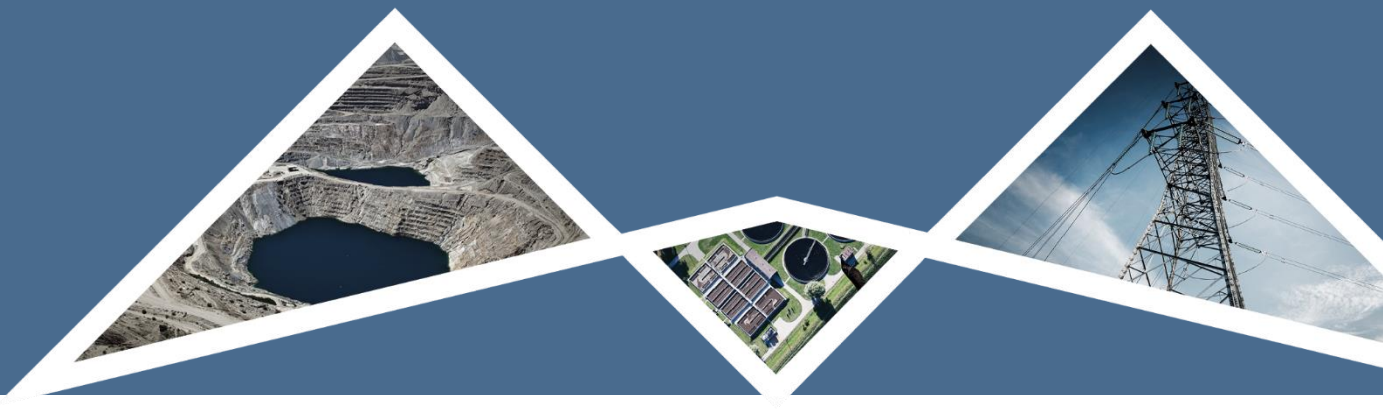
EIMS | ENVIRONMENTAL IMPACT MANAGEMENT SERVICES

T 011 789 7170 E info@eims.co.za W www.eims.co.za

SITE SELECTION REPORT 2

ARNOT ASH DISPOSAL FACILITY



DOCUMENT DETAILS

EIMS REFERENCE: 1140

DOCUMENT TITLE: Arnot Ash Disposal Facility Site Selection Report 2

DOCUMENT CONTROL

	NAME	SIGNATURE	DATE
COMPILED:	John von Mayer		2018/02/05
CHECKED:	Bongani Khupe		2018/02/05
AUTHORIZED:	Liam Whitlow		2018/02/05

REVISION AND AMENDMENTS

REVISION DATE:	REV #	DESCRIPTION
2018/02/05	ORIGINAL DOCUMENT	

Table of Contents

List of Tables

List of Figures

1 INTRODUCTION

Arnot Power Station is a coal fired power station owned by Eskom and makes use of a wet process ashing to dispose of its ash. Arnot Power Station's first ash facility was commissioned in 1971. All ash produced by Arnot Power Station is pumped, in the form of a slurry, to 3 existing ash disposal facilities.

Arnot's ash dams are situated approximately 1.5 km to the South-East of the Power Station in the Rietkuilspruit valley between 25057' and 25059' South and 29047' and 29049' East. The whole ash dam complex, (including penstock 5 (the silt trap) and the low-level ash water return dams) covers approximately 200 hectares.

Two streams were diverted to enable Arnot to ash at the current location. It was necessary to construct the stream diversion in order to keep the toe of the ash dam above the natural ground water table, thus keeping the toe as dry as possible and to construct the ash dam on good stable founding material. The three current ash dams have a remaining storage of ± 33million m3 as at 23 September 2012.

Arnot Power Station uses a wet system for the ashing of the boiler plant. The ashing is conducted in 24 hour cycles. During the day, the plant is dusted to remove fine ash for the building of the day walls and at night the coarse ash is sent to the ash dam for the night paddocks. The ash is pumped to the ash dam from the station. There are four (4) ash lines leaving the station to the ash dam and the deposition of the ash depends on the day plan of the operator. The ash is let to settle and the excess water (Ash Water Return) drained to the silt trap dam to let the finer particle settle before it is pumped back to the station.

The current Ash Disposal Facility (ADF) at Arnot Power Station has been providing disposal services since the establishment of the station. This ash disposal facility is facing some operational challenges, which need to be addressed. The ash complex was designed to operate until the original end of the station life, which was 2021. This date has been revised to 2032. An ash dam capacity study was compiled, and it showed that the rate of rise of the ash dam complex will be more than 4m by the year 2026. The main reason that Arnot Power Station is in need of a new ash dam is to reduce this rate of rise to an acceptable rate, thus, it was recommended that the new ash facility be commissioned. A wet ash disposal facility with appropriate barrier systems and a slurry system pipework and pumping systems is required. The location of the new ash disposal facility will be based on the Least Cost solution, within the constraints of the environmental law and regulations. The study area was identified based on a 5km proximity from the edge of the Arnot power station (refer to **Figure 1**). Through this study, several potential sites for the location of the ash disposal facility were identified.

A preliminary screening study was completed by Environmental Impact Management Services (Pty) Ltd (EIMS) in January 2017. Six 70ha sites were ranked based on their preference in terms of potential environmental and engineering factors. After further discussions, Eskom engineers confirmed that the 70ha size was insufficient for the new ash disposal facility. Following the previously completed site selection and scoping phase activities conducted based on a 70ha site, the following sizes for the ash disposal facility were recommended:

- 80ha for the option of operating the existing ash disposal facility and the new facility in parallel until the end of the life of the Power Station
- 120ha is for the option of operating the existing facility till maximum height then moving on to a new facility (series operation).

This report aims to identify potential feasible site options to accommodate the proposed new ADF.

1.1 PROJECT TEAM

Desktop studies followed by a site inspection were undertaken as part of the site selection process. Specialist studies involved the gathering of data relevant to the site selection process. EIMS was appointed as the Environmental Assessment Practitioner (EAP) on the project. In addition, the engineering design team also provided input. **Table 1**, below, presents a list of the specialists that provided input to the site selection study.

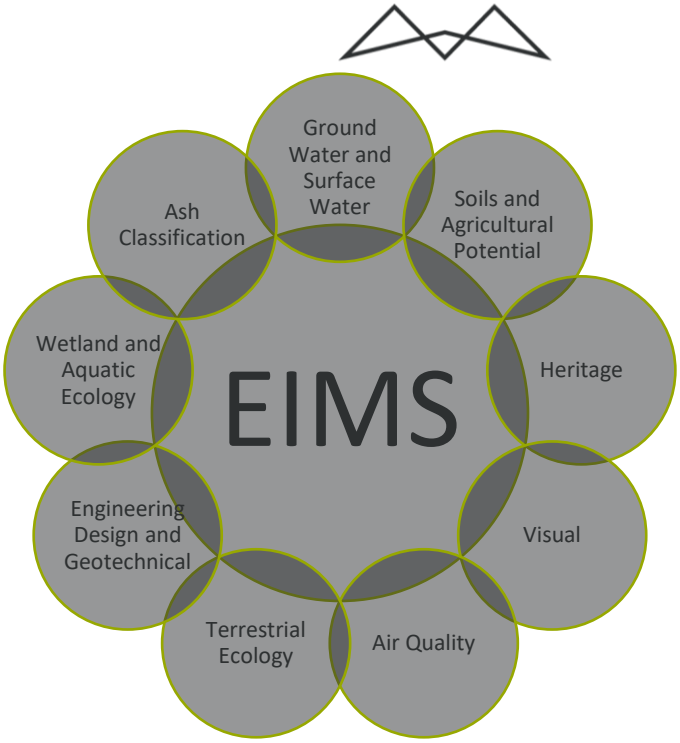


Table 1: List of Specialists who provided input into the site screening study

Component	Company Responsible
Terrestrial Ecology	David Hoare Consulting
Wetland and Aquatic Ecology	Ecotone Freshwater Consultants
Ground Water and Surface Water	GCS Water and Environmental Consultants
Soils and Agricultural Potential	ARC-Institute for Soil, Climate and Water
Visual	Newtown Landscape Architects
Heritage	PGS Heritage
Air Quality	Airshed Planning Professionals
Engineering Design and Geotechnical	BEAL
Ash Classification	GCS Water and Environmental Consultants

1.2 LOCALITY MAP

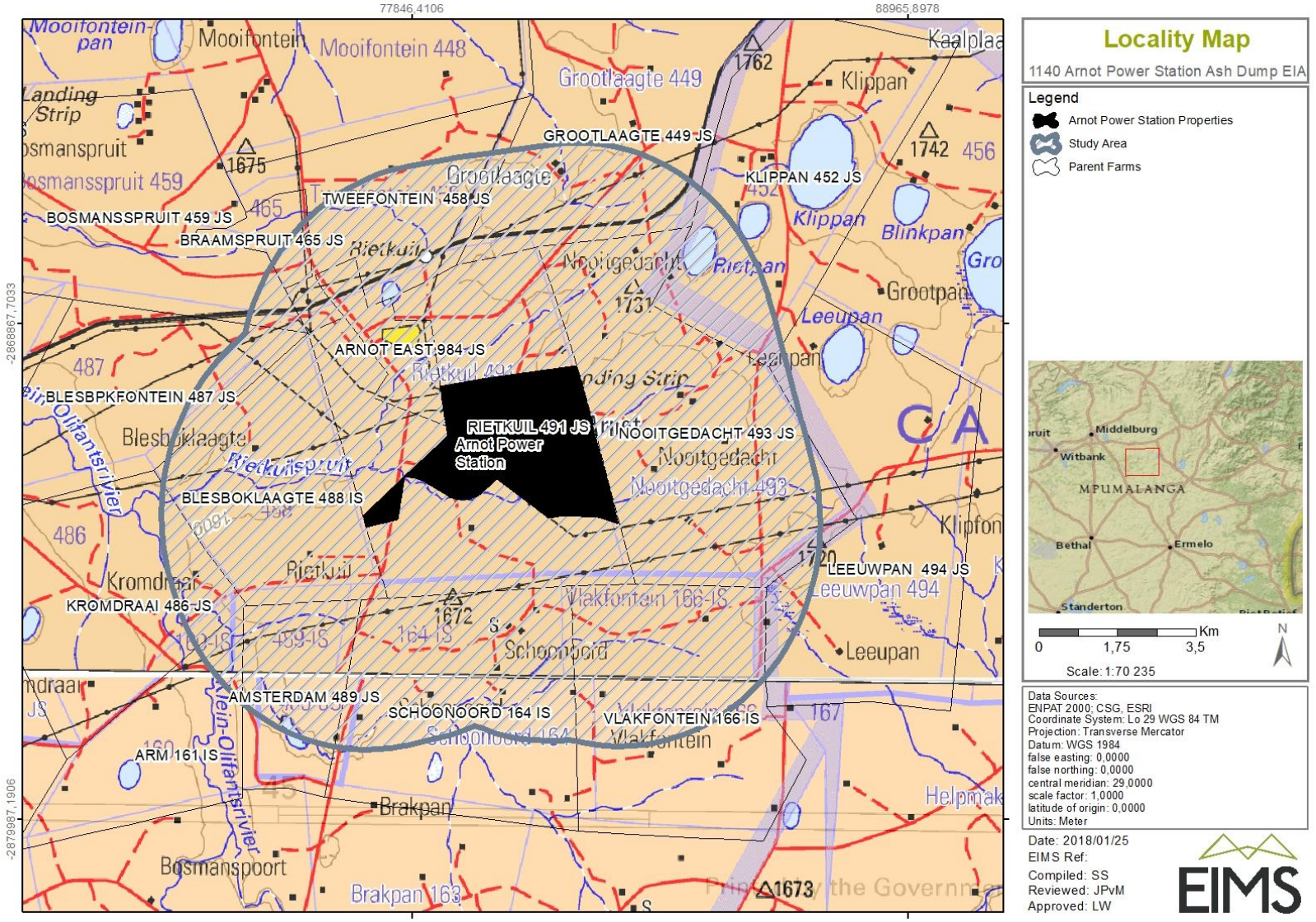


Figure 1: Locality Map indicating study area

2 DESCRIPTION OF SITE SCREENING PROCESS

The New Ash Disposal Facility must be located at a suitable position which should take into consideration the pumping constraints of the current ash plant and the location of the current Ash Water Return (AWR) high level dams. The extent of the scope is from the ash pump including ash lines to the proposed ash deposition sites and the ash water return pump and pipelines until the connection to the existing High Level AWR Dams.

All the specialist input layers were combined into a sensitivity analysis. Engineering and other site selection constraints were then overlaid to indicate preliminary suitable sites. Further refinement to the potential suitable sites was done in order to determine:

- Feasible alternative sites (sites investigated in more detail)
- Preferred alternative sites (up to three 80ha sites and three 120ha sites nominated for scoping and EIA)

The overall methodology is presented in **Figure 2** below:

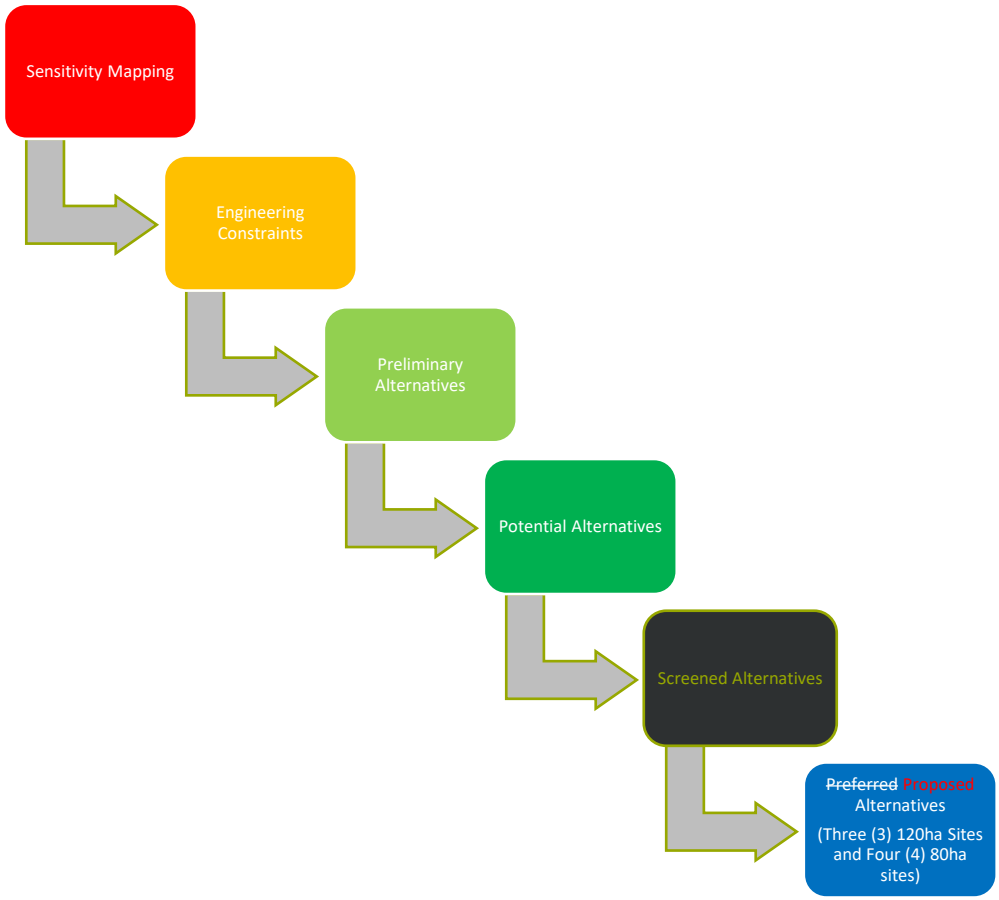


Figure 2: Flow diagram of the screening process.

2.1 ENVIRONMENTAL SENSITIVITY MAPPING

The sensitivity mapping approach is based on a desktop study and GIS study with numerous specialist inputs. The sensitivity mapping process is described by in **Figure 3**.

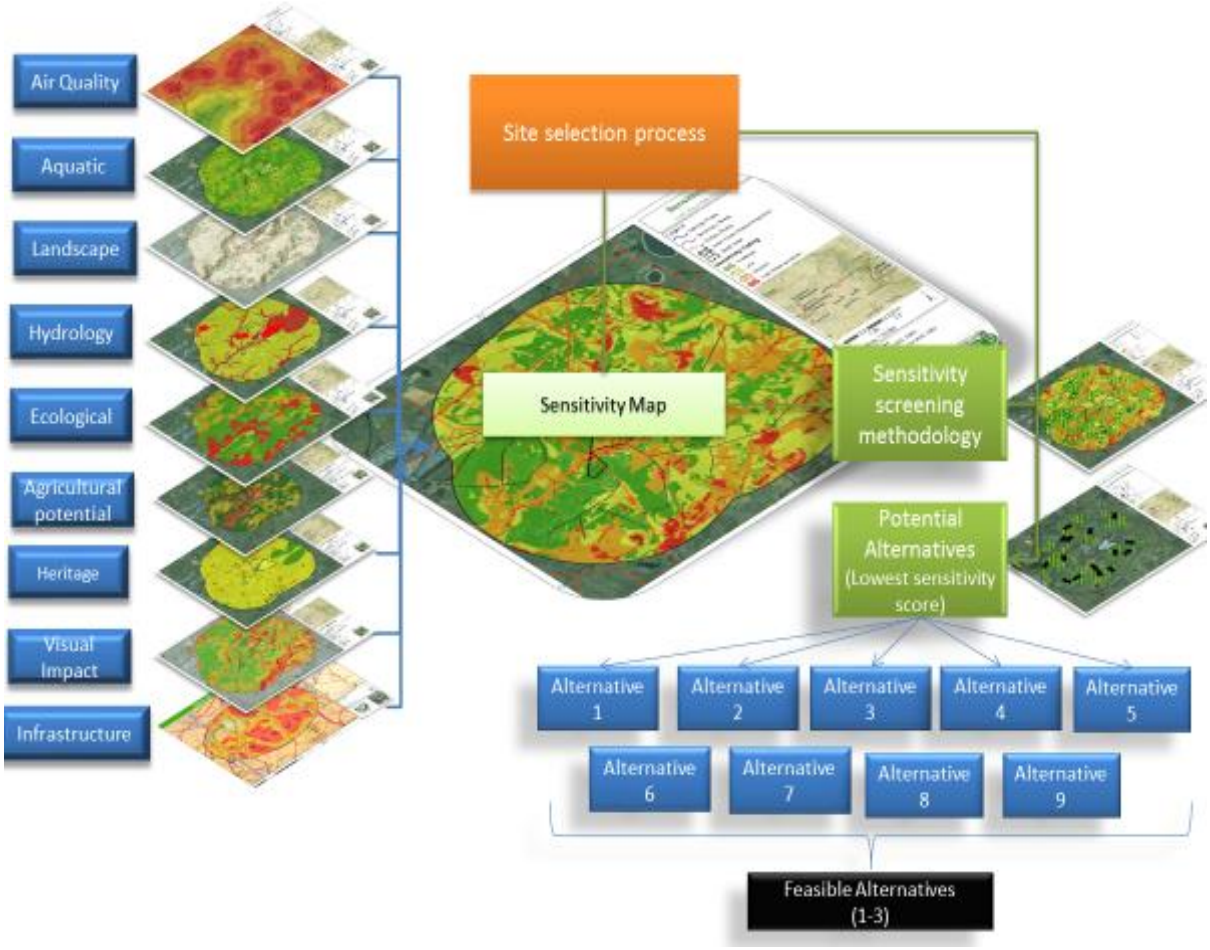


Figure 3: Illustration of GIS mapping methodology

Ten (10) environmental input maps were used for weighted overlay:

- Air Quality;
- Agricultural Potential;
- Aquatic Ecology;
- Ecology;
- Heritage/Palaeontology;
- Hydrology;
- Hydrogeology;
- Landscape Characteristics;
- Visual Sensitivity; and
- Wetlands.

These constraints are mapped in Figure 4 – Figure 10 below.

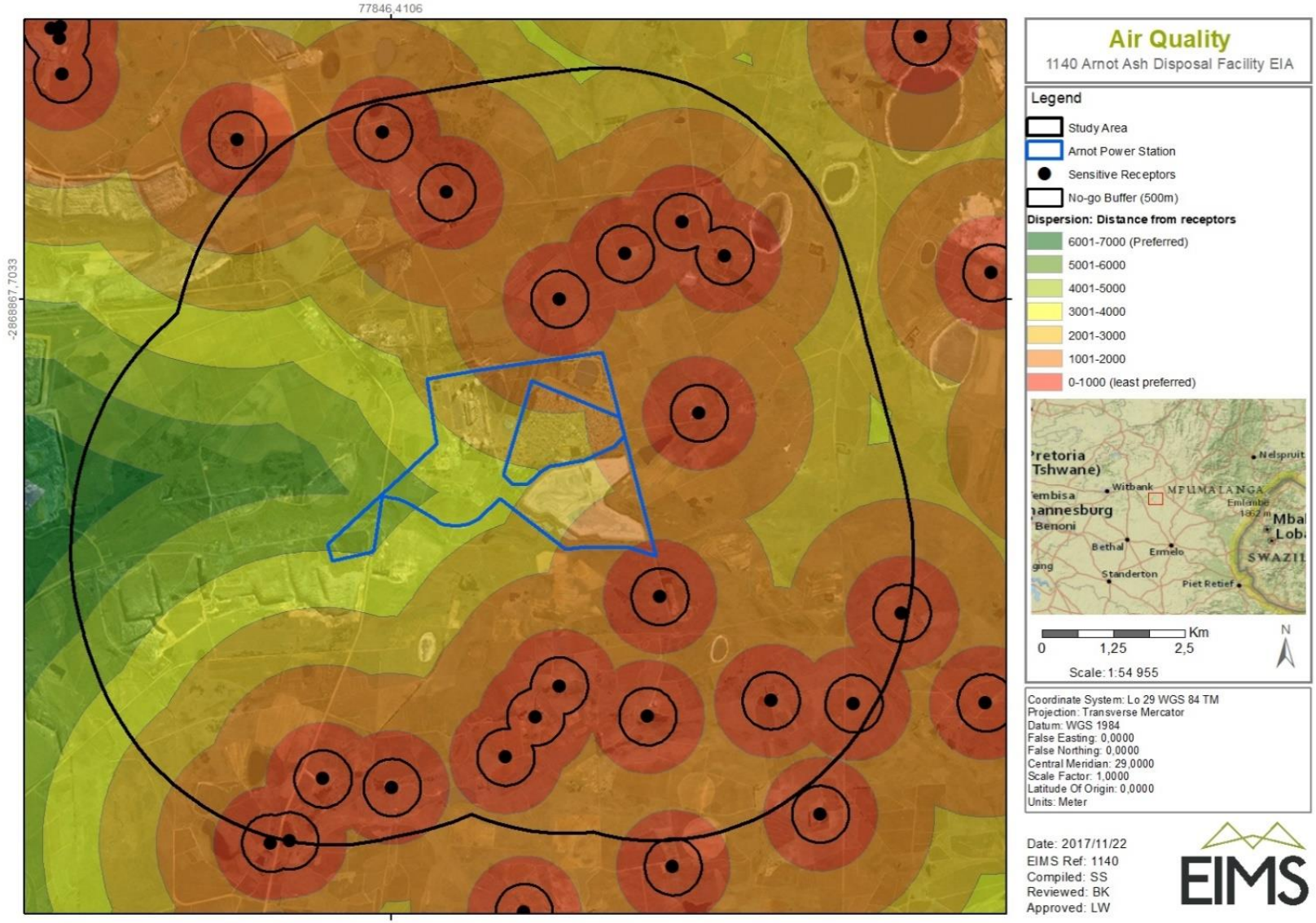


Figure 4: Map indicating sensitive receptors from an air quality point of view.

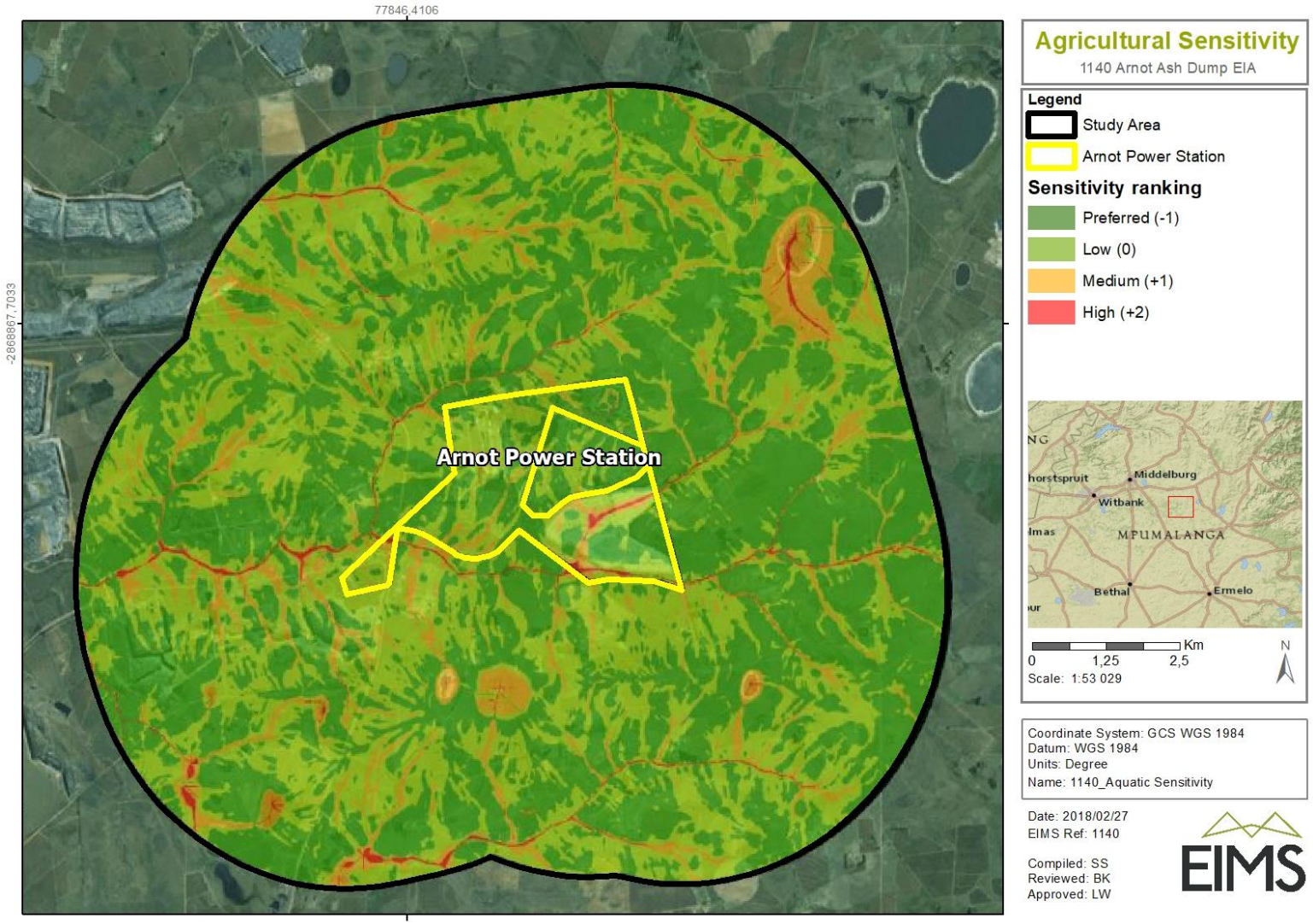


Figure 5: Map indicating aquatic sensitivity in the study area.

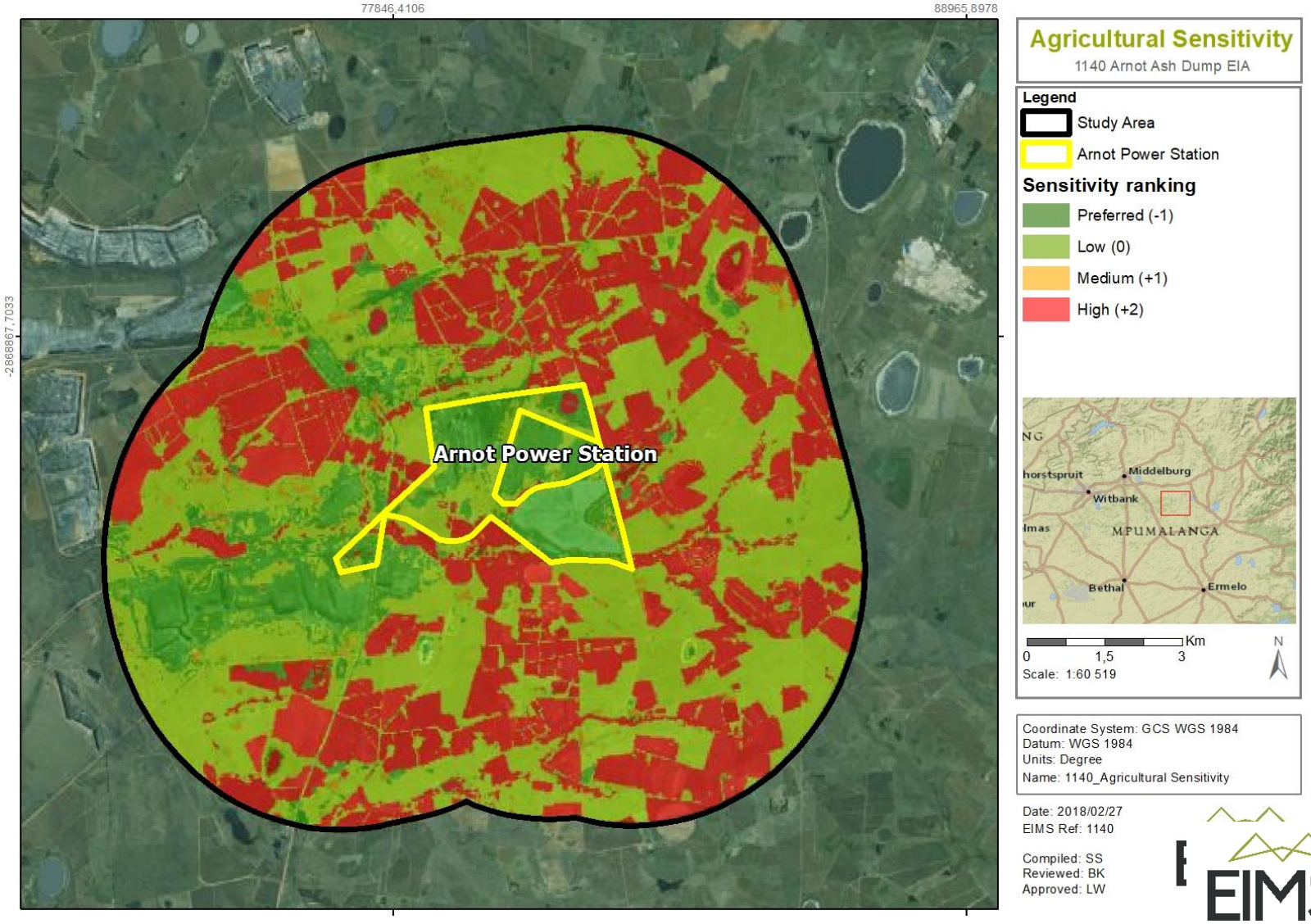


Figure 6: Map indicating agricultural potential in the study area.

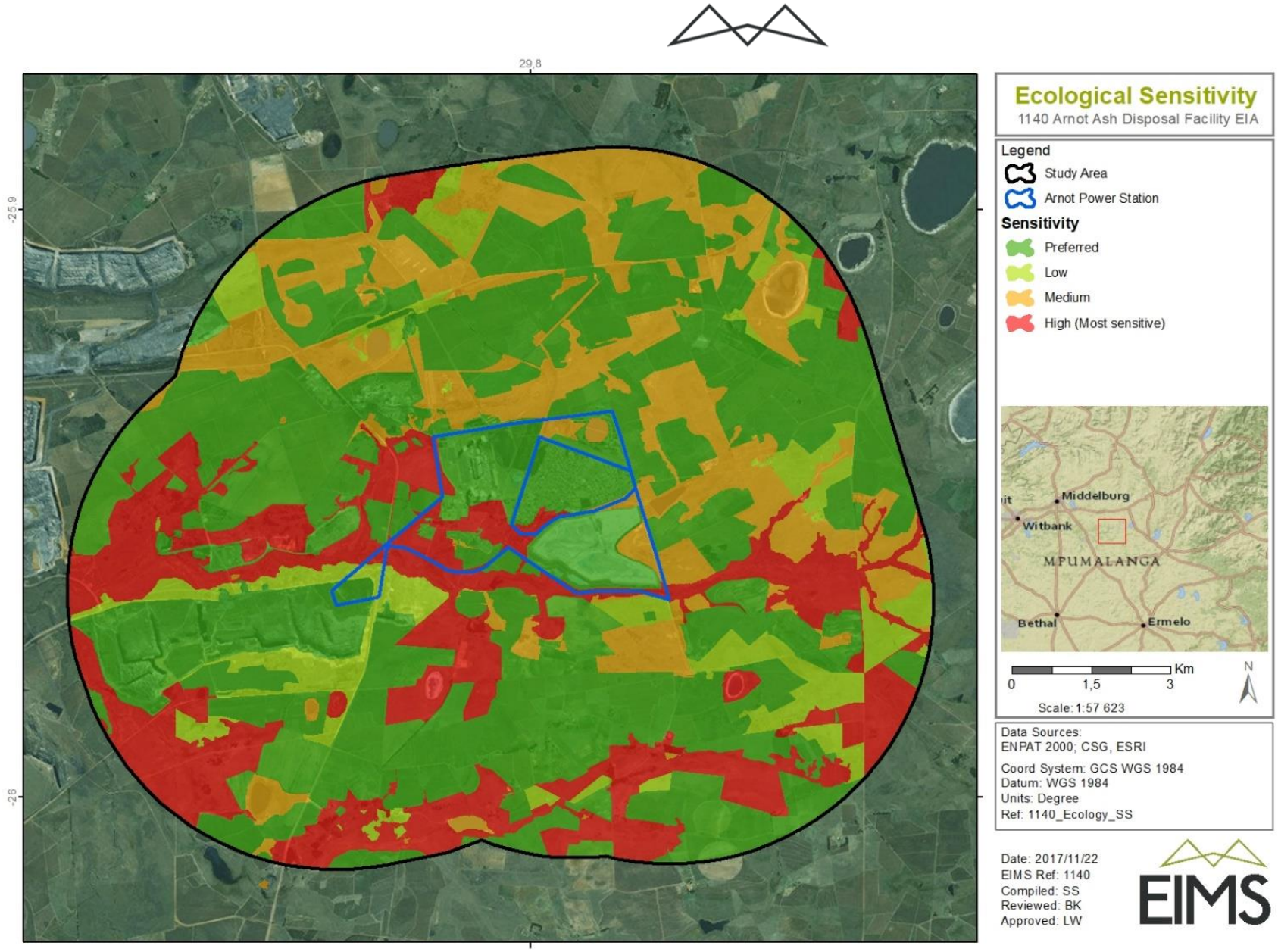


Figure 7: Map indicating ecological sensitivity in the study area.

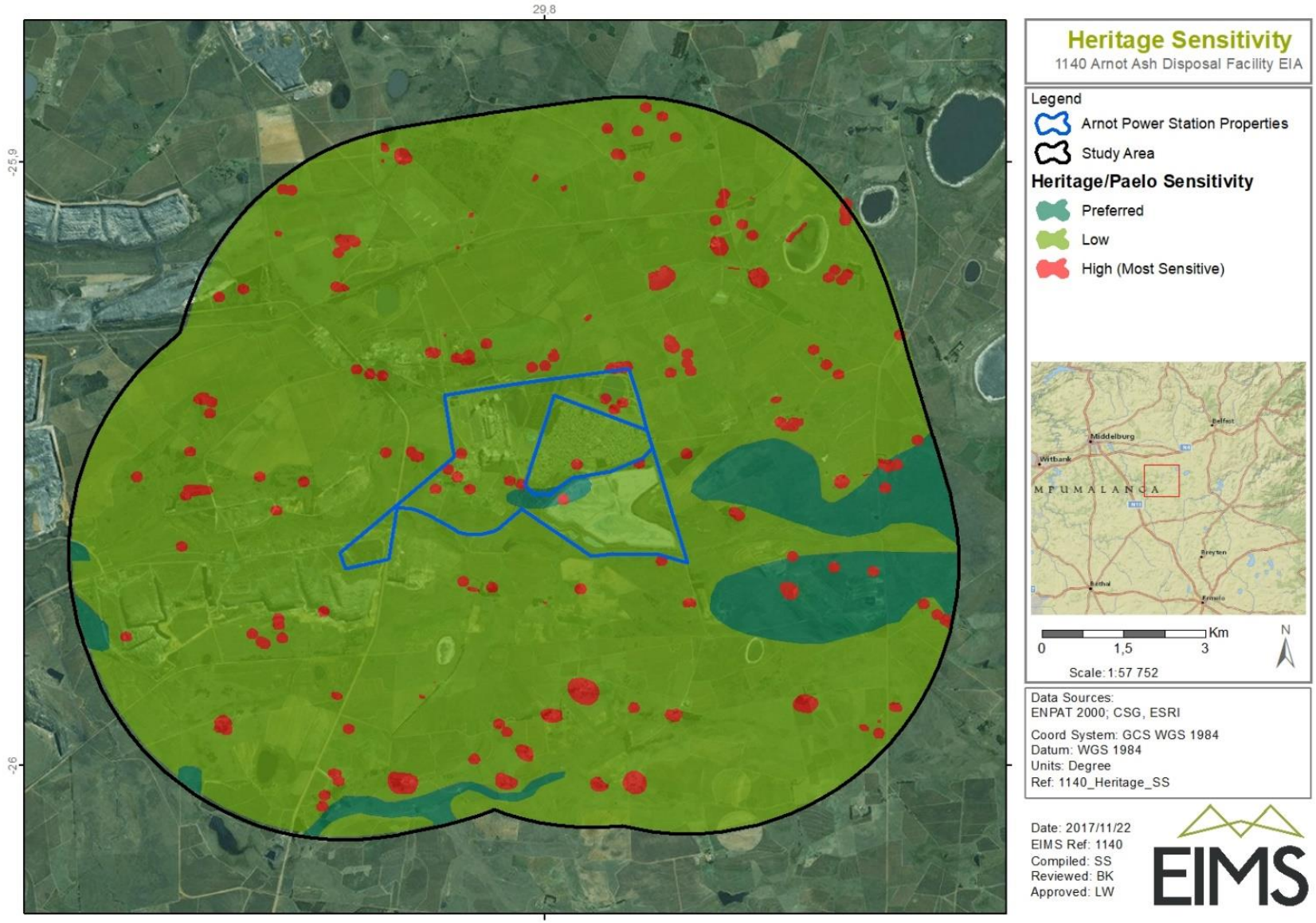


Figure 8: Map indicating heritage and palaeontological sensitivities in the study area.

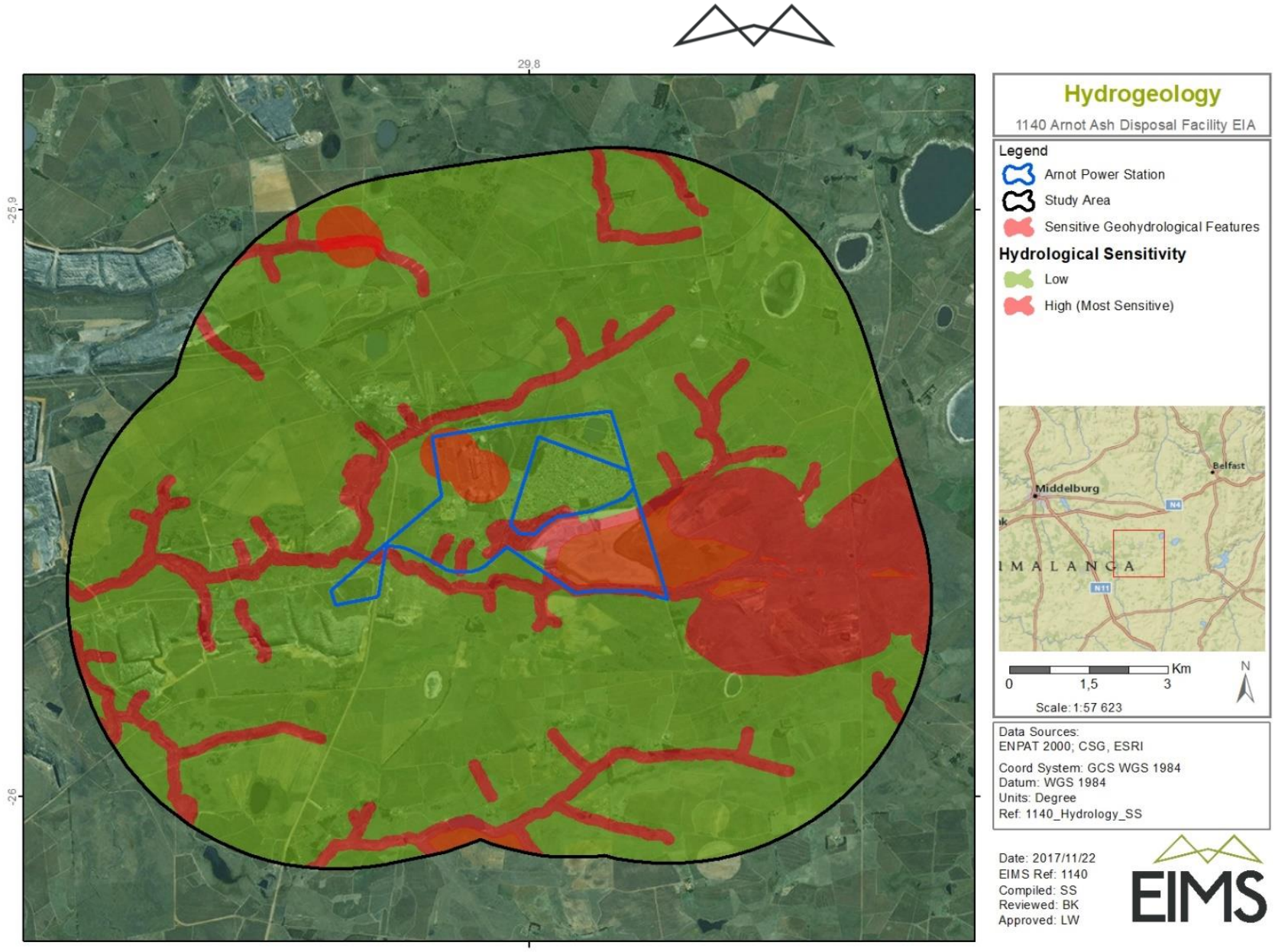


Figure 9: Map indicating sensitive geohydrological features in the study area.

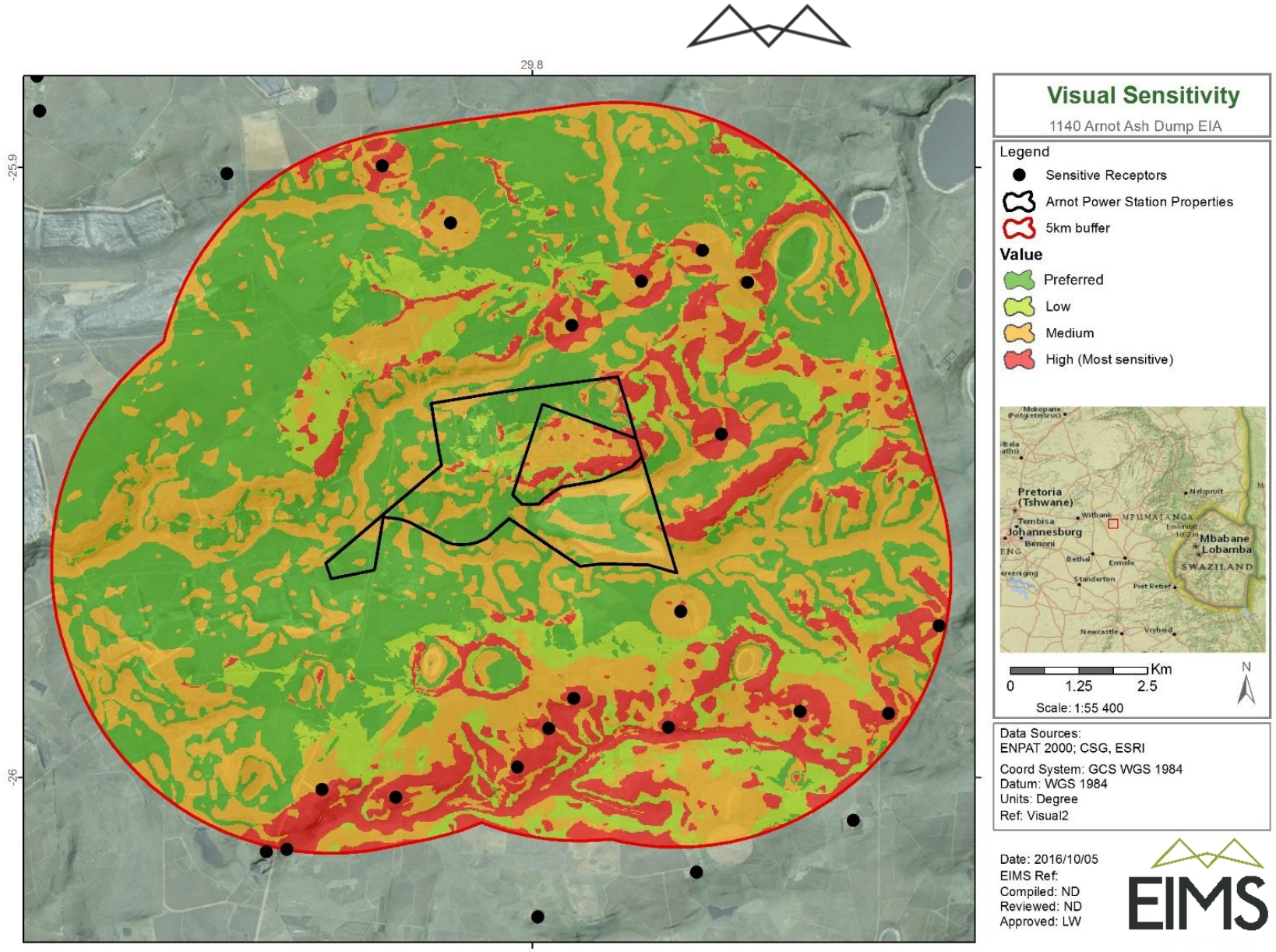


Figure 10: Map showing sensitive visual areas within the study area.

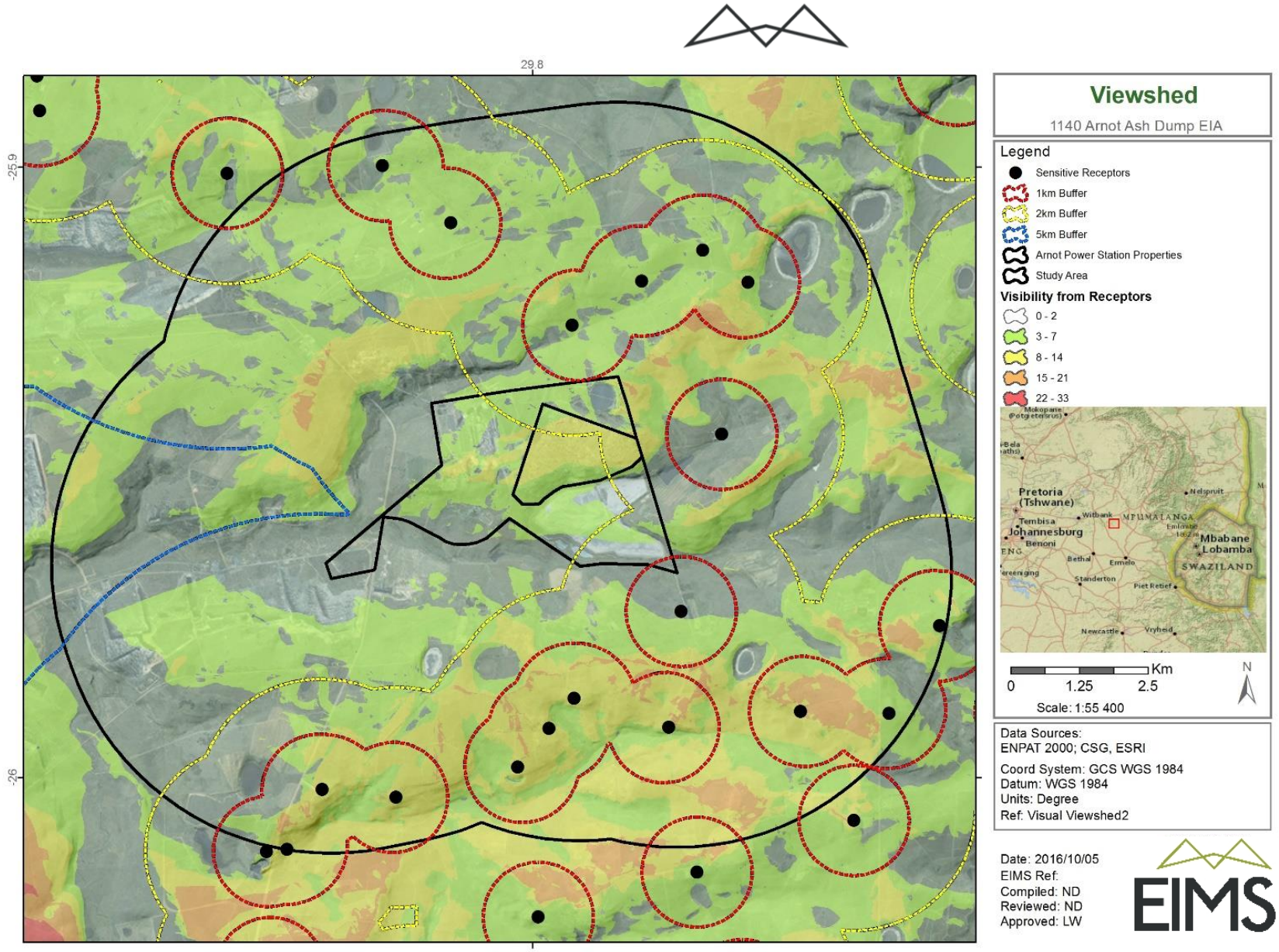


Figure 11: Map showing viewsheds in the study area and visibility to sensitive visual receptors.

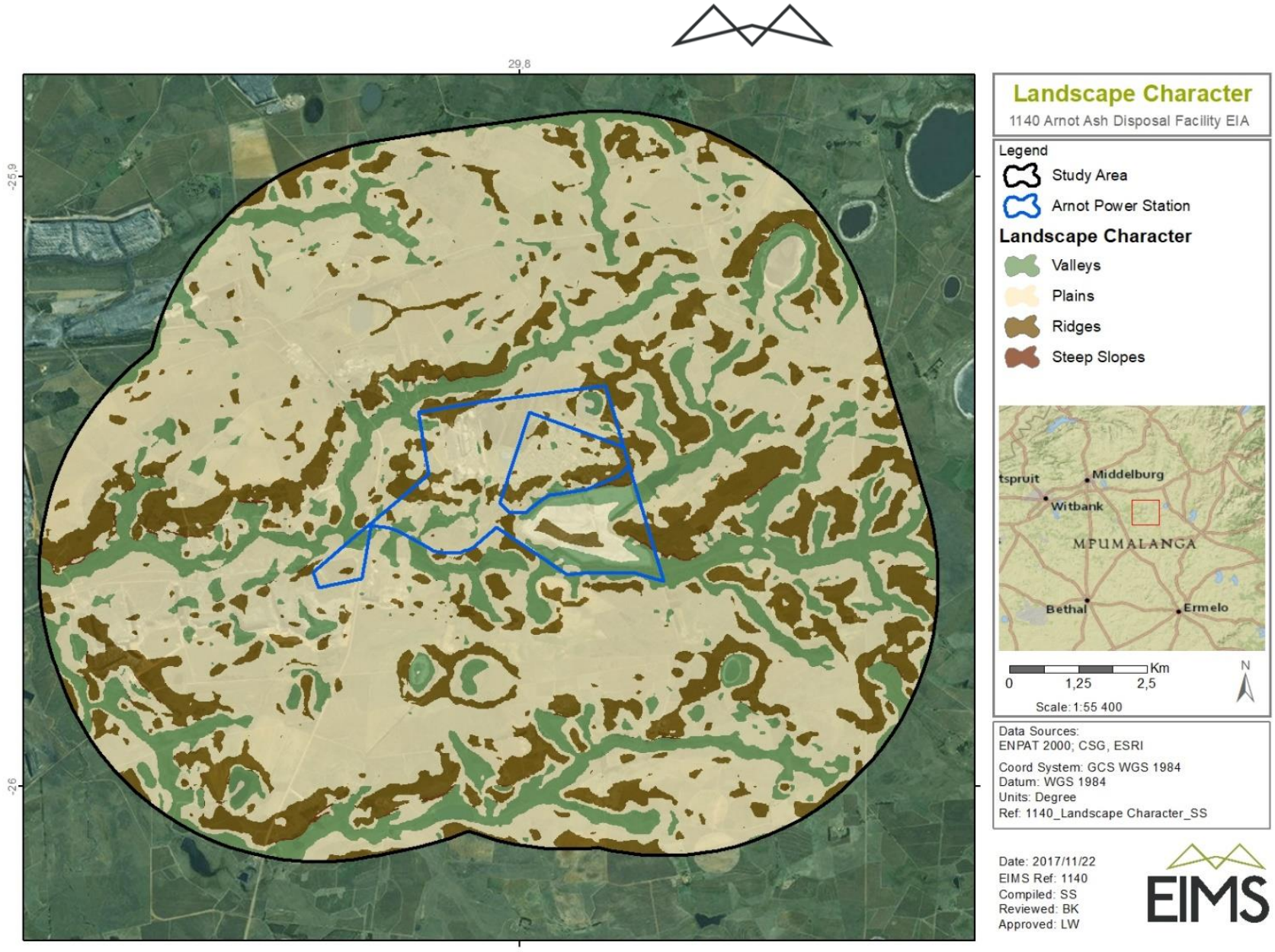


Figure 12: Map showing landscape character. Plains are preferred to ridges, valleys and steep slopes.

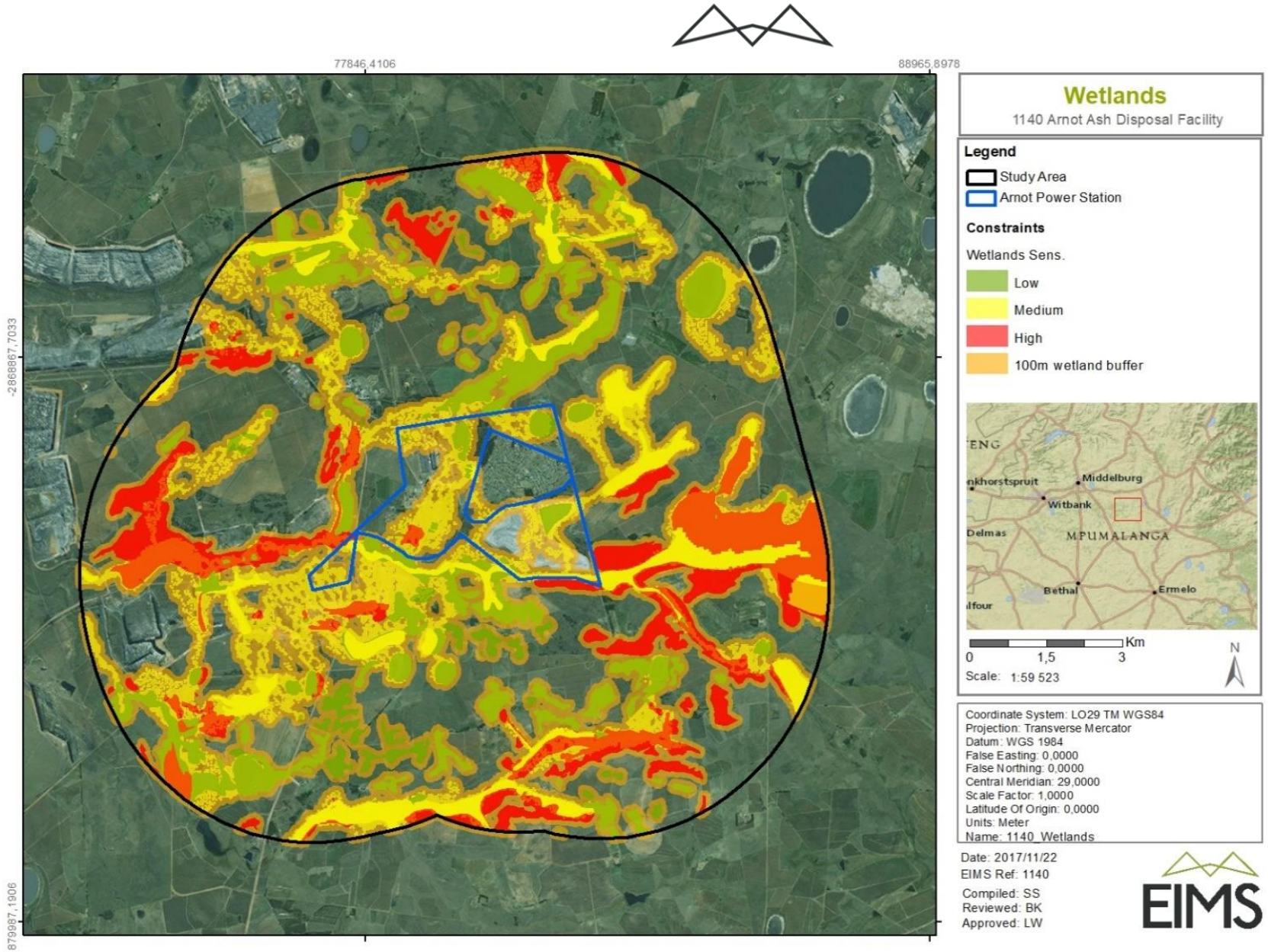


Figure 13: Map showing wetlands in the study area.

2.2 ENGINEERING CONSTRAINTS

Several engineering constraints were also considered. **Figure 14** below provides details of engineering constrains considered as well as reasons for consideration. These constraints are mapped in **Figure 15** - **Figure 19**.

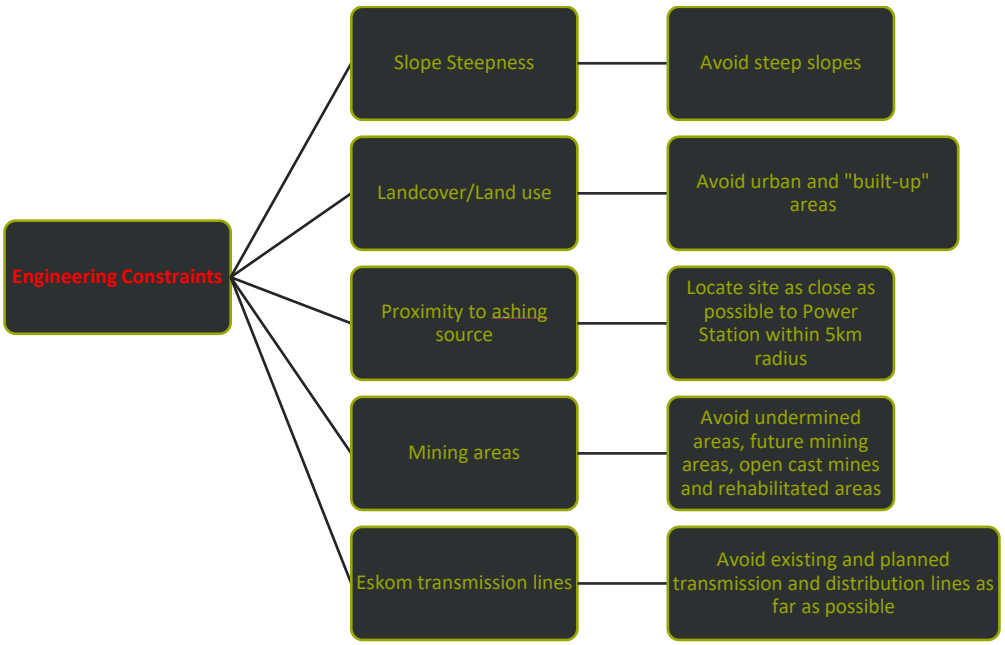


Figure 14: Engineering constraints investigated as part of the GIS-based mapping exercise.

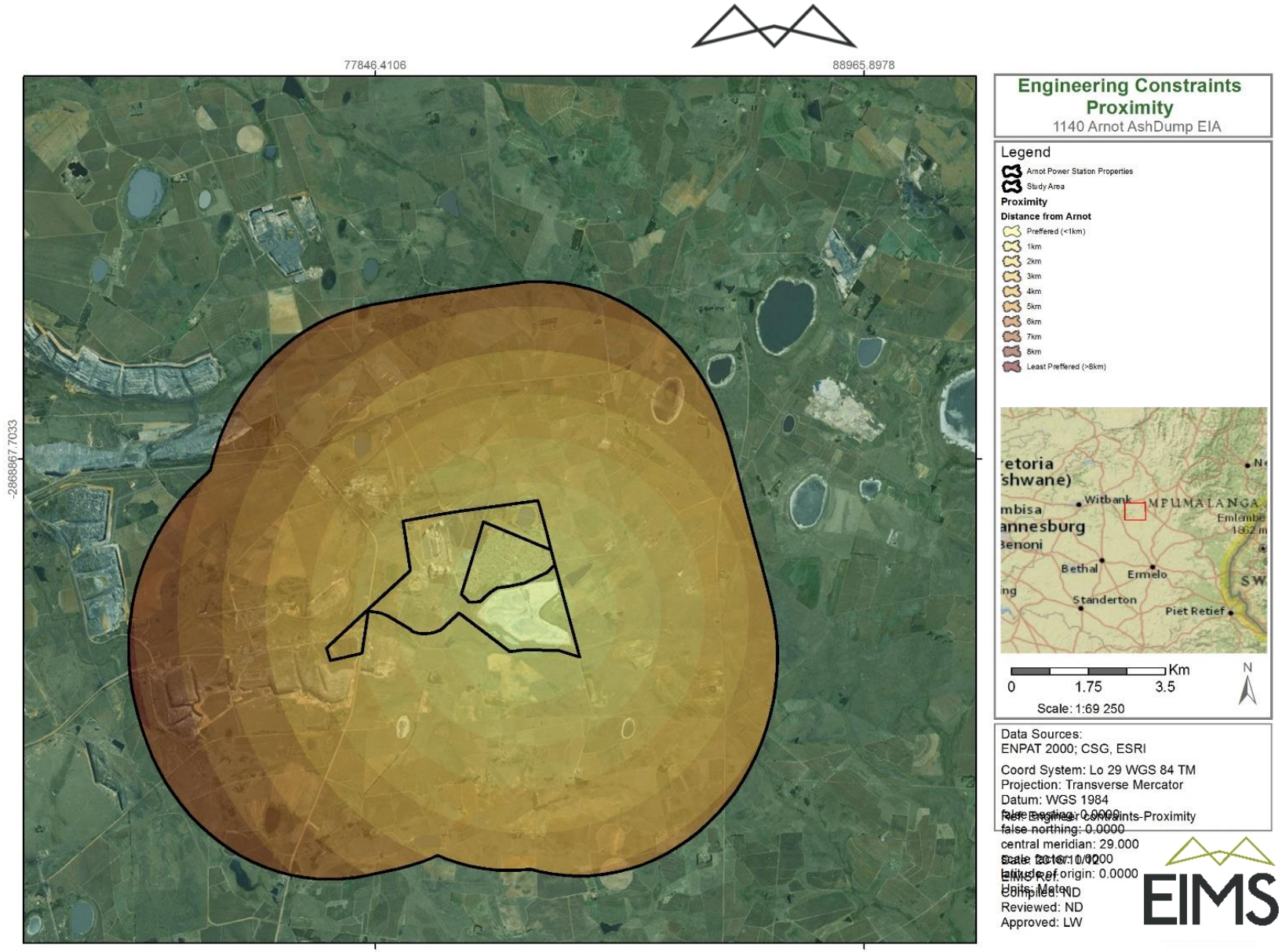


Figure 15: Map showing proximity to existing power station.

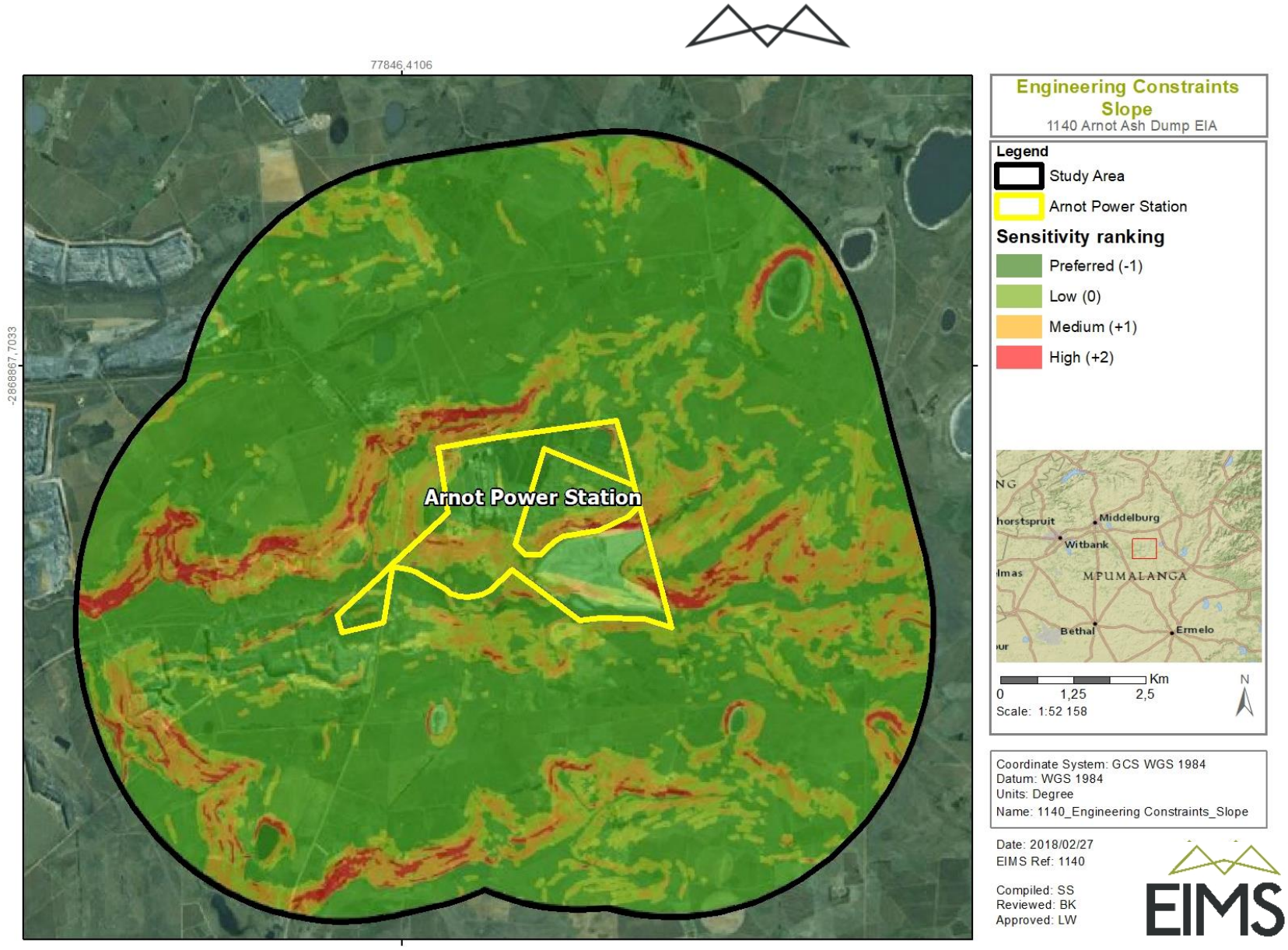


Figure 16: Map showing slope in the study area.

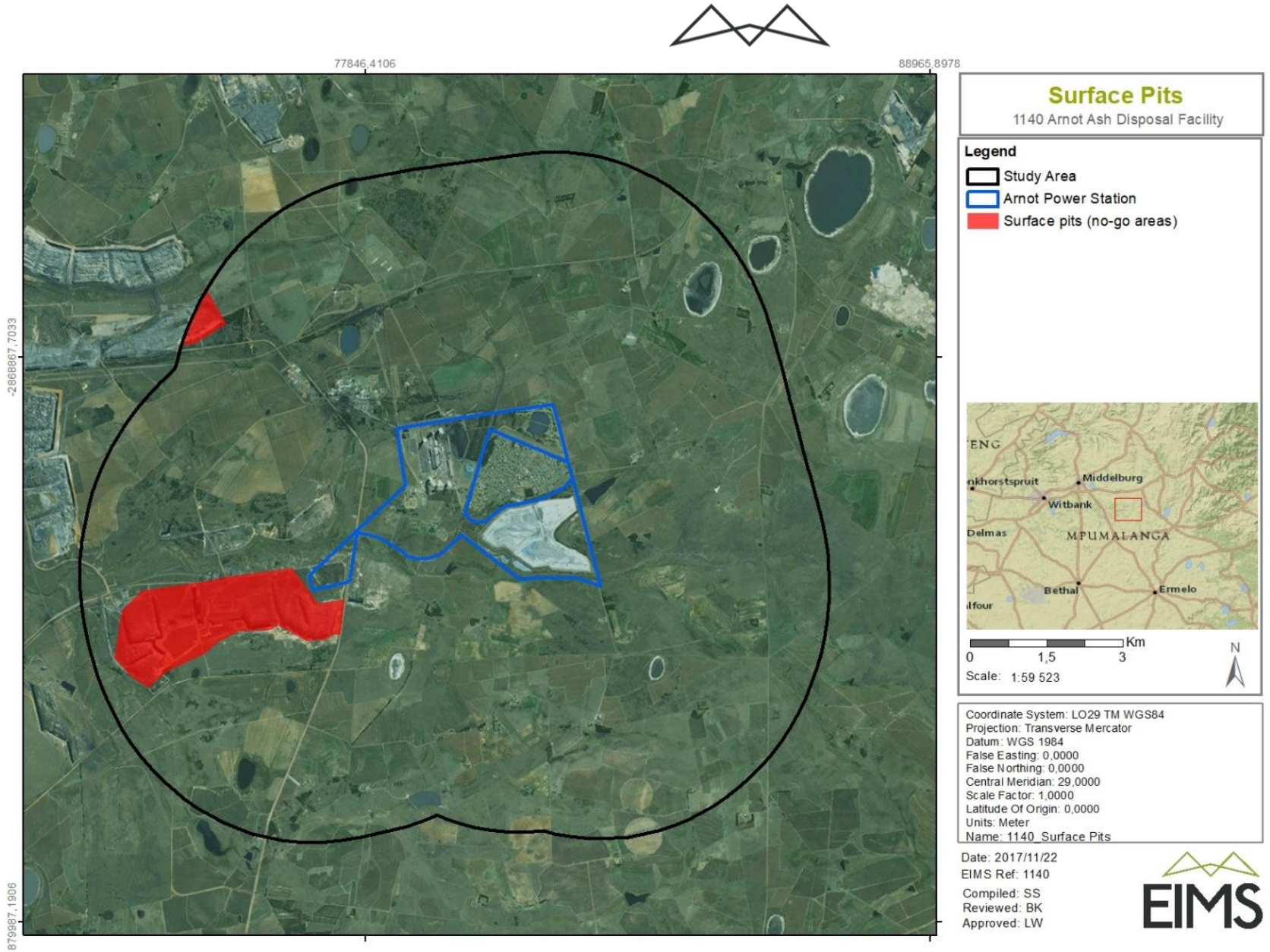


Figure 17: Map showing surface pits in the study area.

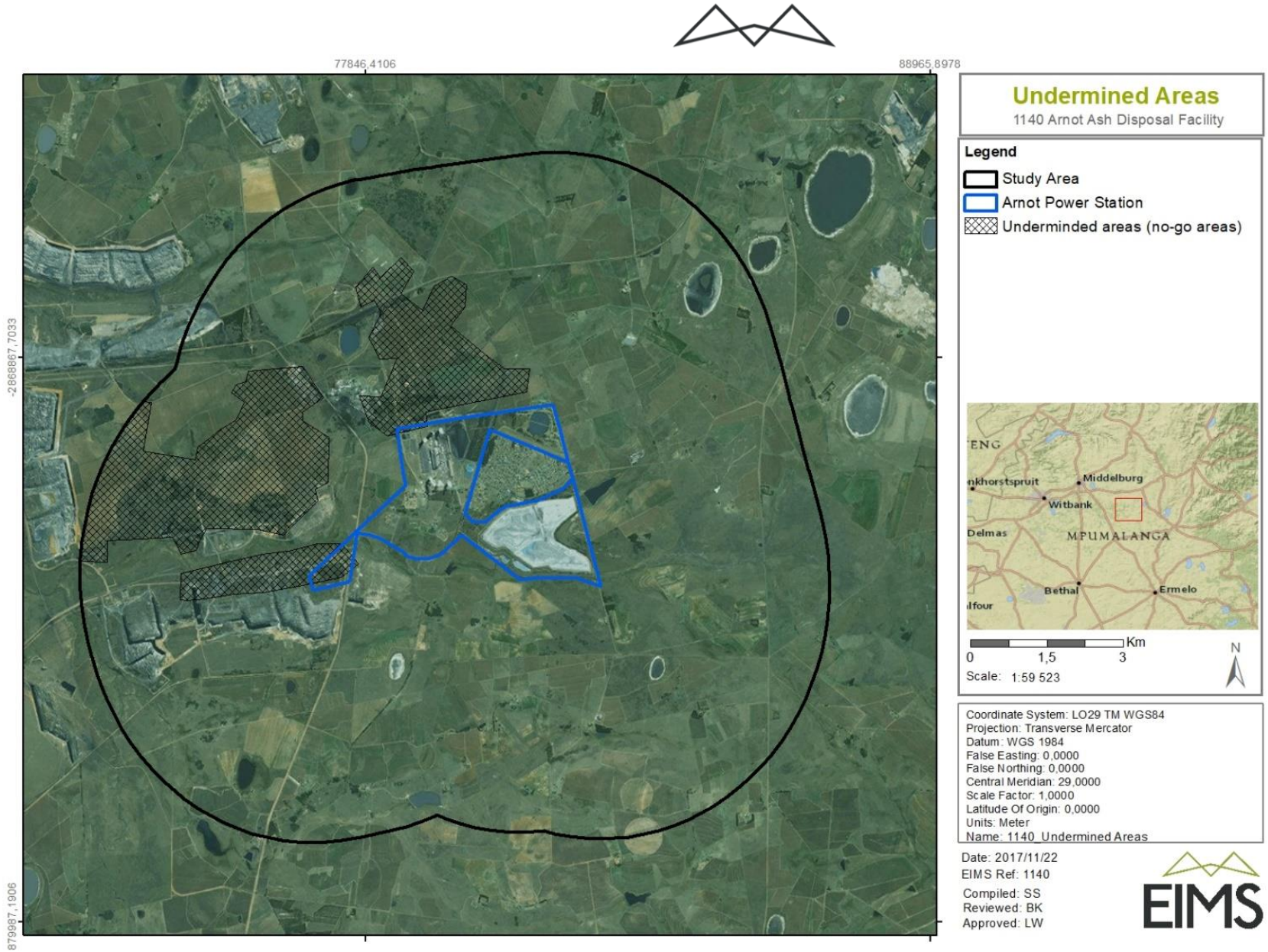


Figure 18: Map showing known undermined areas in the study area.

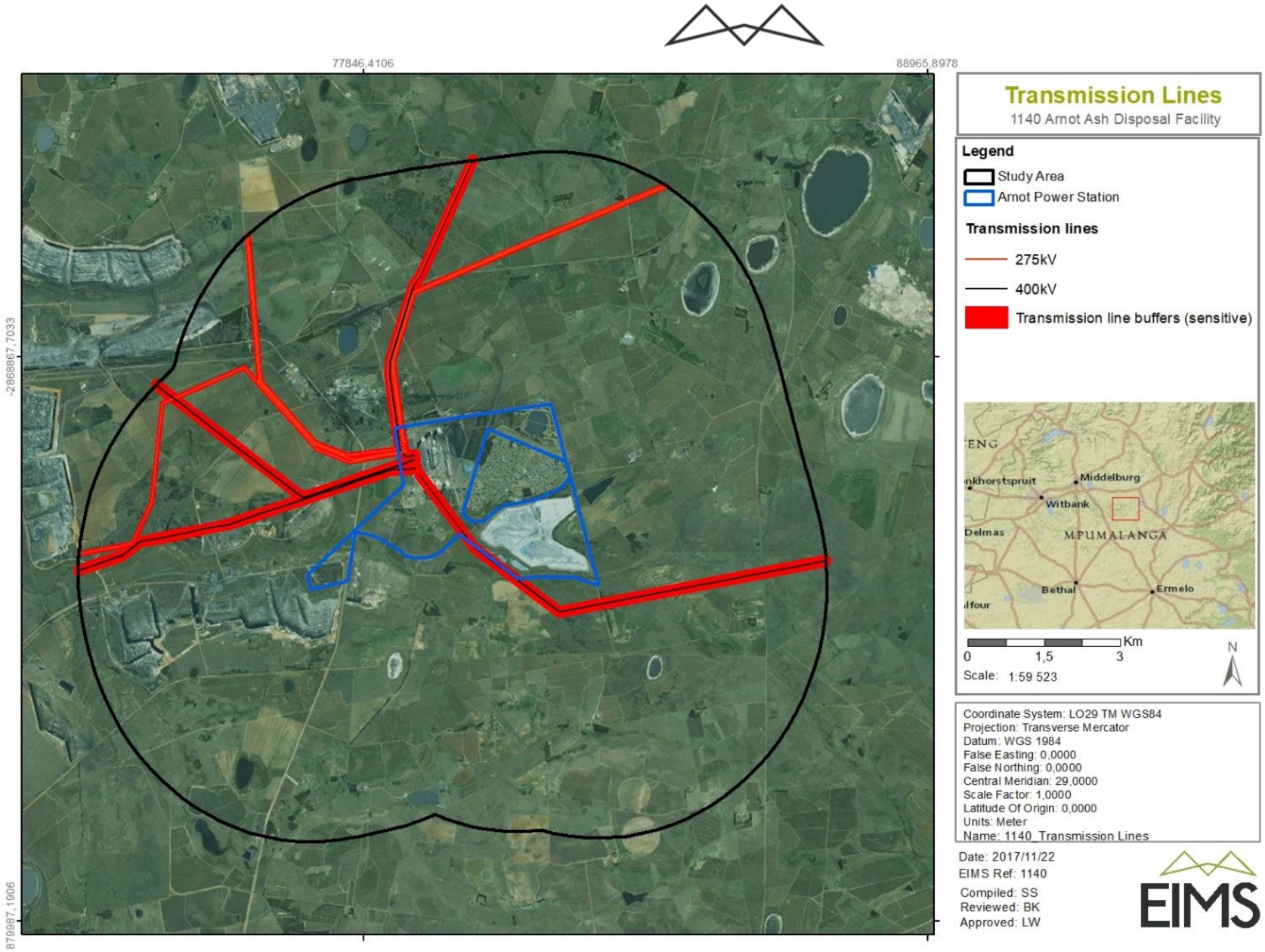
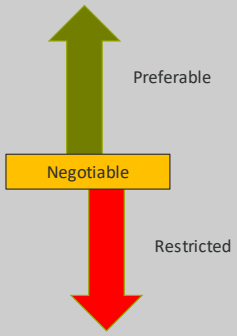


Figure 19: Map showing transmission lines in the study area.

2.3 SENSITIVITY RATING SYSTEM

The sensitivity mapping approach is based on a desktop study with numerous specialist inputs. The rating system is described in **Table 2**.

Table 2: Sensitivity Rating System

Sensitivity Rating	Description	Weighting	Preference Scale
Least Concern	The inherent feature status and sensitivity is already degraded. The proposed development will not affect the current status and/or may result in a positive impact. These features would be the preferred alternative for mining or infrastructure placement.	+1	
Low/Poor	The proposed development will have not have a significant effect on the inherent feature status and sensitivity.	0	
High	The proposed development will negatively influence the current status of the feature.	-1	
Very High	The proposed development will negatively significantly influence the current status of the feature.	-2	

2.4 NO-GO AREAS

Several no-go areas were identified to further reduce the number of suitable sites. **Figure 20** provides details of the no-go areas identified.

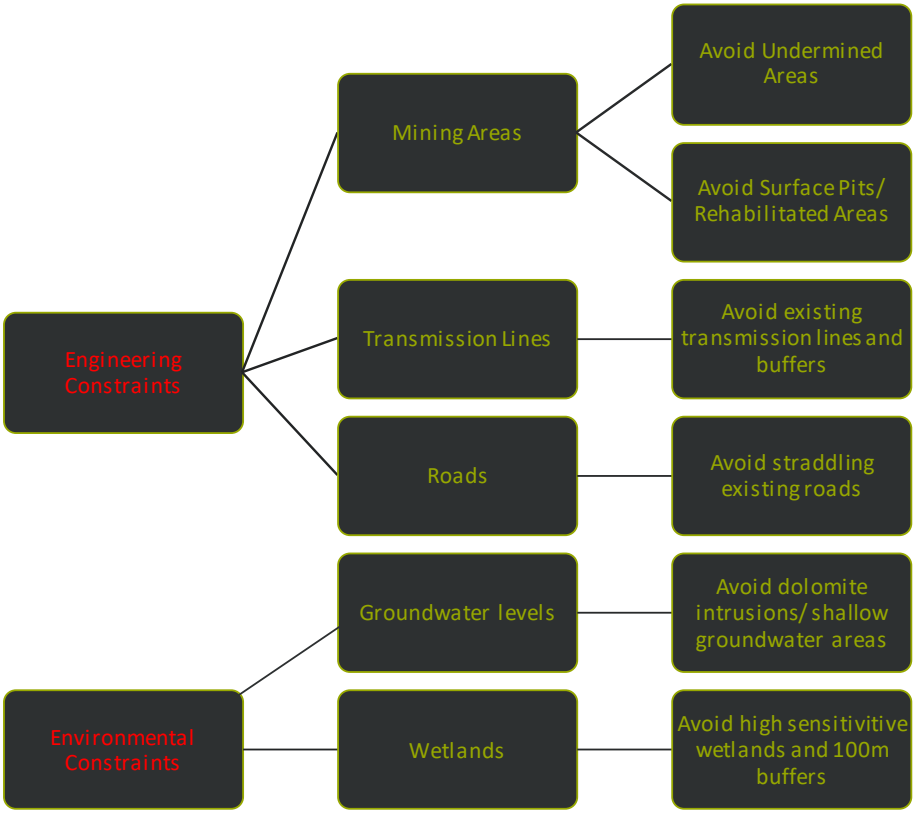


Figure 20: No-go constraints included as part of the GIS-based mapping exercise.

2.5 POTENTIAL IDENTIFIED SITES

All the specialist input layers were then combined into the sensitivity analysis. Engineering and other site selection constraints were overlaid to indicate preliminary alternative sites. Further refinement to the preliminary alternatives was done in order to determine potential alternative sites. These sites are indicated in **Figure 21** and **Figure 22**.

Based on the space requirements, several 80ha and 120 sites were identified for screening. The combined results from the environmental and engineering constraints mapping reduced the number of preferred 80ha sites to six (6) and the number of preferred 120ha sites to three (3). These sites were identified as being of least risk for the development of the ash disposal facility. Potential alternative sites were further refined based on a desktop study in order to identify screened alternatives which are to be further assessed by specialists on-site. Further refinement to the preliminary alternatives was done in order to reduce the number of potential alternative sites from nine (9) to five (5).. These screened sites are indicated in **Figure 23** and **Figure 24**.

It is expected that minor adjustments to the site locations may still occur prior to the start of the EIA, therefore each site also includes a 1km buffer zone area. Specialists were asked to consider the entire area for each site, including the buffer zone, when investigating the five sites as part of their detailed screening assessment.

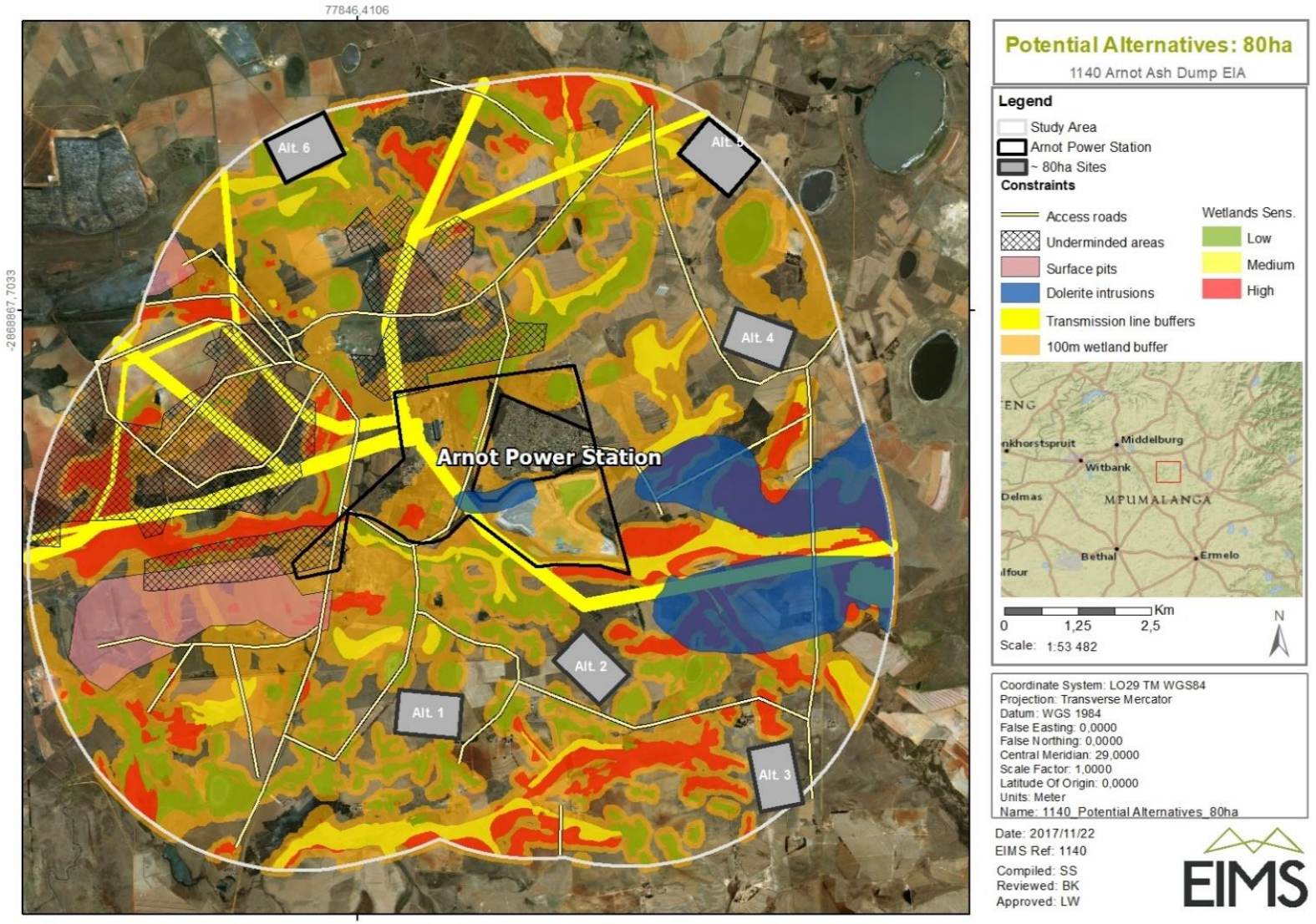


Figure 21: Potential 80 sites identified through GIS mapping as being potentially suitable for development of the ash disposal facility.

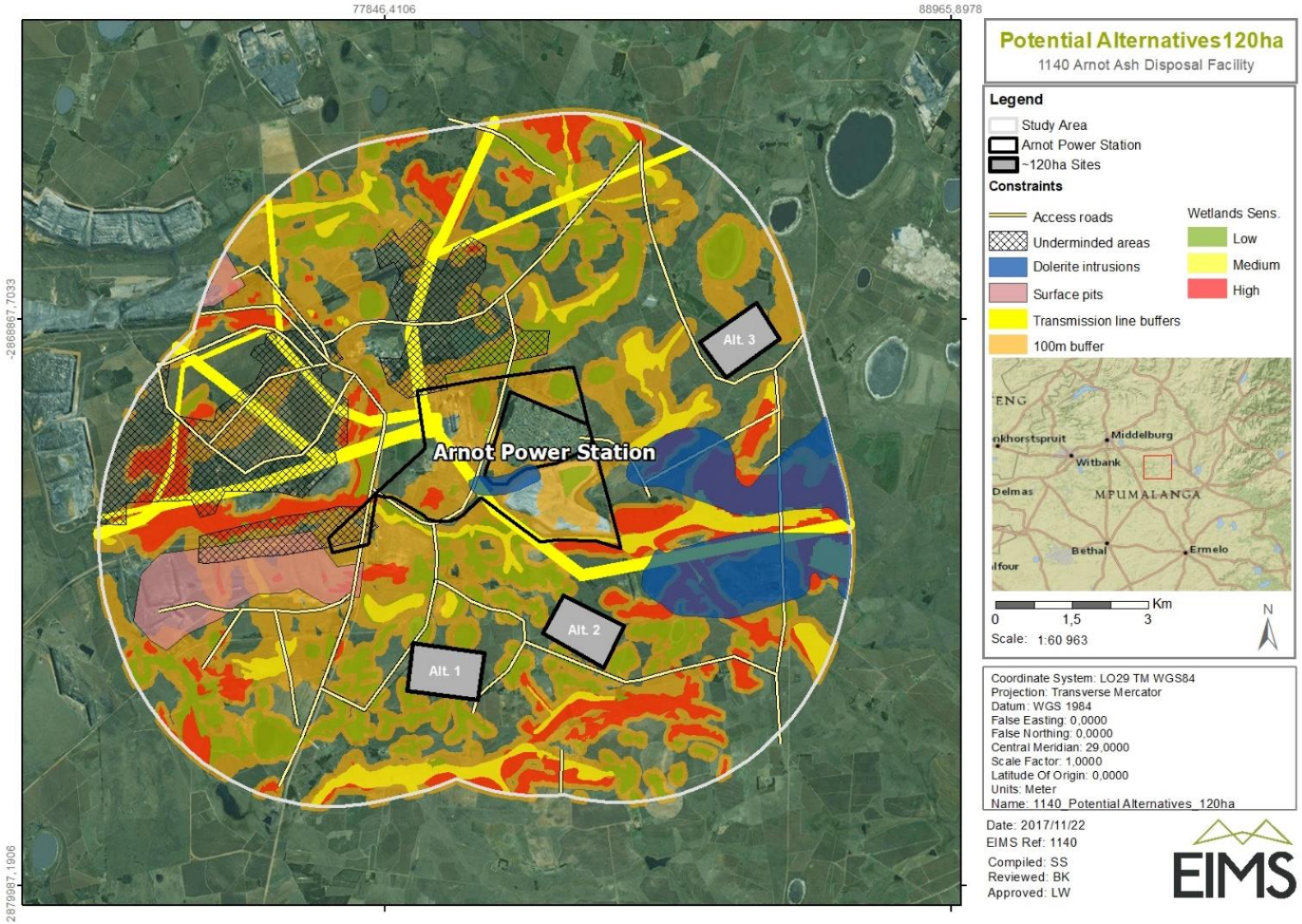


Figure 22: Potential 120ha sites identified through GIS mapping as being potentially suitable for development of the ash disposal facility.

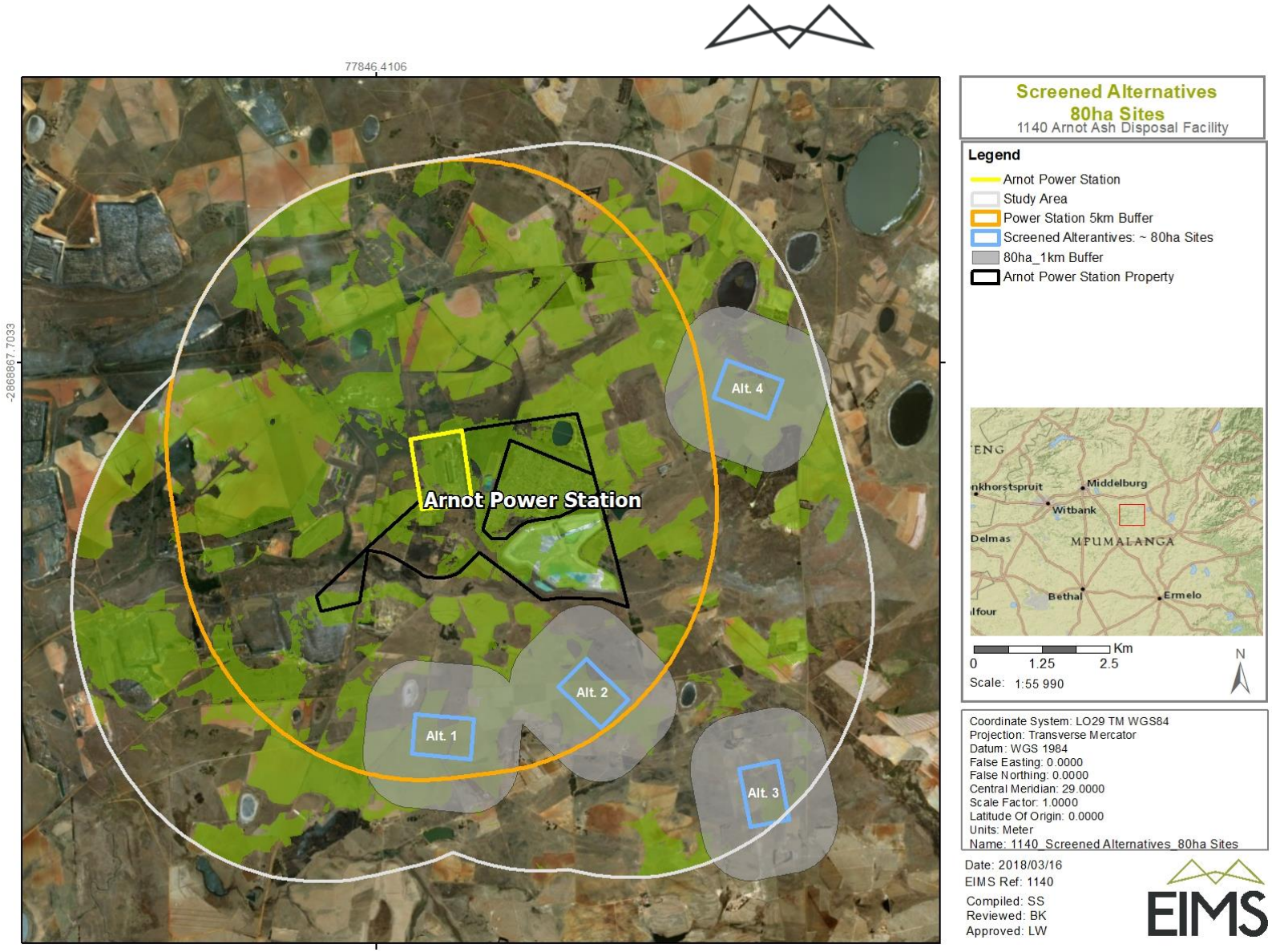


Figure 23: Final screened 80ha alternative sites.

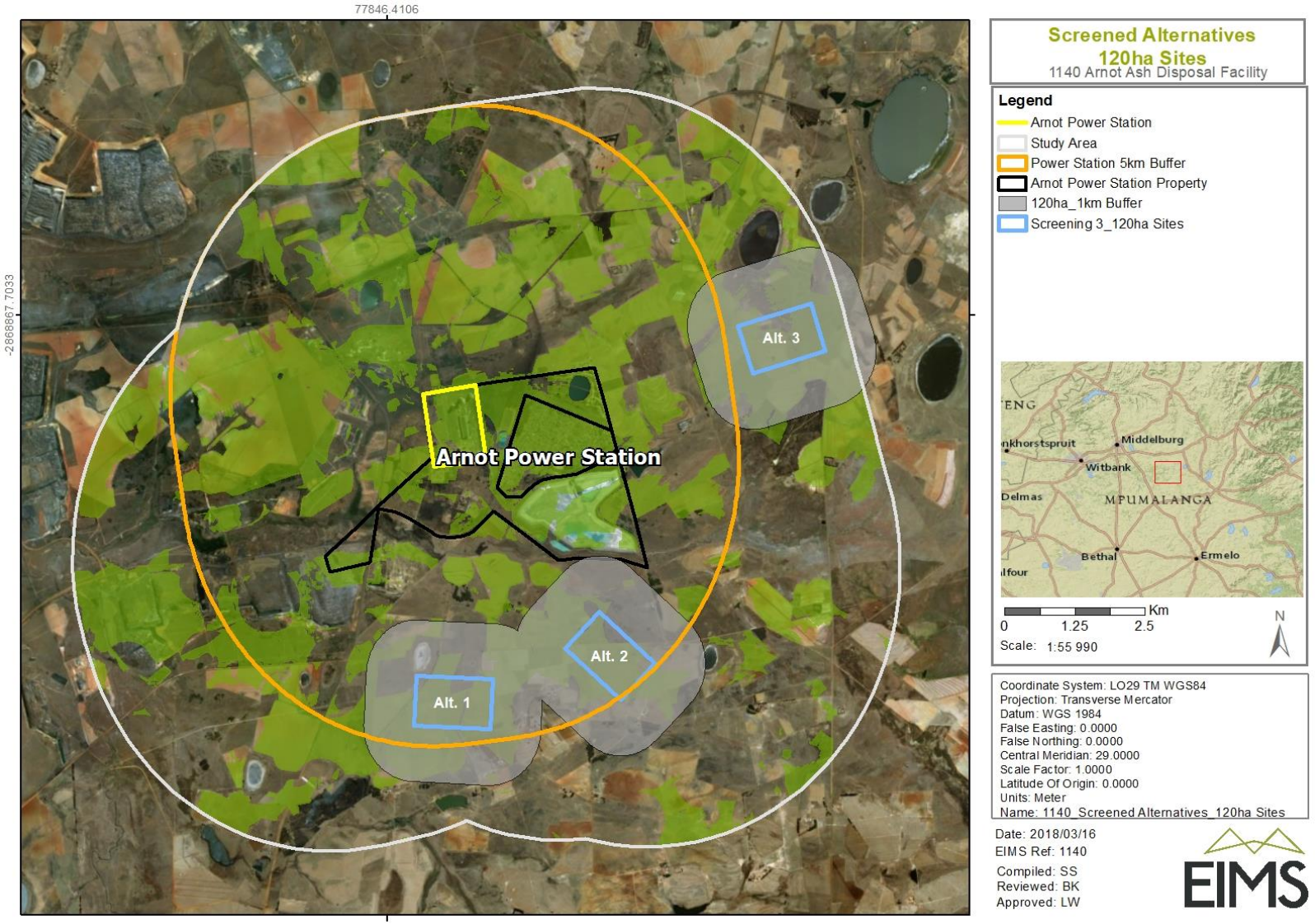


Figure 24: Final screened 120ha alternative sites.

3 SPECIALIST FINDINGS

The remaining specialist input was based on desktop assessments of the sites as well as a site inspection where possible. Each specialist ranked the 120ha sites from 1 (most preferred) to 3 (least preferred) as well as the 80ha sites from 1 (most preferred) to 4 (least preferred). A representative from EIMS also completed a ground-truthing exercise on Friday 19 January 2018. The results of the specialist findings are presented below.

3.1 ECOLOGY

No fatal flaws were identified however there are two pans within the buffer zone and along the edge of the site of Alternative 1 (both 120ha and 80ha options) which make this Alternative not preferred. Alternative 3 (120ha) and Alternative 4 (80ha) are within an area where there is a cluster of large pans. This is a biologically and (probably) hydrologically linked system that should be afforded some level of elevated protection, which is probably not possible if the ash heap is located in this area.

For the 120ha sites, Alternative 1 is the least preferred, due to there being two pans on the northern edge of the site and well within the 1 km buffer zone. Alternative 2 is the preferred option, primarily due to its proximity to the existing ash heap. In addition, no pans are located in the Alternative 2 area. Alternative 3 is also feasible, with the proviso that the integrity of the group of pans within the buffer area in that area is kept intact. In all three cases, there are wetlands for which management measures would need to be put in place to avoid, manage or mitigate impacts. Ranking from most to least preferred: 2, 3, 1.

For the 80ha sites, Alternative 1 is the least preferred, due to there being two pans on the northern edge of the site and well within the 1 km buffer zone. Alternative 2 is the preferred option, primarily due to its proximity to the existing ash heap, but Alternative 3 is also a preferred option, despite having a (cultivated) wetland through the centre. It should be noted that Alternative 2 also includes two valley wetland systems, both of which are within the boundary of the buffer area. Alternative 4 is also feasible, with the proviso that the integrity of pan and wetland system in that area is kept intact. In all four cases, there are wetlands for which management measures would need to be put in place to avoid, manage or mitigate impacts. Ranking from most to least preferred: 2, 3, 4, 1.

The ranking is as follows (site numbers listed from most to least preferable):

- **120ha sites: 2, 3, 1;**
- **80ha sites: 2, 3, 4, 1**.

3.1.1 RANKING OF 120HA ALTERNATIVES

120ha Alternative 1			
Preference	Preferred	Negotiable	Restricted
		X	
Advantages	Relatively close to existing ash facility, therefore consolidating impact within a single area within the broad study area. Large proportion already transformed by cultivation.		
Disadvantages	Wetland features within the 1 km buffer zone, including two pans, both of which are on the northern edge of the 120ha area. Some areas of either grassland or secondary grassland that may have some biodiversity value within the 120ha area.		
Ranking (1-3)	3		
Fatal Flaws	None identified		
Additional Comments	There may be additional wetlands within transformed (cultivated) areas.		

120ha Alternative 2			
Preference	Preferred	Negotiable	Restricted
	X		
Advantages	Close to existing ADF, therefore consolidating impact within a single area within the broad study area. Large proportion already transformed by cultivation.		
Disadvantages	Wetland features within the 1 km buffer zone, including two valley wetland systems, both of which are within the boundary of the buffer area. Some areas of either grassland or secondary grassland that may have some biodiversity value within the 120ha area.		
Ranking (1-3)	1		
Fatal Flaws	None identified		
Additional Comments	There may be additional wetlands within transformed (cultivated) areas.		

120ha Alternative 3			
Preference	Preferred	Negotiable	Restricted
		X	
Advantages	Relatively close to existing ADF, therefore consolidating impact within a single area within the broad study area. Large proportion already transformed by cultivation.		
Disadvantages	Wetland features within the 1 km buffer zone, including one pan and one wetland system, both of which are just within the boundary of the buffer area. Some areas of either grassland or secondary grassland that may have some biodiversity value within the 120ha area.		
Ranking (1-3)	2		
Fatal Flaws	None identified		
Additional Comments	There may be additional wetlands within transformed (cultivated) areas.		

3.1.2 RANKING OF 80HA ALTERNATIVES

80ha Alternative 1			
Preference	Preferred	Negotiable	Restricted
		X	
Advantages	Relatively close to existing ADF, therefore consolidating impact within a single area within the broad study area. Large proportion already transformed by cultivation.		
Disadvantages	Wetland features within the 1 km buffer zone, including two pans, both of which are on the northern edge of the 80ha area. Some areas of either grassland or secondary grassland that may have some biodiversity value within the 80ha area.		
Ranking (1-4)	4		
Fatal Flaws	None identified		
Additional Comments	There may be additional wetlands within transformed (cultivated) areas.		

80ha Alternative 2			
Preference	Preferred	Negotiable	Restricted
	X		
Advantages	Close to existing ash dispposal facility, therefore consolidating impact within a single area within the broad study area. Large proportion already transformed by cultivation.		
Disadvantages	Wetland features within the 1 km buffer zone, including two valley wetland systems, both of which are within the boundary of the buffer area. Some areas of either grassland or secondary grassland that may have some biodiversity value within the 80ha area.		
Ranking (1-4)	1		
Fatal Flaws	None identified		
Additional Comments	There may be additional wetlands within transformed (cultivated) areas.		

80ha Alternative 3			
Preference	Preferred	Negotiable	Restricted
		X	
Advantages	Relatively close to existing ash disposal facility, therefore consolidating impact within a single area within the broad study area. Large proportion already transformed by cultivation.		
Disadvantages	Wetland features within the 80ha site, although ploughed and therefore of low biodiversity value. Some areas of either grassland or secondary grassland that may have some biodiversity value within the 1 km buffer area.		
Ranking (1-4)	2		
Fatal Flaws	None identified		
Additional Comments	There may be additional wetlands within transformed (cultivated) areas.		

80ha Alternative 4			
Preference	Preferred	Negotiable	Restricted
		X	
Advantages	Relatively close to existing ash disposal facility, therefore consolidating impact within a single area within the broad study area. Large proportion already transformed by cultivation.		
Disadvantages	Wetland features within the 1 km buffer zone, including one pan and one wetland system, both of which are just within the boundary of the buffer area. Some areas of either grassland or secondary grassland that may have some biodiversity value within the 80ha area.		
Ranking (1-4)	3		
Fatal Flaws	None identified		
Additional Comments	There may be additional wetlands within transformed (cultivated) areas.		

3.2 AGRICULTURAL POTENTIAL

From the point of view of soils, the most suitable site/s will be where there is no high level of agricultural potential. This means sites where deep, productive soils are either absent or have a limited distribution. Areas where there are disturbed soils either close by or on site, would be preferred, since there will be less disturbance of any unaffected areas, regarding agriculture. In the vicinity of the various proposed alternatives, there is a large variation in soil type and soil characteristics. There are deep, friable soils which will be very suitable for crop production, and there are some shallow soils, with occasional rock outcrops, that will be only suited for grazing. Several soil types are classed as being of arable potential, but due to a restricted depth to underlying rock or plinthite, the potential is low or moderate at best.

In the vicinity of the study area, it can be predicted that grazing capacity will be relatively high, around 6-8 ha per large stock unit as there are some shallow soils, with occasional rock outcrops, that will be only suited for grazing. This classification does not apply to game farming, where more detailed specialized knowledge is required, mainly in terms of relating plant species composition in both the grass layer and woody layer to the requirements of various grazing and/or browsing species of game.

The ranking is as follows (site numbers listed from most to least preferable):

- **120ha sites: 3, 2, 1;**
- **80ha sites: 4, 2, 3, 1**.

3.2.1 RANKING OF 120HA ALTERNATIVES

120ha Alternative 1			
Preference	Preferred	Negotiable	Restricted
		X	
Advantages	No wetlands close by		
Disadvantages	Lot of cultivation, probably high potential soils		
Ranking (1-3)	3		
Fatal Flaws	None identified		
Additional Comments	Falls within land type Ba22, with significant proportion of good soils.		

120ha Site Alternative 2			
Preference	Preferred	Negotiable	Restricted
		X	
Advantages	No wetlands close by		
Disadvantages	Some cultivation, probably high potential soils		
Ranking (1-3)	2		
Fatal Flaws	None identified		
Additional Comments	Falls within land type Ba22, with significant proportion of good soils. Mixture of natural grazing and cultivation practiced on site		

120 Site Alternative 3			
Preference	Preferred	Negotiable	Restricted
	X		
Advantages	No wetlands close by		
Disadvantages	Some cultivation, soils of mixed potential		
Ranking (1-3)	1		
Fatal Flaws	None identified		
Additional Comments	Falls within land type Bb15, with smaller proportion of good soils. Mixture of natural grazing and cultivation practiced on site		

3.2.2 RANKING OF 80HA ALTERNATIVES

80ha Site Alternative 1			
Preference	Preferred	Negotiable	Restricted
		X	
Advantages	No wetlands close by		
Disadvantages	Lot of cultivation, probably high potential soils		
Ranking (1-4)	4		
Fatal Flaws	None identified		
Additional Comments	Falls within land type Ba22, with significant proportion of good soils.		

80ha Site Alternative 2			
Preference	Preferred	Negotiable	Restricted
		X	
Advantages	No wetlands close by		
Disadvantages	Some cultivation, probably high potential soils		
Ranking (1-4)	2		
Fatal Flaws	None identified		
Additional Comments	Falls within land type Ba22, with significant proportion of good soils. Mixture of natural grazing and cultivation practiced on site		

80ha Site Alternative 3			
Preference	Preferred	Negotiable	Restricted
		X	
Advantages	No wetlands close by		
Disadvantages	Lot of cultivation, probably high potential soils		
Ranking (1-4)	3		
Fatal Flaws	None identified		
Additional Comments	Falls within land type Ba22, with significant proportion of good soils. Cultivation practiced on site		

80ha Site Alternative 4			
Preference	Preferred	Negotiable	Restricted
	X		
Advantages	No wetlands close by		
Disadvantages	Some cultivation, soils of mixed potential		
Ranking (1-5)	1		
Fatal Flaws	None identified		
Additional Comments	Falls within land type Bb15, with smaller proportion of good soils. Mixture of natural grazing and cultivation practiced on site		

3.3 AQUATIC ECOLOGY

The System for Automated Geoscientific Analyses GIS standard terrain model was used to model the areas where water would accumulate in the landscape, and therefore increase the potential for wetlands to develop. This module models various topographic features related to hydrology, which include channels and the Wetness Index (WI). Based on the available desktop information and the WI, it is recommended that Alternatives 1 and 2 be assessed during the

upcoming Scoping Phase assessment for both the 80ha and 120ha alternatives. In both cases Alternative 2 obtained the lowest rating scores and was therefore ranked as most preferred.

The ranking is as follows (site numbers listed from most to least preferable):

- **120ha sites: 2, 1, 3;**
- **80ha sites: 2, 1, 3, 4**.

3.3.1 RANKING OF 120HA ALTERNATIVES

120ha Site Alternative 1			
Preference	Preferred	Negotiable	Restricted
		X	
Advantages	Alternative 1 (including the 1km radius) is not located within a wetland and is in an Ecosystem Maintenance aquatic biodiversity area. This alternative has a lower mean slope when compared to Alternative 3.		
Disadvantages	Based on the WI, this alternative has the second largest amount of temporary/seasonal wetland areas within the 1 km radius. Two wetland types with a Critically endangered signature are located within the 1km radius (NFEPA, 2011)		
Ranking (1 – 3)	2		
Fatal Flaws	No fatal flaws with regards to wetland and aquatic ecology based available desktop information and the WI.		

120ha Site Alternative 2			
Preference	Preferred	Negotiable	Restricted
	X		
Advantages	Alternative 2 (including the 1km radius) is not located within a Freshwater Ecosystem Priority Area (FEPA) and is in an Ecosystem Maintenance aquatic biodiversity area. Based on the WI, this alternative has the lowest amount of temporary/seasonal wetland areas.		
Disadvantages	Alternative 2, has the highest mean slope which indicates a higher erosion potential when compared to the other alternatives. The 1km radius is near the Rietkuilspruit. However, this sub-quaternary reach is in an E ecological category, inferring a Seriously modified state, with a Moderate Ecological Importance) and Ecological Sensitivity.		
Ranking (1 – 3)	1		
Fatal Flaws	No fatal flaws with regards to wetland and aquatic ecology based available desktop information and the WI.		
Additional comments	Alternative 2 is the most preferred alternative based on the available desktop information and scored the lowest in the scoring matrix. Selecting Alternative 1 will support the international concepts of keeping impacts together, and it is better that the proposed ash facility should expand as close as feasible possible to the existing facilities, rather than moving into more intact natural areas, which would result in additional habitat loss and fragmentation. Furthermore, Alternative 2 will most likely require the least amount / length of associated infrastructure as it is in the closest proximity to the existing ash disposal facility.		

120ha Site Alternative 3			
Preference	Preferred	Negotiable	Restricted
			X
Advantages	Alternative 3, has the lowest mean slope of all the alternatives reducing the erosion potential of the area.		
Disadvantages	A portion of the 1km radius is situated within a FEPA and a Highly Significant aquatic biodiversity sub-catchment based on the Mpumalanga Biodiversity Conservation Plan (MBCP). This alternative has the highest extent of temporal/seasonal and seasonal/permanent wetland areas according to the WI. Alternative 3 has a higher landcover associated with grassland when compared to the other alternatives (DEA, 201). Furthermore, this alternative is situated more than 3km form the existing ARNOT ash disposal facility and may potentially require the largest/longest infrastructure which may have a greater impact on the surrounding wetland areas.		
Ranking (1 – 3)	3		
Fatal Flaws	Based on the available desktop information and the WI, Alternative 3 is the least preferred alternative and should be excluded from the Scoping Phase.		

3.3.2 RANKING OF 80HA ALTERNATIVES

80ha Site Alternative 1			
Preference	Preferred	Negotiable	Restricted
	X		
Advantages	Alternative 1 (including the 1km radius) is not located within a FEPA and is in an Ecosystem Maintenance aquatic biodiversity area. The landcover database shows low grassland cover with clearing related to cultivated fields. Alternative 1 is associated mainly with pan/depression wetlands and lower order streams (based on desktop assessment) which will help contain the spread of potential water quality related impacts.		
Disadvantages	Based on the WI, this alternative has the second largest amount of potential temporary/seasonal wetland areas within the 1km radius. Two wetland types with Critically endangered signatures are located within the 1km radius (NFEPA, 2011).		
Ranking (1 – 3)	2		
Fatal Flaws	No fatal flaws with regards to wetland and aquatic ecology based on available desktop information and the WI.		

80ha Site Alternative 2			
Preference	Preferred	Negotiable	Restricted
	X		
Advantages	As with Alternative 1, Alternative 2 (including the 1km radius) is not located within a FEPA and is located in and Ecosystem Maintenance aquatic biodiversity area. Based on the WI, this alternative has the smallest potential extent of temporary/ seasonal and seasonal/permeant wetland areas.		
Disadvantages	Alternative 2, has the highest mean slope which indicates a higher erosion potential when compared to the other alternatives. The 1km radius is near the Rietkuilspruit. However, this sub-quaternary reach is in an E Ecological Category, inferring a Seriously modified state, with a Moderate Ecological Importance (EI) and Ecological Sensitivity (ES).		
Ranking (1 – 3)	1		
Fatal Flaws	No fatal flaws with regards to wetland and aquatic ecology based on available desktop information and the WI.		
Additional comments	Alternative 2 is the most preferred alternative and scored the lowest in the scoring matrix. Selecting Alternative 2 will support the concepts of containing impacts within local catchments, and it is better that the proposed ash facility should expand as close as possible to the existing facility, rather than moving into more intact natural areas, which would result in additional habitat loss and fragmentation. Furthermore, Alternative 2 will most likely require the least amount / length of associated infrastructure as it is in the closest proximity to the existing ash disposal facility.		

80ha Site Alternative 3			
Preference	Preferred	Negotiable	Restricted
		X	
Advantages	As with the above two alternatives, Alternative 3 is also located in an Ecosystem Maintenance aquatic biodiversity area. Based on the WI, this alternative has the second smallest amount of temporary/seasonal wetland areas.		
Disadvantages	Alternative 3 is situated furthest form the existing Arnot ash disposal facility and will require more extensive supporting infrastructure, which may have a greater impact on the surrounding wetland and it has the second highest mean slope increasing the erosion potential of the area.		
Ranking (1 – 3)	3		
Fatal Flaws	No fatal flaws with regards to wetland and aquatic ecology based available desktop information and the WI.		

80ha Site Alternative 4			
Preference	Preferred	Negotiable	Restricted
			X
Advantages	Alternative 4, has the lowest mean slope of all the alternatives reducing the erosion potential of the area.		
Disadvantages	A portion of the 1km radius is situated within a FEPA and a Highly Significant aquatic biodiversity sub-catchment based on the MBCP. This alternative has the highest extent of temporary / seasonal and seasonal / permeant wetland areas according to the WI. Alternative 4 has a higher landcover associated with grassland when compared to the other alternatives (DEA, 2015). Furthermore, this alternative is situated more than 3km form the existing ARNOT ash disposal facility will require more extensive supporting infrastructure which may have a greater impact on the surrounding wetland areas.		
Ranking (1 – 4)	4		
Fatal Flaws	Based on the available desktop information and the WI, Alternative 4 is the least preferred alternative and should be excluded from the Scoping Phase.		

3.4 SURFACE WATER

For both the 120ha and 80ha sites, Site Alternative 2 (most suitable) and Site Alternative 1 are considered suitable from a surface water perspective to take into the scoping phase. The remaining alternatives are considered 'Negotiable' as they are not the preferred site but could be used if certain measures are put in place. **The ranking is as follows (site numbers listed from most to least preferable):**

- **120ha sites: 2, 1, 3;**
- **80ha sites: 2, 1, 4, 3.**

3.4.1 RANKING OF 120HA ALTERNATIVES

120ha Site Alternative 1			
Preference	Preferred	Negotiable	Restricted
		X	
Advantages	Alternative 1 is in close proximity to the Arnot power plant therefore future impacts created by pipelines (feed and return water pipes) on watercourses will be minimized. Alternative 1 is in relative close proximity to the current ash disposal facility therefore storm water management infrastructure (return water system) can be combined and utilised. Alternative 1 is in located on top of a sub-catchment of the Rietkuilspruit water course.		
Disadvantages	Two natural pans are located within the 1km buffer of Alt1 A small non-perennial watercourse flowing in a southerly direction fall within the 1km buffer as well as within the site area of Alternative 1. Water crossing(s) at the Rietkuilspruit watercourse for feed and return water pipelines are required.		
Ranking (1 – 3)	2		
Fatal Flaws	None identified		
Additional Comments	None		

120ha Site Alternative 2			
Preference	Preferred	Negotiable	Restricted
	X		
Advantages	Alternative 2 is in closest proximity to the current ADF and Arnot power plant therefore future impacts created by pipelines (feed and return water pipes) on watercourses will be minimized. Alternative 2 is in close proximity to the current ADF therefore storm water management infrastructure (return water system) can be combined and utilised.		
Disadvantages	The Rietkuilspruit watercourse flowing, in the westerly direction, is located very close to the 1km buffer in the northern section of the site which could potentially be in the 1:100 year flood line. A non-perennial water-course flowing in westerly direction falls within the 1km buffer in the northern section of the site. Water crossing(s) at the Rietkuilspruit watercourse for feed and return water pipelines are required.		
Ranking (1 – 3)	1		
Fatal Flaws	None identified		
Additional Comments	The Rietkuilspuit mentioned above has been altered and looks to be severely degraded		

120ha Site Alternative 3			
Preference	Preferred	Negotiable	Restricted
		X	
Advantages	Alternative 3 is in close proximity to the Arnot power plant therefore future impacts created by pipelines pipelines (feed and return water pipes) on watercourses will be minimized.		
Disadvantages	Alternative 3 is situated upstream of the Grootpan, Leeuwpan, Rietpan, Klippan and Blinkpan. Any spillages originating from the Alternative 3, would have a negative effect on the downstream pans. Alternative 3 is situated in the neighbouring Water Management Area (WMA 5) and Quaternary catchment (X11C). It is preferable to localise the infrastructure and associated impacts of the Arnot ADF in a single WMA and quaternary catchment. Several non-perennial water-course flowing, in the south-westerly direction, are located within the 1km buffer in the southern section of the site.		
Ranking (1 – 3)	3		
Fatal Flaws	None identified		
Additional Comments	None		

3.4.2 RANKING OF 80HA ALTERNATIVES

80ha Site Alternative 1			
Preference	Preferred	Negotiable	Restricted
		X	
Advantages	Alternative 1 is in close proximity to the Arnot power plant therefore future impacts created by pipelines (feed and return water pipes) on watercourses will be minimized. Alternative 1 is in relative close proximity to the current ADF therefore storm water management infrastructure (return water system) can be combined and utilised. Alternative 1 is in located on top of a sub-catchment of the Rietkuilspruit water course.		
Disadvantages	Two natural pans are located within the 1km buffer of Alternative 1. A small non-perennial watercourse flowing in a southerly direction fall within the 1km		

	buffer as well as within the site area of Alternative 1. Water crossing(s) at the Rietkuilspruit watercourse for feed and return water pipelines are required.
Ranking (1 – 4)	2
Fatal Flaws	None identified
Additional Comments	None

80ha Site Alternative 2			
Preference	Preferred	Negotiable	Restricted
	X		
Advantages	Alternative 2 is in closest proximity to the current ADF and Arnot power plant therefore future impacts created by pipelines (feed and return water pipes) on watercourses will be minimized. Alternative 2 is in close proximity to the current ADF therefore storm water management infrastructure (return water system) can be combined and utilised.		
Disadvantages	The Rietkuilspruit watercourse flowing, in the westerly direction, is located very close to the 1km buffer in the northern section of the site which could potentially be in the 1:100 year flood line. A non-perennial water course flowing in westerly direction falls within the 1km buffer in the northern section of the site. Water crossing(s) at the Rietkuilspruit watercourse for feed and return water pipelines are required.		
Ranking (1 – 4)	1		
Fatal Flaws	None identified		
Additional Comments	The Rietkuilspuit mentioned above has been altered and looks to be severely degraded		

Site Alternative 3 (80ha)			
Preference	Preferred	Negotiable	Restricted
		X	
Advantages	Alternative 3 is located in close proximity to a public road servitude. Future infrastructure (access roads, pipelines, etc.) can be built along this road servitude and therefore future impacts on surface water can be minimised.		
Disadvantages	A non-perennial watercourse flowing in a westerly direction fall within the 1km buffer and also in close proximity of the site area of Alternative 3. Alternative 3 is located relatively far away from the Arnot power plant and therefore future impacts, created by additional infrastructure that cannot be built along the existing road servitude, on surface water resources can potentially be higher.		
Ranking (1 –4)	4		
Fatal Flaws	None identified		
Additional Comments	None		

80ha Site Alternative 4			
Preference	Preferred	Negotiable	Restricted
		X	
Advantages	Alternative 4 is in close proximity to the Arnot power plant therefore future impacts created by pipelines pipelines (feed and return water pipes) on watercourses will be minimized.		
Disadvantages	Alternative 4 is situated upstream of the Grootpan, Leeuwpan, Rietpan, Klippan and Blinkpan. Any spillages originating from the Alternative 4, would have a negative effect on the downstream pans. Alternative 4 is situated in the neighbouring Water Management Area (WMA 5) and Quaternary catchment (X11C). It is preferable to localise the infrastructure and associated impacts of the Arnot Ash dam in a single WMA and quaternary catchment. Several non-perennial water course flowing, in the south-westerly direction, are located within the 1km buffer in the southern section of the site.		
Ranking (1 – 4)	3		
Fatal Flaws	None identified		
Additional Comments	None		

3.5 GROUND WATER

According to the 1:500 000 hydrogeological map series 2526 Johannesburg (Barnard and Baran, 1999) the site is underlain by an intergranular and fractured aquifer with an average borehole yield between 0.5 to 2l/s. The aquifer vulnerability and classification maps of South Africa classify the underlying aquifer as minor aquifer which is a moderately vulnerable aquifer system. According to Parsons and Conrad, a minor aquifer system can be defined as fractured or potentially fractured rocks which do not have a high permeability, or other formations of variable permeability. The aquifer extent may be limited and seldom produce large quantities of water. The study area falls within quaternary catchment: B12B and X11C. **The ranking is as follows (site numbers listed from most to least preferable):**

- **120ha sites: 3, 1, 2;**
- **80ha sites: 3, 2, 4, 1.**

3.5.1 RANKING OF 120HA ALTERNATIVES

120ha Site Alternative 1			
Preference	Preferred	Negotiable	Restricted
		X	
Advantages	Data is available on groundwater levels and current monitoring boreholes could be incorporated as part of the monitoring network.		
Disadvantages	Various surface water bodies were noted within the 1km buffer zone indicating potential shallow groundwater levels. The risk of groundwater contamination of having the facility within an area with visible surface water bodies and shallow groundwater is significant. One non-perennial river is located within the 1km buffer area.		
Ranking (1 – 3)	2		
Fatal Flaws	None identified		
Additional Comments	Based on previous site data collected, boreholes and shallow groundwater levels are present within the 1km buffer area ranging from 3.42 to 13.99mbgl.		

120ha Site Alternative 2

Preference	Preferred	Negotiable	Restricted
		X	
Advantages	Slightly less shallow water levels were noted compared to the other alternative sites.		
Disadvantages	One surface water body is present within the 1km buffer. A non-perennial river is located within the 1km buffer area (southern section). The 1km buffer boundary is located on the Perennial Rietkuilspruit. The 1km buffer boundary overlies the contact zone between the Ecca Formation and a dolerite intrusion which may lead the enhanced aquifer conditions and preferential pathways.		
Ranking (1 – 3)	3		
Fatal Flaws	None identified		
Additional Comments	Based on previous site data collected, boreholes and shallow groundwater levels are present within the 1km buffer area ranging from 7.51 to 11.51mbgl.		

120ha Site Alternative 3			
Preference	Preferred	Negotiable	Restricted
		X	
Advantages	The area appears to relatively flat. The site is also situated on a higher topographical area than the other sites.		
Disadvantages	A surface water body was noted within the buffer zone area. No data on the groundwater levels in this area. This will need to be confirmed with a detailed groundwater investigation. A non-perennial river is located within the southern boundary of the buffer zone.		
Ranking (1 – 3)	1		
Fatal Flaws	None identified		
Additional Comments	None		

3.5.2 RANKING OF 80HA ALTERNATIVES

80ha Site Alternative 3			
Preference	Preferred	Negotiable	Restricted
		X	
Advantages	Data is available on groundwater levels and current monitoring boreholes could be incorporated as part of the monitoring network.		
Disadvantages	Various surface water bodies were noted within the 1km buffer zone indicating potential shallow groundwater levels. The risk of groundwater contamination of having the facility within an area with visible surface water bodies and shallow groundwater is significant. One non-perennial river is located within the 1km buffer area.		
Ranking (1 – 3)	4		
Fatal Flaws	None		
Additional Comments	Based on previous site data collected, boreholes and shallow groundwater levels are present within the 1km buffer area ranging from 3.42 to 13.99mbgl.		

80ha Site Alternative 2			
Preference	Preferred	Negotiable	Restricted
		X	
Advantages	Slightly less shallow water levels were noted compared to the other alternative sites.		
Disadvantages	One non-perennial river is located within the 1km buffer area.		
Ranking (1 – 3)	2		
Fatal Flaws	None identified		
Additional Comments	Based on previous site data collected, boreholes and shallow groundwater levels are present within the 1km buffer area ranging from 7.51 to 11.51mbgl.		

80ha Site Alternative 3			
Preference	Preferred	Negotiable	Restricted
	X		
Advantages	Deeper water levels were present compared to the other alternative sites.		
Disadvantages	One non-perennial river is located within the 1km buffer area.		
Ranking (1 – 3)	1		
Fatal Flaws	None identified		
Additional Comments	Based on previous site data collected, boreholes are present within the 1km buffer area with groundwater levels ranging from 12 to 33.9mbgl.		

80ha Site Alternative 4			
Preference	Preferred	Negotiable	Restricted
		X	
Advantages	The area appears to relatively flat. The site is also situated on a higher topographical area than the other sites.		
Disadvantages	A surface water body was noted within the buffer zone area. No data on the groundwater levels in this area. This will need to be confirmed with a detailed groundwater investigation. A non-perennial river is located within the southern boundary of the buffer zone.		
Ranking (1 – 3)	3		
Fatal Flaws	None identified		
Additional Comments	None		

3.6 VISUAL

Scenic quality ratings were assigned to each of the landscape types in the study area. The highest value is assigned to Klein-Olifant River, Rietkuilspruit, wetlands, pans and associated grasslands. The agricultural fields, farmsteads and towns were rated as moderate. The landscape types with the lowest scenic quality include the roads, power lines, Eskom Arnot Power Station and existing mining activities. As a result of the combination of the different landscape types the visual resource value was rated as low but with sections that can be regarded as moderate and even high.

The sense of place for the proposed study area derives from the combination of all landscape types and their impact on the senses. The natural rolling topography with its widespread grasslands, rivers, wetlands and pans has been impacted by the mining activities located to the east and west of the R104. The once pastoral sense of place of the overall study area has been compromised by a more industrial sense of place. There are however areas within the study

area, specifically referring to the east and the south-east of Site Alternative 4 that still gives the impression of a rural / pastoral sense of place.

T**he ranking is as follows (site numbers listed from most to least preferable):**

- **120ha sites: 1, 2, 3;**
- **80ha sites: 1, 2, 3, 4**.

3.6.1 RANKING OF 120HA ALTERNATIVES

120ha Site Alternative 1			
Preference	Preferred	Negotiable	Restricted
	X		
Advantages	The proposed ADF will be partially screened from viewers located in Rietkuil. This is mainly due to the existing ADF. The proposed ADF will be partially screened from viewers travelling along the R104 Located within an area already exposed to mining activities.		
Disadvantages	The proposed alternative is located close to a local road and therefore motorist will be exposed to the new ADF , this will however only be for a short period of time. This will not be uncharacteristic since there are other mining activities located along this road. Potential sensitive viewers located within the 1km buffer of the proposed ADF site. The proposed site includes areas with high landscape value (sensitivity) - watercourse (Streams and wetland).		
Ranking (1 - 3)	1		
Fatal Flaws	Potential sensitive viewers located within the 1km buffer of the proposed ADF site.		
Additional Comments	None		

120ha Site Alternative 2			
Preference	Preferred	Negotiable	Restricted
	X		
Advantages	The proposed ADF will be partially screened from viewers travelling along the R104 Located within an area already exposed to mining activities. Although the site alternative is located close to Rietkuil, the activity will be absorbed by the existing mining activities on site.		
Disadvantages	The proposed alternative is located between two local roads and therefore motorist will be exposed to the new ADF, this will however be for only a short period of time. This will not be uncharacteristic since there are other mining activities located along this road. Potential sensitive viewers located within the 1km buffer of the proposed ADF site. The proposed site includes areas with high landscape value (sensitivity) - watercourse (Streams and wetland).		
Ranking (1 - 3)	2		
Fatal Flaws	Potential sensitive viewers located within the 1km buffer of the proposed ADF site.		
Additional Comments	None		

120ha Site Alternative 3			
Preference	Preferred	Negotiable	Restricted
			X
Advantages	The general study area has been exposed to mining activities.		
Disadvantages	Although the area is exposed to mining activities this site is located in an area dominated by agricultural activities. The mines are located in the background of views. The site is located next to Wonderfonetin Road and motorist will be exposed to the ADF but only for a short period of time. Potential sensitive viewers located within the 1km buffer of the proposed ADF site. The proposed site includes areas with high landscape value (sensitivity) - watercourse (Streams and wetland).		
Ranking (1 - 3)	3		
Fatal Flaws	Sensitive viewers located within 1km buffer area. Viewers in this area are more sensitive since the dominant landscape character is agriculture and mining.		
Additional Comments	None		

3.6.2 RANKING OF 80HA ALTERNATIVES

80ha Site Alternative 1			
Preference	Preferred	Negotiable	Restricted
	X		
Advantages	The proposed ADF will be partially screened from viewers located in Rietkuil. This is mainly due to the exiting ADF. The proposed ADF will be partially screened from viewers travelling along the R104 Located within an area already exposed to mining activities.		
Disadvantages	The proposed alternative is located close to a local road and therefore motorist will be exposed to the new ADF, this will however only be for a short period of time. This will not be uncharacteristic since there are other mining activities located along this road. Potential sensitive viewers located within the 1km buffer of the proposed ADF site. The proposed site includes areas with high landscape value (sensitivity) - watercourse (Streams and wetland).		
Ranking (1 - 4)	1		
Fatal Flaws	Potential sensitive viewers located within the 1km buffer of the proposed ADF site.		
Additional Comments	None		

80ha Site Alternative 2			
Preference	Preferred	Negotiable	Restricted
	X		
Advantages	The proposed ADF will be partially screened from viewers travelling along the R104 Located within an area already exposed to mining activities. Although the site alternative is located close to Rietkuil, the activity will be absorbed by the existing mining activities.		

Disadvantages	The proposed alternative is located between two local roads and therefore motorist will be exposed to the new ADF, this will however only be for a short period of time. This will not be uncharacteristic since there are other mining activities located along this road. Potential sensitive viewers located within the 1km buffer of the proposed ADF site. The proposed site includes areas with high landscape value (sensitivity) - watercourse (Streams and wetland).
Ranking (1 - 4)	2
Fatal Flaws	Potential sensitive viewers located within the 1km buffer of the proposed ADF site.
Additional Comments	None

80ha Site Alternative 3			
Preference	Preferred	Negotiable	Restricted
			X
Advantages	Located within an area already exposed to mining activities.		
Disadvantages	Although the area is exposed to mining activities this site is located in an area dominated by agricultural activities. The mines are located in the background of views. The site is located next to Wonderfonetin Road and motorist will be exposed to the dump but only for a short period of time. Potential sensitive viewers located within the 1km buffer of the proposed ADF site. The proposed site includes areas with high landscape value (sensitivity) - watercourse (Streams and wetland).		
Ranking (1 - 4)	3		
Fatal Flaws	Sensitive viewers located within 1km buffer area. Viewers in this area are more sensitive since the dominant landscape character is agriculture and mining.		
Additional Comments	None		

80ha Site Alternative 4			
Preference	Preferred	Negotiable	Restricted
			X
Advantages	The general study area has been exposed to mining activities.		
Disadvantages	Although the area is exposed to mining activities this site is located in an area dominated by agricultural activities. The mines are located in the background of views. The site is located next to Wonderfonetin Road and motorist will be exposed to the ADF. Potential sensitive viewers located within the 1km buffer of the proposed ADF site. The proposed site includes areas with high landscape value (sensitivity) - watercourse (Streams and wetland).		
Ranking (1 - 4)	4		
Fatal Flaws	Sensitive viewers located within 1km buffer area. Viewers in this area are more sensitive since the dominant landscape character is agriculture and mining.		
Additional Comments	None.		

3.7 HERITAGE

The Heritage Fatal Flaw analysis has shown that the study area and surrounding area has a rich cultural and natural heritage background. The data analysis has enabled the identification of possible heritage sensitive areas that included dwellings, clusters of dwellings (homesteads and farmsteads), archaeological sensitive areas (based on historical descriptions) and structures. **The ranking is as follows (site numbers listed from most to least preferable):**

- **120ha sites: 1 and 2 (tied), 3;**
- **80ha sites: 3, 1 and 2 (tied), 4**.

3.7.1 RANKING OF 120HA ALTERNATIVES

120ha Site Alternative 1			
Preference	Preferred	Negotiable	Restricted
		X	
Advantages	The immediate 80ha zone does not appear to contain any heritage. Four possible heritage sensitive features were identified in the data analysis, within the buffer zone.		
Disadvantages	Two farmsteads and a homestead occur in the area. The farmsteads occur on the historical maps and are probably older than 60 years and therefor protected. Possibility of graves in close proximity to the buildings. These identified resources fall in the buffer area but not the footprint area. Close proximity to two working farmsteads can influence the sense of place and cultural landscape.		
Ranking (1 – 3)	1		
Fatal Flaws	None identified		
Additional Comments	It is possible cemeteries and graves will occur in the area. The presence of a cemetery around a homestead or farmstead can severely hinder development as graves are protected and a relocation process will need to take place.		

120ha Site Alternative 2			
Preference	Preferred	Negotiable	Restricted
		X	
Advantages	The immediate 80ha zone does not appear to contain any heritage. Four possible heritage sensitive features were identified in the data analysis, within the buffer zone.		
Disadvantages	Two farmsteads occur in the area. The farmsteads occur on the historical maps and are probably older than 60 years and therefor protected. Possibility of graves in close proximity to the buildings. Close proximity to working farmstead can influence the sense of place and cultural landscape.		
Ranking (1 – 3)	1		
Fatal Flaws	None identified		
Additional Comments	It is possible cemeteries and graves will occur in the area. The presence of a cemetery can severely hinder development as graves are protected and a relocation process will need to take place.		

120ha Site Alternative 3			
Preference	Preferred	Negotiable	Restricted
		X	
Advantages	The only one of the alternatives with structures located in the proposed footprint area. However, moving the position of the footprint within the buffer area can avoid the possible heritage resources.		
Disadvantages	Possible heritage sensitive features in the direct foot print area of the alternative. Nine possible heritage resources were identified in the buffer area.		
Ranking (1 – 3)	2		
Fatal Flaws	None identified		
Additional Comments	It is possible cemeteries and graves will occur in the area. The presence of a cemetery can severely hinder development as graves are protected and a relocation process will need to take place.		

3.7.2 RANKING OF 80HA ALTERNATIVES

80ha Site Alternative 1			
Preference	Preferred	Negotiable	Restricted
		X	
Advantages	The immediate 80ha zone does not appear to contain any heritage. Four possible heritage sensitive features were identified in the data analysis, within the buffer zone.		
Disadvantages	Two farmsteads and a homestead occur in the area. The farmsteads occur on the historical maps and are probably older than 60 years and therefor protected. Possibility of graves in close proximity to the buildings. These identified resources fall in the buffer area but not the footprint area. Close proximity to two working farmsteads can influence the sense of place and cultural landscape.		
Ranking (1 – 4)	2		
Fatal Flaws	None identified		
Additional Comments	It is possible cemeteries and graves will occur in the area. The presence of a cemetery around a homestead or farmstead can severely hinder development as graves are protected and a relocation process will need to take place		

80ha Site Alternative 2			
Preference	Preferred	Negotiable	Restricted
		X	
Advantages	The immediate 80ha zone does not appear to contain any heritage. Four possible heritage sensitive features were identified in the data analysis, within the buffer zone.		
Disadvantages	Two farmstead occur in the area. The farmsteads occur on the historical maps and are probably older than 60 years and therefor protected. Possibility of graves in close proximity to the buildings. Close proximity to working farmstead can influence the sense of place and cultural landscape.		
Ranking (1 – 4)	2		
Fatal Flaws	None identified		
Additional Comments	It is possible cemeteries and graves will occur in the area. The presence of a cemetery can severely hinder development as graves are protected and a relocation process will need to take place.		

80ha Site Alternative 3			
Preference	Preferred	Negotiable	Restricted
	X		
Advantages	The immediate 80ha zone does not appear to contain any heritage. Five possible heritage sensitive features were identified in the data analysis, within the buffer zone.		
Disadvantages	Possible cemeteries and a commemorative building at the northern side of the buffer zone.		
Ranking (1 – 4)	1		
Fatal Flaws	None identified		
Additional Comments	It is possible cemeteries and graves will occur in the area. The presence of a cemetery can severely hinder development as graves are protected and a relocation process will need to take place.		

80ha Site Alternative 4			
Preference	Preferred	Negotiable	Restricted
		X	
Advantages	The only one of the alternatives with structures located in the proposed footprint area. However, moving the position of the footprint within the buffer area can avoid the possible heritage resources.		
Disadvantages	Possible heritage sensitive features in the direct foot print area of the alternative. Eight possible heritage resources were identified in the buffer area.		
Ranking (1 – 4)	3		
Fatal Flaws	None identified		
Additional Comments	It is possible cemeteries and graves will occur in the area. The presence of a cemetery can severely hinder development as graves are protected and a relocation process will need to take place.		

3.8 AIR QUALITY

The wind regime for the area is dominated by easterly and north-westerly flow fields. The north-westerly wind flow is more dominant during day-time conditions, with easterly wind flow more dominant during the night. For the 120ha sites Site Alternative 3 was the least preferred site due to the small residential area of Rietkuil located downwind. Site Alternative 4 was the least preferred 80ha site for the same reason. **The ranking is as follows (site numbers listed from most to least preferable):**

- **120ha sites: 1 and 2 (tied), 3;**
- **80ha sites: 1 and 2 and 3 (all tied), 4**.

3.8.1 RANKING OF 120HA ALTERNATIVES

120ha Site Alternative 1			
Preference	Preferred	Negotiable	Restricted
		X	
Advantages	Site not located close to large residential areas		
Disadvantages	A number of sensitive receptors (individual houses) are in close proximity and downwind of the site		
Ranking (1-3)	1 (Same ranking as provided for Site Alternative 2 as same number of receptors are likely to be impacted)		
Fatal Flaws	None identified		
Additional Comments	None		

120ha Site Alternative 2			
Preference	Preferred	Negotiable	Restricted
		X	
Advantages	Site not located close to large residential areas		
Disadvantages	A number of sensitive receptors (individual houses) are in close proximity and downwind of the site.		
Ranking (1-3)	1 (Same ranking as provided for Site Alternative 1 as same number of receptors are likely to be impacted)		
Fatal Flaws	None identified		
Additional Comments	None		

120ha Site Alternative 3			
Preference	Preferred	Negotiable	Restricted
		X	
Advantages	Site not located close to large residential areas		
Disadvantages	A number of sensitive receptors (individual houses) and a small residential area (Rietkuil) are in close proximity and downwind of the site.		
Ranking (1-3)	2		
Fatal Flaws	None identified		
Additional Comments	None		

3.8.2 RANKING OF 80HA ALTERNATIVES

80ha Site Alternative 1			
Preference	Preferred	Negotiable	Restricted
		X	
Advantages	Site not located close to large residential areas		
Disadvantages	A number of sensitive receptors (individual houses) are in close proximity and downwind of the site		
Ranking (1-4)	3 (Same ranking as provided for Site Alternative 2 and Alternative 3 as same number of receptors are likely to be impacted)		
Fatal Flaws	None		
Additional Comments	None		

80ha Site Alternative 2			
Preference	Preferred	Negotiable	Restricted
		X	
Advantages	Site not located close to large residential areas		
Disadvantages	A number of sensitive receptors (individual houses) are in close proximity and downwind of the site		
Ranking (1-4)	3 (Same ranking as provided for Site Alternative 1 and Alternative 3 as same number of receptors are likely to be impacted)		

Fatal Flaws	None
Additional Comments	None

80ha Site Alternative 3			
Preference	Preferred	Negotiable	Restricted
		X	
Advantages	Site not located close to large residential areas		
Disadvantages	A number of sensitive receptors (individual houses) are in close proximity and downwind of the site		
Ranking (1-4)	3 (Same ranking as provided for Site Alternative 1 and Alternative 2 as same number of receptors are likely to be impacted)		
Fatal Flaws	None		
Additional Comments	None		

80ha Site Alternative 4			
Preference	Preferred	Negotiable	Restricted
		X	
Advantages	Site not located close to large residential areas		
Disadvantages	A number of sensitive receptors (individual houses) and a small residential area (Rietkuil) are in close proximity and downwind of the site		
Ranking (1-4)	4		
Fatal Flaws	None		
Additional Comments	None		

3.9 ENGINEERING DESIGN AND GEOTECHNICAL

The most preferred 120ha site is Alternative 1. This site has a relatively sparse vegetation cover (Cultivated land), undulating topography that facilitates effective drainage but will not jeopardise the stability of the slopes. The site location is close to the existing ash dam and power station, which has a significant financial benefit as most existing infrastructure can be used. The site also has a relatively uniform near-surface geology expected, thereby enabling the use of conventional construction methods. The second most preferred 120ha site is Alternative 2. The site has a relatively sparse vegetation cover, undulating topography facilitating effective drainage but does not jeopardise the slope stability. The site is the closest to the power station compared to all the other sites but the topography has a high ridge in the centre of the facility. This would require deep excavation trenches to ensure free draining or alternatively would require two separate water management systems which will have a large capital expenditure. Alternative 3 has a sparse vegetation cover (Cultivated land), undulating topography that facilitates effective drainage but will not jeopardise the stability of the slopes. The area has the easiest gradient and will provide a stable platform. The site location is relatively close to the power station, which has a significant financial benefit as most existing infrastructure can be used. The site also has a relatively uniform near-surface geology expected, thereby enabling the use of conventional construction methods. The site, however, is located in an undermined area and is therefore ranked as the least preferred site. The engineering team are of the opinion that more investigations should be conducted on this site to obtain the extent of the undermining activities and the impacts it could have on the proposed facility and therefore recommend to include this option as an alternative. Alternatively the option should be excluded going forward as undermining would be considered a fatal flaw from an engineering perspective.

The most preferred 80ha site is Alternative 1. This site has a relatively sparse vegetation cover (Cultivated land), undulating topography that facilitates effective drainage but will not jeopardise the stability of the slopes. The site location is close to the existing ash dam and power station, which has a significant financial benefit as most existing infrastructure can be used. The site also has a relatively uniform near-surface geology expected, thereby enabling the use of conventional construction methods. The second most preferred 80ha site is Alternative 3. This site has similar engineering advantages to Alternative 1 but is further away from the existing Ash disposal facility. The site topography should be investigated to ensure that no water will be collected on the eastern side of the facility due to a single low point (valley) formation. The site will however not be suitable for a 120Ha site. The third most preferred 80ha site is Alternative 2. The site has a relatively sparse vegetation cover, undulating topography facilitating effective drainage but does not jeopardise the slope stability. The site is the closest to the power station compared to all the other sites but the topography has a high ridge in the centre of the facility. This would require deep excavation trenches to ensure free draining or alternatively would require two separate water management systems which will have a large capital expenditure. Alternative 4 has a sparse vegetation cover (Cultivated land), undulating topography that facilitates effective drainage but will not jeopardise the stability of the slopes. The area has the easiest gradient and will provide a stable platform. The site location is relatively close to the power station, which has a significant financial benefit as most existing infrastructure can be used. The site also has a relatively uniform near-surface geology expected, thereby enabling the use of conventional construction methods. The site is potentially located in an undermined area however and is therefore ranked as the least preferred site. BEAL are of the opinion that more investigations should be conducted on this site to obtain the extent of the undermining activities and the impacts it could have on the proposed facility.

Based on the desktop study it is concluded that Alternative 1 and Alternative 3 are the most preferred sites to construct the 80Ha Ash disposal facility. Alternative 1 and Alternative 2 are the most preferred sites for the 120Ha Ash disposal facility. The rating between Alternative 1 and 1, 2 and 3 is based on the fact that Alternative 1 is located relatively close compared to the other alternatives and its topographical arrangement of the area will allow for conventional construction methods with minimal work required to obtain a stable working surface.

The ranking is as follows (site numbers listed from most to least preferable):

- **120ha sites: 1, 2, 3;**
- **80ha sites: 1, 3, 2, 4.**

3.9.1 RANKING OF 120HA ALTERNATIVES

120ha Site Alternative 1			
Preference	Preferred	Negotiable	Restricted
	X		
Advantages	• Relatively sparse vegetation cover (Cultivated land) • Undulating topography facilitating effective drainage but not jeopardising slope stability • Relatively close to existing ash dam and power station, thereby minimising ash transportation costs. • Relatively uniform near-surface geology expected, thereby enabling conventional construction methods • Sufficient space to be converted into 120Ha site.		
Disadvantages	• Existing surface water feature within 1 km buffer zone • Existing farming activities within 1 km buffer zone • Situated close to the watercourse to the South. • Existing road and high voltage electrical infrastructure within the site boundary		
Ranking (1 – 3)	1		
Fatal flaws	None identified		
Additional comments	None		

120ha Site Alternative 2			
Preference	Preferred	Negotiable	Restricted
	X		
Advantages	• Relatively sparse vegetation cover (Cultivated land) • The area has smooth slopes which can promote drainage but does not compromise slope stability • Close to existing ash dam and power station, thereby minimising ash transportation costs. • Sufficient space to be converted into 120Ha site.		
Disadvantages	• Existing farming activities within 1 km buffer zone • Power transmission lines runs through the site • The topographical arrangement has a single high point in the centre of facility which pose potential challenges with effectively draining the facility. This could either require deep excavations with high volume earthworks or two separate drainage systems which will double the implementation cost as well as maintenance costs • Watercourse to the south of the facility		
Ranking (1 – 3)	2		
Fatal flaws	None		
Additional comments	None		

120ha Site Alternative 3			
Preference	Preferred	Negotiable	Restricted
			X
Advantages	• Relatively sparse vegetation cover (Cultivated land) • The area has smooth slopes which can promote drainage but does not compromise slope stability • Close to existing ash dam and power station, thereby minimising ash transportation costs. • Sufficient space to be converted into 120Ha site. • Topographically flat which is ideal for overall stability of the facility • Not close to any watercourses		
Disadvantages	• Potential undermining activities (to be investigated) • Existing farming activities within 1 km buffer zone		
Ranking (1 – 3)	3 (Could be raked as 1 but further investigations would be required)		
Fatal flaws	Potential undermining can trigger a fatal flaw and should be investigated		
Additional comments	None		

3.9.2 RANKING OF 80HA ALTERNATIVES

80ha Site Alternative 1			
Preference	Preferred	Negotiable	Restricted
	X		
Advantages	• Relatively sparse vegetation cover (Cultivated land) • Undulating topography facilitating effective drainage but not jeopardising slope stability • Relatively close to existing ash dam and power station, thereby minimising ash transportation costs. • Relatively uniform near-surface geology expected, thereby enabling conventional construction methods • Sufficient space to be converted into 120Ha site.		

Disadvantages	• Existing surface water feature within 1 km buffer zone • Existing farming activities within 1 km buffer zone • Situated close to the watercourse to the South. • Existing road and high voltage electrical infrastructure within the site boundary
Ranking (1 – 4)	1
Fatal flaws	None identified
Additional comments	None

80ha Site Alternative 2			
Preference	Preferred	Negotiable	Restricted
	X		
Advantages	• Relatively sparse vegetation cover (Cultivated land) • The area has smooth slopes which can promote drainage but does not compromise slope stability • Close to existing ash dam and power station, thereby minimising ash transportation costs. • Sufficient space to be converted into 120Ha site.		
Disadvantages	• Existing farming activities within 1 km buffer zone • Power transmission lines runs through the site • The topographical arrangement has a single high point in the centre of facility which pose potential challenges with effectively draining the facility. This could either require deep excavations with high volume earthworks or two separate drainage systems which will double the implementation cost as well as maintenance costs • Watercourse to the south of the facility		
Ranking (1 – 4)	3		
Fatal flaws	None identified		
Additional comments	None		

80ha Site Alternative 3			
Preference	Preferred	Negotiable	Restricted
	X		
Advantages	• Relatively sparse vegetation cover (Cultivated land) • Undulating topography facilitating effective drainage but not jeopardising slope stability • Relatively close to existing ash dam and power station, thereby minimising ash transportation costs. • Relatively uniform near-surface geology expected, thereby enabling conventional construction methods • No road and high voltage electrical infrastructure within the site boundary		
Disadvantages	• Existing surface water feature within 1 km buffer zone • Existing farming activities within 1 km buffer zone • Situated close to the watercourse to the West. • Topographical arrangement indicates a single low point (valley) which can be beneficial to drainage but due to the upstream collection of water it is not recommended as large water diversion structures will be required to eliminate the risk of water collecting to the east of the proposed facility.		
Ranking (1 – 4)	2		
Fatal flaws	None		
Additional comments	Note that this site is not suitable to accommodate the 120Ha size and should also be considered for project timelines.		

80ha Site Alternative 4			
Preference	Preferred	Negotiable	Restricted
		X	
Advantages	• Relatively sparse vegetation cover (Cultivated land) • The area has smooth slopes which can promote drainage but does not compromise slope stability • Close to existing ash dam and power station, thereby minimising ash transportation costs. • Sufficient space to be converted into 120Ha site. • Topographically flat which is ideal for overall stability of the facility • Not close to any watercourses		
Disadvantages	• Potential undermining activities • Existing farming activities within 1 km buffer zone		
Ranking (1 – 4)	4 (Could be raked as 1 but further investigations would be required)		
Fatal flaws	Potential undermining can be a fatal flaw and should be investigated		
Additional comments	None		

4 PREFERRED SITES AND CONCLUSION

Comparative assessment tables summarizing the specialist input and rating for each site is provided in **Table 3** and **Table 4**.

Table 3: Comparison of 120ha site alternatives showing preference for the site alternatives as well as ranking for each study (1 = most preferred, 5 = least preferred)

120HA	Alternative 1	Alternative 2	Alternative 3
Ecology	*3*	*1*	*2*
	Negotiable	*Preferred*	*Negotiable*
Soils	3	2	1
	Negotiable	*Negotiable*	*Preferred*
Aquatic Ecology	*2*	*1*	*3*
	Negotiable	*Preferred*	*Restricted*
Surface Water	*2*	*1*	*3*
	Negotiable	*Preferred*	*Negotiable*
Ground Water	*2*	*3*	*1*
	Negotiable	*Negotiable*	*Negotiable*
Heritage	1	1	2
	Negotiable	*Negotiable*	*Negotiable*
Visual	1	2	3
	Preferred	*Preferred*	*Restricted*
Air Quality	*1*	*1*	*2*
	Negotiable	*Negotiable*	*Negotiable*

Engineering Design and Geotech	*1*	*2*	*3*
	Preferred	*Preferred*	*Restricted*

Table 4: Comparison of 80ha site alternatives showing preference for the site alternatives as well as ranking for each study (1 = most preferred, 5 = least preferred)

80HA	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Ecology	*4*	*1*	*2*	*3*
	Negotiable	*Preferred*	*Negotiable*	*Negotiable*
Soils	4	2	3	1
	Negotiable	*Negotiable*	*Negotiable*	*Preferred*
Aquatic Ecology	*2*	*1*	*3*	*4*
	Preferred	*Preferred*	*Negotiable*	*R*
Surface Water	*2*	*1*	*4*	*3*
	Negotiable	*Preferred*	*Negotiable*	*Negotiable*
Ground Water	*4*	*2*	*1*	*3*
	Negotiable	*Negotiable*	*Preferred*	*Negotiable*
Heritage	1	2	2	2
	Negotiable	*Negotiable*	*Negotiable*	*Negotiable*
Visual	1	2	3	4
	Preferred	*Preferred*	*Restricted*	*Restricted*
Air Quality	*1*	*1*	*1*	*2*
	Negotiable	*Negotiable*	*Negotiable*	*Negotiable*
Engineering Design and Geotech	*1*	*3*	*2*	*4*
	Preferred	*Preferred*	*Preferred*	*Negotiable*

As indicated by **Table 3**, the preferred 120ha site nominated for consideration in a Scoping and EIA process is therefore, in order of preference from most preferred to least preferred:

- Site Alternative 2 (most preferred);
- Site Alternative 1;
- Site Alternative 3 (least preferred).

As indicated by **Table 4**, the preferred 80ha site nominated for consideration in a Scoping and EIA process is therefore, in order of preference from most preferred to least preferred:

- Site Alternative 2 (most preferred);
- Site Alternative 1;
- Site Alternative 3;
- Site Alternative 4 (least preferred).

Site Alternative 2 (120ha option) and **Site Alternative 2 (80ha option)** are nominated as the most preferred options for consideration in a scoping and EIA process. Site Alternative 1 (120ha) and Site Alternative 1 (80ha) are nominated as the second most preferred options.

The main reasons for the rankings are listed below:

- Potential undermining at Alternative 4 (80ha site) and Alternative 3 (120ha site) could be a fatal flaw and should be investigated if this option is considered further (or alternatively these sites should be excluded going forward);
- A portion of the 1km radius for Site Alternative 3 (120ha option) and Alternative 4 (80ha option) is situated within a **Freshwater Ecosystem Priority Area** and a highly significant aquatic biodiversity sub-catchment based on the Mpumalanga Biodiversity Conservation Plan. This alternative has the highest extent of temporal/seasonal and seasonal/permanent wetland areas;
- Site Alternative 4 (80ha) has the highest extent of temporary / seasonal and seasonal / permeant wetland areas. Alternative 4 has a higher landcover associated with grassland when compared to the other alternatives. Furthermore, this alternative is situated more than 3km from the existing Arnot ash disposal facility will require more extensive supporting infrastructure which may have a greater impact on the surrounding wetland areas.
- Alternative 3 and 4 (both 80ha and 120ha options) is situated upstream of the Grootpan, Leeuwpan, Rietpan, Klippan and Blinkpan. Any spillages originating from the Alternative 4 would have a negative effect on the downstream pans;
- All sites have wetland features within the 1 km buffer zone however Site Alternative 3 (80ha) also contains wetland features within the current proposed ash disposal facility footprint area;
- Topographical arrangements at Site Alternative 3 (80ha) indicate a single low point (valley) which can be beneficial to drainage but due to the upstream collection of water it is not recommended as large water diversion structures will be required to eliminate the risk of water collecting to the east of the proposed facility;
- Site Alternative 2 is located close to the existing ash disposal facility, therefore consolidating impacts within a single area within the broad study area; and
- A large proportion of Site Alternative 2 is already transformed by cultivation.

Minor adjustments (within the 1km buffer zone) may still be made to any of the preferred site locations, if required, in order to avoid certain properties or to avoid existing infrastructure on the sites. A site visit and ground-truthing exercise was undertaken by EIMS on Friday 19 January 2018. Although access to Site Alternatives 1 and 2 was not possible the sites were surveyed from a distance. No major issues or red flags were noted however a 132kV power line does appear to traverse both Alterative 1 and Alternative 2 sites (**Figure 25**). If either of these sites are ultimately chosen it may be necessary for Eskom to either relocate this power line or alternatively shift the location of the facility to avoid the power line within the 1km buffer zone. No other obvious or significant issues with any of the sites were noted during the site visit.

Figure 25: View west from dirt road toward Arnot Power Station (RHS) and Alternative 1 and 2 sites (LHS) with 132kV power line visible traversing both Alternative 1 and Alternative 2 sites.

Further potential significant issues with Site Alternative 2 have been highlighted from an engineering and design perspective and these are listed below:

- Existing farming activities occur within the 1 km buffer zone;
- The topographical arrangement has a single high point in the centre of facility which poses potential challenges with effectively draining the facility. This could either require deep excavations with high volume earthworks or two separate drainage systems which will double the implementation cost as well as maintenance costs; and
- There is a watercourse to the south of the facility.

Overall **Site Alternative 2** is still considered the best site from an overall environmental and engineering design perspective and no fatal flaws or major concerns have been identified with the site at this stage.

The following farm portions fall within the area identified for Alternative 2 (for both 80ha and 120ha options) as the associated buffer zone:

- Farm 164: portions 22 and 28;
- Farm 166: portions 1 and 6; and
- Farm 491: portions 27 and 32.

5 WAY FORWARD

A high-level concept design for each of the 120ha and 80ha alternative sites will be conducted by the engineering design team. This activity will involve modelling of the feasibility of the sites and therefore comparing operating costs versus the capital expenditure. A decision will therefore be made on whether to consider the 80ha or 120 ha sites for inclusion in a scoping and EIA process. From the outcomes of the scoping phase report a single preferred site will be taken forward for detailed consideration in the EIA phase.

6 REFERENCES

Cilliers, J.P. 2010. Phase 1 Archaeological Impact Assessment for Enpact Environmental Consultants concerning the proposed Elandshoek township development on portions 2 and 6 of the farm Lindenau 303 JT and portion 2 of Berlin 466 JT, Mpumalanga Province. Kudzala Antiquity.

Collett, D.P. 1982. Excavations of Stone-Walled Ruin Types in the Badfontein Valley, Eastern Transvaal, South Africa. The South African Archaeological Bulletin Vol. 37, No. 135 (Jun., 1982), pp. 34-43 Published by: South African Archaeological Society. Article Stable URL: http://www.jstor.org/stable/3888578

Crawford, D., 1994. Using remotely sensed data in landscape visual quality assessment. Landscape and Urban Planning. 30: 71-81.

Delius, P and Hay, M. 2009. Mpumalanga: An Illustrated History. The Highveld Pres

Delius, Peter (ed). 2007. Mpumalanga: History and Heritage. University of Kwa-Zulu Natal Press.

DWAF. (1995). Quaternary Catchment Boundaries of South Africa. Department of Water Affairs and Forestry, Pretoria, South Africa.

DWS. (2014). A Desktop Assessment of the Present Ecological State, Ecological Importance and Ecological Sensitivity per Sub Quaternary Reaches for Secondary Catchments in South Africa. Secondary: B1. Compiled by RQIS-RDM: https://www.dwa.gov.za/iwqs/rhp/ eco/peseis model. aspx accessed during August 2016.

Esterhuysen, A and Smith, J. 2007. Stories in Stone. Chapter 2 in Mpumalanga: History and Heritage.

Evers, T.M. 1975. Recent Iron Age Research In The Eastern Transvaal, South Africa. In The South African Archaeological Bulletin, Vol. 30, No. 119/120 (Dec., 1975), pp. 71-83. South African Archaeological Society Stable URL: http://www.jstor.org/stable/3888096 Accessed: 03/05/2012 08:54

Ferrrar, A., & Lötter, M.C. (2007). Mpumalanga Biodiversity Conservation Plan Handbook. Nelspruit: Mpumalanga Tourism and Parks Agency.

Fourie, W. 2008a. Archaeological Impact Assessment: Northern Coal Portion 15 and 16 of the farm Weltevreden 381 JT, Belfast, Mpumalanga. PGS.

Fourie, W. 2008b. Archaeological Impact Assessments within South African Legislation. South African Archaeological Bulletin 63 (187): 77–85, 2008

Fourie, W. 2009. Arnot Colliery Mine Project of Exxaro On Portions 4 and 5 of the farm Mooifontein 448 JS and Portions 3 And 4 of the farm Tweefontein 458 JS , District Middelburg, Mpumalanga

Fourie, W. 2016. Heritage Assessment - The Kwagga North Project, Optimum Coal, Arnot, Mpumalanga.

Geological Survey, 1984. 1: 1 million scale geological map of South Africa. Department of Mineral and Energy Affairs, Pretoria.

Hull, R.B. & Bishop, I.E., 1988. Scenic Impacts of Electricity Transmission Towers: The Influence of Landscape Type and Observer Distance. Journal of Environmental Management. 27: 99-108.

Institute of Environmental Assessment & The Landscape Institute, 1996. Guidelines for Landscape and Visual Impact Assessment, E & FN Spon, London (117)

Ittelson, W.H., Proshansky, H.M., Rivlin, L.g. and Winkel, G.H., 1974. An Introduction to Environmental Psychology. Holt, Rinehart and Winston, New York.

Jooste, C.P. 2002. Anglo-Boer War Battles: The Battle Of Bergendal - The Last Pitched Battle Of The Anglo-Boer War. Military History Journal Vol 12 No 4 - December

Jooste, C.P. 2008. Machadodorp tot en met dorpstigting in 1904 (Afrikaans), MA dissertation, University of Pretoria, Pretoria, viewed 120501 http://upetd.up.ac.za/thesis/available/etd-11132008-124230

Kitto, J. 2012. Exxaro Paardeplaats Project Heritage Impact Assessment Report

Kitto, J. 2015. Proposed expansion of existing mining area into portion re of the farm Roetz 210 IS, Jagtlust Colliery, near Carolina, Albert Luthuli Local Municipality, Gert Sibande District Municipality, Mpumalanga Province .

Koch, F.G.L., 1987. Climate data. In: Land types of the maps 2526 Rustenburg and 2528 Pretoria. Mem. Agric. nat. Res. S. Afr. No. 8. Department of Agriculture and Water Supply, Pretoria.

Lange, E., 1994. Integration of computerized visual simulation and visual assessment in environmental planning. Landscape and Environmental Planning. 30: 99-112.

Lynch, K., 1992. Good City Form, The MIT Press, London. (131)

Macfarlane, D., von Hase, A. & Brownlie, S. (2012). Towards the Best-practise for Wetland Offsets in

MacVicar, C.N., de Villiers, J.M., Loxton, R.F, Verster, E., Lambrechts, J.J.N., Merryweather, F.R., le Roux, J., van Rooyen, T.H. & Harmse, H.J. von M., 1977. Soil classification. A binomial system for South Africa. ARC-Institute for Soil, Climate & Water, Pretoria.

Maggs, T. 1995. Neglected Rock Art: The Rock Engravings of Agriculturist Communities in South Africa Reviewed work(s): Source: The South African Archaeological Bulletin, Vol. 50, No. 162 (Dec.), pp. 132-142 Published by: South African Archaeological Society Stable URL: http://www.jstor.org/stable/3889062. Accessed: 01/05/2012 01:40

Mason, R.J. 1968. Transvaal and Natal Iron Age settlement revealed by aerial photography and excavation. African Studies 27: 167-179.

Morris, D. 2008. Archaeological and Heritage Impact Assessment on Remainder of Carter Block 458, near Lime Acres, Northern Cape. McGregor Museum.

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

Nel, J., Maree, G., Roux, D., Moolman, J., Kleynhans, N., Sieberbauer, M., & Driver, A. (2004). South African National Spatial Biodiversity Assessment. Technical Report, Volume 2. Sanbi. on 28 November 2008.

Nel, J.L., Driver, A., Strydom, W.F., Maherry, A., Petersen, C., Hill, L., Roux, D.J., Nienaber, S., van Deventer, H., Swartz, E., & Smith-Adao, L.B. (2011). Atlas of Freshwater Ecosystem Priority Areas in South Africa: Maps to support sustainable development of water resources. WRC Report No. TT 500/11.

Oberholzer, B., 2005. Guideline for involving visual & aesthetic specialists in EIA processes: Edition 1. CSIR Report No ENV-S-C 2005 053 F. Republic of South Africa, Provincial Government of the Western Cape, Department of Environmental Affairs & Development Planning, Cape Town.

Pakenham, T. 1979. The Boer War. Jonathan Ball Paperbacks. Johannesburg

Pelser, A. 2012. A report on a heritage assessment for the proposed Arnot-Gumeni 400 kv powerline project, in the Middelburg/Belfast area, Mpumalanga Province

Pistorius, J. C. C. 2004. A Heritage Impact Assessment (HIA) study for the proposed New Optimum Colliery on the farm Schoonoord 164IS in the Mpumalanga Province of South Africa

Pistorius, J. C. C. 2014. A phase I Heritage Impact Assessment (HIA) study for the consolidated Environmental Management Programme report (consolidated EMPR) for Arnot Coal on the eastern highveld in the Mpumalanga Province .

Pistorius, J. C. C. 2014. A revised phase I Heritage Impact Assessment (HIA) study for the proposed Rietvlei open cast coal mining operation between Middelburg, Belfast and Stofberg in the Mpumalanga province of South Africa.

Ramsay, J. (October 1993), Identification and assessment of aesthetic values in two Victorian forest regions. More than meets the eye: identifying and assessing aesthetic value. Report of the Aesthetic Value Workshop held at the University of Melbourne.

Sama, J. (2000), Program Policy, Assessing and Mitigating Visual Impact, Department of Environmental Conservation. New York.

Schapper, J. (October 1993), The importance of aesthetic value in the assessment of landscape heritage. More than meets the eye: identifying and assessing aesthetic value. Report of the Aesthetic Value Workshop held at the University of Melbourne.

Schoeman, J.L. & van der Walt, M., 2004. Overview of the status of the agricultural natural resources of South Africa. Report No.

Schoeman, J.L., Meldal-Johnson, A., Fitzpatrick, R.W. & Verster, E., 1985. Land type map 2528 Pretoria. Agricultural Research Council, Pretoria.

South Africa. SANBI. The SANBI Grasslands Project.

van Schalkwyk, J 2007. Heritage Impact Scoping Report for the Planned Hendrina-Marathon Power line, Mpumalanga Province

Walmsley, B., & Tshipala, K. E. (2007). Handbook on Environmental Assessment Legislation in the SADC Region. Midrand: The Development Bank of South Africa in collaboration with the South African Institute for Environmental Assessment.

Warnock, S. & Brown, N., 1998. Putting Landscape First. Landscape Design. 268: 44-46.