = 0; No importance.
- Conditions of the wetlands within the subject property according to the NFEPA database are depicted in Figure 5 below and include:
    - Category C (Percentage natural landcover 25-75%).
    - Category Z1 (Wetland overlaps with a 1: 50 000 artificial inland waterbody).
    - Category Z2 (Majority of the wetland unit is classified as artificial in the wetland delineation GIS layer).

- Category Z3 (Percentage natural land cover <25%)

- All wetlands within the subject property were ranked according to general importance depicted in Figure 6 below.
  - Rank 6 – All other wetlands (no importance)
- According to the NFEPA database, there are no wetlands intersecting with a Ramsar site or within 500m of a threatened amphibian or avifauna locality, with specific reference to *Pyxicephalus adspersus* (Giant Bullfrogs), *Anthropoides paradisea* (Blue Crane), *Balearica regulorum* (Grey Crowned Crane) and *Grus caranculatus* (Wattled Crane).
- The NFEPA database identifies several artificial wetlands within the subject property, as well as two depressions which are considered natural wetlands located in the north-west portion of the subject property.
- Additionally, the NFEPA database indicates un-named tributaries of the Sterkstroom River, Brakspruit and Elandsdrift, as well as several drainage lines, within the subject property. These were considered to be naturally occurring wetlands during the assessment.

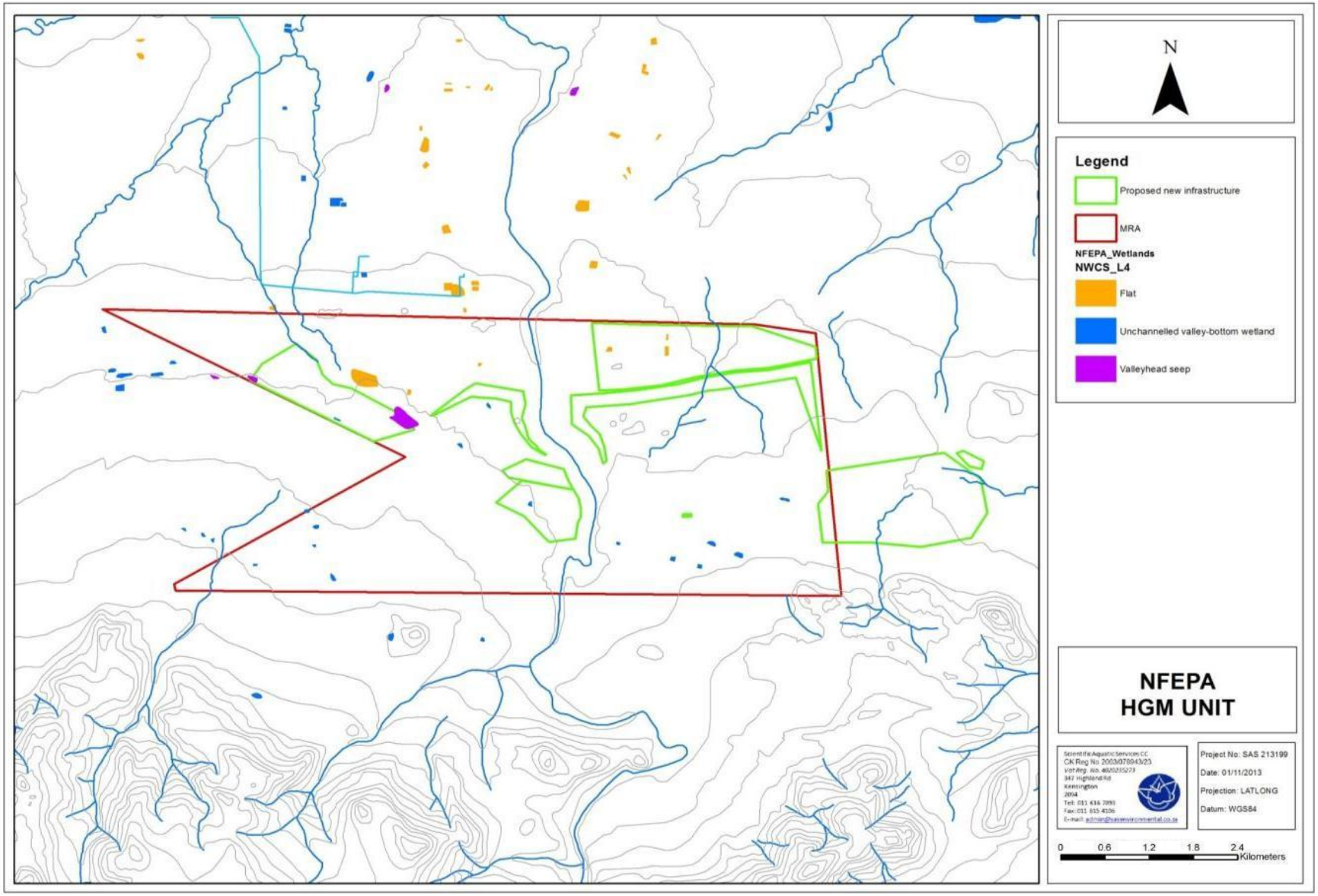

Figure 3: Level 4 Hydrogeomorphic classification of the wetlands in the subject property according to the NFEPA database.

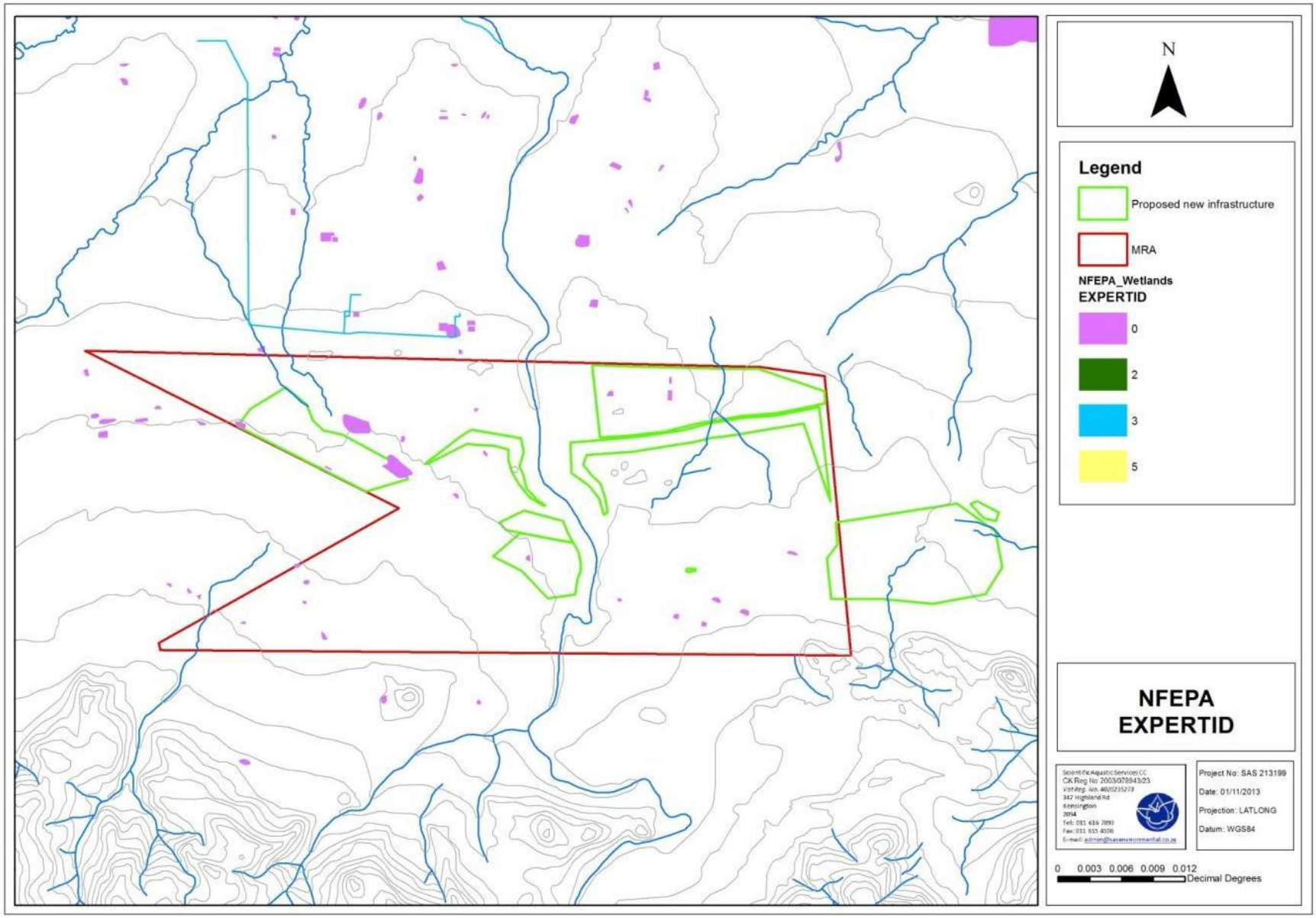

Figure 4: NFEPA EXPERTID indicating the biodiversity importance of the wetlands in the subject property.

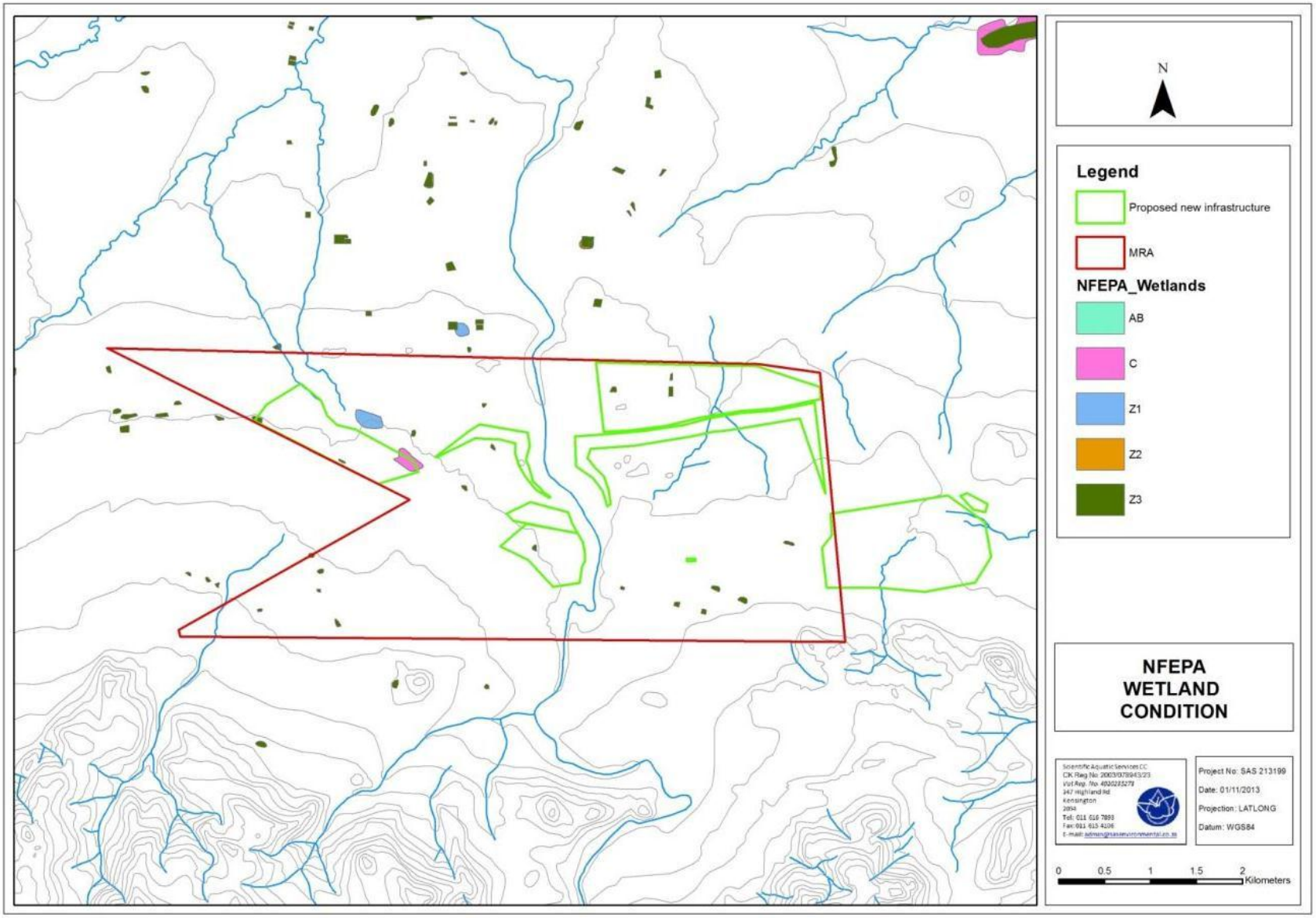

Figure 5: NFEPA wetland condition of the wetlands in the subject property.

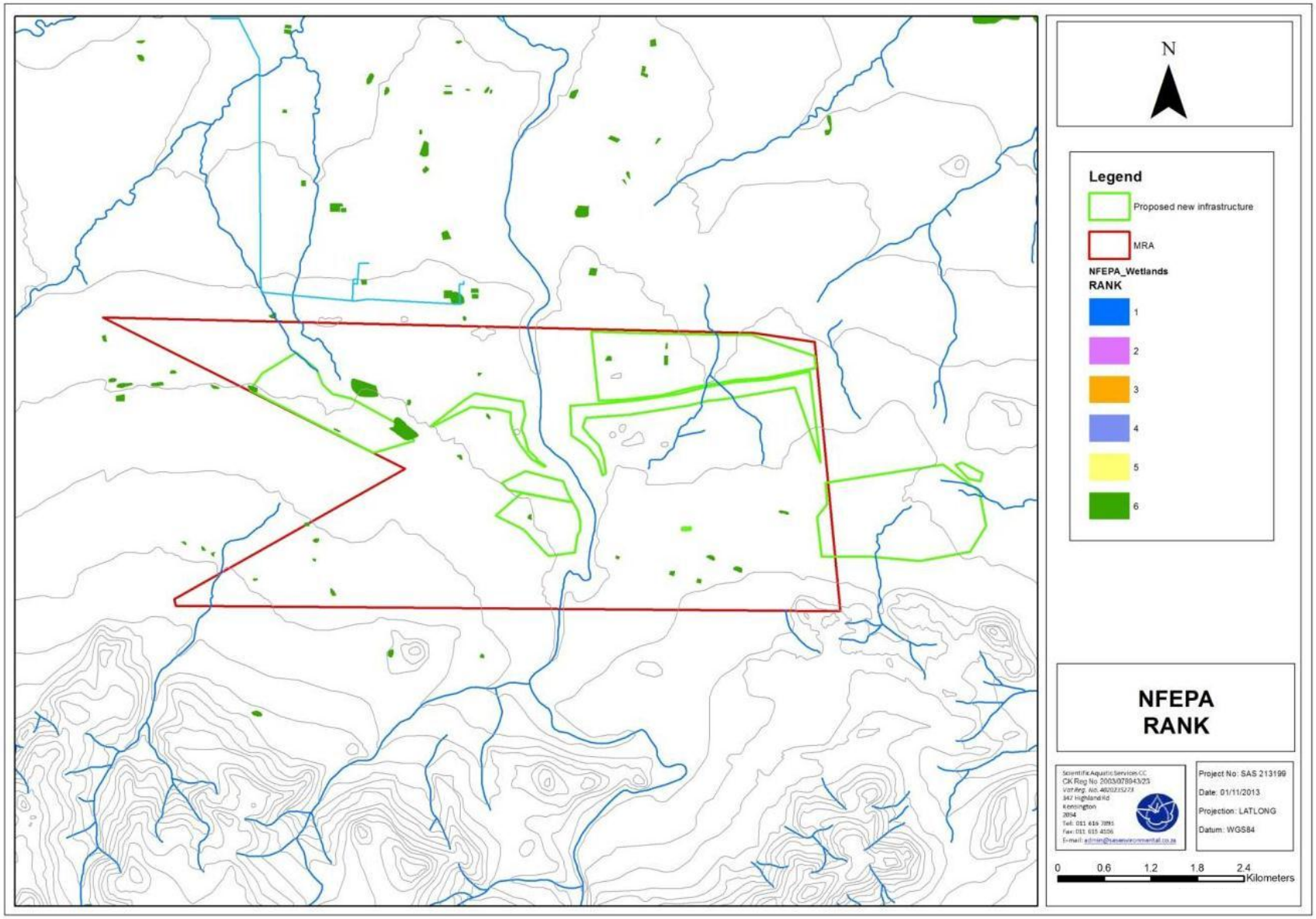

Figure 6: Wetland Rank according to the NFEPA Database.

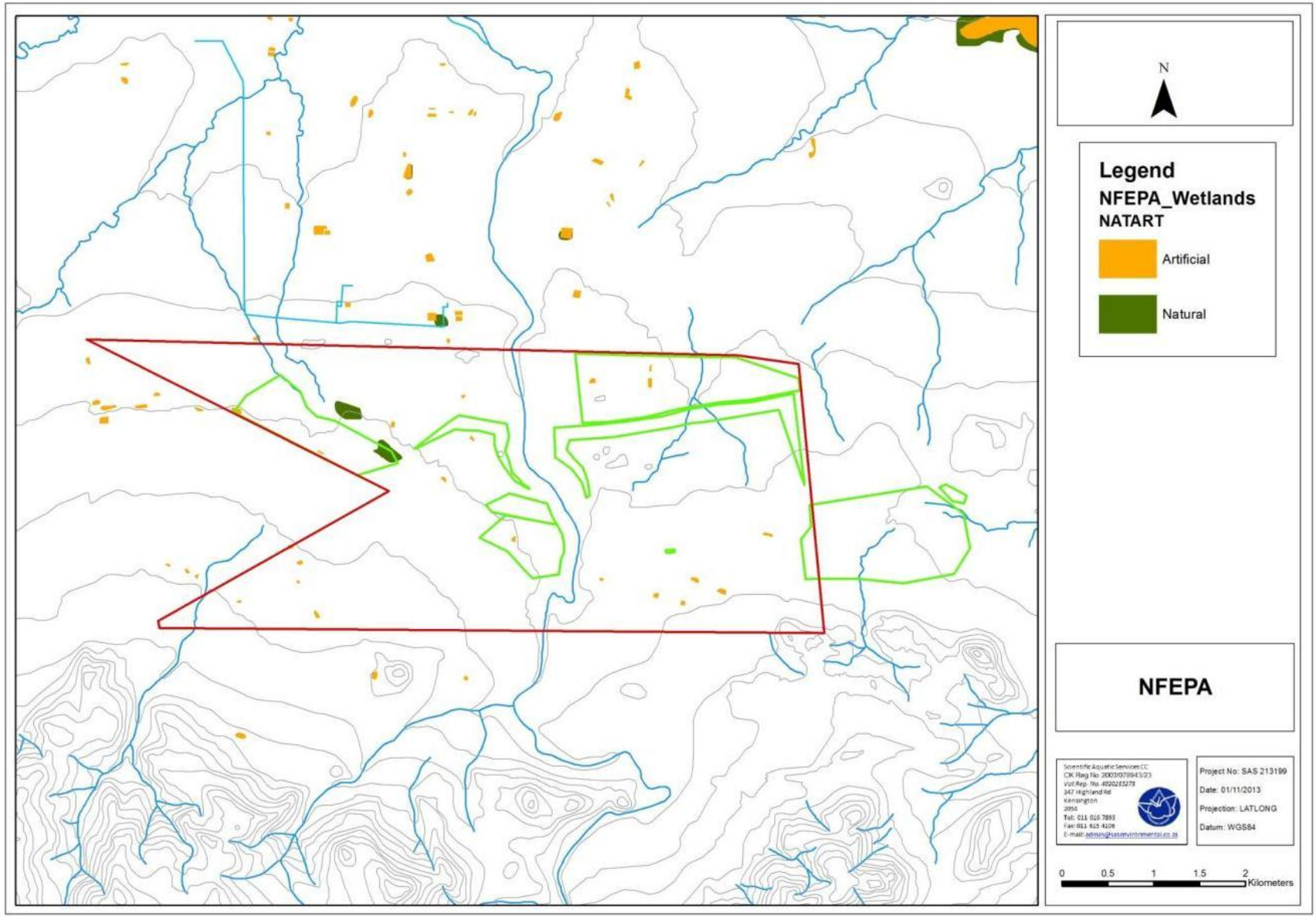

Figure 7: Natural and artificial wetlands within the subject property according to the NFEPA database.

3.3 *Wetland System Characterisation*

The wetlands within the subject property (depicted in Figures 3 - 7) comprise three broad wetland types according to Level 4 of the Classification System compiled by Ollis *et. al.*(2013), and confirmed by the NFEPA database, namely:

- Valley-bottom flat;
- Valley head seep;
- Unchannelled valley-bottom wetlands; and
- Channelled (River)

Two WetVeg Groups apply to the subject property, namely Central Bushveld Group 2 and Central Bushveld Group 5 (Figure 8). Flat and unchannelled valley bottom wetlands occurring in Central Bushveld Group 2 WetVeg group are considered to be 'Vulnerable' ecosystems, whilst all other wetland HGM types occurring in the group are considered to be 'Least Threatened'. Floodplain wetlands occurring in Central Bushveld Group 5 WetVeg group are considered to be 'Critically Endangered' ecosystems; all other HGM types occurring in the Central Bushveld Group 5 are considered 'Least Threatened'.

The location of important wetland and riparian features identified within the subject property (which includes all non-perennial tributaries, drainage lines and the Sterkstroom River) are conceptually presented in Figure 9. Several small man-made reservoirs and dams are present within the subject property; however these were not assessed since these systems are considered to be of limited EIS and only tolerant and common aquatic taxa will be present in the systems.

However, the site inspection revealed that the valley-head seep wetlands indicated by the NFEPA database in the north-western portion of the subject property have been subjected to mining activities. It was not possible to access the area for safety reasons, therefore it was not possible to ascertain the extent of the impact on the wetland; however, it was ascertained from satellite imagery that this wetland has been mined out and no longer exists.

All wetland systems (including non-perennial tributaries and drainage lines found within the subject property) and the Sterkstroom River have been impacted by historial and present agricultural and mining activities to varying degrees,

For the purposes of this discussion and the assessments, the wetland features – including drainage lines and tributaries – were grouped according to their location within the subject property as presented in Figure 9.

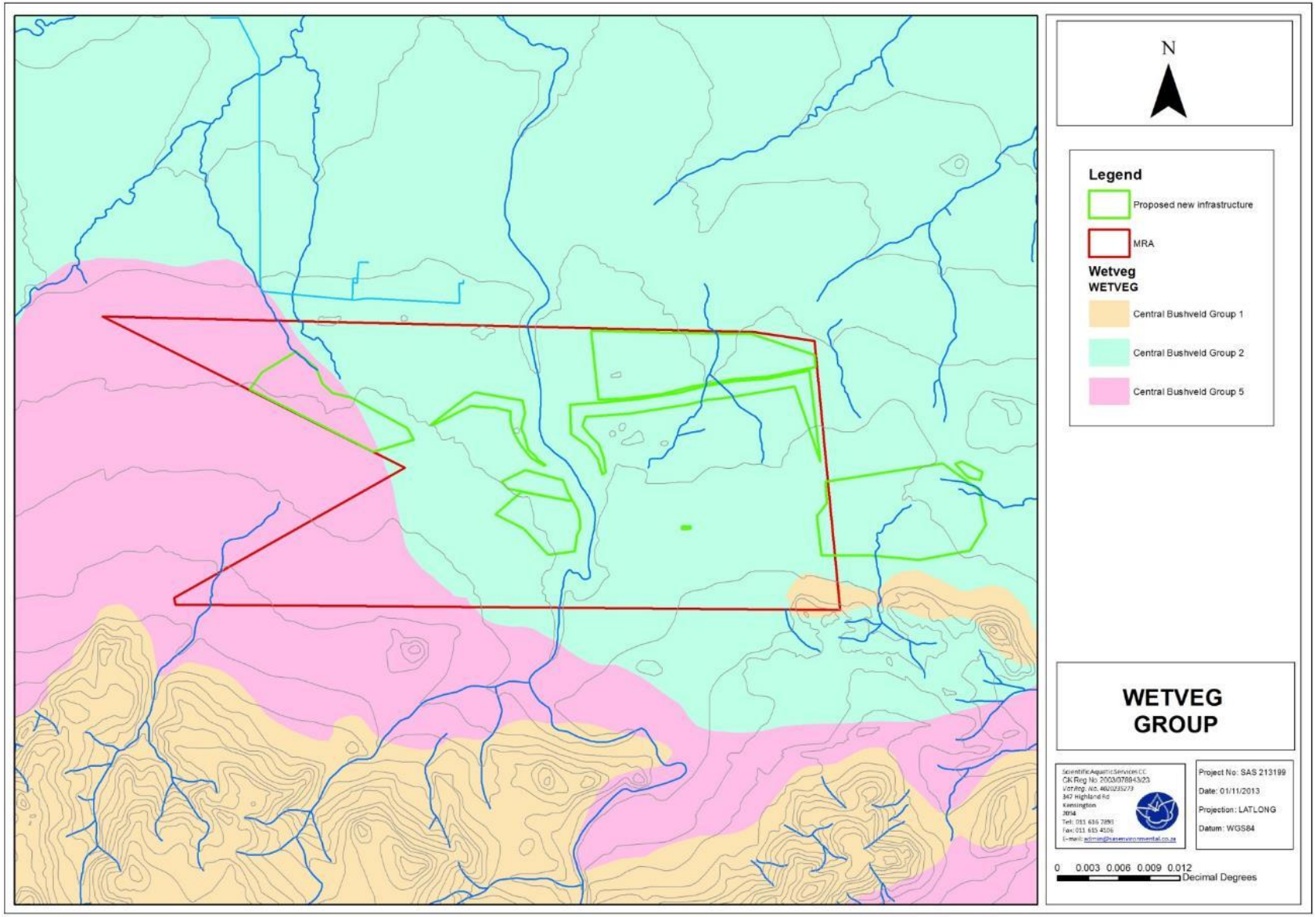

Figure 8: The WetVeg Groups applicable to the wetland systems within the subject property, according to the NFEPA database.

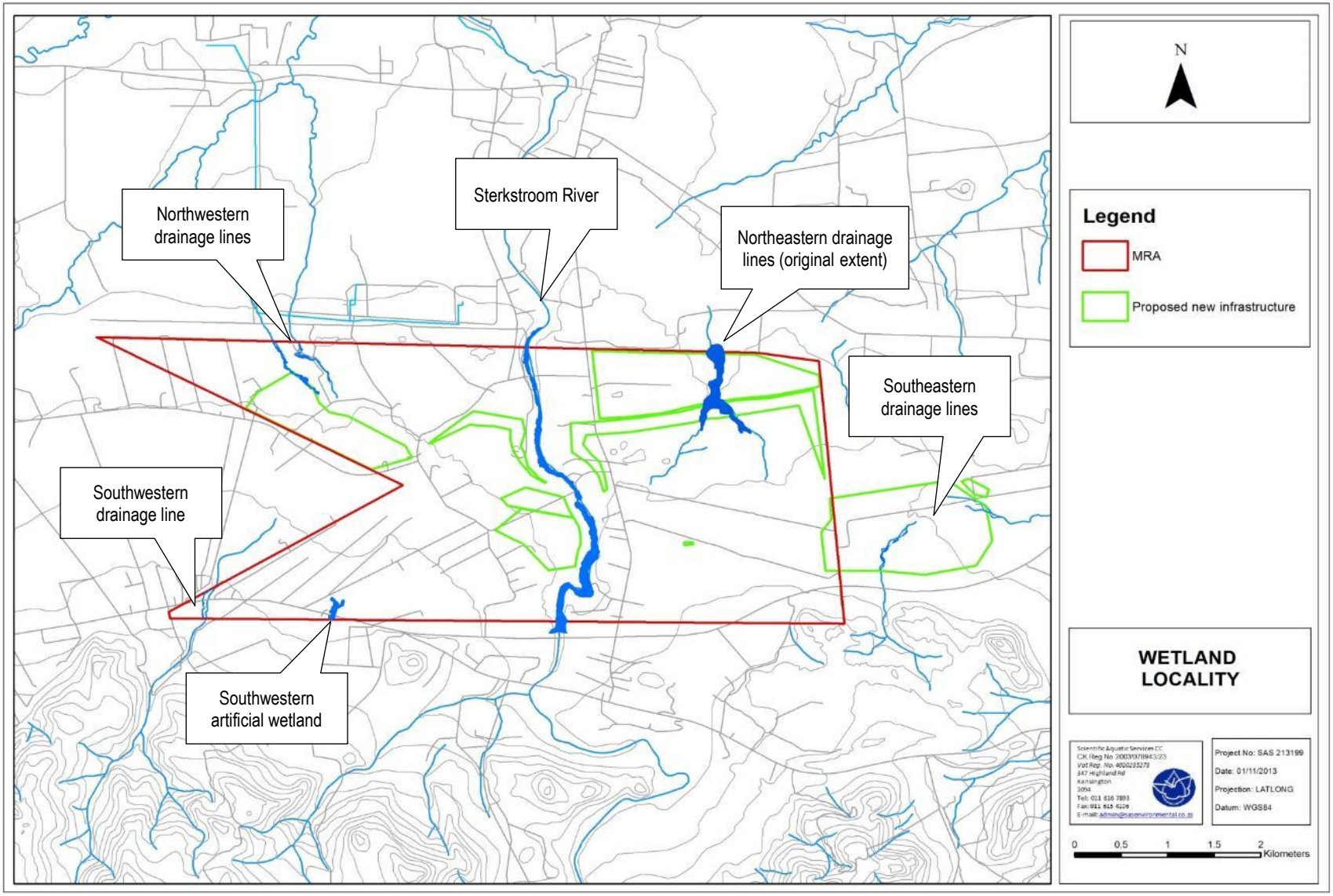

Figure 9: Map of the wetland and riverine features within the subject property in relation to the MRA.

3.3.1 Northwestern Portion of Subject Property

The north-west portion of the subject property contains two non-perennial tributaries of the Brakspruit, hereinafter referred to as the "northwestern drainage lines", as these features are considered to be poorly developed drainage lines. The features were classified according to the Classification System as unchannelled valley bottom (situated slightly to the west within this portion of the subject property) and a channelled valley bottom (situated slightly to the east within this portion of the subject property). This classification is presented in the table below:

Table 12: Classification system for the northwestern drainage lines.

Wetland feature location	Level 1: System	Level 2: Regional Setting	Level 3: Landscape unit	Level 4: Hydrogeomorphic (HGM) unit HGM Type
North-west portion of subject property; situated slightly to the west	**Inland:** An ecosystem that has no existing connection to the ocean but which is inundated or saturated with water, either permanently or periodically.	**Bushveld Basin Ecoregion:** The subject property falls within the Bushveld Basin Ecoregion **WetVeg:** Central Bushveld Group 5	**Valley floor:** The typically gently sloping, lowest surface of a valley	**Unhannelled valley-bottom wetland:** A mostly flat wetland area on a valley floor that is characterised by an absence of distinct channel banks, and the prevalence of diffuse flows. Water inputs are typically from an upstream channel that becomes dominated by diffuse (surface and subsurface) flow as it enters the wetland and seepage from adjacent slopes. There may also be groundwater input.
North-west portion of subject property; situated slightly to the east	**Inland:** An ecosystem that has no existing connection to the ocean but which is inundated or saturated with water, either permanently or periodically.	**Bushveld Basin Ecoregion:** The subject property falls within the Bushveld Basin Ecoregion **WetVeg:** Central Bushveld Group 2	**Valley floor:** The typically gently sloping, lowest surface of a valley	**Channelled valley-bottom wetland:** A mostly flat wetland area on a valley floor that is dissected by and typically elevated above a well-defined stream channel. Dominant water inputs to these areas are typically from the channel (when it overtops or from sub-surface discharge) and from adjacent valley-side slopes

The location of these drainage lines is depicted in the figure below:

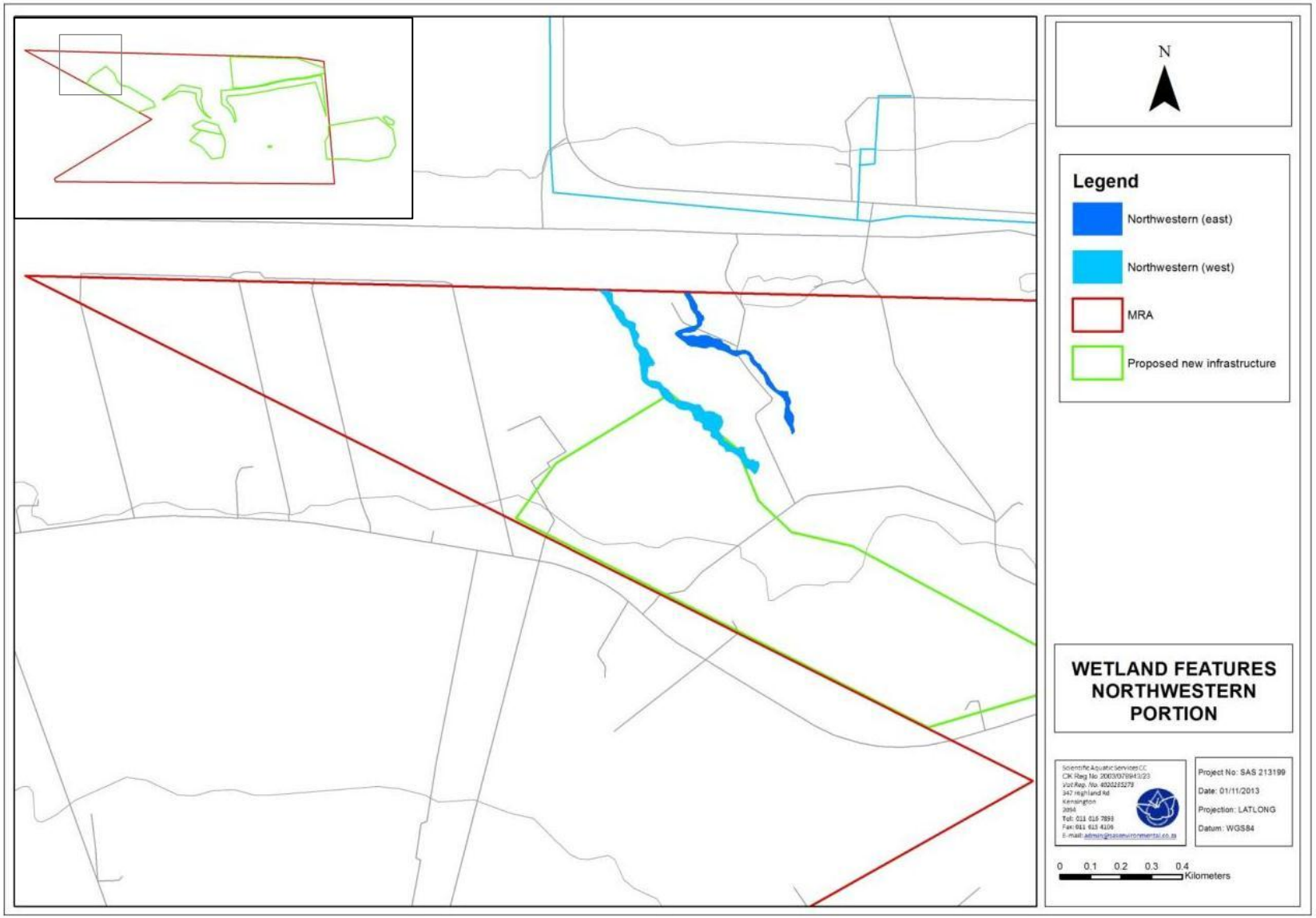

Figure 10: Location of the northwestern drainage lines in relation to the MRA.

Figure 11: Representative photographs of the northwestern drainage lines.

Figure 12: Representative photographs of recent mining activities which have occurred within and adjacent to the northwestern drainage lines.

Figure 13: Representative photographs of soil samples taken from the northwestern wetland features, indicating the presence of mottling and gleyed soils.

3.3.2 Northeastern Portion of Subject Property

Two drainage lines are indicated by the NFEPA database within the north-east portion of the subject property (hereinafter referred to as the "northeastern drainage lines"), in the locality of proposed waste rock dumps. It was not possible to access these drainage lines during the site inspection for safety reasons associated with active mining in the vicinity thereof. The Tharisa Minerals Biodiversity Assessment for the subject property, compiled in March 2008 by Natural Scientific Services (NSS) for Metago Environmental Engineers (Pty) Ltd, was consulted to ascertain the condition of these drainage lines prior to the commencement of mining activities. Whilst NSS did not carry out an extensive survey or assessment of the wetlands within the subject property, the drainage lines located in the north-east portion of the subject property were mapped by NSS as areas of medium concern.

As it was not possible to gain access to these drainage lines to delineate them according to the methods described in Section 2.10, satellite imagery was utilised to delineate the expected original extent. The satellite imagery was compared with observations made during the site inspection, and it was surmised that definite loss of the drainage lines has occurred as a result of mining activities, the addition of a waste rock dump, and by a gravel road. These in turn have likely affected the flow, connectivity and functioning of the northern portions of these drainage lines. The wetland function assessment, WET-Health and EIS methods described in Section 2.6, 2.7 and 2.8 respectively, were not applied to these drainage lines for the reasons outlined above.

The location of the expected original extent these drainage lines in relation to the subject property is depicted in the figure below.

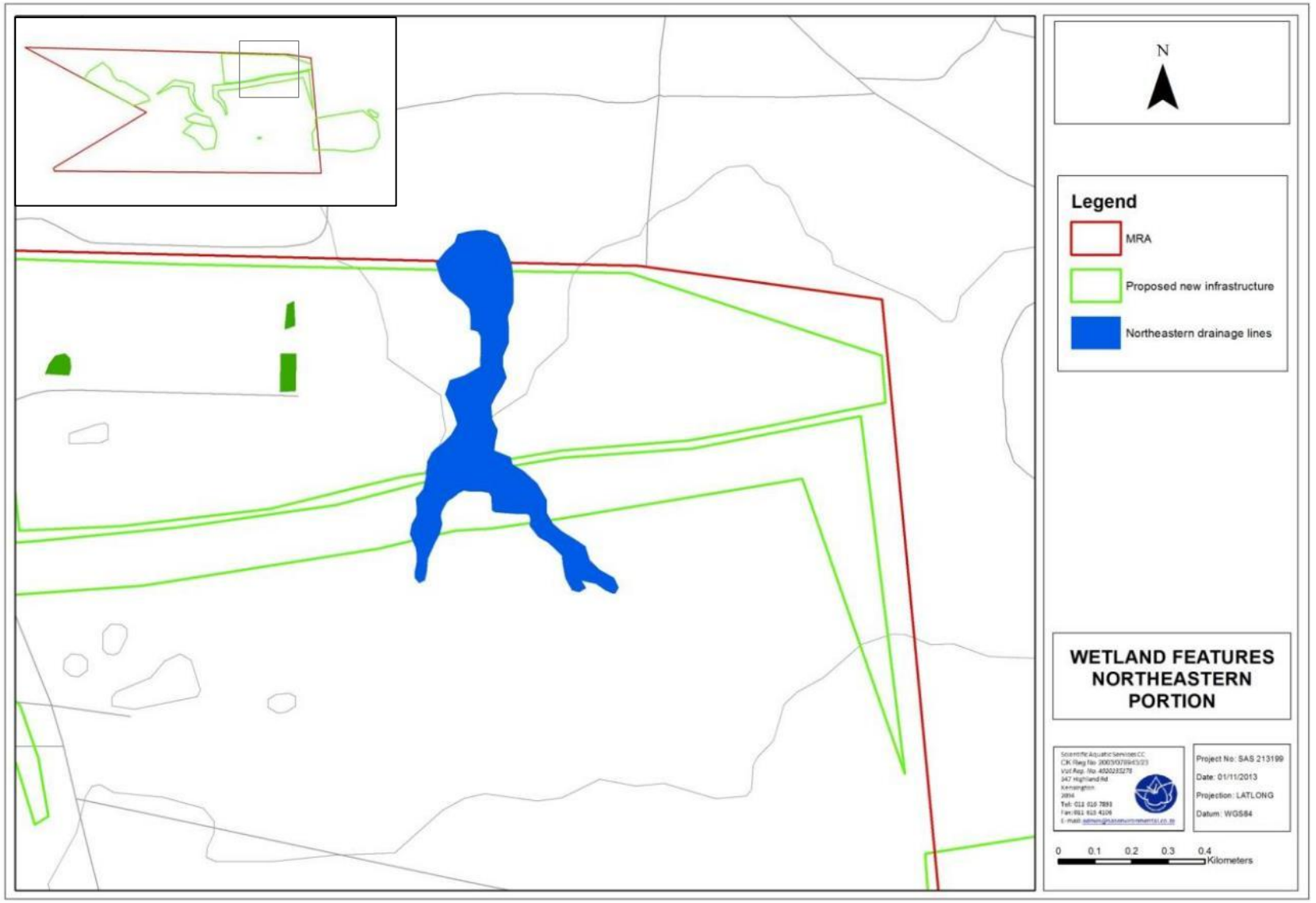

Figure 14: Locality of the expected original extent of the northeastern drainage lines in relation to the MRA.

Figure 15: Representative photographs of the remaining sections of the northeastern non-perennial drainage lines. Mining activities to the south, as well as a dirt road traversing the wetland area, are evident.

3.3.3 Southeastern Portion of the Subject Property

Two wetland features were identified in this portion of the subject property: an un-named, non-perennial tributary of the Elandsdrift, and a drainage line (hereinafter referred to as the 'southeastern drainage lines'). According to the Classification System, these drainage lines are classes as channelled valley bottom wetlands, as presented in the table below.

Table 13: Classification system for the southwestern drainage line.

Wetland feature location	Level 1: System	Level 2: Regional Setting	Level 3: Landscape unit	Level 4: Hydrogeomorphic (HGM) unit HGM Type
South-east portion of subject property	**Inland:** An ecosystem that has no existing connection to the ocean but which is inundated or saturated with water, either permanently or periodically.	**Bushveld Basin Ecoregion:** The subject property falls within the Bushveld Basin Ecoregion **WetVeg:** Central Bushveld Group 2	**Valley floor:** The typically gently sloping, lowest surface of a valley	**Channelled valley-bottom wetland:** A mostly flat wetland area on a valley floor that is dissected by and typically elevated above a well-defined stream channel. Dominant water inputs to these areas are typically from the channel (when it overtops or from sub-surface discharge) and from adjacent valley-side slopes

Figure 16: Representative photographs of sections of the southeastern drainage lines.

3.3.4 Southwestern Portion of the Subject Property

Two wetland features were identified here: an artificial wetland (hereinafter referred to as the “southwestern wetland feature” and a non-perennial drainage line (hereinafter referred to as the “southwestern drainage line”.)

Although facultative and obligate vegetation was observed in the artificial wetland area indicated on the map below, the presence of this vegetation and the formation of this wetland feature is considered to be due to earthworks and increased run-off from the tarred roads to the south, leading to localised changes in hydrology, including ponding, which supports wetland vegetation. This wetland was assessed according to Kotze *et. al.* (2008) at the basic Level 1 WET Health assessment. The results are discussed in Section 3.4.2 of this report.

The southwestern drainage line was assessed as a riverine feature due to its physical, geological structure. The results of the VEGRAI and EIS assessments of this drainage line are presented in Table 19 and Table 20 respectively.

Table 14: Classification system for the southwestern drainage line and southwestern artificial wetland.

Wetland feature location	Level 1: System	Level 2: Regional Setting	Level 3: Landscape unit	Level 4: Hydrogeomorphic (HGM) unit HGM Type
South-west portion of subject property; drainage line situated slightly to the west	**Inland:** An ecosystem that has no existing connection to the ocean but which is inundated or saturated with water, either permanently or periodically.	**Bushveld Basin Ecoregion:** The subject property falls within the Bushveld Basin Ecoregion **WetVeg:** Central Bushveld Group 5	**Valley floor:** The typically gently sloping, lowest surface of a valley	**Channel (River):** a linear landform with clearly discernible bed and banks, which permanently or periodically carries a concentrated flow of water.
South-west portion of subject property; artificial wetland situated slightly to the east	**Inland:** An ecosystem that has no existing connection to the ocean but which is inundated or saturated with water, either permanently or periodically.	**Bushveld Basin Ecoregion:** The subject property falls within the Bushveld Basin Ecoregion **WetVeg:** Central Bushveld Group 5	**Valley floor:** The typically gently sloping, lowest surface of a valley	**Unhannelled valley-bottom wetland:** A mostly flat wetland area on a valley floor that is characterised by an absence of distinct channel banks, and the prevalence of diffuse flows. Water inputs are typically from an upstream channel that becomes dominated by diffuse (surface and subsurface) flow as it enters the wetland and seepage from adjacent slopes. There may also be groundwater input.

The location of the southwestern wetland feature and southwestern drainage line in relation to the subject property are depicted in the following figure.

Figure 17: Locality of the artificial wetland and non-perennial drainage line located in the southwestern portion of the subject property.

Figure 18: Representative photographs of the southwestern wetland feature (left) and southwestern drainage line (right).

3.3.5 Central Portion of the Subject Property

The Sterkstroom River is the major river draining through the subject property in a south-north direction. Activities impacting the riparian zone and water quality of the river include agricultural practices such as water abstraction, mining activities, the proximity of the Hernic Quarry, and edge effects associated with the local settlement such as littering, sewage discharge and pollution due to washing of clothes taking place in the river by the local community.

Due to the close proximity of the Hernic Quarry to the Sterkstroom River there are two potential risks to the sensitive Sterkstroom River system:

The Hernic Quarry currently has a water level which is lower than the level of the adjacent Sterkstroom River. The quarry therefore has the potential to lead to dewatering of the Sterkstroom which could have an impact on the instream and riparian habitat on the areas on the Sterkstroom downstream of this point. In turn impacts on instream flow and habitat have the potential to impact on aquatic and riparian communities. The interactions between the Hernic Quarry and the Sterkstroom need to be clearly defined by a suitably qualified geohydrologist.

If the Tharissa Mining operations expand and the mine disposes of more dirty water in the Hernic Quarry, raising the water level within the quarry to above the level of the Sterkstroom River a hydraulic head may form which could lead to movement of contaminated water to the Sterkstroom River in turn leading to impacts on the local and

downstream instream ecology, and a loss of aquatic biodiversity and general aquatic community sensitivity.

The Sterkstroom River is classified by the Classification System as follows:

Table 15: Classification system for the Sterkstroom River

Wetland feature location	Level 1: System	Level 2: Regional Setting	Level 3: Landscape unit	Level 4: Hydrogeomorphic (HGM) unit
				HGM Type
Sterkstroom River	**Inland:** An ecosystem that has no existing connection to the ocean but which is inundated or saturated with water, either permanently or periodically.	**Bushveld Basin Ecoregion:** The subject property falls within the Bushveld Basin Ecoregion **WetVeg:** Central Bushveld Group 2	**Valley floor:** The typically gently sloping, lowest surface of a valley	**Channel (River):** a linear landform with clearly discernible bed and banks, which permanently or periodically carries a concentrated flow of water.

The figure below depicts the location of the Sterkstroom River in relation to the subject property.

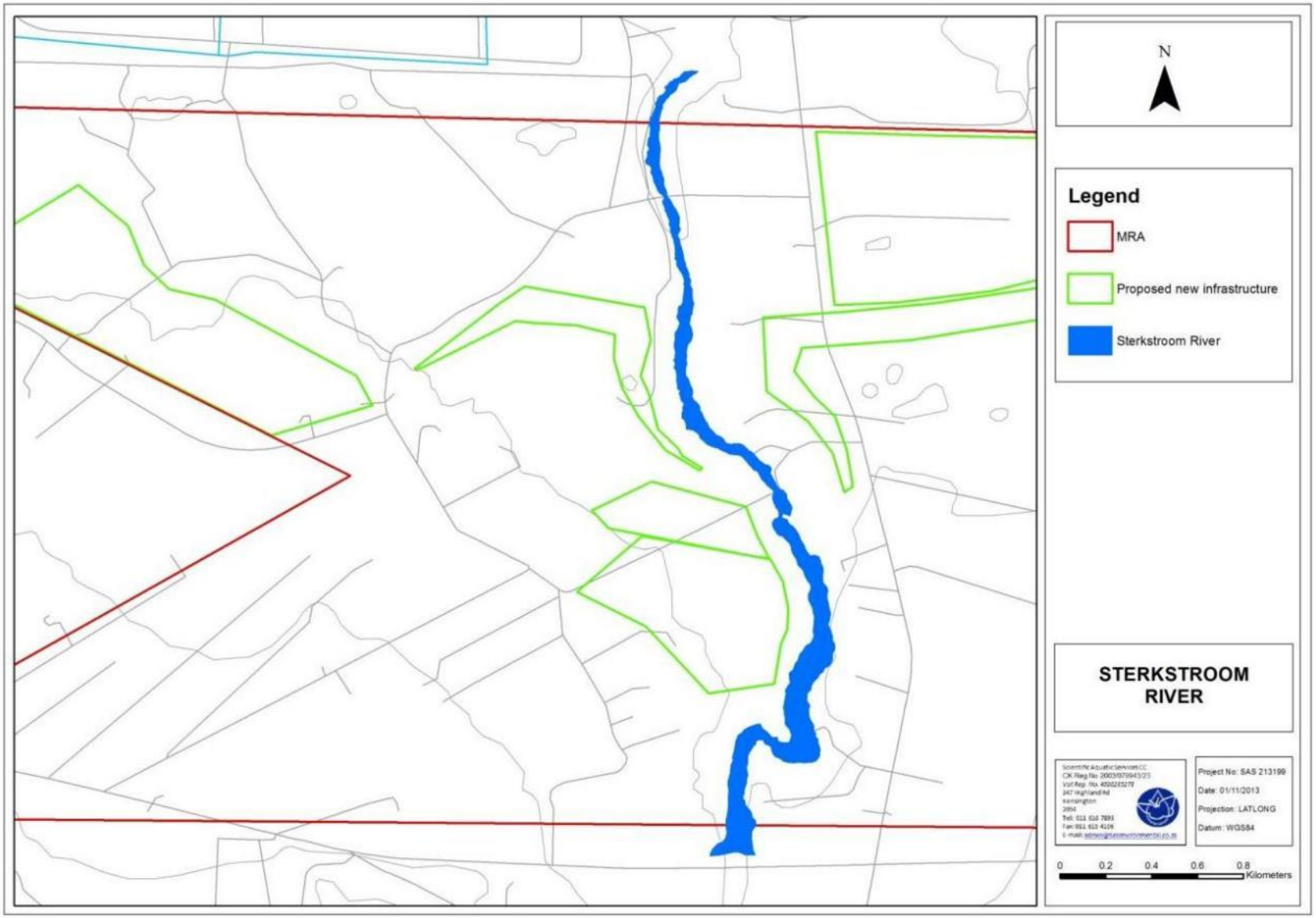

Figure 19: Locality of the Sterkstroom River in relation to the MRA.

Figure 20: Representative photographs of sections of the Sterkstroom River

3.4 *Wetland Assessment*

The various wetland features and the Sterkstroom River are discussed below with reference to the methods of assessment applied to each one, levels of ecoservices provided by each feature, the features' PES as well as the levels of disturbance and overall sensitivities of each feature as noted during the field assessment.

3.4.1 Northwestern Drainage Lines

3.4.1.1 Wetland Function Assessment

Wetland function and service provision were assessed according to the method defined in section 2.6 of this report, taking into consideration the desktop and field assessment results. The average scores for the northwestern drainage lines are presented in the following table as well as the radar plot in the figure that follows.

Table 16: Wetland functions and service provision for the northwestern drainage lines.

Ecosystem service	Northwestern wetlands Unchannelled valley bottom	Northwestern wetlands Channelled Valley Bottom
Flood attenuation	1.6	1.6
Streamflow regulation	1.4	1.4
Sediment trapping	1.8	1.8
Phosphate assimilation	1.5	1.5
Nitrate assimilation	1.2	1.2
Toxicant assimilation	1.7	1.7
Erosion control	1.1	1.1
Carbon Storage	0.6	0.6
Biodiversity maintenance	1.2	1.2
Water Supply	0.6	0.6
Harvestable resources	1.2	1.2
Cultivated foods	1	1
Cultural value	1	1
Tourism and recreation	0	0
Education and research	0	0
SUM	**15.9**	**15.9**
Average score	**1.1**	**1.1**

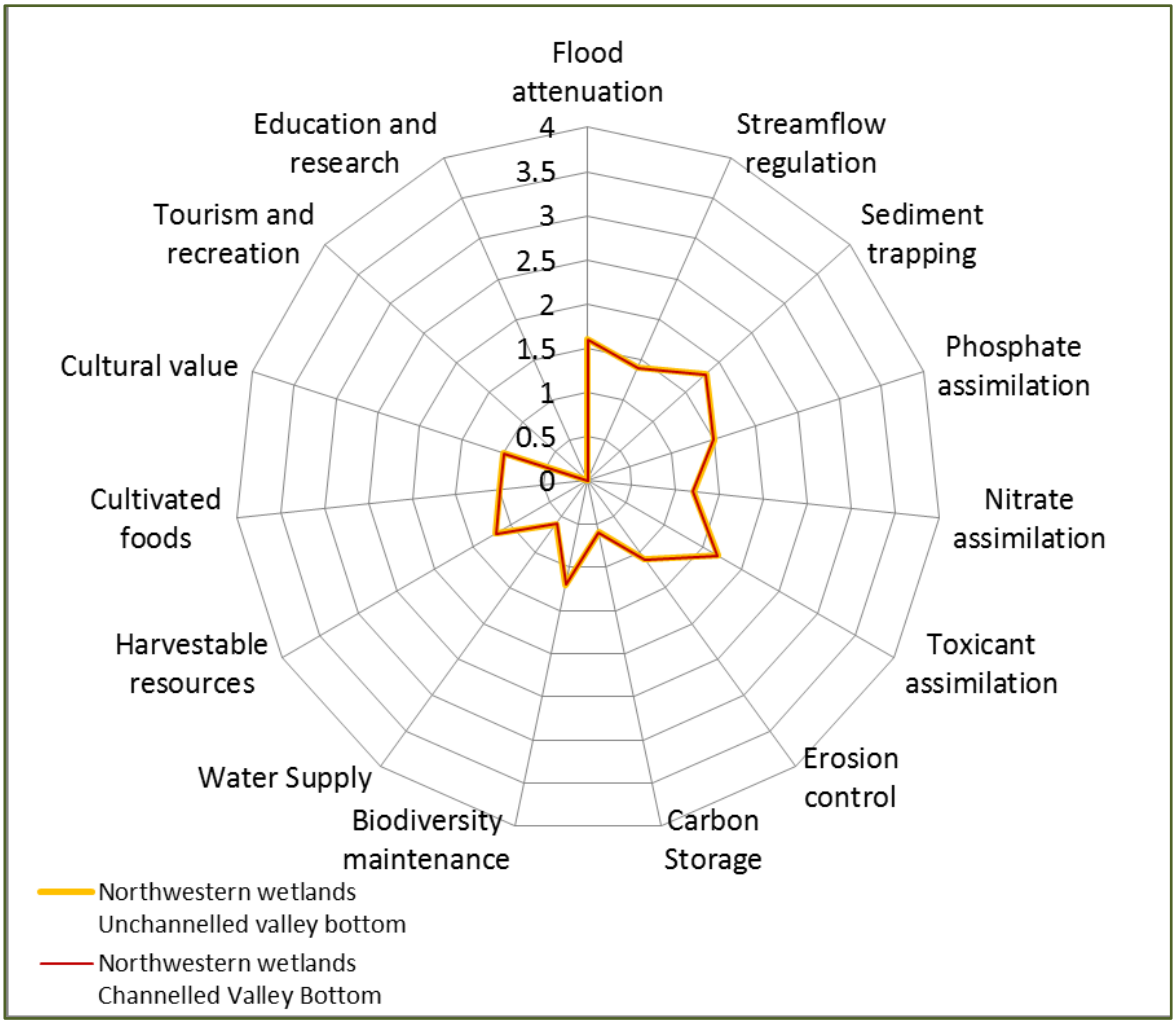

Figure 21: Radar plot of wetland services provided by the northwestern drainage lines.

From the assessment, it is apparent that the two drainage lines each obtained an overall ecological provision score of 1.1, placing them in the moderately low category which indicates that they have moderately low levels of service provision and ecological functioning. Factors taken into consideration when scoring the features included recent agricultural and mining activities which have resulted in loss of natural vegetation and increased sediment input, in turn impacting on the capacity of the features to provide important ecological services such as flood attenuation, nutrient and toxicant assimilation, erosion control and habitat for faunal species. The scores calculated for provision of harvestable resources and cultivated foods are an indication of these wetland features' potential to provide such services and is based primarily on their locality within a rural community. For example, if such wetland features were easily accessible to a local community, they might be utilised for services such as livestock grazing or crop cultivation. Due to the proximity to mining activities, the wetland features are not considered to have any significant cultural, tourism, recreational, or educational importance.

3.4.1.2 WET-Health Assessment

Wetlands protect and regulate water resources, performing vital functions such as flood attenuation, recharging of ground water, nutrient assimilation, filtering of pollutants and prevention of soil erosion. Wetland ecosystems comprise the abiotic characteristics of an area, including climate, geology and soil, water, nutrient supply and radiant energy, together with a biotic community suited to the prevailing environmental conditions and natural disturbance regimes.

A system in which natural inputs of resources or toxins has not been modified by recent human intervention, and which experiences levels of disturbance that are regarded as natural, is considered to be in a 'natural reference condition'. Here, it is worth recognising that humans have long influenced disturbance regimes in Southern Africa through practices such as veld burning. These low-impact disturbances should be regarded as part of the natural disturbance regime. Given this context, wetland health is defined as a measure of the similarity of a wetland to a natural or reference condition. In thinking about wetland health, it is appropriate to consider 'deviation' from the natural or reference condition. For the purposes of the WET-Health assessment, the state of a wetland is a measure of the extent to which human impacts have caused the wetland to differ from the natural reference condition (Macfarlane *et. al.* 2008).

A Level 1 WET-Health assessment of the northwestern drainage lines was undertaken. Three modules were assessed namely hydrology, geomorphology and vegetation. Each HGM unit was assessed separately, and a summary of the results is presented in the table below.

Table 17: Summary of results of the WET-Health assessment of the northwestern drainage lines.

	Hydrology		Geomorphology		Vegetation	
Northwestern drainage lines	Impact Score	Change Score	Impact Score	Change Score	Impact Score	Change Score
Channelled Valley Bottom	C	↓↓	C	↓↓	D	↓↓
Unchannelled Valley Bottom	C	↓↓	C	↓↓	C	↓↓

The above results indicate that moderate to high levels of modifications of hydrology, geomorphology and vegetation have occurred. Modifying factors include past agricultural activities such as vegetation clearing for crop cultivation, past mining activities contributing to

increased erosion and sediment input, and alteration to the channel as a result of water abstraction. Considering the current rate of transformation of the landscape and proximity and expansion of mining activities in the vicinity, deviation from a Category C/D is expected in both systems, unless mitagatory measures are implemented to prevent further deterioration.

3.4.1.3 Wetland EIS Assessment

The results of the wetland function assessment and WET-Health assessment were utilized to inform the EIS assessment.The results of the EIS Assessment of the two northwestern drainage lines are presented in Table 18 below. The score of 1.25 calculated during the assessment indicates that these wetland features fall into the “moderate” EIS category (REC ‘C’). It should be noted that this category was obtained primarily as a result of historical and current mining activities in the immediate vicinity of the drainage lines. Specific mention is made of the excavation to the south of the drainage lines and the gully formed in the lower portion of the drainage line situated slightly to the west. Additionally, historical agricultural practices such as crop cultivation and grazing may have contributed to the present condition of these tributaries through water attenuation, increased siltation and clearing of natural vegetation.

Table 18: Wetland EIS Score for the northwestern drainage lines.

Determinant	Unchannelled Valley Bottom		Channelled Valley Bottom	
	Score	Confidence	Score	Confidence
PRIMARY DETERMINANTS				
1. Rare & Endangered Species	0	3	0	3
2. Populations of Unique Species	0	3	0	3
3. Species/taxon Richness	1	3	1	3
4. Diversity of Habitat Types or Features	1	4	1	4
5 Migration route/breeding and feeding site for wetland species	1	4	1	4
6. PES as determined by WET Health assessment	1	4	1	4
7. Importance in terms of function and service provision	2	4	2	4
MODIFYING DETERMINANTS				
8. Protected Status according to NFEPA Wetveg	2	4	2	4
9. Ecological Integrity	2	4	2	4

TOTAL	10		10	
MEAN	1.25		1.25	
OVERALL EIS	**C**		**C**	

3.4.1.4 Recommended Ecological Category (REC)

The results of the wetland function assessment and WET-Health assessment, together with the results of the EIS assessment, were used to inform the REC, which is deemed to be a Class C (moderately modified).

3.4.2 Southwestern Artificial Wetland Feature

According to Kotze *et. al.* (2008), areas belonging to the HGM type and falling within a similar geological and climatic setting are likely to have a similar structure and exhibit similar processes. Thus HGM types provide a useful way of delimiting broad units of assessment.

Although the southwestern artificial wetland was likely to have been created as a result of modifications to the surrounding areas as mentioned in Section 3.3.4, it nevertheless has the potential to perform certain ecological services and functions in the same manner as a natural wetland. Field observations, satellite imagery and consultation of the NFEPA database ascertained that it may be classified as an unchannelled valley bottom wetland (Table 14) and thus benefits such as erosion control, flood attenuation, sediment trapping and nutrient and toxicant assimilation are likely to be provided. No one HGM type is considered to have higher biodiversity value than another type (Kotze *et. al.* 2008), however it is important to note that the artificial wetland feature does serve to provide suitable habitat for a number of wetland floral and faunal species and should be conserved if at all possible. The threatened species, *Crinum macowanii* (IUCN listed as 'Declining') has a high probability of occurring within this feature.

3.4.2.1 Recommended Ecological Category (REC)

Whilst it is not possible to accurately ascertain a REC for the southwestern artificial wetland, consideration was given to the potentially medium level of biodiversity maintenance supplied by this wetland, in terms of habitat provision for wetland floral and faunal species, particularly *Crinum macowanii* as mentioned above. Factors such as surrounding mining and agricultural activities and the impact that these may have on the wetland (vegetation clearing, alteration to geomorphology, increased sedimentation) were also considered. Given that this wetland, although artificial, may still provide a number of important ecological services, it is

recommended that this wetland be placed in a REC Category C, and that suitable mitigation measures be put in place to provide protection from further modifications.

3.4.3 Southwestern Drainage Line

Two assessment methods were applied to the southwestern drainage line: the VEGRAI and EIS.

3.4.3.1 VEGRAI

The results of the VEGRAI assessment of the southwestern non-perennial drainage line are presented in Table 19 below.

Table 19: Results of the VEGRAI Assessment of the southwestern non-perennial drainage line

LEVEL 3 ASSESSMENT					
METRIC GROUP	**CALCULATED RATING**	**WEIGHTED RATING**	**CONFIDENCE**	**RANK**	**% WEIGHT**
MARGINAL	70.0	31.1	2.5	2.0	80.0
NON MARGINAL	60.0	33.3	0.0	1.0	100.0
	2.0				180.0
LEVEL 3 VEGRAI (%)				64.4	
VEGRAI EC				**C**	
AVERAGE CONFIDENCE				1.3	

The results of this assessment indicate that the non-perennial drainage line falls within an Ecological Class C, meaning that the vegetation within the system has been moderately modified. Some loss and change of natural habitat has occurred, however the basic ecosystem functions are predominantly unchanged. The primary modifier to this system is likely to be water quality, due to the proximity to historical and current agricultural activities which may contribute to increased phosphate and nitrate loads, as well as mining activities. It was however not possible to test these parameters at the time of the site inspection as there was no water present.

3.4.3.2 Wetland EIS Assessment

The EIS assessment utilised the results of the VEGRAI assessment in order to ascertain a suitable EIS class. The results of the EIS assessment of the southwestern non-perennial drainage line are presented in Table 20 below, and show that the overall EIS is a Class C, consistent with the results of the VEGRAI assessment.

Table 20: Results of the EIS Assessment of the unnamed perennial tributary located in the south-west portion of the subject property

Determinant	Score	Confidence
PRIMARY DETERMINANTS		
1. Rare & Endangered Species	1	2
2. Populations of Unique Species	1	2
3. Species/taxon Richness	1	1
4. Diversity of Habitat Types or Features	1	2
5 Migration route/breeding and feeding site for wetland species	2	2
6. PES as determined by VEGRAI assessment	1	3
7. Importance in terms of function and service provision	2	3
MODIFYING DETERMINANTS		
8. Protected Status according to NFEPA Wetveg	2	4
9. Ecological Integrity	1	2
TOTAL	12	
MEDIAN	1.3	
OVERALL EIS	**C**	

3.4.3.3 Recommended Ecological Category (REC)

The outcome of the VEGRAI and EIS assessments applied to the southwestern drainage line indicates that the REC of this feature is a Category C – moderately modified. Thus, suitable mitigation measures should be implemented in order to protect the drainage line from any further modifications.

3.4.4 Southeastern Drainage Lines

3.4.4.1 Wetland Function Assessment

Wetland function and service provision were assessed according to the method defined in section 2.6 of this report, taking into consideration the desktop and field assessment results. Due to both drainage lines being classified as channelled valley bottom HGM units, and accounting for the similarities in wetland and vegetation structure due to their close proximity, both features were assessed as one unit. The average scores for the features are presented in the following table as well as the radar plot in the figure that follows.

Table 21: Wetland functions and service provision for the wetland features present in the southeastern portion of the study area

Ecosystem service	Southeastern Drainage Lines
Flood attenuation	2
Streamflow regulation	1.4
Sediment trapping	1.6
Phosphate assimilation	1.5
Nitrate assimilation	1.2
Toxicant assimilation	1.6
Erosion control	1.1
Carbon Storage	0.6
Biodiversity maintenance	1.2
Water Supply	0.6
Harvestable resources	1.2
Cultivated foods	1
Cultural value	1
Tourism and recreation	0
Education and research	0
SUM	**16**
Average score	**1.1**

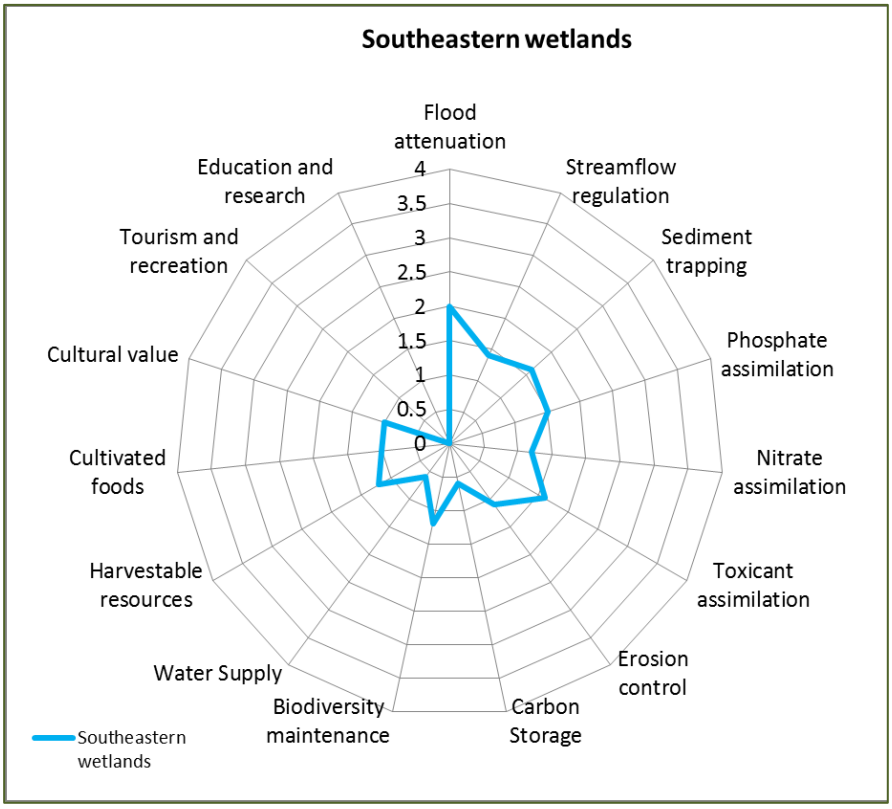

Figure 22: Radar plot of wetland services provided by the wetland features present in the southeastern portion of the subject property.

3.4.4.2 WET-Health Assessment

A Level 1 WET-Health assessment was applied to the two southeastern drainage lines. The results are presented in the table below:

Table 22: Summary of results of the WET-Health assessment of the southeastern drainage lines.

	Hydrology		Geomorphology		Vegetation	
Southeastern drainage lines	Impact Score	Change Score	Impact Score	Change Score	Impact Score	Change Score
Elandsrift Tributary (Channelled Valley Bottom)	C	↓↓	C	↓↓	C	↓↓
Drainage line near N4 (Channelled Valley Bottom)	C	↓↓	C	↓↓	C	↓↓

The results of the WET-Health assessment indicate that the hydrology, geomorphology and vegetation modules all obtained a Category C impact score. These scores are primarily due to the effects of past agricultural activities such as land clearing for crop cultivation and livestock grazing, and tilling. In addition, an increased runoff is expected due to the proximity of one drainage line to the N4 highway. Evidence of erosion was evident in both drainage lines. Personal communications with the Environmental Officer of Tharisa Minerals (Pty) Ltd revealed that the agricultural activities in the vicinity have only ceased in the last 6 to 12 months; therefore the effects of agricultural activities are still evident.

It is anticipated that due to the current rate of transformation of the landscape and proximity and expansion of mining activities in the vicinity, deviation from a Category C is expected in both systems, unless mitagatory measures are implemented to prevent further deterioration.

3.4.4.3 Wetland EIS Assessment

The EIS assessment of the southeastern drainage lines took into consideration the scores attained from the wetland function and WET-Health assessments, and are presented in the table below. These results indicate that the features fall within a Category C (ecologically important and sensitive on a provincial or local scale). Historical agricultural activities such as crop cultivation and grazing of livestock have resulted in the clearing of natural vegetation in the immediate vicinity of these features. It is likely that some degree of water abstraction has occurred in the past and evidence of erosional features was apparent. These activities have influenced the availability of habitat for faunal species.

Table 23: Results of the EIS Assessment of the wetland features present in the southeastern portion of the study area

Determinant	Score	Confidence
PRIMARY DETERMINANTS		
1. Rare & Endangered Species	0	3
2. Populations of Unique Species	0	3
3. Species/taxon Richness	1	3
4. Diversity of Habitat Types or Features	1	4
5 Migration route/breeding and feeding site for wetland species	1	4
6. PES as determined by WET Health assessment	1	4
7. Importance in terms of function and service provision	2	4
MODIFYING DETERMINANTS		
8. Protected Status according to NFEPA Wetveg	2	4
9. Ecological Integrity	1	4
TOTAL	9	
MEAN	1.1	
OVERALL EIS	**C**	

3.4.4.4 Recommended Ecological Category

The results of the wetland function and WET-Health assessments, along with the results of the EIS assessment, were utilized to assign a suitable REC to the southeastern drainage lines. These results indicate that the REC is a Category C and suitable mitigation measures should be put in place to retain this.

3.4.5 Sterkstroom River

Four assessment methods are applicable to the Sterkstroom River: VEGRAI, IHI, Function Assessment, and EIS. The results of each are discussed below.

3.4.5.1 Function Assessment

Wet-EcoServices was applied to the Sterkstroom River in order to assist in gauging the importance of the river in terms of ecological functioning and service provision. The results of the assessment are presented below in Table 24 and the radar plot in Figure 23.

Although the assessment is applicable to the portion transversing the subject property, it should be noted that both the upstream and downstream areas were considered when

applying the scoring, as ecological events occurring upstream of a given point will have some impact on the biota downstream from the event.

Table 24: Wetland functions and service provision for the Sterkstroom River

Ecosystem service	Sterkstroom River
Flood attenuation	2.1
Streamflow regulation	1.8
Sediment trapping	2.2
Phosphate assimilation	2
Nitrate assimilation	2.1
Toxicant assimilation	2.6
Erosion control	2.1
Carbon Storage	1.3
Biodiversity maintenance	3
Water Supply	3
Harvestable resources	1.8
Cultivated foods	1.6
Cultural value	1
Tourism and recreation	1
Education and research	0.7
SUM	**29.9**
Average score	**2.0**

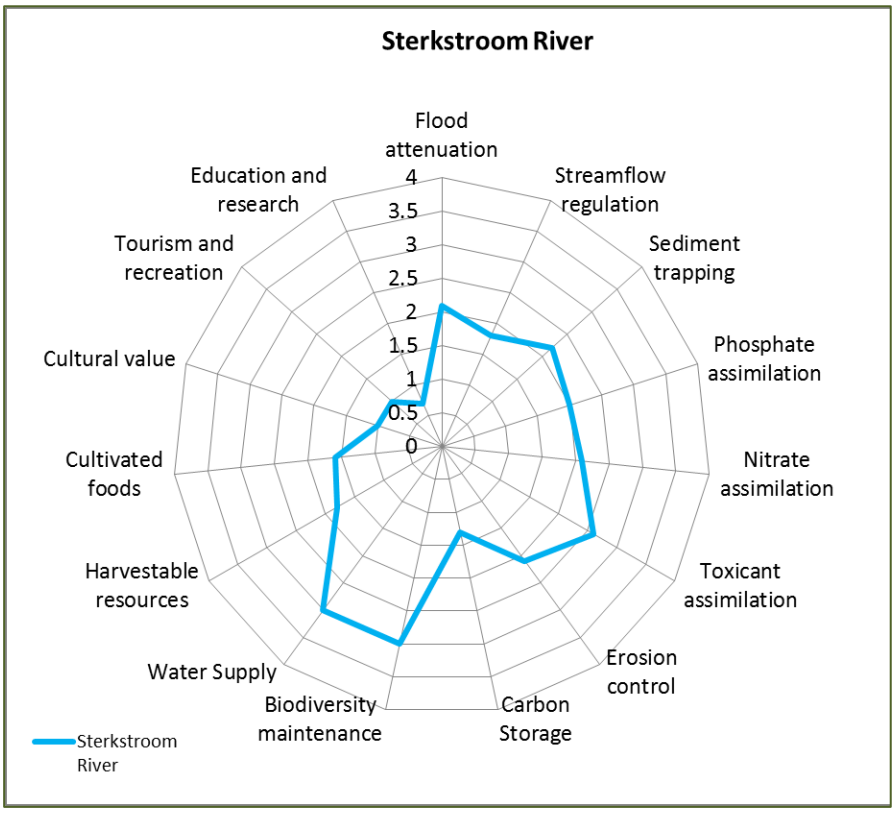

Figure 23: Radar plot of wetland services provided by the Sterkstroom River.

The results of the assessment indicate that the Sterkstroom River obtained an overall ecological provision score of 2, placing it in the moderately high category, indicating that it has moderately high levels of service provision and ecological functioning. Several factors contribute to this rating, most notably the potential for harvestable resources for local communities such as fish, as well as watering and grazing facilities for livestock. Biodiversity maintenance received a high score, primarily due to the river's location within the only remaining extent of the threatened Marikana Thornveld vegetation type within the subject property (Section A) and the cumulative loss of wetlands within the catchment due to agricultural and mining activities. Additionally, this Sterkstroom River provides habitat for faunal species which are sensitive to habitat loss such as *Aonyx capensis* (African Clawless Otter).

Provision of water supply for direct human use attained a high score primarily due to the high number of people residing in the community settlement within the subject property, who are reliant on the river for water for domestic uses. Rural communities located upstream of the Sterkstroom may also be reliant on the river for water.

In addition to the above, the Sterkstroom River provides moderately high levels of ecological services such as flood attenuation, streamflow regulation, sediment trapping and nutrient and toxicant assimilation. It should be noted that these functions are largely reliant on riparian and aquatic vegetation and that removal of indigenous vegetation may adversely affect the system's capacity to perform these essential functions.

3.4.5.2 VEGRAI

The VEGRAI method was applied in order to assess the impacts of the aforementioned anthropogenic activities in the subject property on the riparian vegetation.

Table 25: Results of the VEGRAI Assessment of the portion of the Sterkstroom River located in the subject property

LEVEL 3 ASSESSMENT					
METRIC GROUP	**CALCULATED RATING**	**WEIGHTED RATING**	**CONFIDENCE**	**RANK**	**% WEIGHT**
MARGINAL	70.0	31.1	2.5	2.0	80.0
NON MARGINAL	60.0	33.3	0.0	1.0	100.0
2.0					180.0
LEVEL 3 VEGRAI (%)				64.4	
VEGRAI EC				**C**	
AVERAGE CONFIDENCE				1.3	

The results of the VEGRAI assessment indicate that the vegetation associated with the riparian zone of the Sterkstroom River falls within a Category C. This indicates that the vegetation has been moderately modified and that some loss and change of the natural habitat has occurred, but the basic ecosystem functions are predominantly unchanged. Causes of modification include removal of natural vegetation, which in turn allows for the invasion of alien floral species, changes in water quality which may be due to effluent discharge, run-off of fertilizers or pesticides from the neighbouring agricultural properties, or other forms of pollution emanating from the community settlement, for example washing powder.

Large exotic *Eucalyptus camaldulensis* trees were noted along sections of the Sterkstroom River in dense stands, but a high proportion of indigenous trees, forbs and grasses remain present.

3.4.5.3 IHI

The WET-IHI was applied to the Sterkstroom River in order to assist in ascertaining the PES of the riparian zone associated with the river. The results are presented in Table 26 below:

Table 26: Results of the IHI Assessment of the portion of the Sterkstroom River located in the subject property

OVERALL PRESENT ECOLOGICAL STATE (PES) SCORE					
	Ranking	Weighting	Score	*Confidence Rating*	PES Category
DRIVING PROCESSES:		**100**	**1.6**		
Hydrology	1	100	1.7	*3.1*	**C**
Geomorphology	2	80	1.7	*3.6*	**C**
Water Quality	3	30	0.8	*2.0*	**B**
WETLAND LANDUSE ACTIVITIES:		**80**	**1.0**	***3.9***	
Vegetation Alteration Score	1	100	1.0	*3.9*	**B/C**
OVERALL SCORE:			**1.3**		
	PES %		**74.1**	***Confidence Rating***	
	PES Category:		**C**	***1.7***	

From the above results, it is evident that the PES falls into a Category C, consistent with the results of the VEGRAI assessment.

The predominant modifiers are the presence of flow-modifying structures such as bridges located at various points along the Sterkstroom River, agricultural practices such as water abstraction and the possibility of increased siltation and nitrates due to run-off from ploughed lands, mining activities affecting the water quality, and dumping of waste originating from the community settlement.

3.4.5.4 EIS Assessment

The results of the EIS assessment are presented in Table 27 below. These results, indicating that the riparian zone of the Sterkstroom River falls within a Category C, are consistent with the results of the VEGRAI and IHI assessments applied to this feature, and it can be surmised that due to the modifications to the system as discussed in Sections 3.8.1 and 3.8.2, the riparian zones of the Sterkstroom River are not considered to have a high species or taxon richness, but is considered to have good levels of habitat diversity.

Low habitat diversity and availability in turn decreases the possibility of occurrence of rare or endangered species, or populations of unique species. The faunal aspects are addressed in detail in Section C.

Table 27: Results of the EIS Assessment of the portion of the Sterkstroom River located in the subject property

Determinant	Score	Confidence
PRIMARY DETERMINANTS		
1. Rare & Endangered Species	1	2
2. Populations of Unique Species	1	1
3. Species/taxon Richness	1	1
4. Diversity of Habitat Types or Features	2	2
5 Migration route/breeding and feeding site for wetland species	2	2
6. PES as determined by VEGRAI assessment	1	3
7. Importance in terms of function and service provision	2	3
MODIFYING DETERMINANTS		
8. Protected Status according to NFEPA Wetveg	2	4
9. Ecological Integrity	1	2
TOTAL	12	
MEDIAN	1.3	
OVERALL EIS	**C**	

3.4.5.5 Recommended Ecological Category (REC)

The REC was guided primarily by the results of the EIS assessment, but also took into account the results of the VEGRAI, IHI and function assessments applied to the Sterkstroom River. The REC for the river is thus a Category C and suitable mitigation must take place in order to prevent any further modifications to this river system.

3.5 *Summary of Assessment Results*

A summary of the results obtained from the various assessments applied to each wetland feature (including drainage lines and the Sterkstroom River) are presented below.

Table 28: Summary of the results obtained from the assessments applied to the wetland features within the subject property

Feature	Function Assessment	WET-Health Assessment	VEGRAI Assessment	IHI Assessment	EIS Assessment	REC
Northwestern drainage lines	Moderately low	C / D	N/A	N/A	C	C
Southwestern Artificial wetland	N/A	N/A	N/A	N/A	N/A	C
Southwestern drainage line	N/A	N/A	C	N/A	C	C
Southeastern drainage lines	Moderately low	C	N/A	N/A	C	C
Sterkstroom River	Moderately high	N/A	C	C	C	C

3.6 *Wetland vegetation*

The various wetland vegetation components were identified during the assessment, with special attention being paid to both facultative and obligate wetland vegetation associated with soils that are frequently saturated. Dominant species were characterised as either wetland or terrestrial species. The wetland species were then further categorised as temporary, seasonal and permanent zone species. This characterisation is presented in the table below, including the terrestrial species identified within the wetland and riparian zones. It should be noted that this is not an exhaustive list of all floral species associated with the wetland and riparian zones within the subject property.

Table 29: Dominant floral species identified during wetland delineation of the wetland present on the subject property (alien floral species are indicated with an asterisk).

Terrestrial species	Temporary zone species	Seasonal zone species	Permanent zone species
Andropogon schirensis	*Commelina africana*	*Andropogon schirensis*	*Phragmites australis*
Asparagus laricunus	*Sporobolus africanus*	*Asparagus laricunus*	*Typha capensis*
Commelina africana	*Imperata cylindrica*	*Eragrostis curvula*	*Schoenoplectus*
Eragrotis curvula	*Berkheya radula*	*Eragrostis lehmanniana*	*corymbosus*
Eragrotis lehmanniana	*Cymbopogon pospischilii*	*Heteropogon contortus*	*Dicanthium annulatum*
Heteropogon contortus	*Cynodon dactylon*	*Ledebouria cooperi*	*Juncus effusus*
Ledebouria cooperi	*Eragrotis plana*	*Ledebouria revoluta*	*Cyperus longus*
Panicum maximum	*Asparagus laricunus*	*Panicum schinzii*	**Persicaria laphathifolia*
Eucalyptus camaldulensis	*Searsia pyroides*	*Cynodon dactylon*	**Paspalum urvillei*
Acacia karroo	*Bothriochloa insculpta*	*Combretum erythrophyllum*	*Cynodon dactylon*
Pappea capensis	*Cynodon dactylon*	*Searsia lancea*	*Sporobolus africanus*
Acacia karoo	**Jacaranda mimosifolia*	*Celtis africana*	**Rumex crispus*

Terrestrial species	Temporary zone species	Seasonal zone species	Permanent zone species
Ziziphus mucronata **Melia azedarach* **Jacaranda mimosifolia* **Phytolacca dioica*		*Setaria megaphylla* *Carissa bispinosa* *Eragrostis plana* *Hyparrhenia hirta* *Cynodon dactylon* *Themeda triandra* **Tagetes minuta* **Verbena bonariensis* **Tithonia rotundifolia*	**Populus x canescens* **Veronica anagallis-aquatica*

3.7 *Wetland delineation and sensitivity mapping*

During the assessment, the following temporary zone indicators were used:

- Terrain units were used to determine in which parts of the landscape the wetland feature is most likely to occur, as wetlands occupying the valley bottom landscape unit are easily distinguishable, and the extent of the associated wetland area can often readily be determined.
- The soil form indicator was used to determine the presence of soils that are associated with prolonged and frequent saturation, as well as variation in the depth of the saturated soil zone within 50cm of the soil surface. This indicator was used to identify gleyed soils where the soil is a greyish/greenish/bluish colour due to the leaching out of iron. Whilst mottling was not extensive, it was present in the temporary zone. These factors were utilised to aid in determining the location of the wetland zones and their boundaries.
- The vegetation indicator was used in the identification of the wetland boundary through the identification of the distribution of both facultative and obligate wetland vegetation associated with soils that are frequently saturated. Changes in vegetation density and levels of greening were also considered during the delineation process, particularly in instances such as in the northwestern wetlands where terrestrial species dominate the wetland areas. This indicator was very useful in identifying the boundary of the temporary zone.
- Surface water was absent during the field assessment, apart from within the Sterkstroom River, but saturated soils were noted within the majority some of the wetland areas.

After consideration of findings during the wetland assessment, a suitable buffer zone was considered for the proposed developments. One buffer zone is applicable to this subject property, i.e. a 100m buffer in terms of GN704 of the National Water Act (NWA) (1998).

This buffer zone is deemed sufficient to maintain the PES of the various wetland features, limit any further impact the proposed development could have, and to ultimately achieve the REC determined for each wetland feature as described above. The wetland boundaries and buffer zones are conceptually presented in Figures 24 to 28 below.

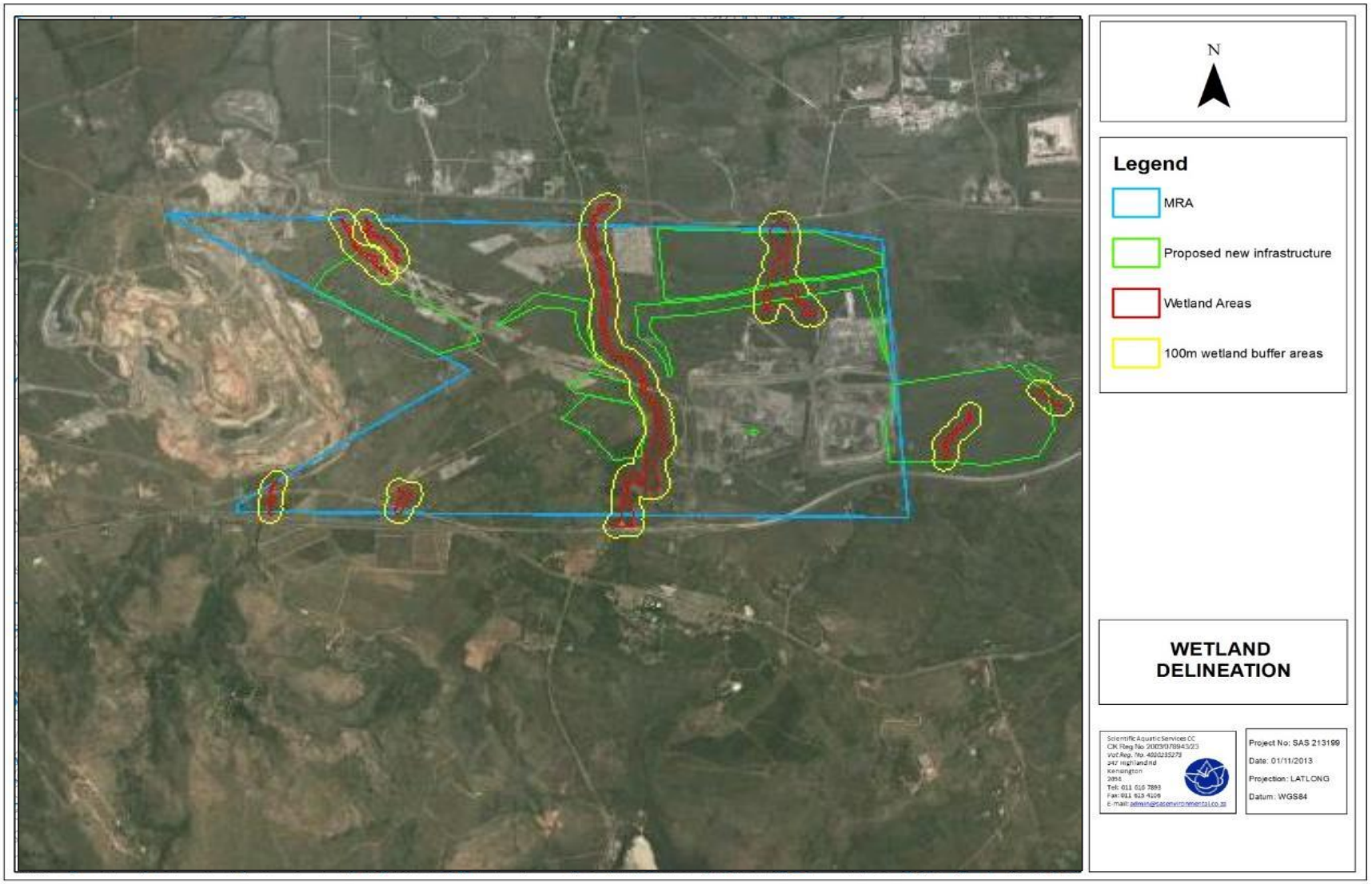

Figure 24: Conceptual representation of the wetland and riverine features present within the subject property with associated buffers.

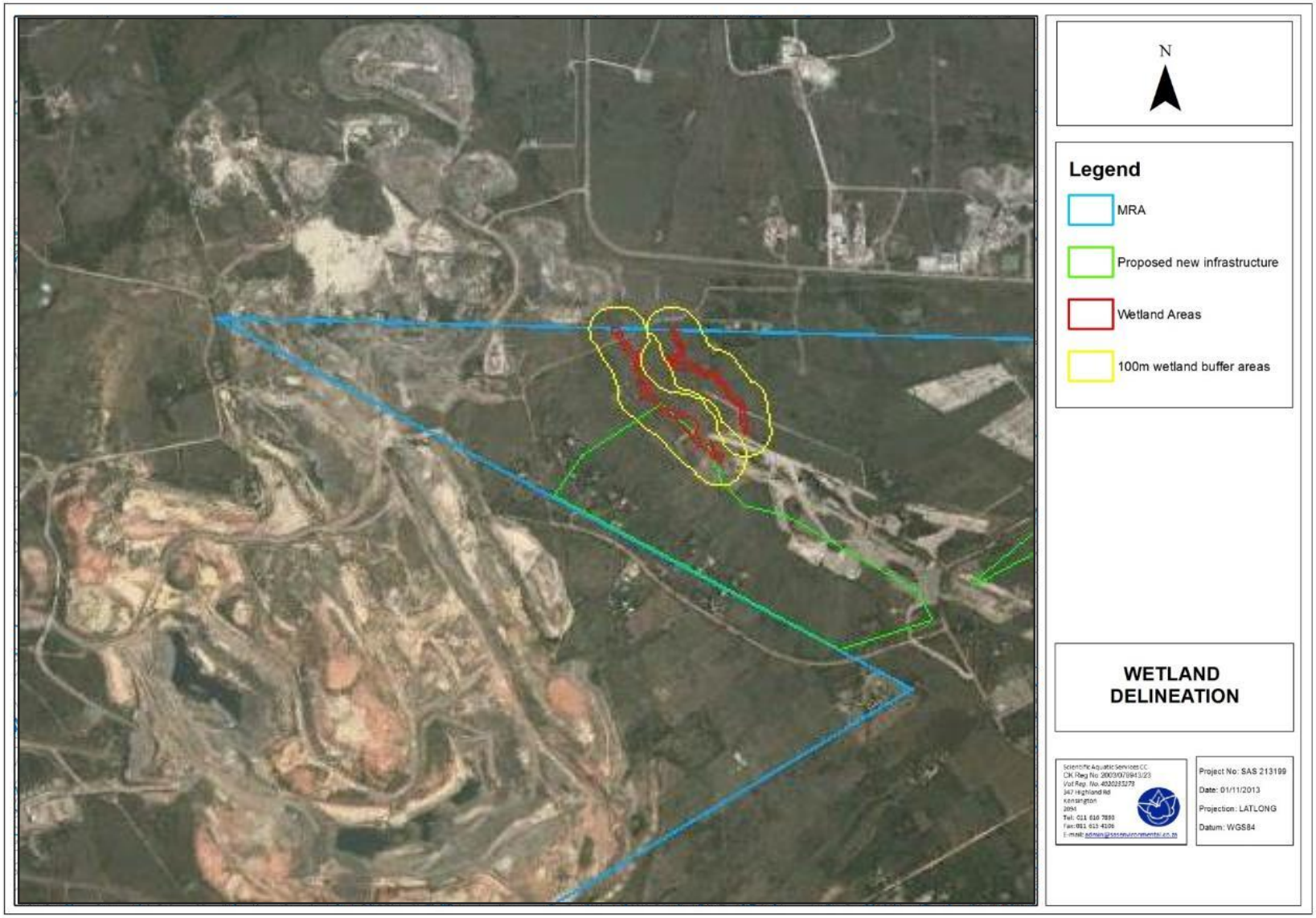

Figure 25: Wetland delineation of the northwestern drainage lines with associated buffer zones.

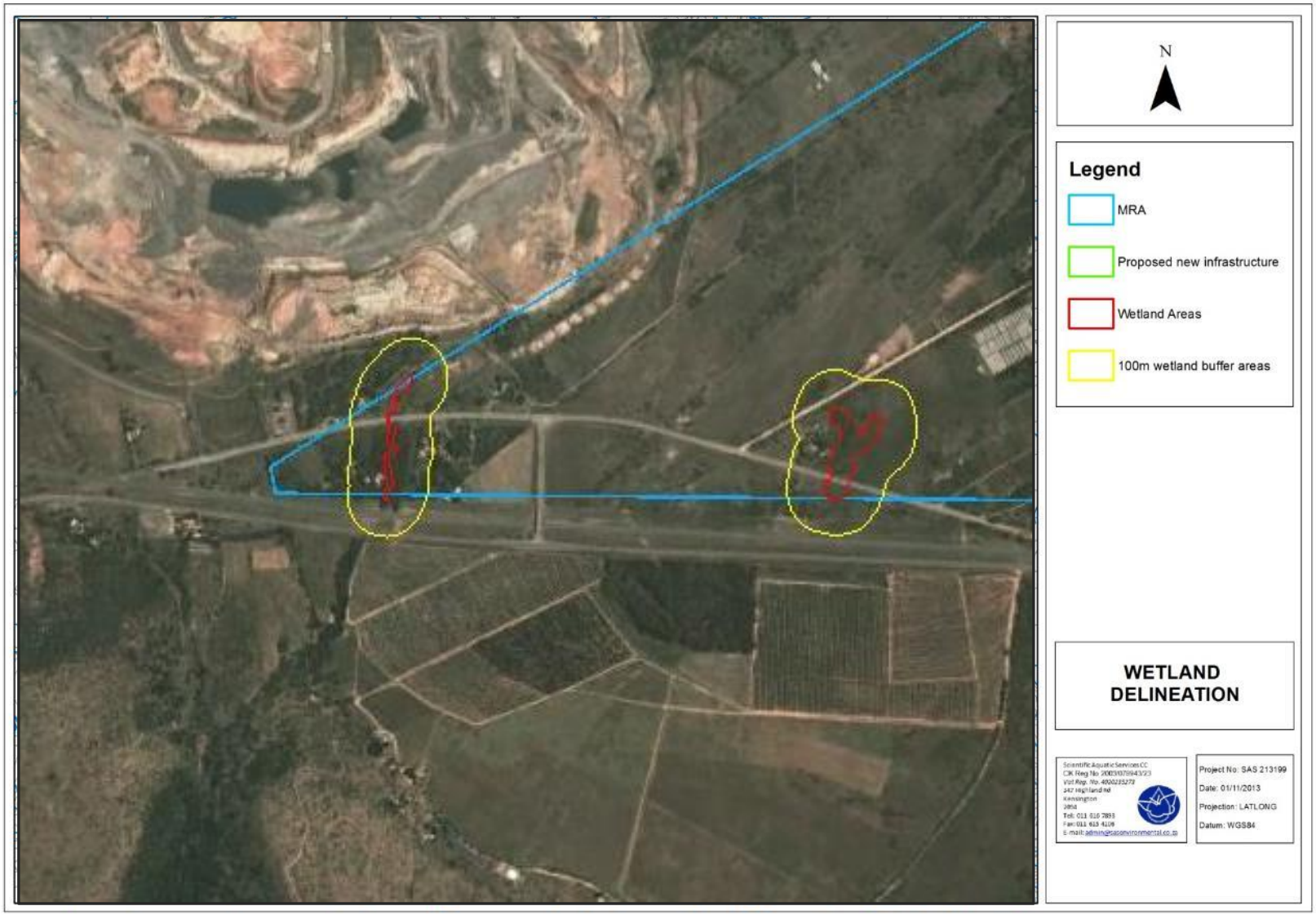

Figure 26: Wetland delineation of the southwestern artificial wetland and southwestern drainage line with associated buffer zones.

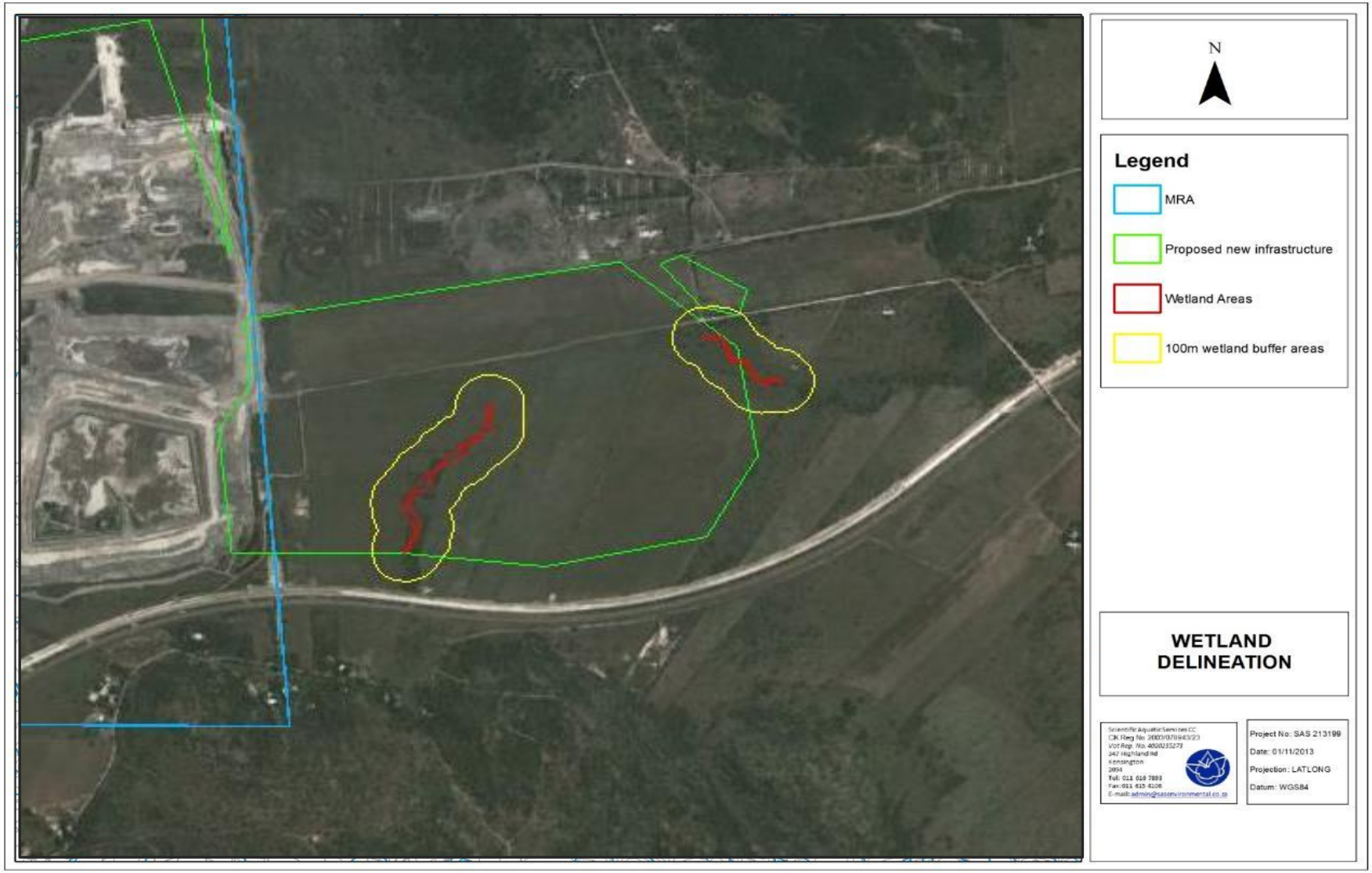

Figure 27: Delineation of the southeastern drainage lines with associated buffer zones.

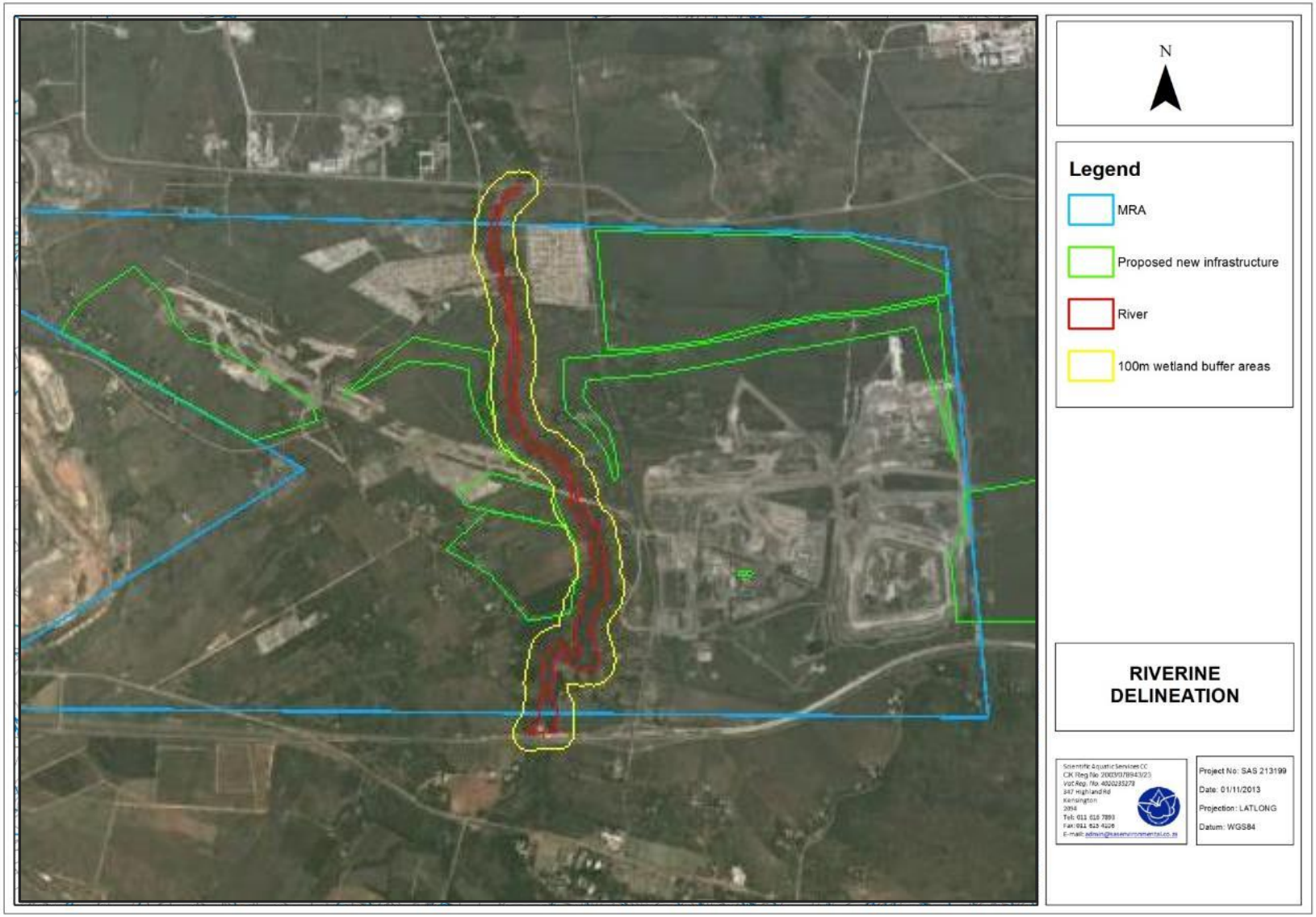

Figure 28: Sterkstroom River delineation with associated buffer zones.

4 IMPACT ASSESSMENT

The tables below serve to summarise the significance of perceived impacts on the wetland ecology and biodiversity of the subject property. The table presents the impact assessment according to the method described in Section A.

The impact assessment was divided into three sections where impacts were determined for:

- Mining activities of the northwestern area of the subject property;
- Mining activities of the southeastern portion of the subject property;
- Mining activities of the central portion of the subject property including the Sterkstroom River;

The drainage line and the artificial wetland in the southwest portion of the subject property were not assessed as there is currently no new infrastructure planned for that portion of the subject property. It is therefore expected that the current impact significance and EIS will remain the same; however it is important to note that should any future activities are planned in close vicinity to these wetland features a detailed impact assessment must be performed. An impact assessment was not carried out on the northeastern drainage lines, as it was not possible to ascertain the PES or EIS of these features due to the existing mining activities occurring in the vicinity thereof.

Alternative	Colour
Mining of the northwestern area of the subject property	
Mining of the southeastern portion of the subject property	
Mining of the central portion of the subject property.	

This section also indicates the required mitigatory measures needed to minimise any perceived impacts. The table presents an assessment of the significance of the impacts taking into consideration the available mitigatory measures assuming that they are fully implemented. The impact assessment also considers mining activities which have already occurred in the north-west and north-east portions of the subject property and adherence to the required mitagatory measures will assist in lessening the impact that these activities have had on the wetland features.

4.1 *Impact Discussion*

IMPACT 1: LOSS OF WETLAND HABITAT AND ECOLOGICAL STRUCTURE

Activities leading to impact

Pre-Construction	Construction	Operational	Decommissioning & Closure
Planning of infrastructure within wetland areas	Site clearing and the removal of vegetation leading to increased runoff and erosion	Ongoing disturbance of soils with general operational activities	Disturbance of soils as part of demolition activities
Inadequate design of infrastructure leading to risks of pollution	Site clearing and the disturbance of soils leading to increased erosion	Spillages and seepage of hazardous waste material into the groundwater	Ongoing seepage and runoff from mining infrastructure to the groundwater regime
Inadequate design of infrastructure leading to changes to wetland habitat	Earthworks in the vicinity of wetland areas leading to increased runoff and erosion and altered runoff patterns	Risk of discharge from the mining infrastructure	Ongoing risk of discharge from mining infrastructure beyond closure
	Construction of stream crossings altering stream and baseflow patterns and water velocities	Potential contamination from mining infrastructure	Potential contamination from the decommissioning of mining infrastructure
	Topsoil stockpiling adjacent to wetlands and runoff from stockpiles	Runoff, seepage and potential discharge from mining infrastructure such as pipelines	Ongoing seepage and runoff from mining infrastructure to the groundwater regime beyond closure
	Movement of construction vehicles within wetlands	Dumping of hazardous and non-hazardous waste into the wetland areas	Decommissioning activities may lead to wetland habitat transformation and alien plant species proliferation
	Dumping of hazardous and non-hazardous waste into the wetland areas	Erosion and sedimentation of wetlands leading to loss of wetland habitat	Ineffective rehabilitation may lead to habitat transformation and alien vegetation encroachment
	Waste material spills and waste refuse deposits into the wetland features		Ongoing erosion and sedimentation of wetlands

Aspects of wetland ecology affected

Pre-Construction	Construction	Operational	Decommissioning & Closure
	Direct impact on wetland habitat	Direct impact on wetland habitat	Direct impact on wetland habitat during decommissioning
	Loss of wetland biodiversity	Loss of wetland biodiversity	Loss of wetland biodiversity
	Contamination of wetland soils	Contamination of wetland soils	Ongoing contamination of wetland soils
	Contamination of water within wetlands	Contamination of water within wetlands	Ongoing contamination of water within wetlands
	Compaction and loss of wetland soils	Compaction and loss of wetland soils	Compaction and loss of wetland soils during decommissioning
	Sedimentation and incision leading to altered habitats	Sedimentation and incision leading to altered habitats	Sedimentation and incision leading to altered habitats
	Changes to the wetland community due to alien invasion vegetation leading to altered habitat conditions	Changes to the wetland community due to alien invasion vegetation leading to altered habitat conditions	Changes to the wetland community due to alien invasion vegetation leading to altered habitat
		Dewatering of wetlands and loss of habitat	Continued dewatering of wetlands and loss of habitat

Management	Probability of Impact	Sensitivity of receiving environment	Severity	Spatial scale	Duration of impact	Likelihood	Consequence	Significance
Unmanaged	5	3	4	3	5	8	12	96 (High)
Managed	4	3	3	2	4	7	9	63 (Medium low)
Unmanaged	5	3	4	3	5	8	12	96 (High)
Managed	4	3	3	2	4	7	9	63 (Medium low)
Unmanaged	5	4	3	3	5	9	11	99 (High)
Managed	4	4	2	2	4	8	8	64 (medium-low)

Essential mitigation measures:

- A sensitivity map has been developed for the subject property, indicating the various wetland features which are considered to be of increased ecological importance. It is recommended that this sensitivity map be considered during the planning/ pre-construction and construction phases of the proposed development activities to aid in the conservation of ecology within the subject property.
- It must be ensured that planning of mining infrastructure, with particular reference to wetland / riparian crossings, includes consideration of adjacent wetland / riparian areas to ensure that these areas are avoided as far as possible.
- The development footprint area must be limited to what is absolutely essential in order to minimise environmental damage.
- The boundaries of footprint areas are to be clearly defined and it should be ensured that all activities remain within defined footprint areas.
- Development impacts on the affected wetland / riparian features should be managed to minimise impacts on adjacent wetland features.
- Edge effects of activities including erosion and alien / weed control need to be strictly managed in these areas.
- Access into adjacent wetland / riparian areas, particularly by vehicles, is to be strictly controlled.
- All vehicles should remain on designated roads with no indiscriminate driving through adjacent wetland / riparian areas.
- Run-off from dirty water areas entering wetland / riparian habitats must be prevented and clear separation of clean and dirty water in the vicinity of the proposed development must take place. Oil must be prevented from entering the clean water system.
- Ensure that seepage from dirty water systems is prevented as far as possible.
- It must be ensured that all hazardous storage containers and storage areas comply with the relevant SABS standards to prevent leakage. All vehicles must be regularly inspected for leaks. Re-fuelling must take place on a sealed surface area to prevent ingress of hydrocarbons into topsoil.
- All spills should be immediately cleaned up and treated accordingly.
- Appropriate sanitary facilities must be provided for the life of the mine and all waste removed to an appropriate waste facility.
- Effective waste management must be implemented in order to prevent construction related waste from entering the wetland / riparian environment.
- All wetland / riparian areas must be rehabilitated upon decommissioning to ensure that wetland / riverine functions are re-instated during decommissioning and all disturbed wetland / riparian areas adjacent to the mining development must be revegetated with indigenous wetland / riparian species.
- All adjacent wetland systems must be monitored for erosion and incision.

- Erosion berms may be installed in any areas where soil disturbances within the vicinity of the wetland features have occurred to prevent gully formation and siltation of the aquatic resources. The following points should serve to guide the placement of erosion berms:
    - Where the track has slope of less than 2%, berms every 50m should be installed.
    - Where the track slopes between 2% and 10%, berms every 25m should be installed.
    - Where the track slopes between 10% and15%, berms every 20m should be installed.
    - Where the track has slope greater than 15%, berms every 10m should be installed.

Recommended mitigation measures

- Restrict construction to the drier winter months if possible to avoid sedimentation of wetland features in the vicinity of the proposed mine development areas.
- Desilt all adjacent wetland areas affected by mining and runoff from dirty water areas.

Probable latent impacts

- Sedimentation of the systems may lead to altered wetland habitats.
- Wetlands / riparian features within the subject property may be permanently altered.
- Proliferation of alien and weed species in disturbed areas will lead to altered vegetation communities within the adjacent wetland / riparian and associated buffer zones.
- Erosion and incision of the adjacent wetland / riparian areas may occur.

IMPACT 2: CHANGES TO WETLAND ECOLOGICAL AND SOCIOCULTURAL SERVICE PROVISION

Activities leading to impact

Pre-Construction	Construction	Operational	Decommissioning & Closure
Poor planning leading to the placement of infrastructure within wetland areas	Site clearing and the removal of vegetation leading to increased runoff and erosion	Ongoing disturbance of soils with general operational activities	Disturbance of soils as part of demolition activities
Inadequate design of infrastructure leading to risks of pollution	Site clearing and the disturbance of soils leading to increased erosion	Spillages and seepage of hazardous waste material into the groundwater	Ongoing seepage and runoff from mining infrastructure to the groundwater regime
Inadequate design of infrastructure leading changes to wetland habitat	Earthworks in the vicinity of wetland areas leading to increased runoff and erosion and altered runoff patterns	Risk of discharge from the mining infrastructure	Ongoing risk of discharge from mining infrastructure beyond closure
	Construction of stream crossings altering stream and baseflow patterns and water velocities	Potential contamination from mining infrastructure	Potential contamination from the decommissioning of the plant and mining infrastructure

Pre-Construction	Construction	Operational	Decommissioning & Closure
	Topsoil stockpiling and runoff from stockpiles may affect adjacent wetlands	Runoff, seepage and potential discharge from the waste rock dump and other mining infrastructure	Ongoing seepage and runoff from mining infrastructure to the groundwater regime
	Movement of construction vehicles within adjacent wetlands	Dumping of hazardous and non-hazardous waste into the wetland areas	Decommissioning activities may lead to wetland habitat transformation and alien
	Dumping of hazardous and non-hazardous waste into the wetland areas	Erosion and sedimentation of wetlands leading to loss of wetland habitat	Ineffective rehabilitation may lead to habitat transformation and alien vegetation encroachment
	Waste material spills and waste refuse deposits into the wetland features	Nitrates from blasting leading to eutrophication of the receiving environment	Ongoing erosion and sedimentation of wetlands
			Nitrates from blasting leading to eutrophication of the receiving environment

Aspects of wetland ecological and socio-cultural services affected

Pre-Construction	Construction	Operational	Decommissioning & Closure
	Loss of phosphate, nitrate and toxicant removal abilities	Loss of phosphate, nitrate and toxicant removal abilities	Loss of phosphate, nitrate and toxicant removal abilities
	Loss of carbon storage capabilities	Loss of carbon storage capabilities	Loss of carbon storage capabilities
	Inability to support biodiversity	Inability to support biodiversity	Inability to support biodiversity
	Loss of water supply to the local community	Loss of water supply to the local community	Loss of water supply to the local community

Management	Probability of Impact	Sensitivity of receiving environment	Severity	Spatial scale	Duration of impact	Likelihood	Consequence	Significance
Unmanaged	5	3	4	3	5	8	12	96 (High)
Managed	4	3	3	2	4	7	9	63 (Medium low)
Unmanaged	5	3	4	3	5	8	12	96 (High)
Managed	4	3	3	2	4	7	9	63 (Medium low)
Unmanaged	5	4	3	3	5	9	11	99 (High)
Managed	4	4	2	2	4	8	8	64 (medium-high)

Essential mitigation measures:

- A sensitivity map has been developed for the subject property, indicating the various wetland features which are considered to be of increased ecological importance. It is recommended that this sensitivity map (Section A) be considered during the planning/ pre-construction and construction phases of the proposed development activities to aid in the conservation of ecology within the subject property.
- It must be ensured that planning of mining infrastructure includes consideration of adjacent wetland / riparian areas to ensure that these areas are avoided as far as possible.
- All demarcated sensitive zones outside of the construction area must be kept off limits during any development and closure phases of the mine.
- The development footprint area must be limited to what is absolutely essential in order to minimise environmental damage.
- Run-off from dirty water areas entering adjacent wetland / riparian habitats must be prevented and clear separation of clean and dirty water in the vicinity of the proposed shaft must take place. Oil must prevented from entering the clean water system.
- It must be ensured that seepage from dirty water systems is prevented as far as possible.
- It must be ensured that the mine process water system is managed in such a way as to prevent discharge to the receiving environment.
- Edge effects of activities including erosion and alien / weed control need to be strictly managed in wetland / riparian areas.

- As much vegetation growth as possible should be promoted within the proposed development area in order to protect soils. In this regard special mention is made of the need to use indigenous vegetation species where hydroseeding, wetland and rehabilitation planting (where applicable) are to be implemented.
- Implement effective waste management in order to prevent construction related waste from entering the wetland environment.
- All wetland / riparian areas must be rehabilitated upon decommissioning to ensure that wetland / riverine functions are re-instated during decommissioning and all disturbed wetland / riparian areas adjacent to the mining development must be revegetated with indigenous wetland / riparian species.

Recommended mitigation measures

- Desilt all wetland / riparian areas affected by mining and runoff from dirty water areas.
- Revegetate all disturbed areas with indigenous wetland / riparian species.

Probable latent impacts

- Impacts on water quality may affect service provision to both the local community and the environment beyond closure.
- Sedimentation of the systems may lead to altered wetland habitats.
- Proliferation of alien and weed species in disturbed areas will lead to altered vegetation communities within the wetland as well as buffer zone.
- Erosion and incision of the wetland areas may occur.
- Inundation of wetland areas caused by stormwater channels and dams.

IMPACT 3: IMPACTS ON WETLAND HYDROLOGICAL FUNCTION

Activities leading to impact

Pre-Construction	Construction	Operational	Decommissioning & Closure
Placement of infrastructure within wetland areas	Site clearing and the removal of vegetation leading to increased runoff and erosion	Ongoing disturbance of soils with general operational activities	Disturbance of soils as part of demolition activities
Inadequate design of infrastructure leading to changes in hydrological function and sediment control capacity	Site clearing and the disturbance of soils leading to increased erosion	Earthworks in the vicinity of wetland areas leading to increased runoff and erosion and altered runoff patterns	Earthworks in the vicinity of wetland areas leading to increased runoff and erosion and altered runoff patterns
	Earthworks in the vicinity of wetland areas leading to increased runoff and erosion and altered runoff patterns	Topsoil stockpiling adjacent to wetlands and runoff form stockpiles leading to sedimentation of the system	Movement of construction vehicles within wetlands

Pre-Construction	Construction	Operational	Decommissioning & Closure
	Construction of stream crossings altering stream and baseflow patterns and water velocities	Movement of construction vehicles within wetlands	Altered hydrology due to in channel stormwater dams
	Topsoil stockpiling adjacent to wetlands and runoff form stockpiles leading to sedimentation of the system	Altered hydrology due to stormwater channels and dams	Movement of construction vehicles within wetlands
	Movement of construction vehicles within wetlands	Increased runoff volumes due to increased paved and other impervious surfaces	
	Increased runoff volumes due to increased paved and other impervious surfaces	Dewatering of wetlands and loss of habitat	

Aspects of wetland hydrology affected

Pre-Construction	Construction	Operational	Decommissioning & Closure
	Change in flood peak flows	Change in flood peak flows	Incision of wetland areas and erosion of wetland habitat
	Concentration and canalisation of flow	Concentration and canalisation of flow	Sediment deposition
	Incision of wetland areas and erosion of wetland habitat	Incision of wetland areas and erosion of wetland habitat	
	Sediment deposition	Sediment deposition	

Management	Probability of Impact	Sensitivity of receiving environment	Severity	Spatial scale	Duration of impact	Likelihood	Consequence	Significance
Unmanaged	5	3	4	3	5	8	12	96 (High)
Managed	4	3	3	2	4	7	9	63 (Medium low)
Unmanaged	5	3	4	3	5	8	12	96 (High)
Managed	4	3	3	2	4	7	9	63 (Medium low)
Unmanaged	5	4	3	3	5	9	11	99 (High)
Managed	4	4	2	2	4	8	8	64 (medium-high)

Essential mitigation measures:

- A sensitivity map has been developed for the subject property, indicating the various wetland features which are considered to be of increased ecological importance. It is recommended that this sensitivity map (Section A) be considered during the planning/ pre-construction and construction phases of the proposed development activities to aid in the conservation of ecology within the subject property.
- It must be ensured that planning of mining infrastructure includes consideration of adjacent wetland / riparian areas to ensure that these areas are avoided as far as possible.
- Keep all demarcated sensitive zones outside of the construction area off limits during development phases.
- Limit the footprint area of any development and closure activity to what is absolutely essential in order to minimise environmental damage.
- Prevent run-off from dirty water areas entering wetland / riparian habitats.
- Ensure that seepage from dirty water systems is prevented as far as possible.
- Ensure that the mine process water system is managed in such a way as to prevent discharge to the receiving environment.
- Implement effective waste management in order to prevent construction related waste from entering the wetland / riparian environment.
- All wetland / riparian areas must be rehabilitated upon decommissioning to ensure that wetland / riverine functions are re-instated during decommissioning and all disturbed wetland / riparian areas adjacent to the mining development must be revegetated with indigenous wetland / riparian species.

- It must be ensured that all activities potentially impacting on geohydrological resources are managed according to the relevant DWA Licensing regulations and groundwater monitoring requirements.
- Post closure groundwater management will need to be very carefully managed to ensure that no impact on the wetland areas and riparian resources in the area takes place after mine closure has taken place.
- Future mine planning should ensure that mining activities does not lead to a reduction of stream flow or dewatering of any wetland areas and connectivity of the wetland features should be maintained throughout. be maintained.

Recommended mitigation measures

- Desilt all adjacent wetland / riparian areas affected by mining and runoff from dirty water areas.
- Revegetate all disturbed areas with indigenous wetland / riparian species upon closure.

Probable latent impacts

- Impacts on water quality may affect service provision of wetland / riparian features to both the local community and the environment beyond closure.
- Sedimentation of the systems may lead to altered wetland / riparian habitats.
- Proliferation of alien and weed species in disturbed areas will lead to altered vegetation communities within the wetland and riparian zone as well as their associated buffer zones.
- Erosion and incision of the wetland / riparian areas may occur.

4.2 *Impact Assessment Conclusion*

Based on the above assessment it is evident that there are three possible impacts that may affect the wetland and riparian ecology of the subject property. The table below summarises the findings indicating the significance of the impacts before mitigation takes place and the likely impact levels if management and mitigation takes place. In the consideration of mitigation it is assumed that a high level of mitigation takes place but which does not lead to prohibitive costs. From the table it is evident that prior to mitigation all of the impacts are high level impacts. If mitigation and effective management takes all impacts will be reduced to a medium low level.

Table 30: A summary of the results obtained from the assessment of wetland and riparian ecological impacts for the proposed new infrastructure at Tharisa Mine

Impact	Unmanaged	Managed
1: Loss of wetland habitat and ecological structure	High	Medium low
1: Loss of wetland habitat and ecological structure	High	Medium low
1: Loss of wetland habitat and ecological structure	High	Medium low
2: Changes to wetland ecological and sociocultural service provision	High	Medium low
2: Changes to wetland ecological and sociocultural service provision	High	Medium low
2: Changes to wetland ecological and sociocultural service provision	High	Medium low
3: Impacts on wetland hydrological function	High	Medium low
3: Impacts on wetland hydrological function	High	Medium low
3: Impacts on wetland hydrological function	High	Medium low

5 RECOMMENDATIONS

After conclusion of this wetland assessment, it is the opinion of the ecologists that the proposed mining development be considered favourably, provided that the recommendations below are adhered to:

- A sensitivity map has been developed for the subject property, indicating the various wetland features which are considered to be of increased ecological importance. It is recommended that this sensitivity map be considered during the planning/ pre-construction and construction phases of the proposed development activities to aid in the conservation of ecology within the subject property.
- It must be ensured that planning of mining infrastructure, with particular reference to wetland or riparian crossings, includes consideration of adjacent wetland / riparian areas to ensure that these areas are avoided as far as possible.
- The development footprint area must be limited to what is absolutely essential in order to minimise environmental damage.
- All demarcated sensitive zones outside of the construction area must be kept off limits during any development and closure phases of the mine.
- The boundaries of footprint areas are to be clearly defined and it should be ensured that all activities remain within defined footprint areas.

- Development impacts on the affected wetland / riparian features should be managed to minimise impacts on adjacent wetland / riparian features.
- Edge effects of activities including erosion and alien/ weed control need to be strictly managed in these areas.
- Access into adjacent wetland / riparian areas, particularly by vehicles, is to be strictly controlled.
- All vehicles should remain on designated roads with no indiscriminate driving through adjacent wetland / riparian areas.
- Run-off from dirty water areas entering wetland / riparian habitats must be prevented and clear separation of clean and dirty water in the vicinity of the proposed shaft must take place. Oil must be prevented from entering the clean water system.
- Ensure that seepage from dirty water systems is prevented as far as possible.
- It must be ensured that all hazardous storage containers and storage areas comply with the relevant SABS standards to prevent leakage. All vehicles must be regularly inspected for leaks. Re-fuelling must take place on a sealed surface area to prevent ingress of hydrocarbons into topsoil.
- All spills should be immediately cleaned up and treated accordingly.
- Appropriate sanitary facilities must be provided for the life of the mine and all waste removed to an appropriate waste facility.
- Effective waste management must be implemented in order to prevent construction related waste from entering the wetland / riparian environment.
- All adjacent wetland / riparian systems must be monitored for erosion and incision.
- Edge effects of activities including erosion and alien/ weed control need to be strictly managed in wetland / riparian areas.
- All wetland / riparian areas must be rehabilitated upon decommissioning to ensure that wetland / riparian functions are re-instated during decommissioning and all disturbed wetland / riparian areas adjacent to the mining development must be revegetated with indigenous wetland / riparian species.
- As much vegetation growth as possible should be promoted within the proposed development area in order to protect soils. In this regard special mention is made of the need to use indigenous vegetation species where hydroseeding, wetland and rehabilitation planting (where applicable) are to be implemented.
- It must be ensured that all activities potentially impacting on geohydrological resources are managed according to the relevant DWA Licensing regulations and groundwater monitoring requirements.

- Post closure groundwater management will need to be very carefully managed to ensure that no impact on the wetland areas and riparian resources in the area takes place after mine closure has taken place.
- Future mine planning should ensure that mining activities does not lead to a reduction of stream flow or dewatering of any wetland / riparian areas and connectivity of the wetland / riparian features in the vicinity of mining activities should be maintained.

6 REFERENCES

Bromilow, C. 2001. Revised Edition, First Impression. *Problem Plants of South Africa.* Briza Publications, Pretoria, RSA.

Cowardin L.M., Carter V., Golet F.C. and LaRoe E.T. 1979. Classification of Wetlands and Deepwater Habitats of the United States. FWS-OBS-79-31. US Fish and Wildlife Service, Washington, DC.

Dada R., Kotze D., Ellery W. and Uys M. 2007. WET-RoadMap: A Guide to the Wetland Management Series. WRC Report No. TT 321/07. Water Research Commission, Pretoria.

Department of Water Affairs, South Africa *Version 1.0 of Resource Directed Measures for Protection of Water Resources, 1999* [Appendix W3].

Department of Water Affairs and Forestry (2007). *Manual for the assessment of a Wetland Habitat Integrity for South African floodplain and channelled bottom wetland types* by M. Rountree (ed); C.P. Todd, C.J. Kleynhans, A.L. Batchelor, M. D. Louw, D. Kotze, D. Walters, S. Schroeder, P. Illgner, M. Uys, and G.C. Marneweck. Report No. N/0000/00/WEI/0407. Resource Quality Services, Department of Water Affairs and Forestry, Pretoria, South Africa

Henderson, L. 2001. *Alien Weeds and Invasive Plants*. Agricultural Research Council, RSA.

Kleynhans C.J. 1999. *A procedure for the determination of the ecological reserve for the purposes of the national water balance model for South African River*. Institute of Water Quality Studies, Department of Water Affairs & Forestry, Pretoria.

Kleynhans C.J., Thirion C. and Moolman J. 2005. *A Level 1 Ecoregion Classification System for South Africa, Lesotho and Swaziland.* Report No. N/0000/00/REQ0104. Resource Quality Services, Department of Water Affairs and Forestry, Pretoria

Kotze D.C., Marneweck G.C., Batchelor A.L., Lindley D.S. and Collins N.B. 2008. *WET-EcoServices: A technique for rapidly assessing ecosystem services supplied by wetlands.* WRC Report No. TT 339/09. Water Research Commission, Pretoria.

Macfarlane D.M., Kotze D.C., Ellery W.N., Walters D., Koopman V., Goodman P. and Goge C. 2008. *WET-Health: A technique for rapidly assessing wetland health.* WRC Report No. TT 340/08. Water Research Commission, Pretoria.

Mucina, L. & Rutherford, M.C. (Eds). 2006. *The Vegetation of South Africa, Lesotho and Swaziland.* Strelitzia 19. South African National Biodiversity Institute, Pretoria, RSA.

Natural Scientific Services. 2008. *Tharisa Minerals Biodiversity Assessment*. Prepared for Metago Environmental Engineers (Pty) Ltd. Johannesburg.

Ollis D.J., Job N., Macfarlane D. and Sieben E.J. 2009. *Further Development of a Proposed National Wetland Classification System for South Africa.* Supplementary Project Report: Application and Testing of Proposed National Wetland Classification System. Prepared for the South African National Biodiversity Institute, Pretoria.

Ollis, DJ; Snaddon, CD; Job, NM & Mbona, N. 2013. *Classification System for Wetlands and other Aquatic Ecosystems in South Africa. User Manual: Inland Systems*. SANBI Biodiversity Series 22. South African Biodiversity Institute, Pretoria

Rowntree K.M. and Wadeson R.A. 2000. *An Index of Stream Geomorphology for the Assessment of River Health. Field Manual for Channel Classification and Condition Assessment*. NAEBP Report Series No. 13, Institute of Water Quality Studies, Department of Water Affairs and Forestry, Pretoria. Available: http://www.csir.co.za/rhp/reports/reportseries13.html.

SANBI. 2009. *Further Development of a Proposed National Wetland Classification System for South Africa.* Primary Project Report. Prepared by the Freshwater Consulting Group (FCG) for the South African National Biodiversity Institute (SANBI).

Van Oudtshoorn, F. 2004. Second Edition, Third Print. *Guide to Grasses of South Africa.* Briza Publications, Pretoria, RSA.

Williams W.D. 1985. Biotic adaptations in temporary lentic waters with special reference to those in semiarid and arid regions. *Hydrobiologia 125: 85-110*.