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 (℃)
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

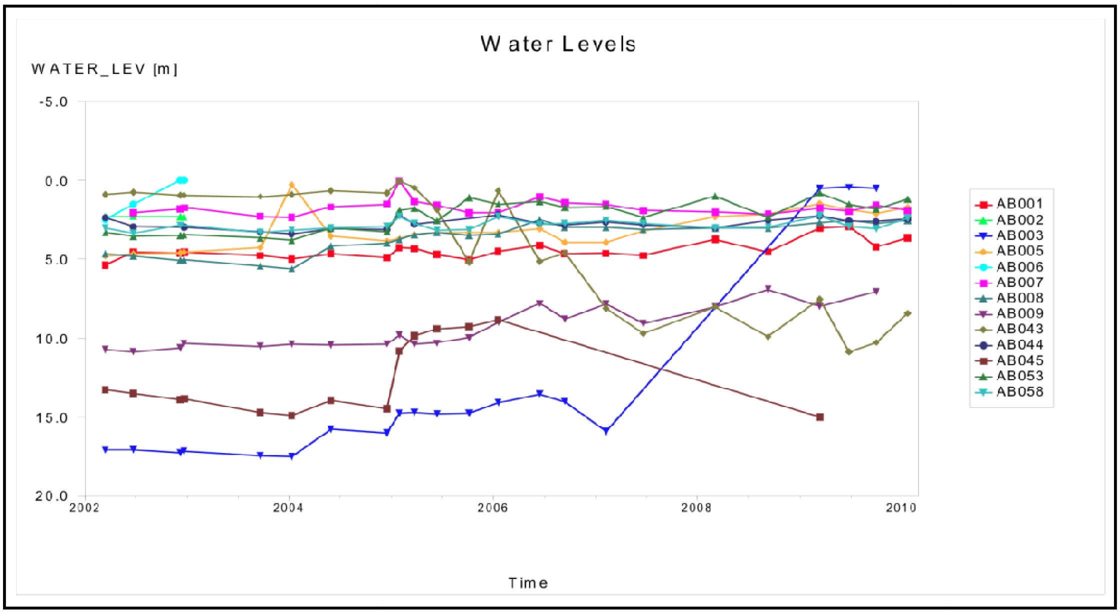

FIGURE 3.4 GROUNDWATER LEVELS (MBGL) CLOSE TO THE HENDRINA ASH DAM (AFTER GHT, 2010)

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.

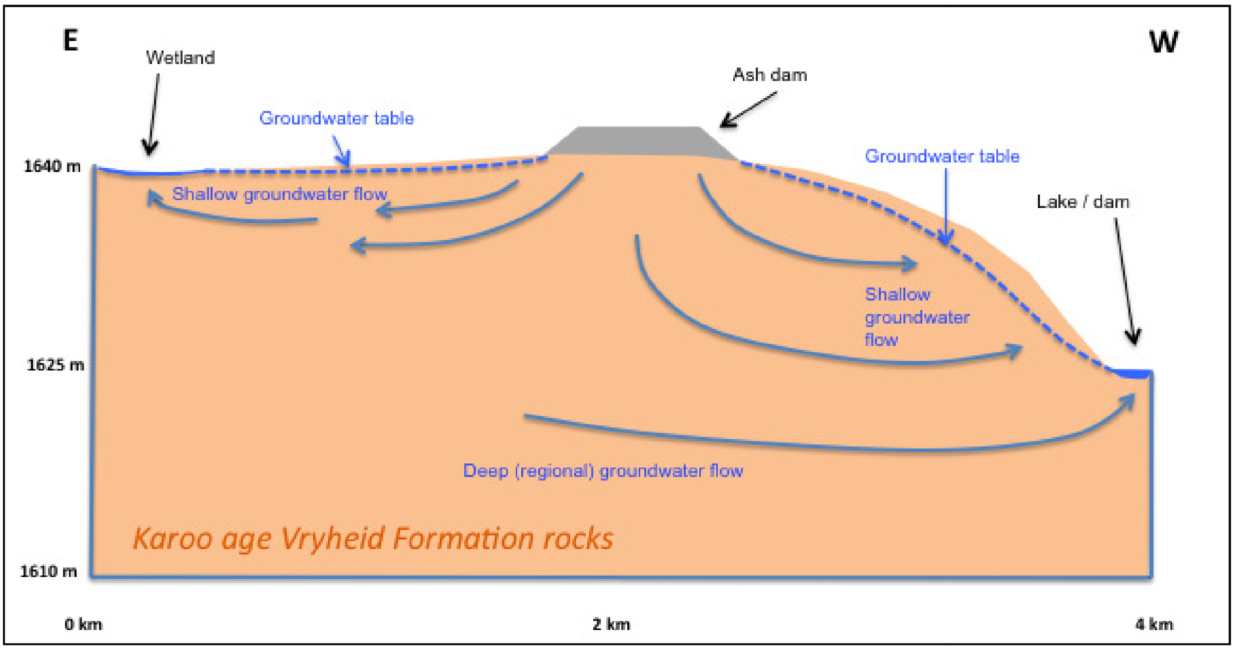

FIGURE 3.5 SKETCH CROSS-SECTION OF GROUNDWATER OCCURRENCE AT HENDRINA (NOTE VERTICAL EXAGGERATION)

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.

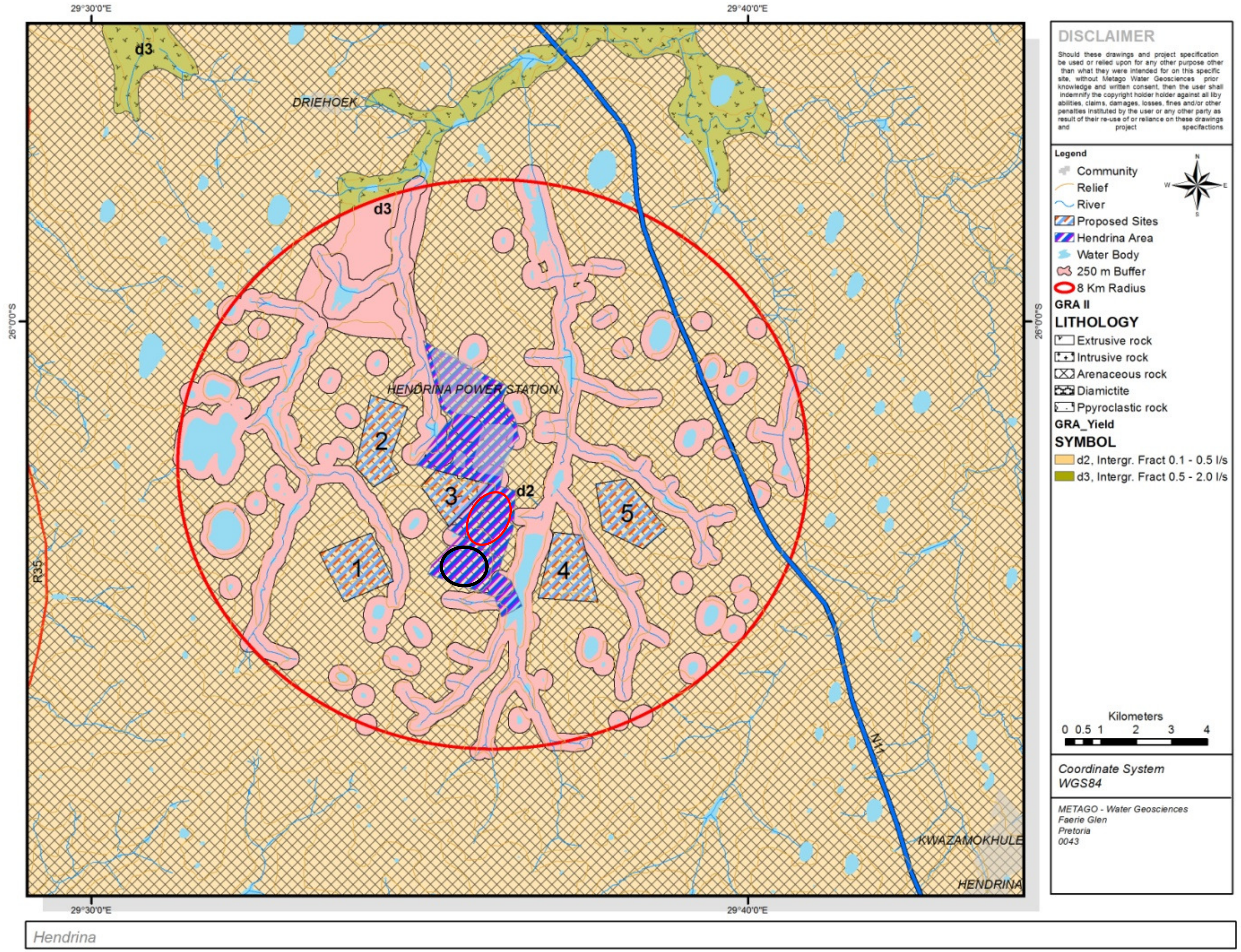

FIGURE 4.1: MAP OF THE FIVE SITES, ON SCREENING MAP BACKGROUND.

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.

7 REFERENCES

Baron J, Seward P and Seymour A (1998) The Groundwater Harvest Potential Map of the Republic of South Africa. Technical Report Gh 3917. Directorate Geohydrology, Department of Water Affairs and Forestry, Pretoria.

DWAF/WRC (1995), Groundwater Resources Map of the Republic of South Africa, Department of Water Affairs and Forestry, Pretoria, 1:3 000 000

DWAF (2000), Groundwater Resources Map of the Republic of South Africa, Department of Water Affairs and Forestry, Pretoria, 1:3 000 000

DWAF (2002), Hydrogeological Series Map 2127, Alldays, Department of Water Affairs and Forestry, Pretoria, 1:500 000

DWAF (1996), Water Management Areas of the Republic of South Africa, First Edition, Department of Water Affairs and Forestry, Pretoria, 1:2 000 000

DWA (2008) Best Practice Guideline for mine residue deposits. DWA series Best Practice Guidelines for Water Resource Protection in the South African Mining Industry. Department of Water Affairs, Pretoria.

GHT (2010) Hendrina Power Station routine monitoring phase 49. Final Report, March 2010. GHT Consulting Scientists, Bloemfontein.

Johnson MR, Anhaeusser CR and Thomas RJ (Eds) (2006) The Geology of South Africa, Geological Society of South Africa/Council of Geoscience, Pretoria.

8 DISCLAIMER

Metago Water Geosciences (Pty) Ltd (Metago) has executed this study along professional and thorough guidelines, within their scope of work. It is based partly on sample material and analytical results provided by others. Metago does not accept any liability for the representivity of the tested samples provided by the client nor for the accuracy of the laboratory test results.

No representation or warranty with respect to the information, forecasts or opinions contained in neither this report nor the documents and information provided to Metago is given or implied. Metago does not accept any liability whatsoever for any loss or damage, however arising, which may directly or indirectly result from its use.

This report is intended for the confidential usage of the client. It may be used for any lawful purpose but cannot be reproduced, excerpted or quoted except with prior written approval of Metago.

Jude Cobbing	**Kai Witthueser**	**Karabo Lenkoe-Magagula and**
(Project Manager)	**(Project Reviewer)**	**Theo Rossouw**
		(Authors)