PRELIMINARY GEOHYDROLOGICAL ASSESSMENT OF THREE (3 NO.) CANDIDATE SITES FOR THE PROPOSED UMZIMKHULU LANDFILL

REFERENCE 41113R02

FINAL REPORT

MAY 2013

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terratest
Geotechnical, Environmental & Earth Science Consultants

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SYNOPSIS :
PRELIMINARY GEOHYDROLOGICAL ASSESSMENT OF CANDIDATE SITES FOR A PROPOSED LANDFILL FOR THE UMZIMKHULU LOCAL MUNICIPALITY.

KEY WORDS :
Desk study, site assessment, hydrocensus, geology, geohydrology, preliminary risk assessment, ranking of sites, detailed site assessment.

QUALITY VERIFICATION

THIS REPORT HAS BEEN PREPARED UNDER THE CONTROLS ESTABLISHED BY A QUALITY MANAGEMENT SYSTEM THAT MEETS THE REQUIREMENTS OF ISO9001: 2008 WHICH HAS BEEN INDEPENDENTLY CERTIFIED BY DEKRA CERTIFICATION UNDER CERTIFICATE NUMBER 90906882

Quality Management ISO 9001:2008 ▸ Voluntary participation in regular monitoring DEKRA Certification DEKRA certified

VERIFICATION	CAPACITY	NAME	SIGNATURE	DATE
BY AUTHOR	GEOHYDROLOGIST	S NDOKWENI		10:05:13
CHECKED BY	ASSOCIATE	R SCHAPERS		16:05:13
AUTHORISED BY	PROJECT LEADER	G VON MAYER		16:05:13

PRELIMINARY GEOHYDROLOGICAL ASSESSMENT OF THREE (3 NO.) CANDIDATE SITES FOR THE PROPOSED UMZIMKHULU LANDFILL

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PRELIMINARY GEOHYDROLOGICAL ASSESSMENT OF THREE (3 NO.) CANDIDATE SITES FOR THE PROPOSED UMZIMKHULU LANDFILL

1. INTRODUCTION

This report presents the results of a preliminary geohydrological assessment, which forms part of the site selection process of three (3 No.) candidate sites, for the proposed new uMzimkhulu Landfill.

The geohydrological investigation was carried out in accordance with the following guidelines:

- The Department of Water Affairs and Forestry, Second Edition, 1998. *Waste Management Series. Minimum Requirements for Waste Disposal by Landfill*
- The Department of Water Affairs and Forestry, Third Edition, 2005. *Waste Management Series. Minimum Requirements for Water Monitoring at Waste Management Facilities*

The above guidelines specify that a stage 1 site selection process be carried out for the candidate sites. The minimum requirements for a specialist geohydrological assessment for a waste disposal site with a G:S:B rating is as follows:

Stage 1 Preliminary Geohydrological Assessment for Candidate Sites			
Phase	Activities	By	G:S:B-Requirement
Desk top assessment of each site	Review existing maps and reports	geohydrologist	Yes
Field confirmation and hydrocensus	Geological and structural mapping	Geohydrologist	Yes to all
	Soil characteristics and permeability	Geotech/geohydro	
	Groundwater use within 1km	Geohydrologist	
	Borehole characteristics; depth, water level, yield etc	Geohydrologist	
	Aquifer yield and flow direction	Geohydrologist	
	Preliminary aquifer classification	Geohydrologist	
	Preliminary risk assessment	Geohydrologist	
Ranking of sites and site selection	Geohydrological ranking in terms of suitability/flaws	Geohydrologist	Yes

Following the preliminary geohydrological assessment, the candidate sites were ranked according to their geohydrological suitability. A detailed site investigation can be carried out on the selected site.

2. INFORMATION SUPPLIED

The following information has been used in the preparation of this report:-

Reports and Documents

- Report reference 41113 of Terratest (Pty) Ltd, titled “Draft Candidate Landfill Site Report for the Umzimkhulu Local Municipality”, draft, dated August June 2012
- The Department of Water Affairs and Forestry, Second Edition, 1998. *Waste Management Series. Minimum Requirements for Waste Disposal by Landfill*

- The Department of Water Affairs and Forestry, Third Edition, 2005. Waste Management Series. *Minimum Requirements for Water Monitoring at Waste Management Facilities.*

Maps

- Map Sheet titled "3029BD Umzimkulu", at a scale of 1:50000, of the Topocadastral Map Series, supplied by the Surveyor General, digital version, dated 1981
- Map Sheet titled, "Durban 2928", at a scale of 1:500 000, first edition, dated 1998, of the Hydrogeological Map Series of the Republic of South Africa, supplied by the Directorate: Geohydrology, of the Department of Water Affairs and Forestry
- Map Sheet titled, "3028 KOKSTAD", at a scale of 1:250 000, dated 2002, of the Geological Map Series, supplied by the Council for Geoscience (digital format)

3. BACKGROUND

In March 2012, Terratest (Pty) Ltd carried out a pre-feasibility study for the identification and ranking of candidate sites for a new uMzimkhulu Local Municipality Landfill. For this study, twelve potential sites were identified. These sites were identified by a process of negative mapping and then subjected to ranking based on the following criteria:

- Economic/technical
- Environmental
- Public acceptance.

The existing landfill site was considered fatally flawed and unsuitable due to the poor expansion ability limited by its proximity to a water source. From the remaining twelve potential sites, three (3 No.) candidate sites were identified for further assessment.

Candidate Site Name	Site Number	Rank	Score
East Clydesdale 9	9	1	55
South Clydesdale	11	2	54
East Clydesdale 8	8	4	52

4. SITE DESCRIPTION

The three candidate sites are located within the uMzimkhulu Local Municipality within the Sisonke District Municipality. The candidate sites are within 5 km of the town of uMzimkhulu. The prevailing vegetation of the uMzimkhulu area can be divided into three vegetation types; the Midlands Mistbelt Grassland (Gs9), the Drakensberg Foothill Moist Grassland (Gs10) and the Ngongoni Veld (SVs4). The soil cover for the Midlands Mistbelt comprises slightly sandy clayey silts to silty clay, while expansive silty clay or sandy clayey silt derived from dolerite intrusions and mudstone, form the cover of the Drakensberg Foothill Moist Grassland and the Ngongoni Veld. The colluvial silty sand to sandy silt soils are expected in valley bottoms and depressions.

The candidate sites are located in the T52D quaternary catchment which has a Mean Annual Precipitation (MAP) of 791mm and a recharge of 39.14mm/a. The T52D quaternary catchment is primarily drained by the Mzimkhulu River, which flows north west to south east immediately north east of two of the proposed sites.

East Clydesdale (Site No. 8) is located at S 30° 16' 39.95"; E 29° 56' 40.13" on the lower part of a gentle north facing slope. The site is bounded by the Kwankuku River 200m to the north west, the Mzimkhulu River 300m to the east, and an unnamed non perennial stream to the west. Small scale commercial agriculture is located immediately north west of the site. A residential development is located to the north west on the opposite side of the Kwankuku River. A cemetery and sewage treatment works are located immediately north on the opposite side of the Kwankuku River. The site can be accessed by a gravel road off the R56.

East Clydesdale (Site No. 9) is located at S 30° 17' 14.44"; E 29° 57' 07.33" on a gentle north east facing slope. The site is bounded by the Mzimkhulu River 800m to the north and north east, with an unnamed stream 500m to the south east, and an unnamed non perennial stream 500m to the north west. The site is located on unimproved grassland. The Clydesdale Mission is located 1.1km south west of the site. The site can be accessed by a gravel road off the R56

South Clydesdale (Site 11 No.) is located at S 30° 18' 35.24"; E 29° 55' 44.55" south west of the Clydesdale community. The site is bounded by D2425 immediately to the east, with an unnamed non perennial stream 540m further to the south east. The site is located on unimproved grassland. The site can be accessed by the D2425from the R56.

5. PRELIMINARY GEOHYDROLOGICAL ASSESSMENT

5.1 Introduction

The preliminary geohydrological assessment comprised a desktop study, site walkover and hydrocensus mapping exercise for the candidate sites.

5.2 Desk study

5.2.1 Existing Groundwater Resources

The National Groundwater Archive (NGA) and the KZN GRIP datasets of the DWA were interrogated to establish the existence of boreholes in the area and to review the expected geohydrological conditions and existing groundwater use in the project area. The NGA and GRIP datasets reported five (5 No.) resources within a 2km radius of the proposed sites. The borehole resource information is summarised in Table 5.2 and the approximate locations are shown in Figure 1.

Table 5.2: Summary of DWA Dataset Resources within 2 km of the Proposed Sites

ID	Resource Type	Latitude	Longitude	Accuracy (m)	Depth	Water Level (m)	Yield (l/s)	Equipment	Comment
3029BD00019	Borehole	30.295321	29.941370	100	126.9		0.54	None	Domestic, unused
3029BD00020	Borehole	30.294761	29.929710	100	126.0			None	Domestic, unused
3029BDA0007	Borehole	30.295321	29.928873	100	126.9		0.50	None	Domestic, unused
3029BDA0008	Borehole	30.294765	29.929706	100	5.0		0.35	None	Domestic, unused
3029BDR0007	Borehole	30.294790	29.939534	10	140.0			Mono	unused

Additional resources identified during the hydrocensus survey and not presented in the DWA datasets are discussed further in Section 5.3.

5.2.2 Regional Geology

The regional geology underlying the project area is characterized by shale of the Pietermaritzburg Formation, with sandstone of the Vryheid Formation and shale of the Volksrust Formation to the west, all of the Ecca Group. Dark grey shale of the Pietermaritzburg Formation underlies sandstone and shale of the Vryheid and Volksrust Formations. The Pietermaritzburg Formation attains a maximum thickness of 400m in the southeast, thinning towards the north. The Vryheid Formation to the west thins towards the north, west and south from a maximum thickness of 500m. The Volksrust Formation further to the west reaches a thickness of 380m and thins to 250m towards the east. The Ecca Group is regionally intruded by Post Karoo Dolerite in the form of sills and dykes. The regional geology is presented in Figure 2,

5.2.3 Regional Geohydrology

The regional geohydrology of the project area is described as predominantly argillaceous rocks comprising shale, mudstone and siltstone, with localised mafic intrusive rock comprising dolerite. The principle groundwater occurrence in the shale is from an intergranular and fractured aquifer with median borehole yields in the range 0.5 to 2.0 litres per second. The regional geohydrology of the area is presented in Figure 3.

Hydraulic conductivity in Ecca Group shale ranges from 0.05m/d in solid rock to 0.5m/d in fractured rock. Fractures usually constitute reasonable aquifers, however, fractures within fine grained rocks tend to close if dewatered. Iron Pyrite mineralisation along fractures is also common. The success rate for a properly sited borehole within the Ecca Group is between 65 and 80% of achieving borehole yields greater than 0.5 l/s. No major faulting is evident in the project area. Groundwater quality is generally bicarbonate, calcium, magnesium type which indicates recently recharged waters. Electrical conductivity is quite variable but generally acceptable (<70mS/m).

5.2.4 Structural Geology and Air Photo Interpretation

Air Photo and satellite imagery interpretation was carried out to determine the presence of any geological structures in the area. The structural geology and air photo interpretation of the area is presented in Figure 2. Geological structures are often targeted during groundwater drilling programs as zones of heightened groundwater potential. Any structural features in close proximity to the candidate sites would present a potential fatal flaw due to the associated groundwater potential and preferential groundwater flow path. Structural features should be assessed further with geophysics and exploratory drilling.

5.3 Hydrocensus Survey

During the site assessment, a hydrocensus was carried out. The results of the hydrocensus are summarized in Table 5.3.1 and the locations of resources are shown in Figure 1.

Table 5.3.1: Summary of Hydrocensus Survey Information

Proposed Site	Distance (m)	Resource	South	East	Type	Comments
8 East Clydesdale	1106	TOTALM1	30°16'28.50"	29°56'0.80"	borehole	Borehole upslope of site, equipped with submersible and in use Sample Taken
9 East Clydesdale	No resources identified within 1km					
11 South Clydesdale	1012	MALANDA1	30°18'4.10"	29°55'32.80"	borehole	Borehole downslope of site, equipped with submersible and in use Sample taken
	1293	MALANDA2	30°17'55.10"	29°55'59.30"	borehole	Borehole downslope of site, equipped with submersible and in use
	1621	CDALE2	30°17'42.70"	29°55'42.30"	borehole	DWA resource **3029BD0007** Borehole downslope of site, equipped with electric mono pump and in use
	1627	CDALE1	30°17'42.50"	29°55'45.00"	borehole	DWA resource **3029BD0008/20** Borehole downslope of site, equipped with electric mono pump and in use

Groundwater samples were collected from resources designated MALANDA1 and TOTALM1 to characterise the groundwater quality status quo in the project area and to determine the strategic value for the risk assessment. Samples were collected from the discharge of the borehole pumps and sent to Talbot Laboratory for analysis of the SANS241 shortened suite of compounds.

The results of analysis indicate that groundwater in the area is typically suitable for human consumption except for marginally elevated levels of iron and manganese. Base on these results groundwater in the area has strategic value in terms of domestic use. The results are presented in Table 5.3.2.

Table 5.3.1: Summary of Hydrocensus Survey Information

Sample Position		MALANDA1	TOTALM1	SANS 241 : 2011 Drinking Water Standards			
Sample Date		24:07:12	24:07:12				
Sampled by		DM	DM				
Sample Method		Sub	Sub	Upper Limits			
Laboratory Certificate Number		12291/12	12292/12				
Laboratory Sample Reference		MALANDA1	TOTALM1	Acute health - 1	Chronic health	Aesthetic	Operational
Determinand	Unit						
Micro biological determinands							
E. coli or faecal coliforms	Count per 100 mL	0	0	Detected			
Total coliforms	Count per 100 mL	0	0				10
Physical and aesthetic determinands							
Colour	mg/L Pt-Co	<1	<1			15	
Conductivity at 25 °C	mS/m	23	23			170	
Odour or taste	–	nil	nil			Inoffensive	
Turbidity	NTU	2.2	7.7			5	1
pH at 25 C	pH units	7.4	7.4				≤ 5 or ≥ 9.7
Alkalinity		92	54				
Total hardness		65	51				
Chemical determinands — macro-determinands							
Nitrite/nitrite as N	mg/L	<0.01	0.18	0.9			
Sulphate as SO_4^{2-}	mg/L	1.21	2.82	500		250	
Fluoride as F^-	mg/L	0.2	0.15		1.5		
Chloride as Cl^-	mg/L	7	16			300	
Calcium as Ca	mg/L	15	11			150*	
Magnesium as Mg	mg/L	6.8	5.7		70*	100*	
Potassium as K	mg/L	<0.2	0.4		50*		100*
Sodium as Na	mg/L	17	12			200	
Chemical determinands — micro-determinands							
Iron as Fe	mg/L	0.36	0.66		2	0.3	
Manganese as Mn	mg/L	0.14	0.02		0.5	0.1	
Chemical determinands — organic determinands							
Total organic carbon as C	mg/L	0.95	1.68		10		

* SANS 241:2006 Limits - Class I | Class II

5.4 Candidate Site Assessment

5.4.1 East Clydesdale (Site 8)

Geology and Structures

The site is covered by colluvial soils which are underlain by the residual shale of the Pietermaritzburg Formation. The residual material is underlain by soft to medium hard rock shale. East Clydesdale 8 is surrounded closely by three notable structural features on the up and downslope sides. Due to their proximity and occurrence, these features would need to be assessed further with geophysics to determine groundwater potential beneath the site. The close proximity of these features is considered a negative aspect for site development due to possible groundwater contamination.

Topography

The surface gradient is approximately 1:11 in a northerly direction towards the Kwankuku/Mzimkhulu confluence, with the ground dropping away to the west and east at similar gradients. Groundwater is anticipated to flow radially from the site in a north west, north, and north easterly direction. The groundwater gradient will mirror the surface topography but be slightly flatter at an expected maximum gradient of 1:20. The resulting groundwater flow velocity will be moderate to high. The elevation difference to the Mzimkhulu River is 45m. With such a

large river, baseflow is expected to contribute to the river flow, thus groundwater levels beneath the site will be in the range 10 to 30m below ground level. The inferred groundwater flows are considered a negative aspect for site development due to inferred travel times of potential contaminants in the groundwater to the receiving surface waters.

Surface Water Bodies

The Mzimkhulu River is located within 300m of the site on the eastern boundary. The Kwankuku River is located 200m north west of the site. The close proximity of these resources is considered a negative aspect for site development due to potential contamination of receiving surface waters through baseflow.

Resources

The hydrocensus survey identified a borehole resource 1.2km north west of the site which is in use. This borehole is located upslope of the site and it is considered unlikely to be impacted.

Inferred Aquifer Characteristics

The site is uniformly underlain by shale. Heightened groundwater potential is expected at contact zones between fine grained shale and medium grained sandstone at depth. Linear features need to be assessed further to determine groundwater potential

5.4.2 East Clydesdale (Site 9)

Geology and Structures

The site is covered by colluvial soils which are underlain by residual shale and subsequently weathered soft to medium hard rock shale. The host rock has been intruded locally by dolerite 350m on the downslope side to the east. Groundwater potential may be heightened along fracture zones associated with the dolerite intrusion. Groundwater flow in this area may be complex and multidirectional, but in general towards the Mzimkhulu River. East Clydesdale 9 is adjacent to one of the same structural features passing site 8 but 200m upslope of the site. The proximity of the dolerite intrusion is partly considered a negative aspect for site development due to possible groundwater contamination, however, groundwater flow is expected to be in a northerly direction bypassing this feature.

Topography

The surface gradient is approximately 1:12.6 in a northerly direction towards the Mzimkhulu River. Groundwater is anticipated to flow in a northerly direction along the shallow valley depression of the unnamed non perennial stream towards the Mzimkhulu River. The groundwater gradient will mirror the surface topography but be slightly flatter at an expected maximum gradient of 1:25. The resulting groundwater flow velocity will be moderate. The elevation difference to the Mzimkhulu River is 62m. With such a large river, baseflow is expected to contribute to the river flow, thus groundwater levels beneath the site will be in the range 20 to 50m below ground level. The inferred groundwater flows are considered a negative aspect for site development due to inferred travel times of potential contaminants in the groundwater to the receiving surface waters.

Surface Water Bodies

The Mzimkhulu River is located within 700m of the site on the northern and eastern boundary. The close proximity of these resources is partly considered a negative aspect for site development due to potential contamination of receiving surface waters through baseflow.
Small non perennial streams closer to the site will have to be managed in terms of surface water egress from the site.

Resources

The hydrocensus survey identified no boreholes within 1km of the site.

Inferred Aquifer Characteristics

The site is uniformly underlain by shale, with a localised dolerite intrusion 350m north east and downslope of the site. Heightened groundwater potential is expected at contact zones between the dolerite and shale and at contacts between fine grained shale and medium grained sandstone at depth. A linear feature was identified on the upslope side and a dolerite dyke to the east. Being upslope, the linear feature does not warranty further assessment. The dyke may require further review subject to the footprint of the waste site.

5.4.3 South Clydesdale (Site 11)

Geology and Structures

The site is covered by colluvial soils which are underlain by residual and soft to medium hard shale. Post Karoo dolerite has intruded the host shale to the north east and south east but in the range 350 to 450m. The host rock has further been intruded locally by dolerite 200m on the downslope side to the north. Groundwater potential may be heightened along fracture zones associated with the dolerite intrusion. Groundwater flow in this area may be complex and multidirectional. The dyke may further act as a cut off of groundwater flow in a northerly direction towards known groundwater users. No other structural features were evident near the site. The proximity of the dolerite intrusion is partly considered a negative aspect for site development due to possible groundwater contamination, however, groundwater flow may be cut off in a northerly direction, thus protecting down stream users.

Topography

The surface gradient is approximately 1:18 in a north westerly direction towards the invert of the non perennial stream and towards the Clydesdale community. Groundwater is anticipated to flow in a northerly direction. The groundwater gradient will mirror the surface topography but be slightly flatter at an expected maximum gradient of 1:40. The resulting groundwater flow velocity will be moderate to low. The elevation difference to the stream is 70m. Being non perennial, baseflow not always contributing hence the inferred depth to groundwater will be greater. Inferred groundwater levels beneath the site will be in the range 20 to 60m below ground level.

Surface Water Bodies

There are no surface water bodies but furrows in the area indicate potential sheet wash erosion associated with high rainfall events. Surface water management will have to be addressed as recharge is expected to be low.

Resources

The hydrocensus survey identified four borehole resources in the range 1.0 to 1.6km north of the site. All resources were in use and are inferred to be downslope. The existence of these resources is considered a fatal flaw for the site, as they may be impacted in the long term.

Inferred Aquifer Characteristics

The site is uniformly underlain by shale, with a localised dolerite intrusions north, east and south of the site. Heightened groundwater potential is expected at contact zones between the dolerite and shale and at contacts between fine grained shale and medium grained sandstone at depth. Linear features were identified in excess of 800m west and east of the site. The dolerite dyke immediately downslope and north of the site warrants further assessment and is considered potentially a fatal flaw.

6. GEOHYDROLOGICAL RANKING AND SELECTION

Geohydrological parameters have been given a score and the candidate sites have been ranked based on the following scoring system:

Description	Score
Negative impact or aspect	-1
Minimal or no impact	0
Reasonable aspect for development	+1

A summary of the scoring and rank is presented in Table 6.

Table 6 Geohydrological Scoring and Site Ranking

Parameter	East Clydesdale (Site 8 No.)	East Clydesdale (Site 9 No.)	South Clydesdale (Site 11 No.)
	Score		
Geology and Structure	-1	0	-1
Topography	-1	-1	0
Surface water bodies	-1	-1	+1
Resources	0	+1	-1
Aquifer Characteristics	-1	0	-1
Total Score	-4	-1	-2
Rank	**3rd**	**1st**	**2nd**

7. PRELIMINARY RISK ASSESSMENT

Following the Stage 1 – Preliminary Geohydrological Assessment, a preliminary risk assessment of the selected site was carried out on the East Clydesdale 9 site. The assessment of the impact of the development should be based on the level of risk of the development to contaminate the groundwater. A risk assessment is carried out to determine whether the aquifer underneath and adjacent to the development will become polluted by leachate emanating from the site and associated activities. In carrying out the risk assessment, the following is considered:

- An evaluation of the potential contaminants
- An evaluation of the zone or barrier between the system and the aquifer, and
- An evaluation of the aquifer.

The preliminary risk assessment may be augmented during the Stage 2 – Detailed Geohydrological Assessment following final site selection and confirmation of the selected site

Preliminary Risk Assessment Classification

Risk Category	Risk Classification
Vulnerability of Aquifer due to Geohydrological Conditions	Low to medium
Vulnerability due to Flow Rate and Contaminant Load	Medium
Overall Risk Based on Aquifer Vulnerability and Contaminant Load	Medium
Strategic Value of Groundwater and Risk of Impact	Low

Summary

Preliminary Risk Assessment	
Aquifer Vulnerability	**Aquifer Strategic Value**
Medium	Low

8. CONCLUSIONS

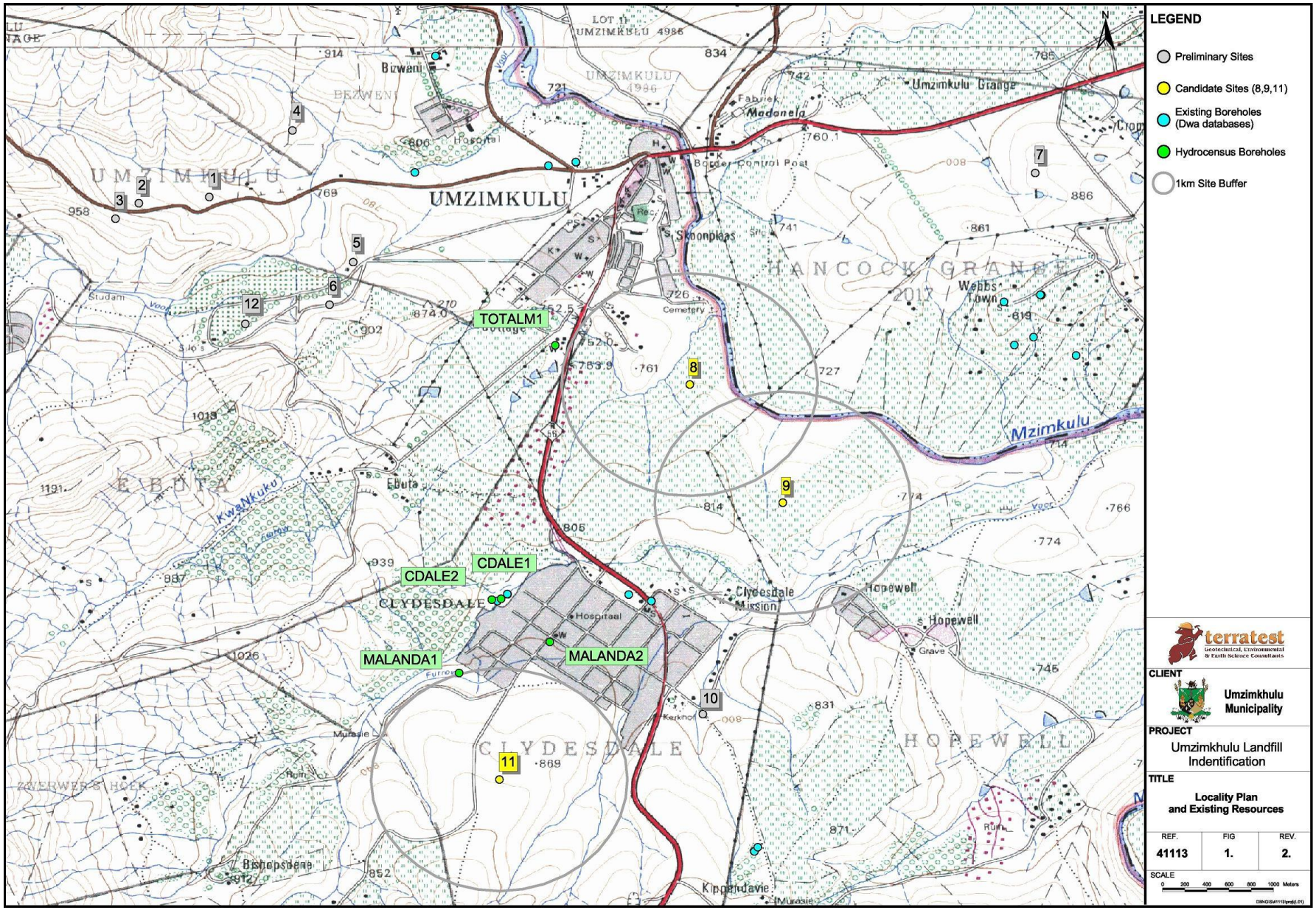
This report presents the results of a preliminary geohydrological investigation of three candidate sites for the proposed Umzimkhulu Landfill. Three candidate sites were selected from a preliminary list of twelve sites following ranking in terms of economic/technical, environmental and public acceptance. The East Clydesdale 8, East Clydesdale 9, and South Clydesdale 11 sites were short listed as candidate sites.

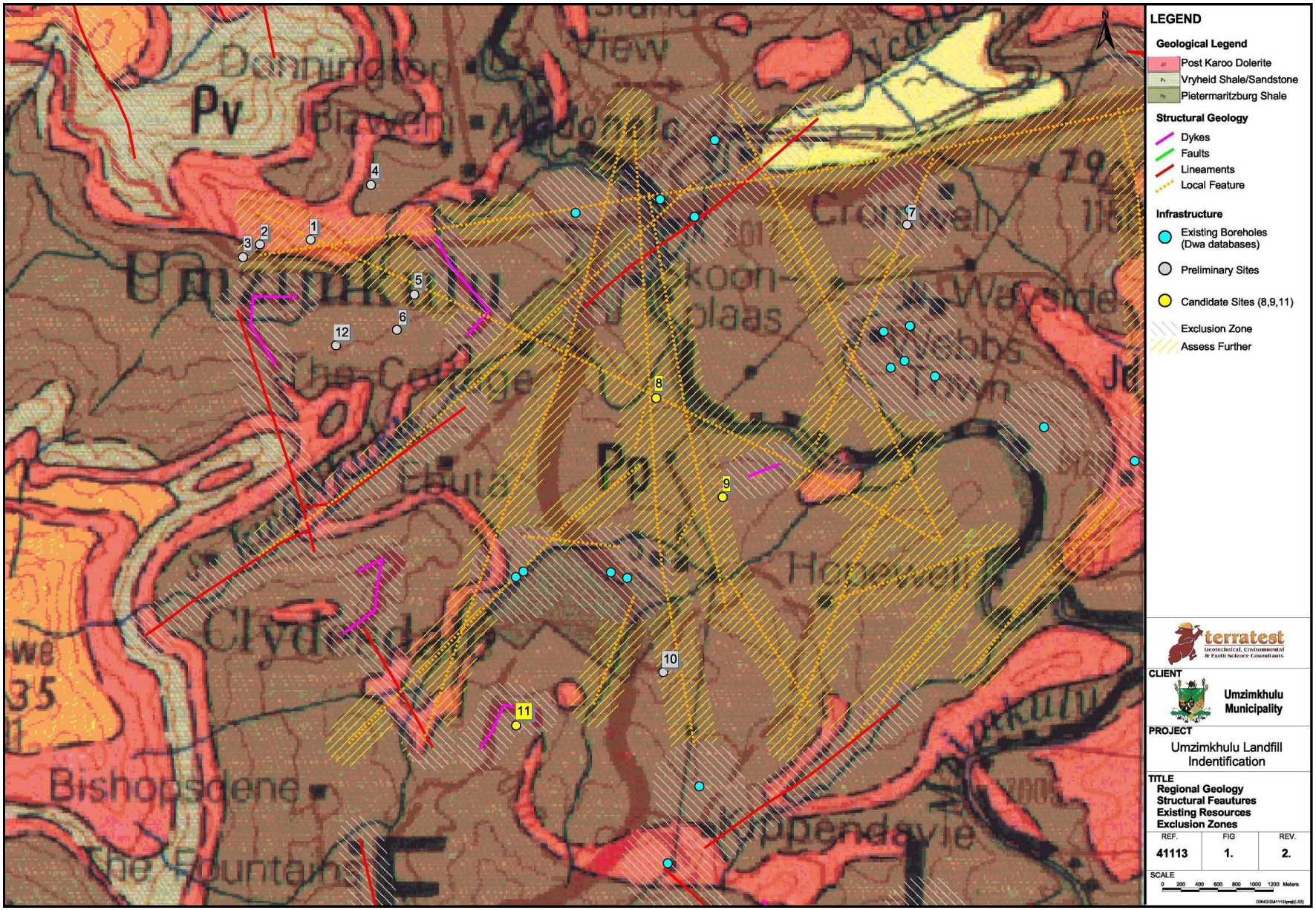
The sites were assessed at the desktop level and a site walkover was carried out conceptualise the geohydrology of the area. A Hydrocensus survey was carried out with a 1km buffer around each site to determine existing groundwater use in the area.

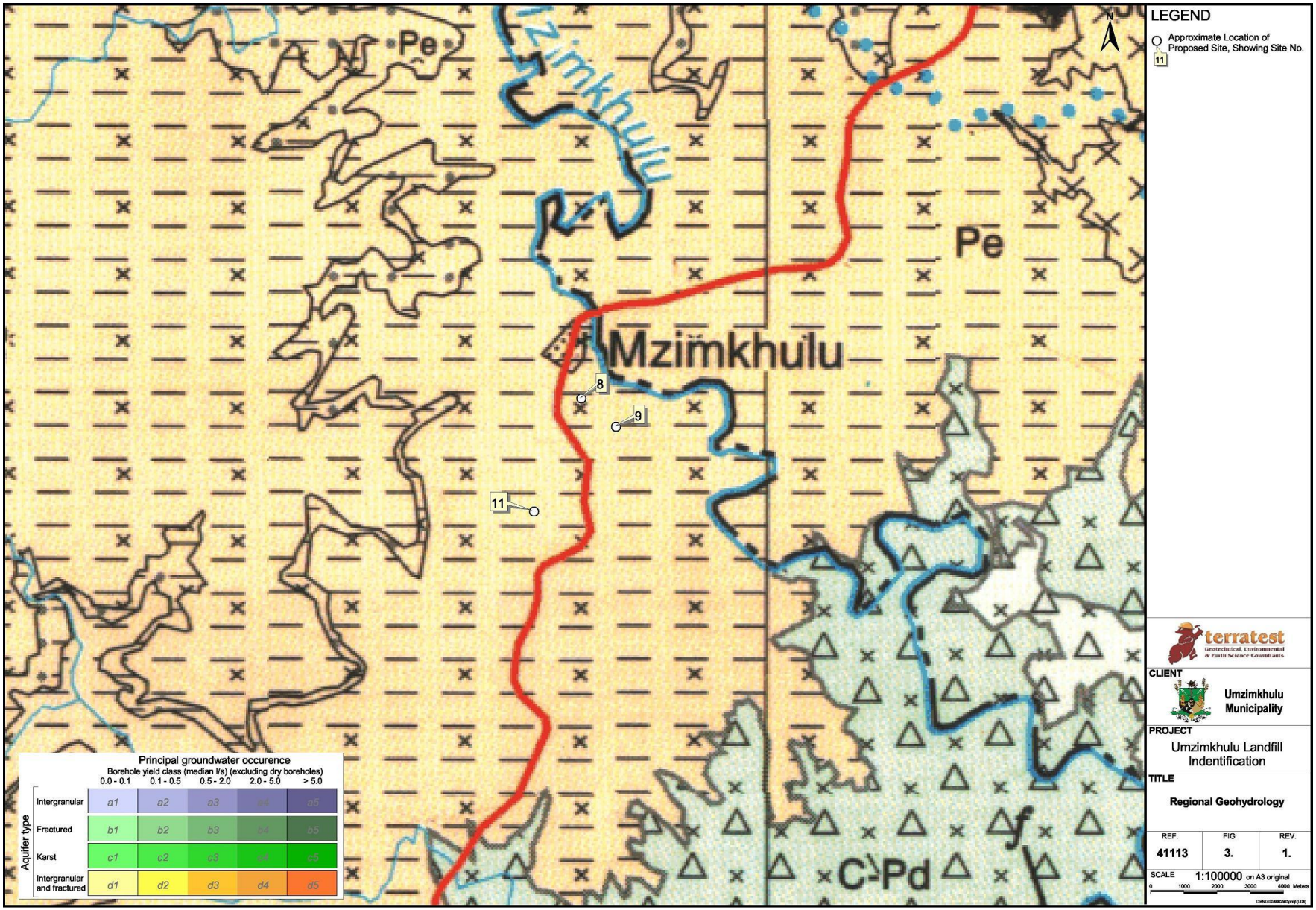
Based on the assessment the sites were ranked using basic geohydrological parameters including geology and structures, topography, surface water bodies, groundwater resources and aquifer characteristics. The ranking was achieved by a scoring system for each parameter, based on the potential to impact of a landfill on groundwater or groundwater users.

The East Clydesdale 9 site ranked the highest of the three sites from a ***geohydrological perspective.*** A preliminary risk assessment was carried out on the East Clydesdale 9 site, scoring medium and low for aquifer vulnerability and strategic value respectively. Once the candidate site has been selected, additional detailed geohydrological assessment can be proposed and carried out to meet the DWA requirements for landfill development.

FIGURES


LEGEND
Preliminary Sites
Candidate Sites (8,9,11)
Existing Boreholes (Dwa databases)
Hydrocensus Boreholes
1km Site Buffer
TOTALM1
CDALE1
CDALE2
MALANDA1
MALANDA2
UMZIMKULU
CLYDESDALE
HOPEWELL
HANCOCK GRANGE
Umzimkulu Grange
Webbs Town
Hopewell
Clydesdale Mission
Mzimkulu
terratest
Geotechnical, Environmental & Earth Science Consultants
CLIENT
Umzimkhulu Municipality
PROJECT
Umzimkhulu Landfill Indentification
TITLE
Locality Plan and Existing Resources
REF. 41113
FIG 1.
REV. 2.
SCALE


LEGEND
Geological Legend
Post Karoo Dolerite
Vryheid Shale/Sandstone
Pietermaritzburg Shale
Structural Geology
Dykes
Faults
Lineaments
Local Feature
Infrastructure
Existing Boreholes (Dwa databases)
Preliminary Sites
Candidate Sites (8,9,11)
Exclusion Zone
Assess Further
terratest
Geotechnical, Environmental & Earth Science Consultants
CLIENT
Umzimkhulu Municipality
PROJECT
Umzimkhulu Landfill Indentification
TITLE
Regional Geology
Structural Feautures
Existing Resources
Exclusion Zones
REF. 41113
FIG 1.
REV. 2.
SCALE
0 200 400 600 800 1000 1200 Meters
Pv
Bishopsdene
The Fountains
Clydesdale
1
2
3
4
5
6
7
8
9
10
11
12


Pe
Umzimkhulu
Mzimkhulu
Pe
8
9
11
C1Pd
N
LEGEND
Approximate Location of Proposed Site, Showing Site No.
11
Principal groundwater occurence
Borehole yield class (median l/s) (excluding dry boreholes)
0.0 - 0.1
0.1 - 0.5
0.5 - 2.0
2.0 - 5.0
> 5.0
Aquifer type
Intergranular
Fractured
Karst
Intergranular and fractured
a1 a2 a3 a4 a5
b1 b2 b3 b4 b5
c1 c2 c3 c4 c5
d1 d2 d3 d4 d5
terratest
Geotechnical, Environmental & Earth Science Consultants
CLIENT
Umzimkhulu Municipality
PROJECT
Umzimkhulu Landfill Indentification
TITLE
Regional Geohydrology
REF.
41113
FIG
3.
REV.
1.
SCALE
1:100000 on A3 original
0 1000 2000 3000 4000 Meters