The Waterval Waste Disposal Facility: A Construction Supervision Case Study

G.A. Dode. Golder Associates Africa (Pty) Ltd, Pretoria, South Africa. gdode@golder.co.za
P.A. Legg. Peter Legg Consulting, South Africa. peterlegg@telkomsa.net

ABSTRACT

The Waterval Waste Disposal Facility, located in Rustenburg, is a large general waste facility for which construction began in January 2013. The facility will initially consist of two general waste cells, a rubble disposal cell, a leachate pond, a contaminated stormwater pond as well as various buildings and infrastructure. Golder Associates Africa was appointed to license, design and supervise the construction of the facility. Envisaged to set a benchmark in solid waste management in South Africa, the facility design has also taken future development into consideration in the form of space for materials recovery and composting facilities. This paper focuses primarily on the construction supervision aspect of the project, looking at the construction quality assurance of the geosynthetic installations and specific construction challenges encountered.

1.0 INTRODUCTION

The Waterval Waste Disposal Facility, located in Rustenburg, is a large general waste facility for which construction began in January 2013. The facility will initially consist of two general waste cells, a rubble disposal cell, a leachate pond, a contaminated stormwater pond as well as various buildings and infrastructure. Future development was also taken into consideration in the designs, allowing room for additional cells as well as materials recovery facilities (MRF) and composting facilities. The integrated waste disposal facility is envisaged to set a benchmark in solid waste management, allowing not only for waste to be disposed of in an environmentally acceptable manner, but with the planned development of on-site recycling and re-use facilities.

Although the first phase of this project deals largely with conventional approaches to waste management in the form of disposal to waste cells, the facility as a whole has future potential for alternate waste management options which would ultimately lengthen the life of the site and create a much more sustainable waste facility.

This paper focuses primarily on the construction supervision aspect of the project with special attention given to CQA of the liner systems installation as well as construction specific challenges.

1.1 Background

In 2001 the Rustenburg Local Municipality (RLM) proposed the development of a new Waste Disposal Facility to serve the Rustenburg area. The primary reasons for this relate to the declining airspace at the current Townlands waste disposal site as well as environmental and social issues at the facility. Golder Associates Africa (previously as Jarrod Ball & Associates, since 2005 incorporated with Golder) was appointed, in association with certain other consultants, to proceed with the project.

A disposal needs assessment of the area indicated that a facility with an airspace capacity of between 4.8 and 8.8 million m^3 was required to serve the area for 30 years. After a formal site selection process, detailed geological and geohydrological investigations were carried out at the Waterval candidate landfill site, an old opencast platinum mine. A scoping report was completed and submitted in 2008 with the EIA process starting in early 2009. After various challenges a Waste Management Licence for the facility was issued on 03 May 2012.

From this point, detailed engineering designs were completed by Golder in June 2012 followed by the necessary tender documentation. Following the tender process, the construction contractor was appointed by the RLM in November 2012 and construction commenced in January 2013, under Golder's supervision as Consulting Engineer. The project is being funded through Municipal Infrastructure Grant (MIG) funding from central government.

1.2 Site Description

The Waterval WDF site is located on a former platinum mine site which has been subjected to historical underground and opencast mining of the Merensky platinum-containing reef (i.e. Waterval Merensky Reef Opencast Mine, closed in the mid-nineties). The 107 hectare site, which is owned by Anglo Platinum and is currently leased to the Municipality, is located approximately 5 km east southeast of the Rustenburg Central Business District. Prior to construction commencing, the "Brownfield" site contained various disused open cast mining pits mine shafts and was surrounded by perimeter berm of norite waste rock.

1.3 Project Overview

The construction of the Waterval WDF was split into phases owing to the size of the facility and potential for future expansion. The construction contract referred to herein involves the construction of Phase 1a of the WDF. Phase 1a includes site clearance and bulk earthworks, two general waste disposal cells including landfill liner systems and drainage systems, a rubble disposal cell, the construction of a leachate pond and contaminated stormwater pond, roads, water reticulation, sewer and stormwater systems. In addition, the contract also includes the construction of various buildings and facilities such as ablution and canteen facilities, administration building, educational and training facility, guard house, taxi stop, weighbridge, workshop and public drop off facility. Finally, the fencing of the site is also included.

Table 1. Waterval WDF construction phases

Phase		Description
1a	(current)	Cells 1 and 2, Rubble Disposal Cell, Ponds and infrastructure
1b	(future)	Cells 3 and 4
2	(future)	Future expansion within perimeter berm to the east

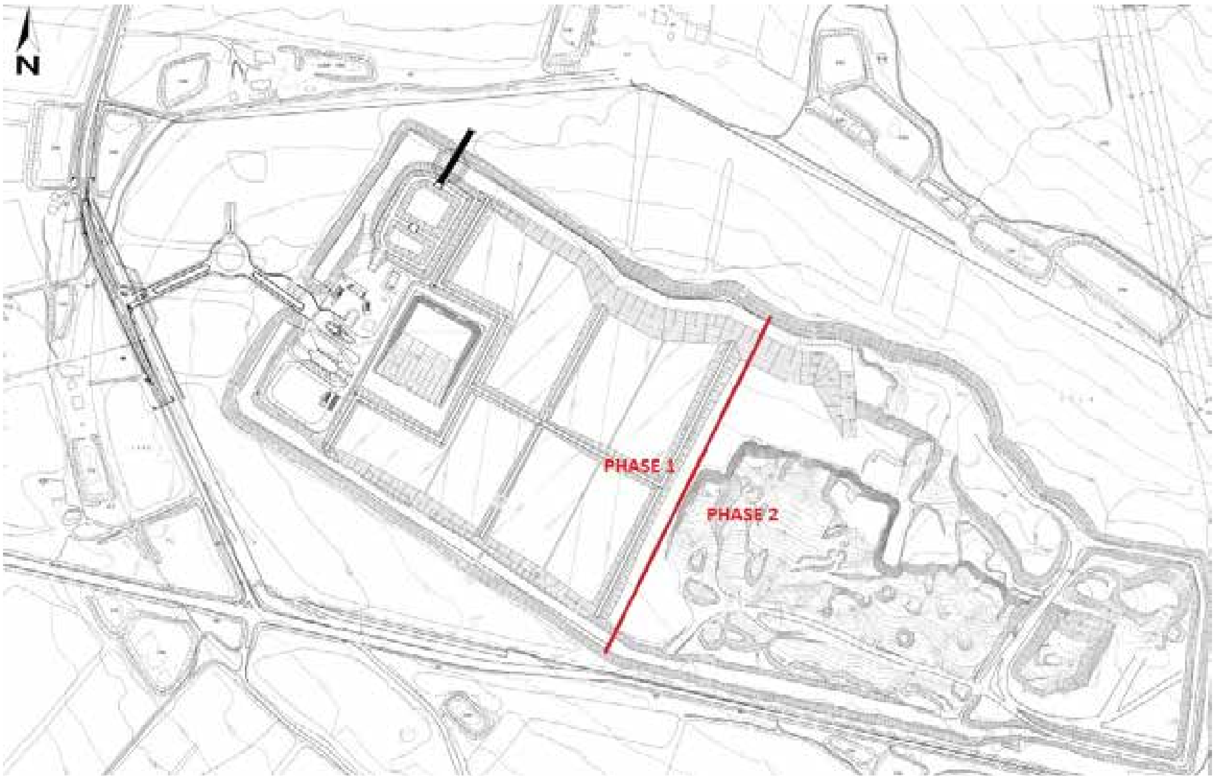

Figure 1. Site and phases overview

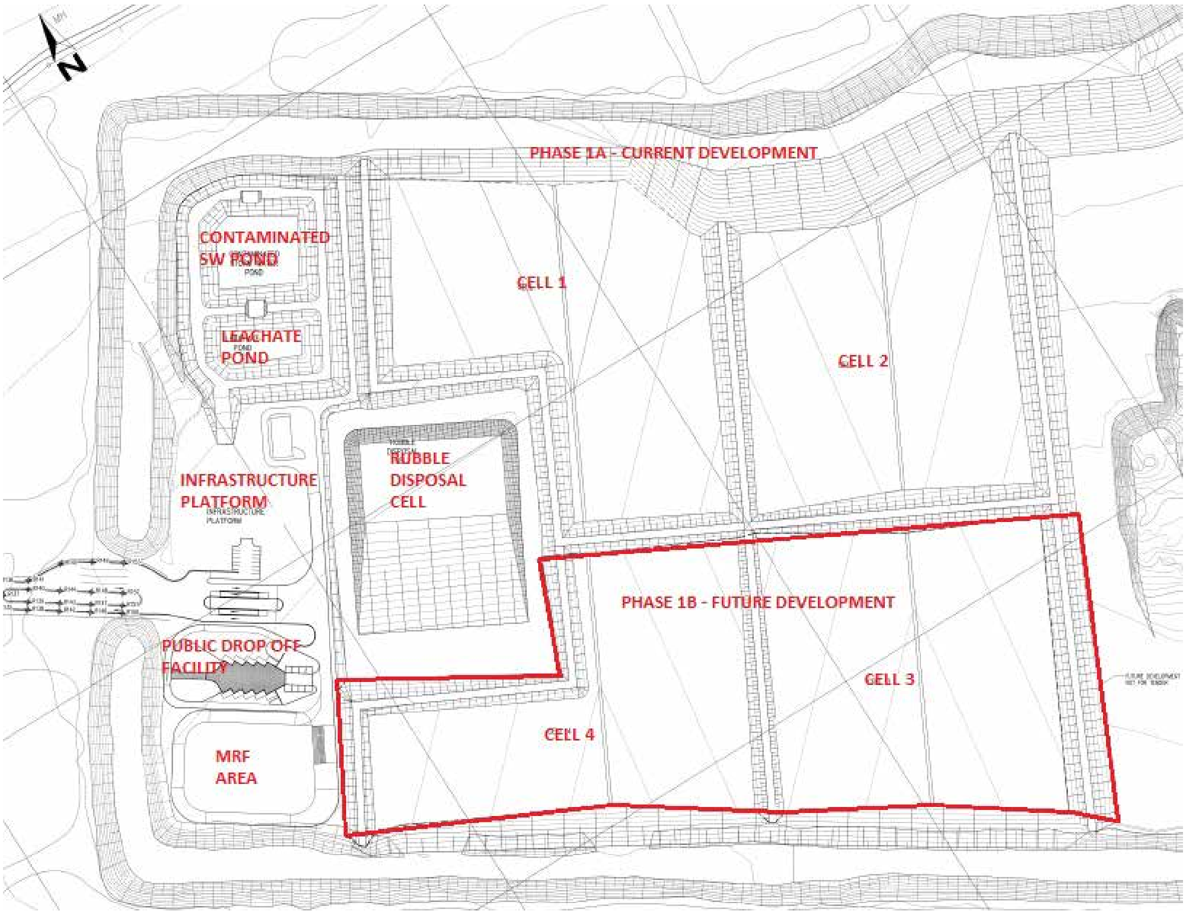

Figure 2. Phase 1 layout

The approximate sizes of the various areas of the Waterval WDF are shown in Table 2.

Table 2. Waterval WDF areas

Area	Size (m^2)	Depth/Height of surrounding berms (m)
Cell 1	45000	4 – 20
Cell 2	47000	4 – 20
Rubble Disposal Cell	12000	0 – 15
Contaminated Stormwater Pond	6000	4.5
Leachate Pond	4000	4.5
Infrastructure Platform	25000	-

2.0 LEGISLATIVE FRAMEWORK OVERVIEW

The design of the liner system for the Waterval WDF was carried out in accordance with the relevant South African legislation. This includes the following:

- National Norms and Standards for Disposal of Waste to Landfill (GN R. 636), 23 August 2013;
- The *Minimum Requirements Series* developed by the Department of Water Affairs

It should be noted that although the GN R. 636 was only promulgated on 23 August 2013, it had been issued for comment in August 2012, under General Notice 615. In order to comply with future regulations, the design of the facility was therefore carried out in accordance with these standards.

The Norms and Standards are also particularly relevant to the construction phase of the project in that construction quality assurance (CQA) is specified as a requirement.

3.0 WASTE STREAMS AND LINER REQUIREMENTS

Given that the facility is to be used for the disposal of non-hazardous, primarily municipal waste, the waste cells have been designed and licensed in accordance with the requirements for general waste and the site was classified as a G:L:B$^-$ facility. General waste requires a Class B barrier as per the National Norms and Standards for Disposal of Waste to Landfill (2013).

Due to the potentially hazardous nature of the leachate generated on the site, the ponds required Class A barrier systems in accordance with the National Norms and Standards.

4.0 BARRIER DESIGN OVERVIEW

4.1 Waste Cells

The barrier system (Class B) for the general waste cells (Cells 1 and 2) is as follows, from the bottom upwards:

- In situ material compacted in 300 mm layers to 98% Proctor Density;
- Geosynthetic clay liner (4250 g/m^2 bentonite layer with carrier layer of 310 g/m^2 woven and non-woven composite geotextile and cover layer of 200 g/m^2 non-woven geotextile)
- 2 mm HDPE geomembrane;
- 1000 g/m^2 non-woven geotextile;
- 150 mm drainage layer of washed 38 to 50 mm stone;
- Woven geotextile filter and separation layer.

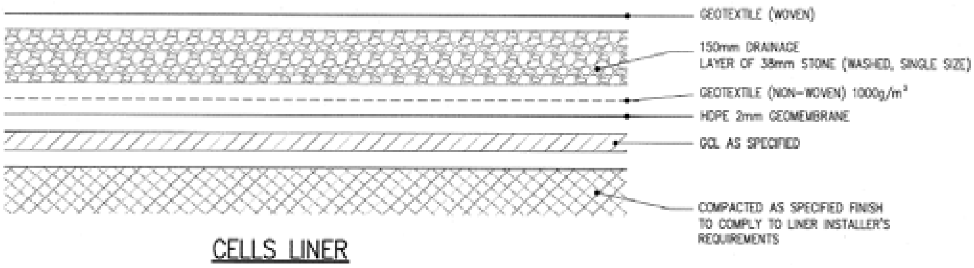

Figure 5. Waste cells barrier design

4.2 Rubble Disposal Cell

The barrier system (Class B) for the rubble disposal cell is as follows, from the bottom upwards:

- In situ material compacted in 300 mm layers to 98% Proctor Density;
- 150 mm layer of screened norite (ripped and recompacted);
- Geosynthetic clay liner (specification as for waste cells above);
- 2 mm HDPE geomembrane;
- 1000 g/m^2 non-woven geotextile;
- 150 mm drainage layer of washed 38 to 50 mm stone;
- 750 g/m^2 non-woven geotextile;
- 300 mm pioneering layer of fine waste rock spoil material.

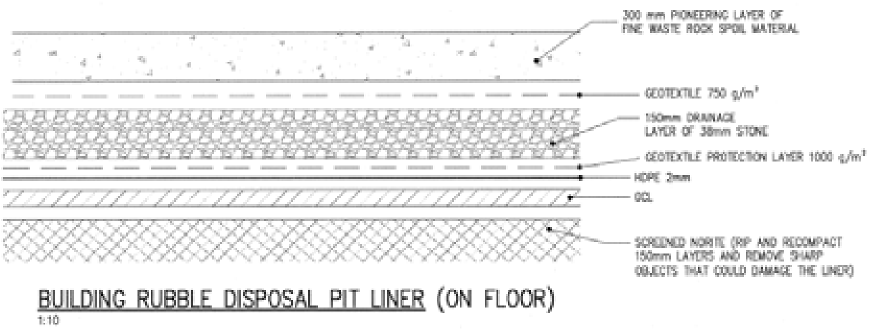

Figure 6. Rubble Disposal Cell barrier design

4.3 Ponds

The triple barrier system (Class A) for the ponds (Leachate Pond and Contaminated Stormwater Pond) is as follows, from the bottom upwards:

- In situ material compacted in 300 mm layers to 98% Proctor Density;
- 1.5 mm HDPE geomembrane;
- 750µ HDPE cuspated drainage layer (leak detection layer);
- 1.5 mm HDPE geomembrane;
- 750µ HDPE cuspated drainage layer (leak detection layer);
- 2 mm HDPE geomembrane;

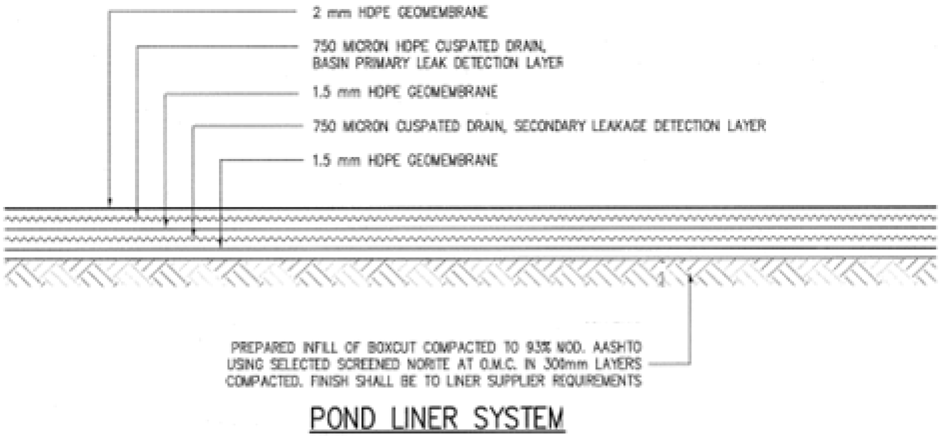

Figure 7. Ponds barrier design

5.0 CONSTRUCTION QUALITY ASSURANCE (CQA)

In order to ensure that the construction was in accordance with the designs, project specifications and regulations, as well as to justify the costs involved in such a project, it was essential for the Engineer to put an emphasis on the quality assurance of the liner systems installations. Although not always apparent to most outside of the waste profession, quality assurance of liner installations contributes significantly to the value of a project which may be measured by its effectiveness as an environmentally acceptable waste facility. This is particularly relevant when considering that leakage from liner systems is directly related to the level of CQA implemented. The quality of liner installations is also directly linked to the environmental and social sustainability of the region which the facility serves. This highlights the importance of not only the quality assurance procedures, but also the ability to deal with construction challenges on a project of this nature.

The National Norms and Standards for Disposal of Waste to Landfill (GN R. 636) indicates that Construction Quality Assurance is a requirement during the construction of a landfill site. As the appointed Engineer on the Waterval WDF project, the CQA was therefore the responsibility of Golder. The primary team assembled by Golder for the overall construction supervision of the project consisted of a Project Manager, Senior Engineer, Resident Engineer (RE) and Assistant Resident Engineer (ARE), with the latter two being stationed on site full-time.

This section of the paper will concentrate on the CQA associated with the liner installations and directly related civil works. It should be noted that the Engineer's CQA work is independent of the quality control (QC) programmes conducted by the Contractors and Manufacturers.

5.1 Methodology

The following general measures were carried out as part of the Engineer's CQA process:

1. Reviewing of the Contractor's quality control documentation and processes;
2. Material conformance testing; and
3. Construction monitoring and testing.

For the purpose of this Paper, focus will be put on the third point, namely the construction monitoring.

The construction monitoring aspect of the CQA ensures that the construction is carried out in accordance with the designs and project specifications. Along with this, the following aspects are closely monitored by the Engineer:

- Inspecting the subgrade surfaces for each area to be covered by the lining system;
- Inspecting the geosynthetic materials delivered to site for any significant damage or defects as well as checking identification slips and quantities for verification and generation of an on-site materials inventory;
- Ensuring methods of storage and transport of geosynthetic materials on site do not cause damage to the materials;
- Observing of permanent anchoring of geosynthetics to ensure that design and project specifications are met;
- Checking that required overlap distances are met;
- Checking that all equipment is being calibrated regularly by the responsible Contractors and that Contractors' quality control documentation is satisfactory and up to date;
- Regular witnessing and inspection of on-site testing on installed liners (including destructive testing and pressure testing) to ensure compliance with requirements;
- Monitoring and recording of weather conditions relevant to geosynthetic installations (specifically wind speed and precipitation);
- Observing and ensuring that all geosynthetic layers are installed in such a manner so as not to damage the underlying layer or the layer being installed; and
- Ensuring that all damages and/or installation defects are repaired correctly (to the Engineer's approval, depending on the material type) and timeously.

For the items listed above, records are kept and filed to form part of the Construction Completion Report. Photographic documentation and daily records in the form of a daily diary also form an important part of the CQA process followed.

5.2 Site Specific Challenges

Site specific challenges make each project and its implementation unique. While the challenges in themselves may be similar from project to project, the conditions within which they are met are rarely the same. The construction of the Waterval WDF brought about various interesting challenges. This section considers specific challenges on the site and the solutions which were implemented to ensure that the required quality of work was maintained while not incurring significant additional costs or time.

5.2.1 Damage to installed geosynthetics

Whilst efforts are made to avoid damage to the installed materials, including GCL, HDPE or geotextile, this can be difficult to avoid completely. In the case of the Waterval project, the most common cause of damage to the geosynthetics was due to plant being driven directly over the material. Another common cause was the use of tools such as spades to remove sand or stone from the liner surface.

Figure 8. Liner damage by a tipper truck

Figure 9. Liner damage by a skid steer

Both Figures 8 and 9 are examples of damage to the liner system due to plant driving directly over it. In the case of Figure 8, a tipper truck delivering stone for the drainage layer on Cell 1 was not guided and reversed too far onto the Cell. In getting out again, the truck's tyres created a hole through all three geosynthetic layers (GCL, HDPE and geotextile). Figure 9 shows the case of damage caused by a skid steer which drove up a lined embankment before any protective layers had been applied.

Figure 10. Liner damage from tools

Figure 11. Geotextile damage

Figure 10 provides an example of damage to HDPE on the Leachate Pond where spades were used to remove stone which was erroneously placed. Figure 11 shows damage to the geotextile on Cell 1 after being driven over by plant. Also evident from this photo is the fact that the geotextile overlap was insufficient and has thus separated after movement on the surface, allowing stone to come into direct contact with the HDPE.

All of the above cases were inspected by the Engineer and repaired by the Contractors without significant delays or additional costs. Larger holes in the GCL and HDPE are patched with additional material. Small holes in the GCL may be closed by using a bentonite paste while small holes in the HDPE are simply extrusion welded. In the case of the geotextile damage and insufficient overlap, the surrounding stone was removed and additional geotextile was placed on top of the affected area.

5.2.2 Water ingress under installed liner

After the installation of the first liner layer (bottom) in the Contaminated Stormwater Pond, some significant rainfall events were experienced at the site. Due to the fact that the anchor trenches were still open (as two more liner layers were yet to be installed), stormwater which filled the trenches was able to pass under the liner in the Pond. This caused damage to the subgrade surface underneath the already installed liner, causing an uneven surface in certain areas (Figure 12). Further to this, the installed liner 'floated' in some areas due to the water under the HDPE (Figure 13). Upon further inspection it was also observed that the anchor length of the HDPE was not sufficient in isolated areas, which may have contributed to this event.

In order to fix the damage caused, the water was first pumped out of the Pond before the HDPE could be cut open in the affected areas. The surface in these areas was repaired and recompacted before being closed again.

Figure 12. Surface damage under liner

Figure 13. Floating liner

5.2.3 Prolonged surface exposure

Due to a work stoppage over a period of approximately 3 months, the prepared subgrade surface in Cell 2 and the Rubble Disposal Cell was left exposed. Significant rainfall was experienced during this stoppage which caused significant erosion of the subgrade surface.

Figure 14. Rubble Disposal Cell surface damage

Figure 15. Surface damage on Cell 2

The subgrade surface was repaired by placing fine material on the damaged areas. The surface was then prepared by grading and compacting these areas as required.

5.2.4 Wind damage

Wind can cause significant damage to liners during installation. The Waterval WDF experienced strong winds on several occasions during construction. In general, geosynthetic installation work is stopped when wind speeds are too high. In one case, a certain portion of installed HDPE on Cell 1 was not sufficiently secured over a weekend. High winds lifted a section of the liner and tore a portion of several metres next to a seam. The torn liner was repaired by patching it with additional HDPE and welding it closed again, before securing the liner with sand bags.

Figure 16. HDPE tear caused by strong winds

Figure 17. Inspection for damage to HDPE under geotextile

5.2.5 Geotextile protection efficiency inspection

In order to check that the geotextile was accomplishing its purpose of protecting the HDPE under the load of stone delivery trucks, an inspection was carried out. The entrance path where the stone drainage layer was at its thinnest and through which all trucks passed, i.e. the area exposed to the most significant wear, was used as the inspection location. An area of stone was cleared and the geotextile was cut open to inspect the HDPE for any damage. As seen in Figure 17, no damage was observed. The HDPE was smooth, without any indentations, indicating that the 1000 g/m^2 geotextile was performing well under the loads experienced.

6.0 CONCLUSION

The design and construction of the Waterval WDF is one of the first of its kind in South Africa, with regards to the size of the facility and infrastructure built into it. The barrier design provided a system which was in accordance with applicable regulations (both current and anticipated at the time of design). Construction challenges throughout the project were suitably handled through close co-operation between the Engineer and the Contractors to ensure a high quality and effective product. In this case, it is evident that construction quality assurance contributed significantly to the value of the project.

REFERENCES

Department of Environmental Affairs (2013). *GN R. 636: National Norms and Standards for Disposal of Waste to Landfill,* Government Gazette No. 36784 issued under the National Environmental Management: Waste Act (59/2008), Pretoria, South Africa.

Department of Water Affairs and Forestry (1998). *Minimum Requirements for Waste Disposal by Landfill*, 2nd ed., CTP Book Printers, Cape Town, South Africa.

Rustenburg Local Municipality (2011). *Final Environmental Impact Assessment Report and Environmental Management Plan*, Report No. 8041-9415-12 submitted by Golder Associates Africa, Midrand, South Africa.