Metago

HENDRINA ASH DAM EXTENSION

GROUNDWATER SCOPING REPORT

Prepared For

Lidwala Consulting Engineers

METAGO PROJECT NUMBER: WGC130

REPORT NO. 01

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HENDRINA ASH DAM EXTENSION GROUNDWATER SCOPING REPORT

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ACRONYMS AND ABBREVIATIONS

Below is a list of acronyms and abbreviations used in this report.

Acronyms / Abbreviations	**Definition**
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
MBGL	Metres below ground level
Mg/L	Milligrams per litre
SWL	Static water level
TDS	Total dissolved solids

EXECUTIVE SUMMARY

This Groundwater report was undertaken and compiled by Metago Water Geosciences in their capacity as groundwater specialists. Following a pre-screening phase assessment of the area around Eskom's Hendrina Power Station, an interim groundwater vulnerability map was produced. As a result of the pre-screening phase study, five sites close to the existing Hendrina ash dam have been suggested as suitable sites for the proposed ash dam extension. This Scoping Phase report considers the five sites from a groundwater perspective, and ranks them in terms of their estimated impact on groundwater resources in the area. The work relies on two field visits to Hendrina power station, a review of existing data, and the development of a conceptual groundwater model for the vicinity of the existing ash dam. All five sites for the ash dam extension fall into the same DWA hydrogeological classification (i.e. D2: Intergranular and fractured aquifers with borehole yields between 0.1 - 0.5 L/s), and on the same geological formation (Vryheid Formation). Proximity to surface water resources and mine workings (potential receivers of leachate from the ash dam), proximity to the existing ash disposal dam and topographic setting were therefore regarded as the most important factors in distinguishing one site from another.

According to the available data, site 1 is the preferred site. The site is not within any surface water buffer zone and additionally in close proximity to the existing active ash storage facility. While the hydrogeological setting of site 2 is very similar, it is less preferred due to its potential impacts on two water courses in close proximity.

While sites 3 and 4 fall partially within the 250 m buffer zone around surface water features, sites 4 and 5 are in close proximity to mine voids and sites 3 to 5 therefore not preferred.

1 INTRODUCTION

1.1 BACKGROUND

This groundwater specialist input is made for the Scoping Phase of the Environmental Impact Assessment for the proposed expansion of ash disposal facilities at Eskom's Hendrina power station, situated about 40 km south of Middelburg in Mpumalanga Province. As part of Eskom's plans to ensure continous electrical power supplies in years to come, Hendrina power station requires additional ash disposal facilities. The power station is expected to produce approximately 64.2 million m^3 of ash between now and the end of its estimated life span in 2035. Current ash disposal facilities (ash dams 3 and 5) will only last another five or so years. Hendrina power station uses a wet ashing facility (ash is pumped to the ash disposal facility as a slurry), incorporating ash water dams, pipelines, stormwater trenches, seepage water collection systems, pump stations and seepage dams.

1.2 HYDROGEOLOGY

Hendrina power station and surrounds is located on coal-bearing rocks of the Vryheid Formation, part of the lower Karoo Supergroup. These rocks are principally deltaic and fluvial siltstones and mudstones, with subordinate sandstones (Johnson et al, 2006). The coal seams originated as peat swamps, or similar environments. Where the Dwyka Group is absent (suspected in the study area), the Vryheid Formation has been deposited directly onto rugged pre-Karoo topography, and the thickness of the Formation can be quite variable as a result. The Vryheid Formation rocks are well lithified (hard) and have little primary porosity. Groundwater storage and transport in the unweathered Vryheid Formation is likely to be mainly via fractures, bedding planes, joints and other secondary discontinuities. The success of a water supply borehole in these rocks depends on whether one or more of these structures are intersected. In general the Vryheid Formation is considered to be a **minor aquifer**, with some abstractions of local importance. Relatively minor outcrops of the Rooiberg and Quaggasnek Formations that underlie the Vryheid Formation are also found in the study area.

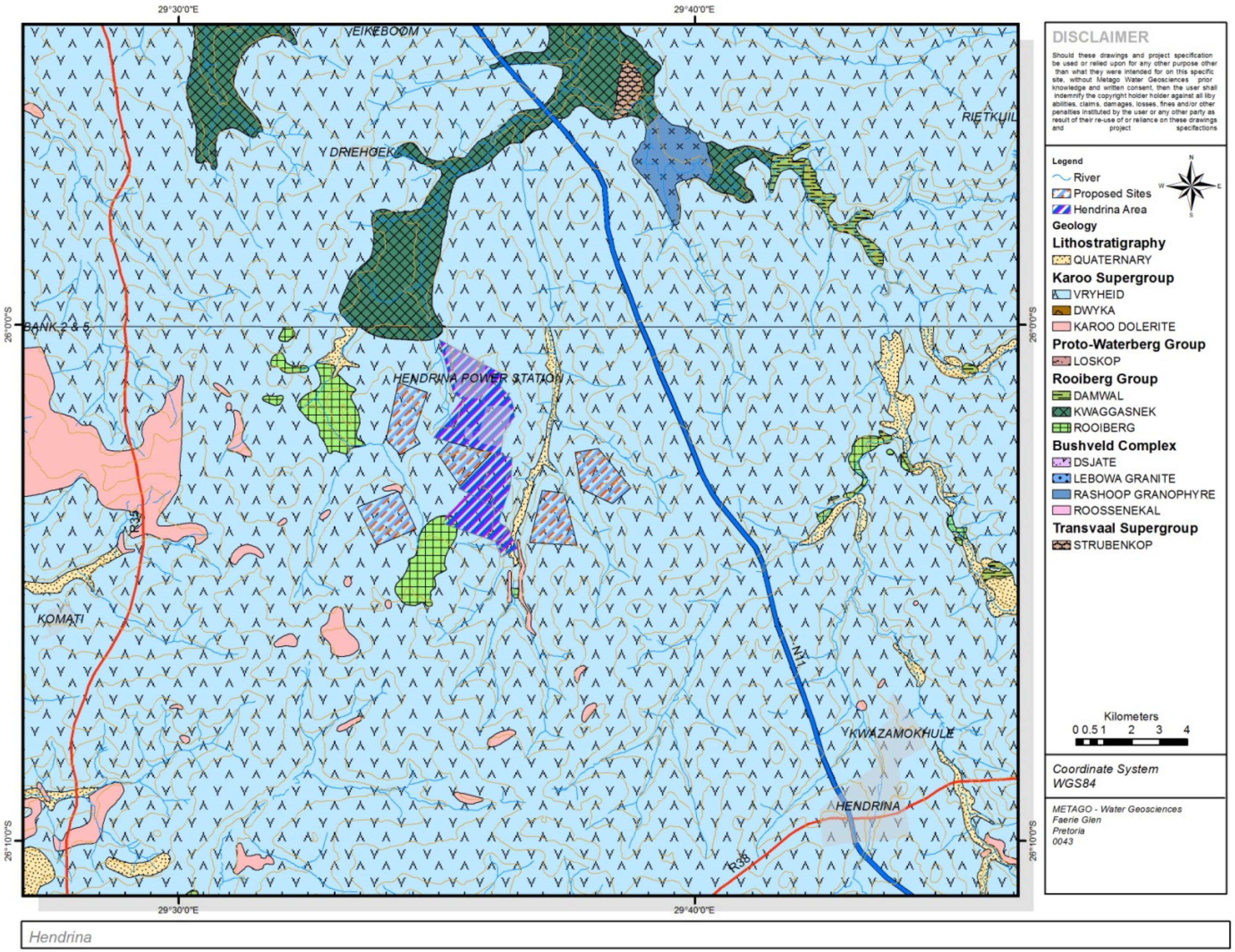

FIGURE 1.1: GEOLOGY MAP OF THE HENDRINA AREA

1.3 PRE-SCREENING PHASE GROUNDWATER STUDY

Pre-screening phase groundwater study

A sensitivity analysis was completed for the pre-screening stage of the EIA process, and an interim groundwater vulnerability map was produced allowing a basic distinction to be made between more and less favourable areas for the siting of the proposed ash dump at Hendrina power station. This map was based on the hydrogeological map classification of the area within 8 km of the power station, combined with a 250 m buffer zone placed around surface water features as the receiving environment of potential groundwater pollution. This allowed three zones (lower, medium and higher sensitivity) to be defined within the 8 km buffer zone, as shown in Table 1.1 below:

TABLE 1.1 SENSITIVITY CLASSIFICATIONS USED IN THE PRE-SCREENING PHASE STUDY

	Description
Lower Sensitivity	Areas falling outside of the 250 m buffer around surface water features, and outside of the area classified as "D3" (higher borehole yields) on the general hydrogeology map series (GRA1 data)
Medium Sensitivity	Areas falling within the area classified as D3, but still outside of the 250 m surface water buffer zone.
Higher Sensitivity	Those areas within the 250 m surface water buffer zone.

2 SCOPE AND LIMITATIONS

This study is limited to a consideration of groundwater and hydrogeology in the vicinity of Hendrina power station. Two field visits (the second to measure water levels and electrical conductivity in boreholes) have been made, but this study also relies on available published information about the geology and hydrogeology of the area. It is assumed that the available data is correct in its representation of the groundwater conditions in the area. This document does not evaluate the existing groundwater monitoring and management programme at Hendrina; it is assumed that this is in line with best practice (see DWA, 2008 for more information).

3 METHODOLOGY

3.1 DESCRIPTION OF THE METHODOLOGY/IES USED.

Information gained from a site visit was combined with a review of available literature and available data sources to form a conceptual model of groundwater occurrence in the vicinity of Hendrina power station. The five sites were then evaluated against the conceptual model, to arrive at an estimate of their relative impacts on local groundwater resources.

The DWA Best Practice Guideline – Water Management for Mine Residue Deposits (DWA, 2008) suggests that the groundwater impacts of a mine residue deposit (MRD, also applicable to an ash disposal facility) should be identified before a final site is chosen. Suggested criteria (DWA, 2008) include:

- The impact on downstream water users
- Impacts on sensitive or protected areas
- Impacts on any open-cast or underground workings, shafts or occupied premises; the stability of the underground/excavated workings can be affected by possible seepage and the mass of the MRD,
- Effects of seepage on dam stability, and/or
- Groundwater quality impacts.

These factors and others have been considered in this study.

3.2 SUMMARY OF EXISTING DATA

The Department of Water Affairs (DWA) have produced a series of 1:500 000 scale hydrogeology maps (General Hydrogeology Map Series), together covering the whole of South Africa. Analysis of median borehole yields and aquifer types has allowed DWA to classify the hydrogeology of the country according to an alphanumeric code incorporating aquifer type and borehole yield, as follows:

TABLE 3.1 GENERAL HYDROGEOLOGY MAP CLASSIFICATION OF SOUTH AFRICA

Aquifer Type	**Borehole Yield Class (L/s)**				
	Class "1" 0 - 0.1	Class "2" 0.1 - 0.5	Class "3" 0.5 - 2.0	Class "4" 2.0 - 5.0	Class "5" >5.0
Type "a": Intergranular	A1	A2	A3	A4	A5
Type "b": Fractured	B1	B2	B3	B4	B5
Type "c": Karst	C1	C2	C3	C4	C5
Type "d": Intergranular and fractured	D1	D2	D3	D4	D5

The area within an 8 km radius of the Hendrina site is almost all classified as "D2". The small outcrop of the Quaggasnek Formation in the NW of the study area appears to be the reason for the small area classified as "D3" on the general hydrogeology map series.

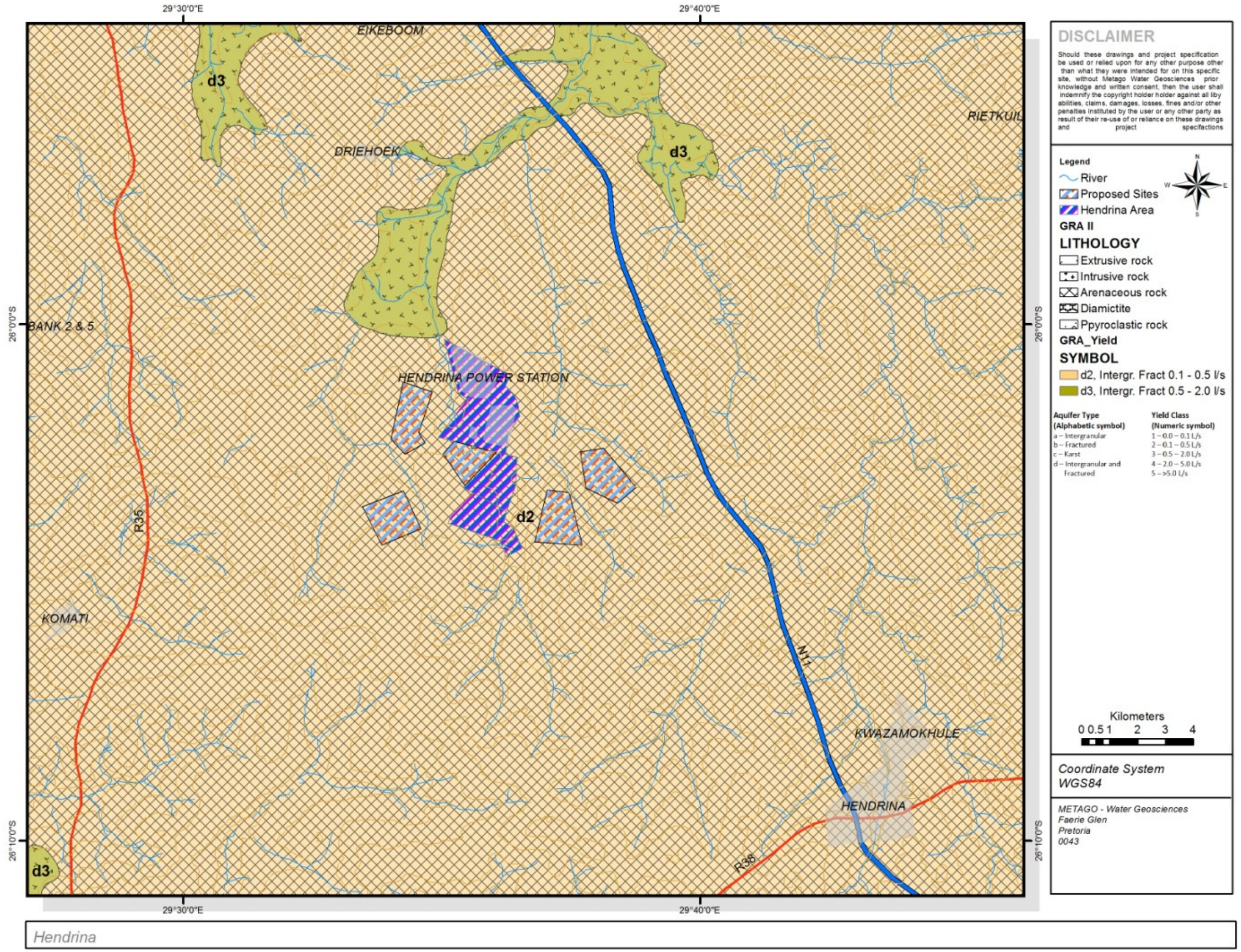

FIGURE 3.1: HYDROGEOLOGY MAP OF THE HENDRINA AREA

A number of databases including the National Groundwater Database (NGDB), data from the Water Management System (WMS), maps published for the Groundwater Resource Assessment Phase I (GRA I) project, data from the Groundwater Resource Assessment Phase II (GRA II) project and information on water-use registrations obtained from the WARMS (Water Authorisation and Resource Management System) dataset managed by the Department of Water Affairs (DWA) were consulted for this study. The type of data collated included borehole yield estimates, groundwater level and groundwater chemistry data, as well as information on aquifer characteristics and exploitation potential.

From the NGBD, there are only 3 boreholes available within close proximity of the site (with one of the borehole within the 8km radius). Most of the data sourced from the database, plots far from the site (Figure 3.2). No rates of abstraction were recorded. Highly elevated concentration of sulphate (SO_4) was recorded for the Optinum borehole (Table 3.2).

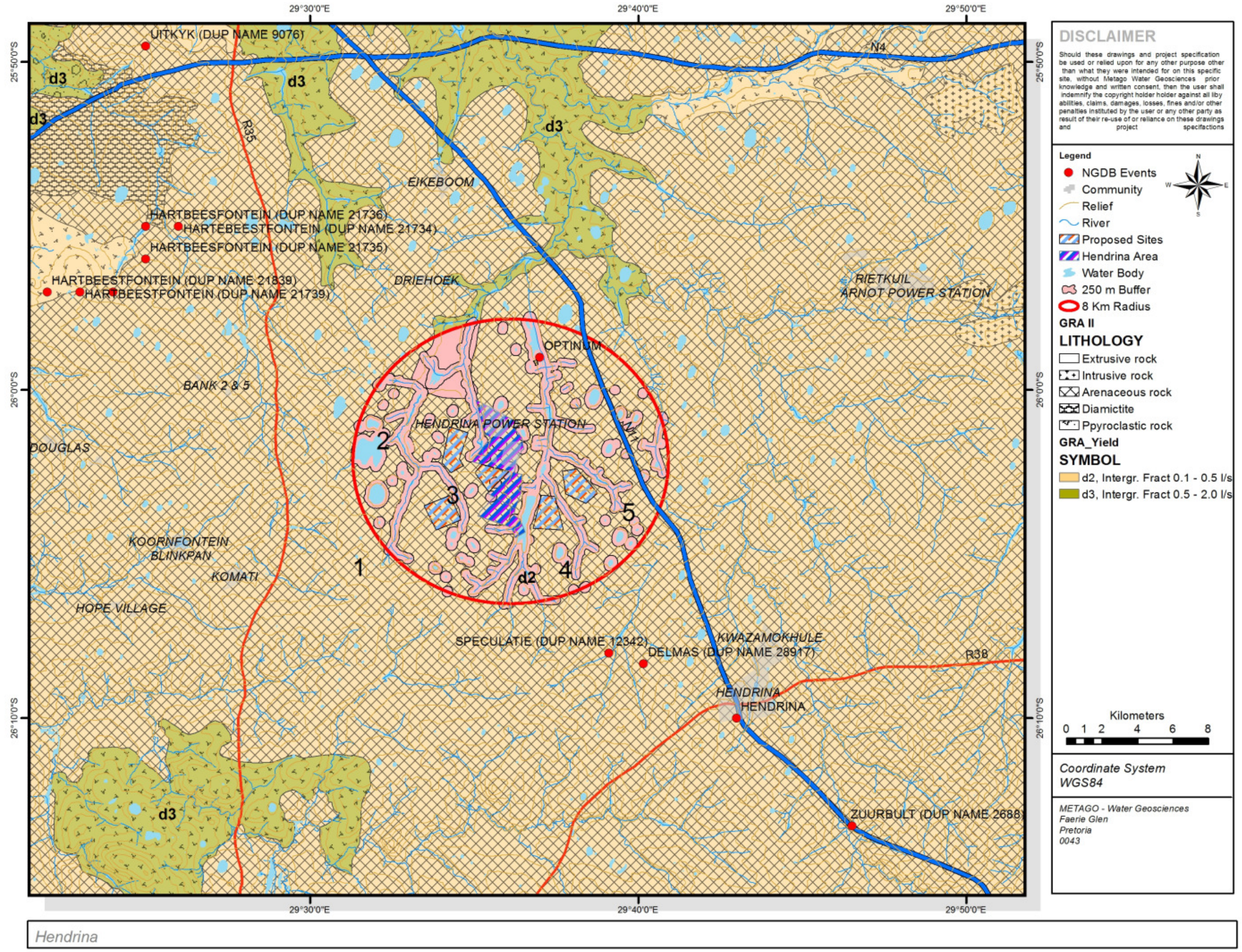

FIGURE 3.2: MAP OF AVAILABLE BOREHOLES (NGBD, 2011).

TABLE 3.2: GROUNDWATER CHEMISTRY RESULTS (IN MG/L) FOR THE HENDRINA POWER STATION AREA (NGBD, 2011)

BH name	pH	HCO_3	Ca	Cl	EC	F	K	Mg	NH4-N	NO3 as N	Na	PO_4	SO_4	Si
SPECULATIE	8.2	138.9	10.9	6.6	35.2	0.05	1.21	34.7	0.6	9.1	4.3	0.003	2	10.14
OPTINUM	7.9	189.2	175.7	3	180	0.6	14.5	164.2	0.05	1.26	6.6	0.059	919.1	2.31
DELMAS	8.09	139.4	24.6	3.6	28	1.12	2.14	20.4	0.02	0.195	6.9	0.011	8.6	7.28

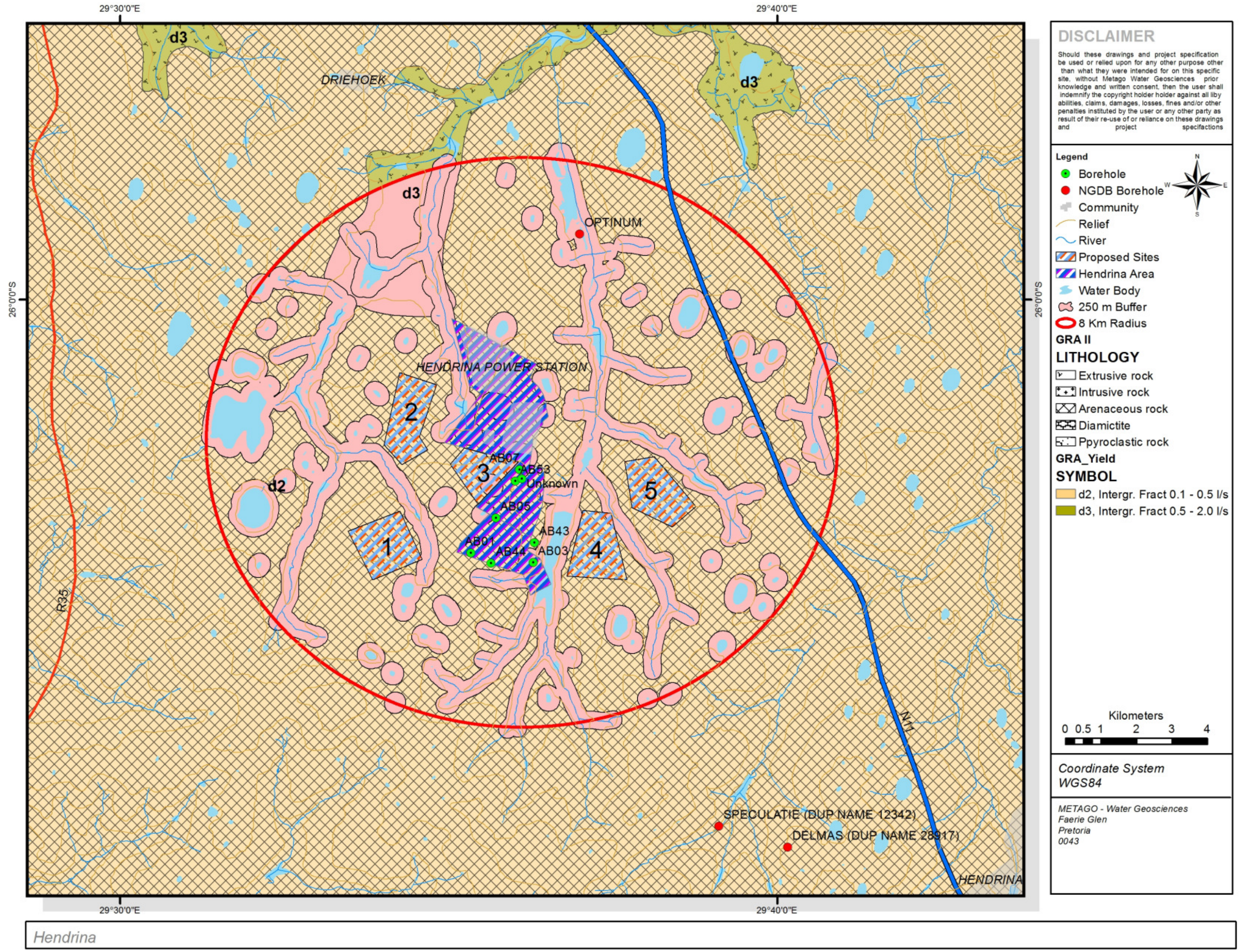

FIGURE 3.3: MAP OF THE AVAILABLE POWER STATION BOREHOLES AND NGDB BOREHOLES.

A field visit was undertaken on 21 April 2010 in order to inspect the Hendrina power station site, identify potential receiving environments (e.g. wetlands, water sources) (where possible) and take groundwater level measurements and electrical conductivity readings where accessible boreholes allowed. Information from the field visit was combined with the desktop study using existing datasets to develop a conceptual model of groundwater occurrence in the vicinity of the site. Based on the conceptual model, possible groundwater issues of concern were identified, and management actions proposed. Possible sources, pathways and receptors of groundwater contamination were considered.

The boreholes are shown in Table 3.3 and Figure 3.3

TABLE 3.3 BOREHOLES VISITED ON 21 APRIL 2011

Borehole	**Latitude**	**Longitude**	**SWL (mbgl)**	**EC (uS/cm)**	**T (°C)**
AB07	26.04323	29.60143	1.61	973	19.4
AB53	26.04611	29.60033	1.04	135	19.1
AB44	26.06693	29.59417	2.25	149	19.1
AB03	26.06678	29.60485	0.52	1841	17.6
AB43	26.06175	29.60519	9.53	1083	17.1
Unknown	26.04552	29.60198	2.25	164	18.5
AB05	26.05547	29.59538	0.36	294	18.5
AB01	26.06432	29.58906	3.28	306	18.2

The study area is located in quaternary catchment B12B, within the Olifants Water Management Area. The Groundwater Harvest Potential Map of South Africa (Baron et al, 1998) classifies the study area as having an estimated groundwater harvest potential of 10 000 to 15 000 m^3/km^2/year (i.e. relatively low). The average borehole yield is > 0.4 litres per second (L/s), and the total dissolved solids concentration of the (unpolluted) groundwater is between 200 and 300 mg/l (i.e. relatively fresh). No major groundwater abstractions are shown on the DWA 1:500 000 scale hydrogeology map of the area (Sheet 2526 Johannesburg). The GRA2 data for the quaternary catchment B12B is summarized in Table 3.4 below:

TABLE 3.4 GRA2 DATA SUMMARY FOR B12B

QUATERNARY CATCHMENT	**B12B**
Area (km^2)	658.5
Average water level (metres below ground level)	8.7
Volume of water in aquifer storage (Mm^3/km^2)	467.7
Specific Yield	0.003
Harvest Potential (Mm^3/a)	14.6
Contribution to river base flow (Mm^3/a)	7.8
Utilizable groundwater exploitation potential in a wet season (Mm^3/a)	9.5
Utilizable groundwater exploitation potential in a dry season (Mm^3/a)	6.3

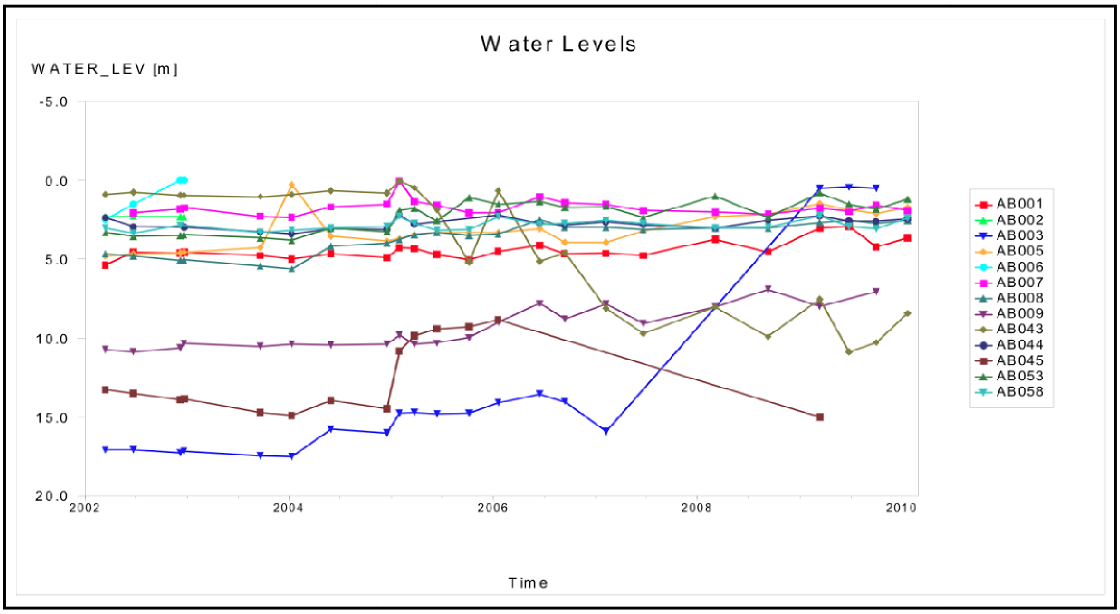

FIGURE 3.4 GROUNDWATER LEVELS (MBGL) CLOSE TO THE HENDRINA ASH DAM (AFTER GHT, 2010)

Several of the boreholes in the ashing area that are routinely sampled (GHT, 2010) have poor water quality, due to increased concentrations of elements such as K, Cl, Mn, SO_4, or due to low pH values. Low pH can lead to increased mobility of a range of groundwater contaminants, such as trace metals. A range of conductivity values were observed in the boreholes visited, and groundwater levels (with one exception) were found to be within 5 m of the ground surface. With one or two exceptions, groundwater levels appear to be stable in the vicinity of the ash dam (see Figure 3.4 above). Borehole AB03, which has shown a large rise in groundwater level in the last eight years, is located close to a pumping station used for the control of water from the ash dam, and may have been influenced by leakage or discharge from this facility.

3.3 CONCEPTUAL MODEL OF GROUNDWATER OCCURRENCE

Recharge moving through the soil zone combines with leachate from the ash storage facility and migrates downwards through the unsaturated zone to the water table. Groundwater below the water table moves with the local groundwater gradient towards discharge zones (surface water resources such as rivers, wetlands and dams). Due to the shallow depth to groundwater in the immediate vicinity of the ash dams and associated infrastructure, it is assumed that leakage from the base of the ash dam occurs (i.e. a groundwater mound has formed under the ash dam). This is supported by the poor groundwater quality in some boreholes close to the ash dam, reported by GHT (2010). Following observations made during the field visit, it is likely that any leachate from the current ash disposal area that is not intercepted by the underdrain systems (or other leachate control facilities) will flow through the aquifer towards the lake or dam that is located about 1 km due east of the ash dam. Groundwater will flow at shallow depth in the weathered zone or via fractures, faults, fissures and other secondary discontinuities in the deeper rock. Locally the groundwater gradients are expected to be modified by mounding associated with the ash dams and other water sources.

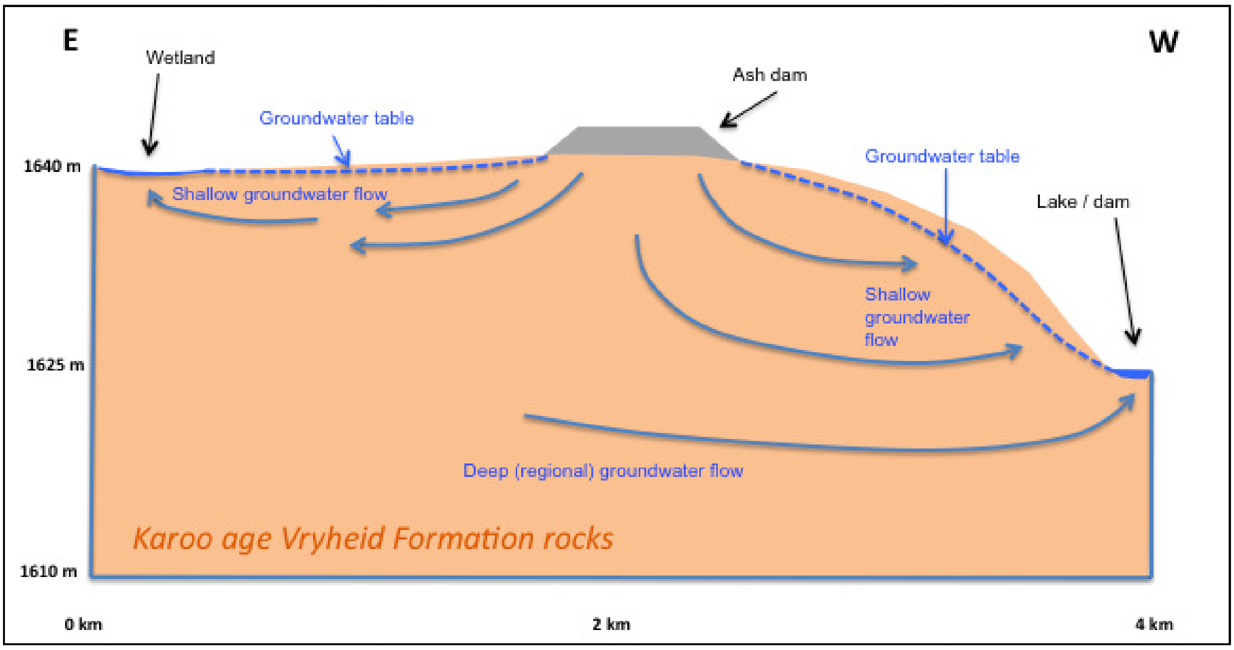

FIGURE 3.5 SKETCH CROSS-SECTION OF GROUNDWATER OCCURRENCE AT HENDRINA (NOTE VERTICAL EXAGGERATION)

3.4 CRITERIA USED TO RANK SITES

Following the pre-screening phase study, the location for the ash dam extension has been narrowed down to five potential sites: Each site was assessed with regard to the aquifer type, topographic elevation, proximity to the existing ash dam, and proximity to surface water. A site that is close to the existing ash dam is preferred, since not only is the ash haulage or pumpage distance reduced, but it is probably also easier to monitor and manage leachate at one site than at two. Sites close to existing mining operations or existing groundwater users are not preferred, because of the increased risk of pollution. The five sites were then ranked according to these factors, as described in the site preference rating table (Table 3.5).

3.5 SITE PREFERENCE RATING

The rankings below all assume that the hydrogeological map classification / aquifer type is the same for each site. If different, this will need to be taken into account.

TABLE 3.5 SITE PREFERENCE RATINGS FOR THE PROPOSED SITES

Site Preference Ranking	Criteria
Preferred (4)	Distant from surface water and wetlands (250 m buffer) and other groundwater users, topographically high (maximum depth to groundwater), and adjacent to the existing ash dam. Not close to existing open cast or underground mining operations.
Acceptable (3)	Distant from surface water and wetlands (250 m buffer), and other groundwater users, and close to the existing ash dam. Not close to existing open cast or underground mining operations.
Not Preferred (2)	Close to either surface water and wetlands, or other groundwater users. Close to existing open cast or underground mining operations.
No-Go (1)	Adjacent or overlapping surface water and wetlands, or other groundwater users.

4 REGIONAL OVERVIEW

All five sites are located within an 8 km radius of the Hendrina power station. All five are located on similar geology, and share similar hydrogeological characteristics. The average elevation of each site is similar (i.e. between 1620 and 1660 mamsl). Site 3 and site 4 intersect the 250 m buffer around the surface water features. The wet ashing system used at Hendrina is likely to lead to leachate formation and underground migration away from the ash disposal facility. Some of the water will evaporate, but some will leach downwards into the aquifers. The system of drains and pumps will recapture some of this leachate, but not all of it. Existing open cast and underground coal mining operations are found in the vicinity of the power station. It is best that the ash disposal facility or its extension are not adjacent to these mining operations, since the hydraulic and geochemical characteristics of the subsurface will have been modified and there may be a greater risk of pollution.

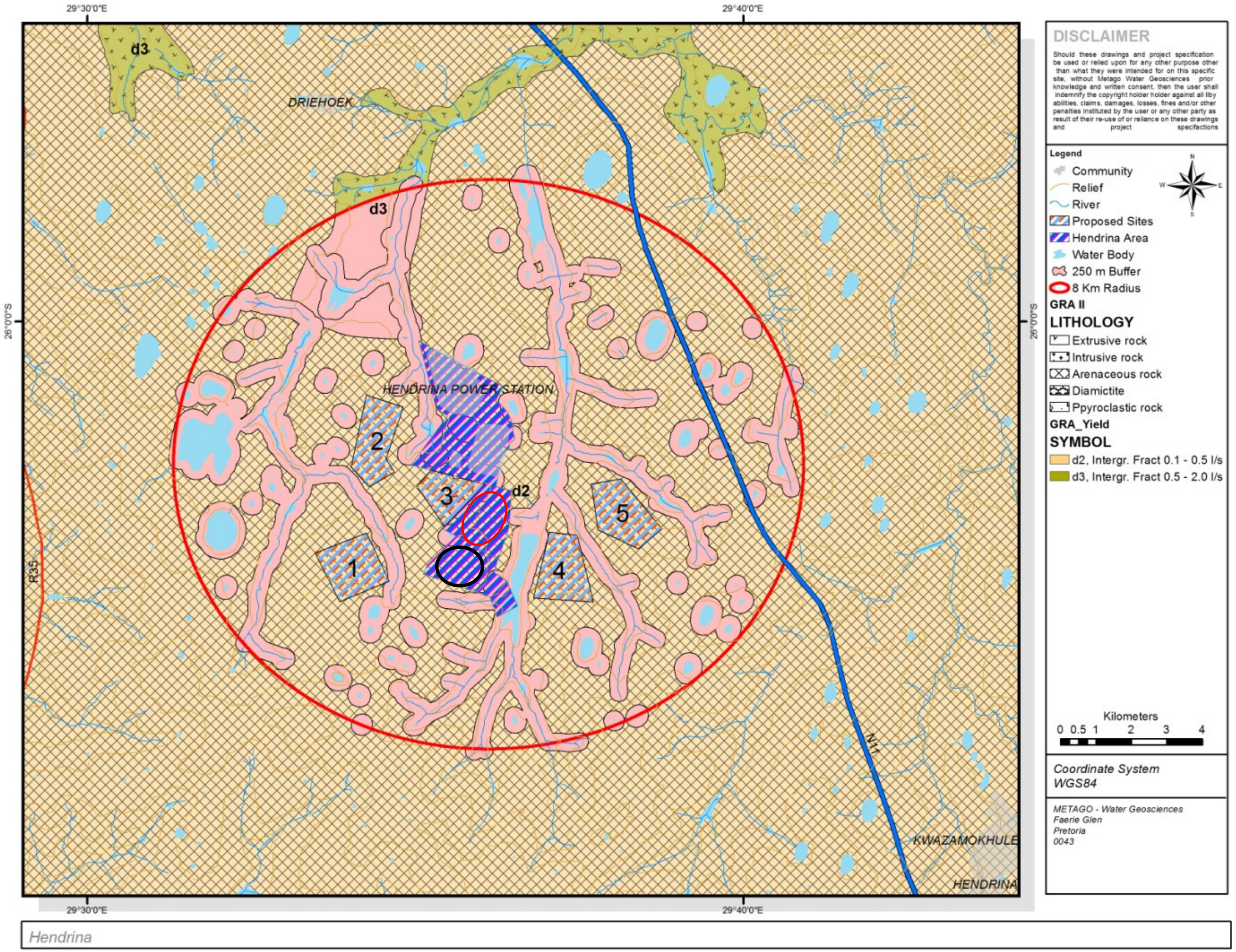

FIGURE 4.1: MAP OF THE FIVE SITES, ON SCREENING MAP BACKGROUND.

5 SITE SPECIFIC RESULTS

5.1 SITE PREFERENCE RATING

TABLE 5.1 SITE PREFERENCE RATINGS FOR THE PROPOSED SITES

Site	Score	Site Preference rating
1	4 (preferred)	First
2	3 (acceptable)	Second
3	2 (not preferred)	Third
4	2 (not preferred)	Third
5	2 (not preferred)	Third

6 CONCLUSIONS

The five potential sites for a new ash storage facility at Hendrina power station have been evaluated in the light of a conceptual hydrogeological model of the area, built up by studying available data and by visiting the site.
All sites are located on very similar geology and aquifer type as well as at similar topographic elevations. No major groundwater abstractions are shown on the DWA 1:500 000 scale hydrogeology map of the area (Sheet 2526 Johannesburg) in the area.

According to the available data, site 1 is the preferred site. The site is not within any surface water buffer zone and additionally in close proximity to the existing active ash storage facility (Figure 4.1, **circled in black**), therefore minimising groundwater monitoring and pumping efforts.

While the hydrogeological setting of site 2 is very similar, it is less preferred due to its potential impacts on two water courses in close proximity in comparison to site 1, which is likely to impact on only one.

Site 3 and 4 fall partially within the 250 m buffer zone around surface water features (wetlands and water bodies in the area) and are therefore not preferred. Site 4 is furthermore in close proximity to an open cast mine.

Site 5 is adjacent to an existing open cast mine and as a result also not preferred.

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