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FINAL DESIGN AND OPERATING PLAN REPORT FOR THE EXTENSION OF THE TUTUKA POWER STATION LANDFILL SITE

Report No : P029-02

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May 2010 P029

TABLE OF CONTENTS

SECTION **PAGE**

LIST OF FIGURES

LIST OF APPENDICES

1 INTRODUCTION

1.1 Background and Terms of Reference

Eskom has a general waste landfill site within the premises of the Tutuka Power Station complex that receives general waste (including building rubble and garden waste) from the power station itself, as well as from the nearby township of Thuthukani and the New Denmark colliery. The landfill site was permitted in terms of Section 20 of the Environment Conservation Act in August 1994 as a Class 2 Domestic Waste Disposal Site, with Permit No B33/2/3/310/45-P129. The landfill has reached its capacity in terms of the permit requirements, and waste is currently being sent to the Kriel landfill. Eskom would therefore like to extend the footprint of the existing landfill, to provide an additional disposal capacity for the next 40 years.

Zitholele Consulting has been appointed by Eskom to carry out the EIA, EMP, Landfill Licence Application, Design and Operating Manual for the landfill extension. Zitholele Consulting has subsequently appointed Peter Legg Consulting as its engineering consultant for the survey of the landfill site, geotechnical investigation, design and operating plan for the proposed landfill extension.

This report covers the engineering design and operating plan for the proposed extension of the Tutuka Landfill Site.

1.2 Objectives

The overall project objective is to provide an environmentally acceptable landfill to accommodate the general solid waste disposal needs of the Tutuka Power Station, Thuthukani Township and New Denmark Colliery for the next 40 years.

More specifically, the objectives of this preliminary design phase are as follows:

- To classify the waste disposal facility in terms of waste types, size of waste stream and the potential for leachate generation.
- To confirm the suitability of the existing landfill site and surrounds for the development of the long-term waste disposal facility.
- To develop a preliminary design and operating plan for the landfill site that meets the disposal need and that incorporates the necessary precautionary measures to mitigate the identified environmental impacts and critical factors.
- To provide recommendations for the closure and rehabilitation of the existing landfill site.

The purpose of this Design Report is to document the design criteria, assumptions and preliminary details of the proposed waste disposal facility, for the purpose of incorporation into the Waste Management Licence Application and EIA reports to be submitted to the regulatory authorities. Once authorisation is obtained, the detailed design, tender process and construction of the facility can proceed.

1.3 Scope

The scope of the Preliminary Design relates to the design of a waste management facility that addresses the waste disposal needs of the Tutuka Power Station, Thuthukani township and New Denmark Colliery, and that mitigates the potential impacts the facility could have on the environment, including the socio-economic and biophysical environments.

The design of the Tutuka Landfill site is based on the “Minimum Requirements – Waste Management Series”, second edition of 1998, specifically the following documents:

- Minimum Requirements for Waste Disposal by Landfill (1).
- Minimum Requirements for Monitoring at Waste Management Facilities (2).

The Minimum Requirements for Waste Disposal by Landfill addresses landfill classification, site selection, investigation, design, operation and monitoring of landfill sites. In the landfill classification system, a landfill is classified in terms of waste class, size of operation, and potential for significant leachate generation, all of which influence the risk it poses to the environment. Graded requirements are then set for all aspects of landfill design and operation, including public participation.

The scope of this report therefore includes the following:

- Determination of the waste disposal need in terms of the types and quantities of waste to be managed and disposed of at the site, and hence the airspace and leachate management requirements.
- Description of the site and surrounds based on various site inspections and previous investigations carried out.
- Preliminary design of the waste disposal facility which includes site access, drainage, facilities and infrastructure, cell development and sequencing, leachate management, rehabilitation measures and monitoring systems.
- A preliminary operating plan which outlines the operating procedures for all aspects of the facility.
- Preliminary design for the closure and rehabilitation of the existing landfill.

Although the original terms of reference called for a landfill with a site life until 2030 (20 years), Eskom has instructed that the new landfill should have a design site life of 40 years.

2 SITE CLASSIFICATION AND WASTE DISPOSAL NEED

2.1 Introduction

In order to design a landfill facility that would meet the waste disposal needs of Tutuka Power Station, Thuthukani township and New Denmark Colliery for a period of 40 years, it is necessary to qualify and quantify the current and future waste streams. An estimate of current waste generation volumes is necessary to forecast future waste generation volumes, and hence landfill airspace utilisation. Forecasting is done by evaluating and extrapolating existing or historic data.

As the design of the landfill facility is to be based on the Minimum Requirements (1)(2), the landfill needs to be classified in terms of the Minimum Requirements, so as to determine the technical and operational standards to which the facility has to comply.

The Minimum Requirements' landfill classification system defines the disposal situation or need according to the:

- Waste type
- Size of the waste stream and landfill operation
- Potential for significant leachate generation, and the need for leachate management.

These factors will determine the potential impact of the waste facility on the receiving environment and public health. The Tutuka landfill facility has been classified on the current and projected waste stream, and on conditions at the existing landfill site.

The site classification has been carried out by Golder Associates Africa and reported in Report No 12330-9390-1 "Tutuka Power Station - Classification of New and Current Tutuka Disposal Site", January 2010(3). This section therefore gives a short summary of landfill site classification.

2.2 Waste Types and Origin

There are two generic categories of waste, General and Hazardous, according to the risk that each type poses. These are defined as follows:

General waste is normally municipal solid waste, comprising rubble, garden, domestic, commercial and general dry industrial waste. It may also contain small quantities of hazardous substances dispersed within it, such as batteries, insecticides, weedkillers, fluorescent tubes and household medical waste such as used plasters and bandages.

Hazardous waste is waste which, on account of its inherent properties such as toxicity, corrosivity, ignitability or carcinogenicity, has the potential to have a significant adverse effect on public health, even in small quantities.

Since the design of a waste disposal facility relates to the risk posed by the wastes disposed, design specifications for a general waste facility would be considerably less stringent than those for a hazardous waste facility.

Hazardous waste generated at Tutuka Power Station is either disposed of on the station's permitted hazardous waste disposal facility at the ash dumps, or it is sent to a commercial hazardous waste site.

The existing general waste landfill site currently receives solid waste from the following main sources:

Tutuka Power Station:- Domestic/office waste, garden waste, building rubble from station cleaning operations, horticultural operations and maintenance work by contractors.

New Denmark Colliery:- Domestic/office waste, garden waste and building rubble from the mines offices, plant and hostel.

Thuthukani Township:- Domestic waste, garden waste and building rubble from the residences and businesses in the township.

No hazardous waste is disposed of at the Tutuka landfill site. The existing landfill and its proposed extension would therefore be classified as a **General (G)** waste landfill site.

2.3 Size of the Waste Stream and Landfill Airspace requirements

2.3.1 Size of waste stream

In the site classification report[3], the size of the waste stream was analysed using records of waste deposited on Tutuka landfill site since its commissioning circa 1993. From this analysis, it was determined that the current rate of deposition on the landfill is approximately **35 tonnes per day**, based on 260 days of deposition in the year. This would therefore represent the initial rate of deposition (IRD) for determining the size classification of the site. After consideration of various waste stream growth rates during the life of the existing landfill site, it was decided to use a growth rate of 3.7% per annum, for determining the maximum rate of deposition (MRD) at the end of the site life, and for calculating the landfill airspace required for 40 years of waste disposal.

Using the Minimum Requirements procedure for calculating the MRD:

$$MRD = (IRD)(1+d)^t$$

Where: IRD = 34 T/d
d = 3.7%
t = 40 years

MRD = 149.7 T/d

Since the MRD is between 25 T/d and 150 T/d, the site would classify as a **Small (S)** landfill site.

2.3.2 Landfill airspace requirements

For the 40 year life of the site, the total mass of general waste to be disposed of would be approximately 845 000 tonnes, assuming no reduction due to composting or recycling. With an assumed ***in-situ*** landfill density of 1 000 kg/m^3 and a cover to waste ratio of 1:5, the total landfill airspace required is **1 014 000 m^3**. This would require approximately 167 000 m^3 of cover material for a proper sanitary landfill operation.

Details of the landfill airspace calculations are included in Appendix 1.

2.4 Potential for leachate generation

The potential for significant leachate generation depends on the water balance associated with a waste disposal site. This is dictated by ambient climatic conditions or by other site specific factors such as the moisture content of the incoming waste and/or ingress of either ground water or surface water run-off from high ground into the waste body.

2.4.1 Climatic water balance

The climatic water balance for the Tutuka Landfill site was calculated and included in the site classification report(3), according to the following equation:

$$B = R - E$$

where B is the climatic water balance in mm.

R is rainfall in mm.

E is the evaporation from a soil surface in mm, taken as 0.7 x A-pan evaporation in mm or 0.88 x S-pan evaporation in mm.

The value of B is calculated for the wet season of the wettest year on record. It is then recalculated for successive drier years until it is established whether B is positive for less than one year in five for the years for which data is available. If so, the following criteria apply:

- No significant leachate generation.
- Classified B^-
- No leachate management system necessary.

or B is positive for more than one year in five for the years for which data is available. If so, the following criteria apply:

- Significant leachate generation can be expected
- Classified B^+

- A leachate management system is a Minimum Requirement

For the climatic data available for the Tutuka area (rainfall and evaporation), B was found to be negative for nine of the ten years of climatic data used. This means that the landfill is not expected to generate significant leachate.

Other factors that could affect the water balance of a waste site include the moisture content of the incoming waste, and the ingress of groundwater and/or surface water into the waste body due to poor siting, design and maintenance of the site.

No significant volumes of high moisture content wastes are expected to be received at the site. Provided that upslope surface water drainage systems are installed to prevent the ingress of stormwater runoff onto the waste body, the site water balance should not be affected and significant leachate generation should not be expected.

Based on the above, the Tutuka landfill site is therefore classified as a $\mathbf{B^-}$ waste disposal facility. In terms of the Minimum Requirements, it should not be necessary to install a leachate management system. However, based on the fact that the existing landfill has already impacted negatively on the groundwater environment, it would be advisable to install a bottom liner and leachate detection and collection system on the new landfill.

2.5 Discussion

The design of the Tutuka landfill facility must make provision for approximately 1 014 000 m^3 of general waste disposal airspace for the 40 year design life.

The landfill operation and infrastructure will have to accommodate a waste stream of up to 150 tonnes per day.

On account of the negative climatic water balance, significant leachate generation from the landfill is unlikely, and a formal leachate management is not required. However, a leachate detection and collection system should be installed as a precautionary measure.

Based on the foregoing, the Tutuka landfill facility is to classified as a $\mathbf{G{:}S{:}B^-}$ waste disposal facility.

3 SITE DESCRIPTION

3.1 Introduction

As part of the EIA process for the development of the new waste disposal facility, a number of alternative candidate landfill sites were identified on Eskom/Tutuka Power Station property. These sites were visited and evaluated according to various technical, economic, environmental and public acceptance criteria. Sites where potential fatal flaws were identified were eliminated as candidate landfill sites. The remaining candidate sites were then scored for each criterion, and ranked in order of suitability. Based on this evaluation and ranking process, the most suitable candidate landfill site (Alt 3) turned out to be the area immediately to the west of the existing landfill, followed by the two adjacent areas immediately southwest (Alt 4) and south (Alt 2) of the existing landfill site. These alternative sites are indicated on Figure 1. It was therefore decided that the new Tutuka landfill facility should be developed as an extension to the existing landfill, in the area immediately adjacent to the west side of it.

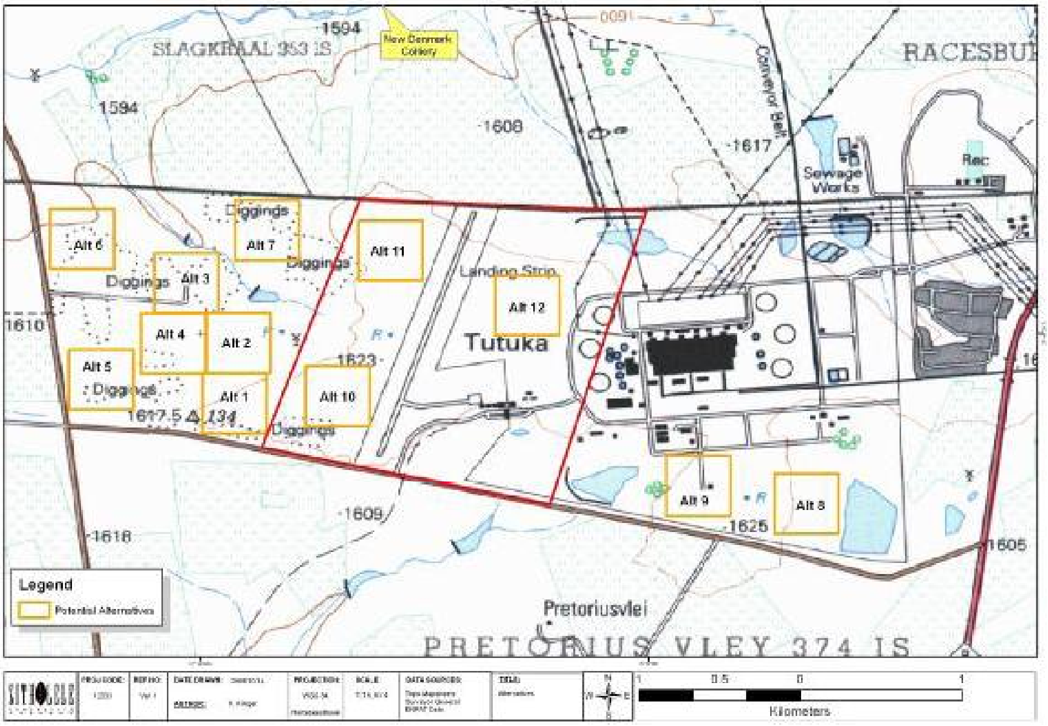

Figure 1: Location of alternative candidate landfill sites

If feasible, it would be preferable to integrate the new landfill into the existing landfill by extending the footprint and raising the current height of the landfill. Based on preliminary estimates, a total footprint of approximately 8.48 ha will be required to provide sufficient airspace for 40 years of waste disposal. This will be achieved by using the existing landfill footprint together with the area between the current landfill and the borrow pit to the west, and by extending the landfill in a southerly direction.

The area of the existing landfill site and surrounds has been surveyed to determine topography, significant features such as trees, roads, fences, drains, buildings, tracks, boreholes and drainage courses, see Drawing No 12333/01. The positions of the ten testpits excavated and profiled as part of the geotechnical investigation are shown on Drawing No 12333/02. These testpits were positioned in the area proposed for the new landfill site. The drawings are included in Appendix B.

The area of the waste site is described to produce an overview of the status quo of the site and its current impact on the environment, and to identify problems or factors that would need to be addressed in the design.

3.2 Location, Size, Ownership and Current Land-use

The landfill site is located approximately 2 km to the west of Tutuka Power Station precinct on the farm Pretorius Vley 374 IS, on property that is owned by Eskom. This entire property has been zoned for industrial use. The permitted landfill site covers an area of 3.224 ha, although the landfill itself has a footprint area of 2.543 ha. The area available for the new landfill is in excess of 50 ha, which is far greater than required. The site is located within a highly disturbed area as a result of extensive gravel excavation operations for the power station site. The landfill itself was sited within a previous borrow pit, although there is a small area of undisturbed land approximately 100 m wide immediately to the west of the landfill. To the west of this undisturbed area, and to the east of the landfill, there is evidence of gravel excavations, resulting in a highly uneven ground surface and ponded water.

The location of the site is indicated on Figure 2.

Figure 2: Site locality plan

The current landfill is approximately 250 m long by 100 m wide, and is 7 m above natural ground level at its northern end. At the southern end, the landfill surface is at ground level. There is an upslope stormwater diversion drain along the southern side of the landfill that drains in a westerly direction to the borrow pit on the west side. Access to the landfill site is by means of a gravel road from the south side, which then runs along the western toe of the landfill. Cover material for the landfilling operations is obtained from a dolerite borrow pit approximately 400 m to the south west of the landfill.

3.3 Topography and Drainage

The site is situated in sub-catchment C11K-B and has been developed upon gradual slopes and a semi-developed drainage system. An east-west trending ridge that falls to more moderately sloping country defines the southern boundary of the site. On the eastern side of the site, surface relief is gently sloping at approximately 3% in a northerly direction towards an ephemeral stream that flows in a north westerly direction past the northern side of the landfill towards the Racesbult Spruit. The Racesbult spruit in turn flows in a westerly direction into the Leeuspruit. The ridge terminates along the western boundary of the property, where the country falls steeply towards the Leeu Spruit. The Leeu Spruit drains the area to the west of the site to the Grootdraai Dam, an artificial impoundment constructed across the Vaal River approximately 10 km from the site.

3.4 Climate

The site falls within the summer rainfall region of the Highveld, with warm, wet summers, and mild, dry winters, with annual equivalent evaporation depths exceeding precipitation. Winds blow predominantly from the northwest, particularly in the afternoon, although they do gust from the southwest during thunderstorm events. Regular dust storms can also be expected during periods of prolonged dry weather.

Air temperatures show significant daily and seasonal variations, with mean temperatures at their maximum in December and January (27^0C), and minimum in June and July (-1^0C). Frosts can be expected in the 150-day period between May and September.

Average annual rainfall is about 680 mm, whilst average annual evaporation is about 1 780 mm. The site therefore has a definite negative climatic water balance.

3.5 Flora and Fauna

Notwithstanding the high level of disturbance of the site, the area is well vegetated by typical Highveld grasses. Even in the older borrow pits, natural vegetation has re-established itself.

Although no animals were observed on the site, there is evidence of small animals such as rabbits, etc on the site. There is also extensive bird life in the area as a result of the ponded water in the gravel borrow pits that have formed artificial wetlands.

3.6 Geology, Soils and Groundwater

3.6.1 Geology

According to 1 in 1 000 000 "Geological Map of the Republic of South Africa and the Kingdoms of Lesotho and Swaziland 1997" as prepared by the Council for Geoscience, the site is located within the Vryheid Formation of the Ecca Series of the Karoo Supergroup. This formation consists principally of dark-grey shale, which is carbon rich in places (coal), together with interbedded sandstone units. The shale is laminated and, on weathering, breaks up into plates and flakes. In the Tutuka area, the Power Station itself is situated directly over the Karoo shales, whilst at the landfill site, the Karros hales are overlain by a large dolerite sill of significant thickness.

A geological map showing the site location is included in Figure 3 below.

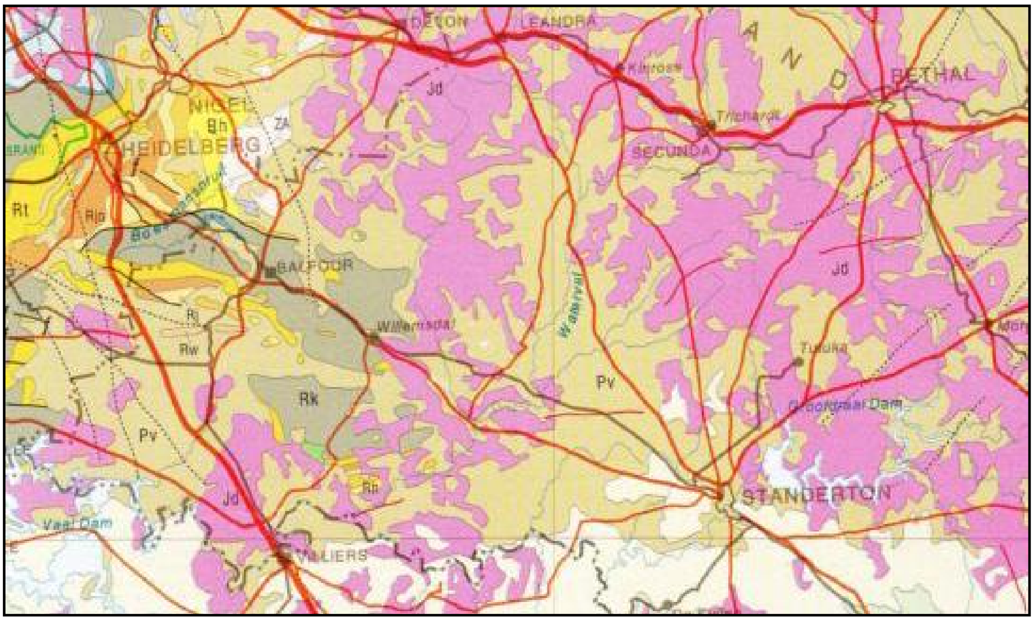

Figure 3: Geological Map showing the Tutuka Power Station site

Legend: Jd = Dolerite
Pv = Karoo Vryheid Formation

According to Brink[(4)], in areas where the Weinert climatic N-value[1] is between 2 and 5, the weathering of the dolerite results in the primary minerals decomposing into secondary minerals of the smectite group, mainly montmorillonite, occurring in the form of grey to black, highly active clays.

[1] The N-value is calculated as $N = 12xE_j/P_a$, where E_j = Evaporation during January
P_a = Annual precipitation

These clays are best developed in poorly drained areas or flat terrain. The depth of clay is therefore related to the topography, being thicker in flat areas and thinner in steeper areas. The Tutuka Power Station complex and surrounds falls within the zone of 2 < N-value < 5. Therefore highly active black clays, commonly referred to as “black turf” would be expected in the area of the landfill site.

3.6.2 Site Soils

From the geotechnical investigation[5] carried out, refusal of the excavator occurred on weathered dolerite in all 10 testpits, with the deepest (2.1 m) being at the lower end of the site, and the shallowest (1.0 m) being at the higher end of the site. This is consistent with the literature, with increased erosion of weathered materials on the higher slopes and increased in-situ weathering of rocks lower down the slope. The sequence of soils on the site are as follows:

Colluvial Soil (black clay)

There is a layer of expansive colluvial black clay that varies in thickness across the site from 0.25 m to 0.5 m. Because of its highly expansive nature, this clay is totally unsuitable as a founding stratum or for use in a compacted clay liner. As the site investigation was carried out during the summer rainfall period and because there had been significant rain in the weeks prior to the investigation, the black clay was moist to very moist, and did not show desiccation cracking. However, the very high linear shrinkage of the black clay results in large shrinkage cracks on desiccation. It should therefore be removed from the site before the landfill liner is constructed and stockpiled for use as landfill cover material.

Residual dolerite

Beneath the black clay there is a layer of light brown (yellow to orange brown) medium dense to dense, residual dolerite that varies from gravely sand, to sandy gravel, to sandy clay in places. This material should form the base of the landfill liner. It could also be used as a founding stratum for lightly loaded buildings with foundation bearing pressures up to 200 kPa.

Weathered Dolorite

Beneath the residual dolerite soil is a layer of weathered dolerite that increases in strength with depth. The weathered dolerite appears as “granular (sugar) dolerite” in the upper zones of the soil profile with typical “onion” shell cobbles and small boulders. There is evidence of decomposition of the dolerite. Lower down in the profile, the weathered dolerite becomes more like “gravel dolerite” with a disintegrated and fractured nature. The consistency of this horizon is dense to very dense, which indicates a safe bearing capacity of about 400 kPa.

Bedrock

Depth to weathered dolerite bedrock increases down the slope from about 1.0m on the upper side of the site to 2.1 m on the lower side of the site. If required as a founding stratum, the weathered dolerite bedrock would provide a safe bearing capacity of about 500 kPa. The weathered rock would be excavatable by means of a large hydraulic excavator or dozer ripper, without the need for blasting.

3.7 Groundwater

GHT Consulting Scientists recently carried out a geohydrological investigation of the Tutuka landfill and its surrounds, that included geological mapping, geophysical investigations, installation of three more monitoring boreholes, a hydocensus, sampling and analysis of surface water and groundwater, and a geohydrological assessment. The results of this investigation are contained in GHT Report No RVN574.1/1025 "Proposed Extension Domestic Waste Site, Tutuka Power Station", April 2010[6]. Included hereunder are the key findings forthcoming from the GHT geohydrological report.

There are perched and regional aquifer systems associated with the Karoo sediments at the site. The upper aquifer appears to be perched on an impermeable dolerite sill and has a relatively localized occurrence depending on the thickness of the weathered dolerite zone, while the deeper aquifer is restricted to minor fractures, cracks and joints interfaces within the fresh dolerites. Aquifers within these structures are essentially unconfined and perched on top of the impermeable dolerite sill. This is confirmed by the depth to the perched groundwater table beneath the proposed landfill extension which varies from approximately 3 mbgl in the south to less than 1 mbgl in the north (see Figure 4).

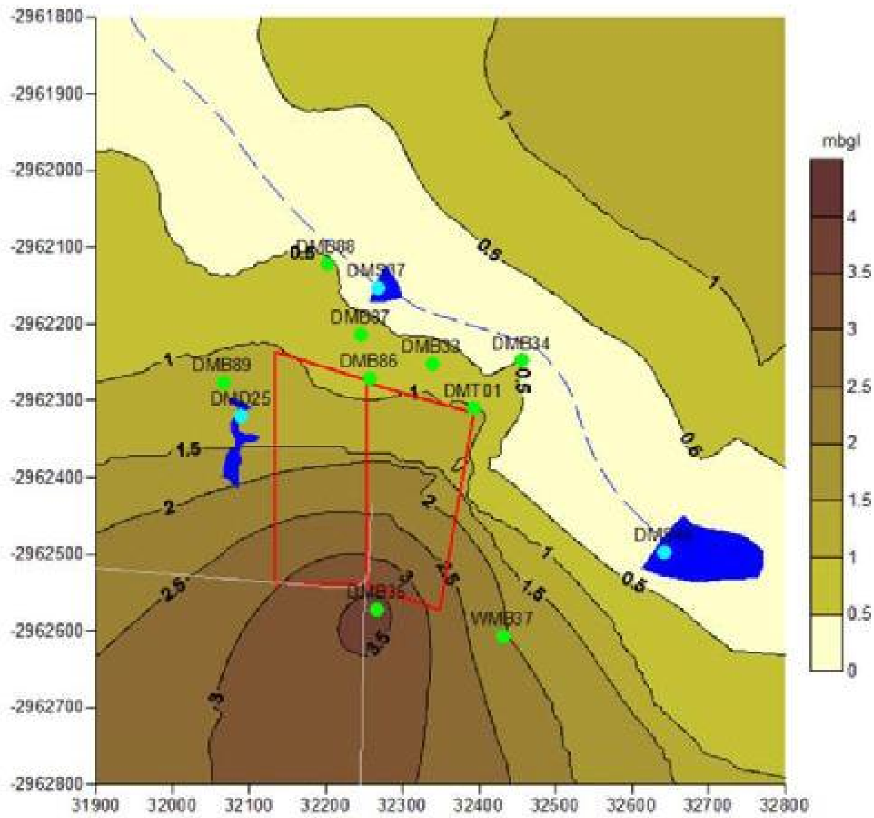

Figure 4: Unsaturated zone / depth to top of groundwater table in meters below ground level [5]

These aquifers can be recharged directly from rainfall or from surface water bodies, with the rate of recharge influenced by site hydraulic conductivity. Laboratory testing indicates that the in-situ soils are more permeable than the underlying dolerites by at least and order of magnitude. The lowest K value measured for in-situ soil/weathered dolerite was 1.2×10^{-7} m/s, compared with a value of 6.7×10^{-8} m/s for the aquifer within the dolerites. Water will therefore preferentially flow through the soil profile of weathered fractured dolerite. Further, once a moisture front reaches the weathered/fresh dolerite interface, lateral as opposed to vertical flow will predominate.

From the geohydrological investigation it was estimated that contaminants from the landfill would take at least 200 years to reach the ephemeral stream north of the site through the dolerite aquifer. However, the rate of groundwater movement through perched aquifers in the weathered fractured zone is significantly higher than through deeper aquifers, and it would take at least 37 years for contaminants to reach the same ephemeral stream.

The following conclusions and recommendations were made from the geohydrological investigation:

- Groundwater is used predominantly for stock use in the surrounding area, although there is also some rural domestic water use and this appears unlikely to change in the near future.
- Aquifers in the area surrounding the landfill site would be classified as “Low / No significance”.
- Groundwater quality in the area to the north of the landfill site has already been degraded by past waste disposal activities.
- Geohydrological assessment of the site using WASP (Parsons and Jolly, 1994) suggests the site be classified “marginal” to “suitable” for solid waste disposal, and aquifer pollution on adjoining properties is unlikely.
- The control of surface run-off and sub-surface seepage with a view to preventing the pollution of adjacent surface water bodies is of major importance at the site. Interception drains should be constructed down to the soil/weathered rock interface around the perimeter of the site to prevent and control the rapid migration of pollutants through perched aquifers towards the ephemeral stream.
- Investigation data indicates that the underlying dolerite sill is relatively impermeable at the site. Thus, excavations associated with waste disposal activities could extend to the soil/weathered rock interface.
- Site soils are unsuitable for use as a landfill liner material, but can be used as waste cover material. The final covering layer should predominantly comprise topsoil, however, to aid with site rehabilitation.
- Detection monitoring at the landfill site must be performed as per the frequency and parameter list for the overall Tutuka Power Station complex. It is recommended that groundwater be monitored at seven borehole sites and surface water at three sites. The existing leachate detection sump should also be included in the monitoring program.

- Additional sampling will also be required in those areas where surface water impoundments are constructed as part of any waste disposal operations. Should detection monitoring indicate that water quality has degraded over time, an increase in the sampling frequency and the number of parameters to be determined during laboratory testing will be required. Specialist geohydrological advice should also be sought.

3.8 Discussion

The proximity of the existing landfill site to the Tutuka Power Station, Thuthukani Township and New Denmark Colliery, and its relatively easy access from the main road support its extension and development as a long-term waste disposal facility. By integrating the new waste disposal facility with the closure and rehabilitation of the existing landfill represents the best environmental alternative. As the existing landfill has already impacted on the environment (including the groundwater), it would be preferable to address the current environmental impacts of the existing landfill, and extend the landfill, rather than create a new potential environmental impact by developing a new landfill site elsewhere.

The existing site has infrastructure such as a gate house, monitoring boreholes, drains and fencing that could be used for the new extended landfill site.

There is sufficient land available for the proposed extension of the landfill. The natural topography of the area with a slope of about 3% favours the development of a landfill. Due to the dolerite gravel excavation activities on and around the site, it is not pristine and the development of the landfill extension should not impact significantly on flora and fauna.

The shallow excavatable soils on the site mean that soil for waste covering operations will have to be imported from nearby borrow pits. The black clayey colluvial soils are unsuitable for use in the landfill liner construction, and will have to be removed and stockpiled for use as cover material in the landfilling operaions. The residual dolerite soils are gravelly and sandy and therefore also not suitable for use in the liner construction, but would be used to form the base of the liner.

From a groundwater perspective, the site has a perched aquifer within the fractured/weathered dolerite, and a deeper aquifer beneath the dolerite sill. The aquifer is classified as “low / no significance”, and the WASP[2] geohydrological assessment rates the site as “marginal” to “suitable” for the development of a waste disposal facility. The deep soils also favour landfill development, however the fact that the soils are fairly permeable and the area is underlain by significant dolomitic aquifers, means that the landfills will have to be provided with good engineered barrier systems to protect the groundwater.

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[2] WASP - Waste Aquifer Separation Procedure. Developed by Parsons, R. & Jolly, J. 1994. *The development of a systematic method for evaluating site suitability for waste disposal based on geohydrological criteria.* WRC Report No. 485/1/94, Pretoria.

4 PRELIMINARY DESIGN OF THE LANDFILL FACILITY

4.1 Introduction

The design presented in this section is a preliminary technical design of the proposed new Tutuka landfill site. It is presented with a view to providing the general layout and content of what is envisaged at this stage, rather than providing a detailed technical design and construction specification. The design is based on the Minimum Requirements for the class of landfill under consideration [(1)], although in certain instances, the design has been changed from the Minimum Requirements due to site specific conditions. Included in this preliminary design are the proposed layout, liner details, drainage features, infrastructure and development of the site. Regarding implementation, it is noted that a full design specification, including construction drawings and schedules of quantities, would have to be drawn up on the basis of this design once approved.

The general objective of landfill design is to provide a cost-effective, yet environmentally safe and socially acceptable waste disposal facility. More specifically, the design presented is aimed at minimising the potential for pollution of the environment, particularly the ground water and surface water bodies, as well as the surrounding air. Due attention is therefore given to the site specific aspects identified during the on-site investigations.

The design makes provision for the phased development of the site, as determined by the waste disposal need. The intention is to monitor the operation of the facility closely for the first few years, particularly regarding the size and nature of the waste stream, and operation of the facility. On the basis of this monitoring, the design may then be modified and further refined for the subsequent phases of the development.

The layout and details of the design proposed for the Tutuka Landfill site are shown on Drawing No's 12333/01 to 12333/08 included in Appendix B of this report.

4.2 Constraints and factors affecting the design

Taking into consideration the waste disposal need, the physical conditions of the site, and discussions with various Eskom and project personnel, there are several factors that affect the design philosophy adopted. These are as follows:

- The Tutuka landfill facility design needs to comply with the Minimum Requirements for a $G:S:B^-$ landfill.
- The design of the landfill needs to cater for a total waste stream of 845 000 tonnes over the 40 year site life. With a 20% allowance for soil cover material, a total landfill airspace of 1 014 000 m^3 is required.
- The northern boundary of the site is defined by the ephemeral stream, whilst the western boundary is defined by the borrow pit with ponded water. The existing landfill defines the eastern boundary of the new landfill. Although the site fence and stormwater drain define the southern

boundary of the site, it is possible to move this boundary southwards to achieve the required airspace.

- The soils on the site are not suitable for use in the landfill liner construction. The liner design is therefore based on a geocomposite landfill liner.
- The existing landfill has impacted negatively on the groundwater environment and must therefore be closed and capped without delay.
- The design of new landfill should be integrated with the closure and capping of the existing landfill in terms of liner and drainage.
- The design must make provision for the sequential phased development of the landfill, such that leachate flows from the lowest point of the landfill cell can discharge into the leachate pond under gravity.

4.3 General site layout

Based on the aforementioned constraints and factors, the overall layout of the initial phase of the Tutuka landfill facility has been developed as shown on the attached drawings in Appendix B. The arrangement of the various facilities and the sequence of development have been determined according to topography, drainage requirements, geology and distribution of soils over the site, access to the various portions of the site, and the possible impacts on surrounding land users.

Initially a strip of land adjacent to the western toe of the existing landfill is to be developed together with the shaping and capping of the existing landfill as indicated on Drawing No 12333/05. This area (0.68 ha) is still within the originally permitted footprint of the landfill site and can proceed under the existing landfill permit. Thereafter the remainder of the area (1.77 ha) on the west of the existing landfill is to be developed up to the borrow pit as indicated on Drawing No 12333/03. Once this landfill footprint (including the existing landfill) has filled with waste up to its maximum design height, the area to the south of the site would be developed as shown on Drawing No 12333/07 to give the 1 million m^3 of total landfill airspace required for the 40 years of site life. The total final footprint area would be approximately 8.54 ha.

The entrance to the site would remain in its current position at the south western corner of the existing landfill for the Phase 1 landfill operation. The existing gravel access road off the Tutuka Power Station road would continue to be used for waste deliveries to the site. The existing gate house at the entrance would also continue to be used for Phase 1 operations. Once the Phase 2 area is developed on the south side of the existing landfill, the southern fence, site entrance and gate house would have to be relocated further south on the access road.

The Phase 1 landfill cells are to be developed adjacent to the western side of the existing landfill with the contaminated water and leachate ponds located downslope to the north of the landfill to facilitate gravity drainage of contaminated run-off and leachate.

The landfill cells are to be developed generally according to the footprint shapes shown on the drawings. The initial development of the strip alongside the western toe of the existing landfill and the shaping of the surface of the existing landfill up to its maximum permitted height of 5 m above natural ground level would give approximately 4 years of operational life.

Once the new landfill site licence is obtained the remainder of Phase 1 would be developed and landfilling would take place up to a height of 30 m above natural ground level. Development sequence would be from south to north, starting at the higher elevation to enable gravity drainage of leachate and contaminated water away from the waste body. A starter berm is to be constructed around the perimeter of the landfill by means of a cut-to-fill operation.

At the lower end of the site on the northern side, the contaminated water and leachate ponds would be constructed and lined to the Minimum Requirements standards. Provision is to be made at the ponds to extract excess leachate and water either for disposal at the nearby sewage works or for spraying over the landfill for dust control. This would facilitate reduction of the contaminated water and leachate through evaporation of the water component whilst retaining the contaminants within the lined landfill.

A ring road would be constructed around the perimeter of the site, as well as storm water drains to divert clean up-slope run-off away from the facility.

4.4 Services and infrastructure

4.4.1 Access and Roads

Access to the site is directly from the existing Tutuka Power Station eastern access road. The road to the landfill site from this road is a gravel road which will have to be maintained regularly according to weather and traffic conditions. A gravel ring road is to be constructed around the facility to allow for maintenance and monitoring, as well as to form a firebreak.

Incoming vehicles would be checked at the gatehouse for the type of waste being delivered. From there, the vehicles would be directed to active tipping area on the landfill.

4.4.2 Weighbridge

Due to the small quantities of waste expected, it does not justify the installation of a weighbridge. In exceptional circumstances where vehicle weighing is necessary, this can be arranged at the Power Station.

4.4.3 Laboratory

For a small general waste landfill, a laboratory is not required on site. Water quality analyses are to be conducted at commercial laboratories or at the Power Station laboratory.

4.4.4 Fencing

The entire perimeter of the site is to be fenced with a 1.8 m high razor mesh security fence to prevent unauthorised access. Lockable vehicle access gates are to be provided at the entrance to the site, which should also be manned 24 hours per day by a security guard.

4.4.5 Water

For the small size of operation and small number of site personnel, there is no need to pipe potable water to the site. Potable water can be brought to the site in containers for drinking purposes.

For dust control purposes on the landfill, water from the contaminated water pond is to be used however, if this is insufficient, additional water from the nearby gravel borrow pits will have to be used.

4.4.6 Electricity

There is no need for electrical power at the site. Lighting is not required as the site is only operated during daylight hours.

4.4.7 Staff facilities

The only building required on the site for the size of the current operation is the existing gatehouse, which has a toilet for the use of the few site staff. When the site entrance is moved to accommodate the southern extension of the landfill, the new gate house should be larger to include a mess room for the site staff.

4.4.8 Plant maintenance facilities

Due to the landfill site's close proximity to the Tutuka Power Station, there is no need to establish a plant and equipment maintenance facility on the site, as the plant and equipment would be sent to the Station workshops for maintenance.

4.5 Landfill design

4.5.1 Design approach

As stated in Section 2, the Tutuka landfill site has been classified as a G:S:B$^-$ landfill. The Minimum Requirements for this class of landfill calls for only a recompacted base preparation layer beneath the landfill rather than a proper liner, and no leachate management system. However, based on the fact that the existing landfill has already impacted on the groundwater environment and that the fractured/weathered dolerite is highly permeable, it is believed that an engineered landfill liner is required at the site.

Although the climatic water balance suggests that there should not be generation of significant leachate, a leachate detection and collection system, as well as a small leachate sump is to be constructed as a precautionary measure, particularly since the existing landfill has already impacted the groundwater. This is in line with the approach adopted in the draft 3rd edition of the "Minimum Requirements for Waste Disposal by Landfill".

The existing landfill needs to be capped without delay. It is proposed that this cap would double as a bottom liner for extending the landfill on top of the existing landfill. This "piggy-back" liner would tie in to the new landfill liner and leachate collection system.

4.5.2 Existing landfill capping and initial landfill development

In order to address the short-term disposal needs, the remaining permitted landfill footprint is to be developed for waste disposal. This development is to be done in conjunction with the construction of a landfill capping / "piggy-back" liner over the existing landfill. In addition, a leachate sump is to be installed as part of this development. The extent and details of this development are shown on Drawing Nos 12333/05 and 1233/06 included in Appendix B.

The surface of the existing landfill is to be raised and shaped to create a cross-fall in a north-westerly direction using deposited waste, to the levels indicated on Drawing No 12333/05. The "piggy-back" liner is to be constructed on this shaped surface as described in section 4.7. Perforated HDPE leachate collector pipes are to be installed on the "piggy-back" liner as detailed, to connect into the main leachate drain running along the western toe of the existing landfill. The outer slopes of the landfill are to be cleared of vegetation, trimmed and the outer capping constructed as detailed.

Along the western side of the existing landfill, a strip approximately 30 m wide is to be developed for waste disposal as shown on Drawing No 12333/05. The area is to be stripped of black clay and stockpiled for use as cover material, and a 1 m high perimeter berm constructed to clearly demarcate the extent of the landfill footprint. The landfill liner is to be constructed as shown on Drawing No 12333/06. A 315 mm dia HDPE leachate main drain is to be installed along the toe of the existing landfill, to drain into an HDPE leachate sump installed to the north of the site. Perforated leachate collector pipes are to be installed "herring-bone" fashion on top of the landfill liner to drain into the leachate main drain.

By landfilling the area with waste up to the raised levels of the existing landfill, it will give an airspace of approximately 40 500 m^3, which would give an operational site life of about 4 years.

4.5.3 Phase 1 landfill development

Once the landfill site licence has been issued, the remainder of Phase 1 can be developed. The layout and details of this development are shown on Drawing Nos 12333/03 and 12333/04 included in Appendix B.

The area is to be stripped of black clay and a 1.5 m high starter berm is to be constructed around the perimeter of the new landfill. The landfill liner is to be constructed as detailed, and a “herring-bone” system of perforated HDPE leachate collector pipes installed diagonally down the slope, to connect into the leachate pipes beneath the initial development area. A contaminated water drain lined with geocells is to be constructed along the outside of the landfill toe, to drain into the contaminated water pond to the north of the site.

The existing upslope stormwater cut-off drain is to be extended in a westerly direction to drain into the western borrow pit water body.

By landfilling this entire Phase 1 area with waste up to the raised levels of the existing landfill, it will give an airspace of approximately 86 500 m^3, which would give an operational site life of about 7 years. If the landfill is then taken up to its maximum practicable height of approximately 30 m above natural ground level, it will give an airspace of approximately 454 000 m^3, which would give an operational site life of about 25 years

4.5.4 Development plan

The aim of the Development Plan is to develop the landfill from its initial constructed state, to its proposed final landform.

Landfilling is to commence on the existing landfill to achieve the required cross falls for drainage, and in the initial development area at the higher end of the cell, and is to proceed downslope in a northerly direction. Initially, a pioneering layer of waste at least 600 mm thick is to be placed over the liner by means of end tipping and spreading to protect the installed liner.

The working surface of the landfill is to be sloped towards the leachate collector drains at the lower end of the cell. Landfilling is to be taken up to maximum practicable height (approximately 5 m above natural ground level) before moving downslope to the next deposition area. The outer slopes of the landfill are to be taken up at a slope of 1V:3H.

Once the Phase 1 area has been developed, landfilling can be taken up to final height of approximately 30 m above natural ground level. Once this area has been landfilled with waste, the operation would move into the southern extension area.

As each section of the landfill cell is completed to final height, the outer slopes of the landfill are to be graded and final cover applied on an ongoing basis. This will help to minimise leachate generation and will also make the landfill more aesthetically pleasing.

Drawing No 12333/07 shows the sequential development plan for the various stages of development from the initial development through to the final landform after 40 years.

4.6 Leachate and drainage management

The drainage systems normally associated with a landfill site address three components:

- Uncontaminated upslope run-off
- Contaminated run-off from the landfill itself
- Highly contaminated leachate generated within the landfill

All upslope run-off water must be diverted away from the waste, to prevent water contamination and minimise leachate generation. Surface run-off from uncovered waste on the landfill and waste handling areas is considered to be potentially contaminated, and should not enter natural drainage courses without prior treatment or sufficient dilution. Highly contaminated leachate should similarly not enter the natural water regime without prior treatment or purification.

The different drainage streams are discussed separately below.

4.6.1 Upslope storm water drainage

Uncontaminated upslope run-off is to be prevented from entering the landfill facility area by means of a diversion drain along the higher southern side of the landfill. The existing drain will have to be extended in a westerly direction past the Phase 1 landfill area. When the landfill development moves into the southern extension area, a new upslope drain will have to be constructed.

In addition, due to the presence of the perched aquifer within the fractured/weather dolerite, a “fin drain” is to be constructed upslope of the landfill site to intercept and divert groundwater seepage away from the waste body. This “fin drain” would comprise of a perforated HDPE pipe with a geonet vertical fin, all wrapped in a geotextile, set in a trench through the fractured/weathered dolerite, and backfilled with granular soil (dolerite gravel). The “fin-drain” would daylight on either side of the landfill. In addition, the perimeter road around the landfill will also act as a drainage diversion berm. At the side of the landfill, the upslope cut-off drains would discharge into the open fields or into the adjacent water bodies. The drains are to be sized to handle peak flows from the 1 in 50 year recurrence interval design storm.

The layout and details of the storm water drainage system are shown on the attached drawings.

4.6.2 Contaminated surface run-off

Potentially contaminated run-off from the outer surfaces of the waste body and site roads is to be directed towards an open V-drain along the outer toe of the starter berm. This contaminated water drain would discharge into the contaminated water pond located next to the north of the site. The working surface of the landfill is to slope towards the outer berms so that water drains away from the working face towards the toe drains. As portions of the landfill reach final height and final cover has been applied, run-off from these areas would be considered as uncontaminated, and the toe drain would then be directed to link up with the clean storm water system.

The contaminated water pond has been sized to contain the runoff from half of the exposed waste body for the 1 in 50 year recurrence interval 24 hour duration storm. The run-off pond has been sized at 1 880 m^3, plus a 500 mm freeboard. The contaminated water pond is to be 50 m x 25 m x 3 m deep, with a geocell lined spillway to discharge overflow water during extreme rainfall events. The liner design for the contaminated water pond is discussed in Section 4.7, and the details of the pond are shown on Drawing No 12333/08.

4.6.3 Leachate Management

The three main components of a leachate management system include the following:

- The liner beneath the landfill to prevent infiltration into the ground water.
- The collection system to transfer leachate to the treatment system.
- The leachate treatment system to prevent surface water pollution by leachate.

Any leachate emanating from the waste in the landfill would appear in the 150 mm thick granular soil layer overlying the composite liner and would flow downslope beneath the landfill towards the leachate collector drains. These drains would consist of 110 mm diameter perforated HDPE pipes placed within a zone of 38 mm aggregate approximately 1 m wide.

These primary leachate collectors would discharge into a 315 mm diameter main leachate gravity drain running along the centre of the landfill, to discharge into the leachate sump located to the north of the facility. Manholes are to be provided at the top and bottom of this leachate main drain for inspection and maintenance purposes. Manholes on all leachate drains are to have vented manhole covers to prevent the build up of landfill gas in these manholes.

Leachate emanating from the landfill is to be contained in an HDPE sump, located to the north of the landfill. Leachate from the leachate sump is to be removed by tanker and taken to the nearest sewage treatment works for treatment. The leachate sump will have a manhole to facilitate leachate removal and an overflow into the contaminated water pond.

Since the landfill is located within a water deficit area with a negative climatic water balance, significant leachate generation is not expected. However, during the early stages of waste desposition over the exposed liner, there would be significant run-off that will enter the leachate system. This run-off would tend to be a very weak contaminated water rather than actual leachate, so there should be no problem allowing it to overflow from the leachate sump into the contaminated water pond. The leachate sump is to consist of a “Weholite” HDPE pipe 1.8 m dia by 6 m long laid horizontally and with blank flanges welded to both ends. The leachate inlet and outlet pipes will be welded through the end flanges, and a vertical manhole is to be welded into the top of the sump. The effective volume of the leachate sump would be approximately 12 m^3. The details of the leachate sump are shown on Drawing No 12333/08.

4.7 Liner designs

The liner designs for the landfill and the contaminated water pond have been developed in accordance with the Minimum Requirements, although various modifications and improvements have been made to address site specific conditions. The various liner designs are shown on Drawing Nos 12333/04, 12333/06 and 12333/08.

4.7.1 Landfill liner (G:S:B$^-$)

In terms of the Minimum Requirements, an G:S:B$^-$ landfill liner would normally comprise of only a recompacted base preparation layer of in-situ soil. However, in view of the fact that the in-situ dolerite soils and fractured dolerite are highly permeable, and because the existing landfill, that does not have a bottom liner, has contaminated the groundwater, an upgrade liner is proposed for the landfill extension. As there is no suitable clay in the area for the construction of a compacted clay liner, a geosynthetic clay liner (GCL) is proposed. The liner proposed for the landfill extension would therefore comprise of the following components, working from the top downwards:

- Leachate detection and collection drains at 25 m centres, comprising of 110 mm dia perforated HDPE pipes, set in 1 m wide strips of 38 mm aggregate 300 mm deep.
- 150 mm layer of granular soil (blocky, "sugar" dolerite).
- 150 mm layer of fine soil.
- Geosynthetic clay liner (GCL) (3 600 kg/m^2).
- 150 mm base preparation layer (recompaction of in-situ sandy soil).

4.7.2 Existing landfill "Piggy-back" liner

As stated earlier, the top of the existing landfill is to be brought up to the required levels to achieve gravity drainage in a north westerly direction by means of landfilling further waste on top. Thereafter, the surface is to be compacted and shaped to receive the "Piggy-back" liner system over the existing landfill surface, comprising of the following components, working from the top downwards:

- Leachate detection and collection drains at 25 m centres, comprising of 110 mm dia perforated HDPE pipes, set in 1 m wide strips of 38 mm aggregate 300 mm deep.
- 150 mm layer of granular soil (blocky, "sugar" dolerite).
- 150 mm layer of fine soil.
- Geosynthetic clay liner (GCL) (3 600 kg/m^2).
- 150 mm layer of fine soil.

- Geogrid (RockGrid PC50/50 or equivalent) to address localised differential settlement of the waste.
- 150 mm base levelling layer of dolerite soil on compacted waste.

4.7.3 Contaminated water pond liner (G:S:B$^-$)

The liner design for the contaminated water pond would be similar to the landfill liner, except that the leachate drainage layer would not be required. The liner layers on the base and walls of the pond would therefore comprise of the following components, working from the top downwards:

- 500 mm soil protection and confining layer
- Geosynthetic clay liner (GCL) (3 600 kg/m^2).
- 150 mm base preparation layer (recompaction of in-situ silty soil)

4.7.4 Existing landfill final cover

The outer slopes of the existing landfill will have to be capped and rehabilitated. As these slopes are steeper than 1:3 (V:H), it will be necessary to retain the soil on the slopes. The final cover for the eastern and northern slopes of the existing landfill include the following components, working from the top downwards:

- 200 mm topsoil with indigenous grass
- !50 mm deep geocells filled with dolerite soil.
- Geosynthetic clay liner (GCL) (3 600 kg/m^2).
- 150 mm base preparation and levelling layer of soil

4.7.5 Construction Quality Assurance

The main risk to the performance of a geosynthetic liner system is mechanical/physical damage, during and after installation. For this reason, it is imperative that the liner is supplied and installed by a competent and reputable contractor, and in accordance with a strict quality assurance programme. In particular, extreme care must be taken when placing the cover soil over the installed GCL so as not to damage the liner. Strict supervision is required.

4.8 Landfill Gas Management

On account of the organic content of the general waste it is highly likely that the landfill will produce landfill gas. However, due to the remote location of the landfill away from any human development, as well as the small size of the landfill operation, it is proposed at this stage that a formal gas management system at the site is not necessary. This is in accordance with the Minimum Requirements. Due to the limited compaction applied by the site TLB (tractor-loader-backhoe) and the fact that cover material is not always applied on a daily basis, it is accepted that landfill gas generated will diffuse into the atmosphere without creating any health and safety risks.

If however it is determined at a later stage that significant landfill gas is being generated causing odour problems and explosion hazard risks in confined structures such as manholes, etc, a formal gas management plan should be developed. This could include a simple passive gas venting system comprising rock filled gabion chimneys constructed within the waste body and extending upwards as the landfill rises. Each chimney is to be wrapped in geotextile filter fabric and a small mound of soil is to be placed around it to prevent ingress of surface run-off, and to stabilise the chimney. These gas chimneys are to be spaced at approximately 1 per 0,1 hectare.

When the final capping is applied to the landfill at various stages of completion, appropriate capping structures would be constructed over the gas chimneys to enable passive venting to continue. Although active gas extraction and flaring of landfill gas would be preferable to passive venting, it is not considered to be appropriate or cost effective for such a small landfill located in a remote area.

Notwithstanding the above, the gas management system at the site must incorporate a gas monitoring system, including the following:

- Monitoring of landfill gas concentrations on a regular basis on the landfill during operation and after closure.
- Regular monitoring of safe practices to avoid hazardous concentrations of gases at temporary or permanent working areas of the site.

4.9 Closure and End-use

The objectives of the end-use design of the landfill are as follows:

- To create an aesthetically acceptable landform with gentle slopes (not exceeding 1:3) that, as far as possible, blends in with the surrounding terrain.
- To maximise the landfill airspace available for waste disposal and hence the site life.

4.9.1 Final landform and end-use

At this stage, the proposed final shape of the landfills would be determined according to the surrounding terrain, and to maximise the airspace from the available footprint. It would also be designed to meet drainage and end-use requirements. It is recommended that the end-use of the landfill be considered as restricted open space, on account of the waste disposed on it. Other forms of development could also be considered. The end-use of the site should, however, be discussed with all stakeholders to ensure that the rehabilitated site is acceptable to them.

Based on the surrounding topography and land use, the maximum height of the landfills would be about 30 m above the original natural ground level. The upper surfaces of the landfill must have general slopes of at least 1:50 to promote rapid drainage of the landfill surface.

4.9.2 Closure and rehabilitation

As the different sections of the landfill are completed to final height, they are to be appropriately shaped, graded and capped in accordance with the Minimum Requirements. As the new landfill would have a bottom liner, the final capping for a G:S:B$^-$ landfill would only need to include a 200 mm layer of topsoil, appropriately grassed.

Vegetation of completed areas is to commence as soon as possible after capping. Indigenous shrubs could be planted around the site for screening purposes, as well as in any areas where the substrate will support growth. Over the rest of the site, grass is to be established using indigenous grass types. The intention is to implement what is known as "the rising green wall effect" by progressively grading and vegetating the side berms and then working behind them.

Provided the vegetation is always maintained during operation, there should be no need for later rehabilitation. After closure, ongoing maintenance of the landfill capping and vegetation will be required.

4.10 Discussion

In formulating the preliminary design for the Tutuka landfill site, every effort has been made to meet the objectives of landfill design, i.e. to provide a cost effective, environmentally and socially acceptable facility. In addition, the requirements of the Minimum Requirements have been followed and the “Precautionary Principle” has been implemented throughout.

Whilst the design meets the waste disposal needs of the current users of the Tutuka landfill site, it also addresses all the site specific factors and constraints identified during the site investigations. The various issues and impacts associated with landfilling operations on a facility of this nature have also been considered in the design.

5 PRELIMINARY OPERATING PLAN

5.1 Introduction

This section provides a preliminary Operating Plan, in terms of which the Tutuka landfill facility will be operated. The objective of the Operating Plan is to ensure that all waste is disposed of in a manner that is environmentally acceptable. In this way, the negative impacts normally associated with waste disposal operations would be avoided or minimized. This implies that the operation must conform to the "Minimum Requirements for Waste Disposal by Landfill" [(1)] and the "Minimum Requirements for Monitoring at Waste Management Facilities" [(2)] associated with the site classification.

The Operating Plan is site specific and describes the way in which the facility should be operated, addressing aspects such as access, controls, drainage, landfilling, etc.

In order to ensure that the operation complies with the aforementioned requirements, resources such as funds, suitable facilities, equipment and staff, including a Responsible Person, are required.

It is noted that this is a preliminary Operating Plan and that it is to be superseded by a comprehensive Operating and Maintenance Manual to be prepared as part of the detailed engineering phase.

5.2 Access

Vehicle access must always be limited to a single entrance, to facilitate control. During hours of operation, this entrance must be manned and it must be locked when the facility is not in operation, to prevent unauthorised entry. A notice board must be erected at the entrance, stating the name, address, and telephone number of the operator, the hours of operation and an emergency telephone number. Suitable signs must also be erected on-site, to direct drivers and to control speed.

Road access to the landfill working face must be maintained at all times in a manner suitable to accommodate vehicles normally expected to utilise the facility. All on-site roads must be so surfaced and maintained as to ensure that waste can reach the working face with minimum inconvenience in all weather. Roads must also be regularly graded and wetted to control dust, when necessary.

5.3 Control

5.3.1 Waste reclaimers

Informal waste reclamation (or scavenging) is a feature of many landfills in developing countries. Such reclamation has security and public health risks associated with it, and for this reason it is recommended that it be strictly forbidden at the facility.

5.3.2 Waste acceptance

Prior to waste being accepted at the gate, it must be verified as general waste by visual inspection by the gatekeeper and confirmed with the transporter. Industrial wastes, liquids, sludges, and drummed wastes should be regarded as potentially hazardous. In the event of such wastes being intercepted, the site operator should be informed and hazardous waste must not be accepted at the landfill site. It must be directed back to the generator for subsequent disposal at a permitted hazardous waste facility, as appropriate. The operator at the landfill working face must also ensure that no hazardous wastes are disposed of in this area.

At all times the precautionary principle should apply, i.e. any consignment of waste suspected of being hazardous, must be considered hazardous unless proven otherwise by means of laboratory testing.

No hazardous or medical waste may be accepted at the landfill site.

5.3.3 Records

Accurate and comprehensive records must be kept of all waste entering the site. Waste must be categorised by the number of loads, defined by quantity, type and origin. Records must be kept on both a daily and a cumulative basis. One or a combination of the following systems could be used for record keeping:

- A simple record system where entries are made by hand onto pre-prepared forms in such a way that it can be collated manually and later introduced into a computer. Office personal computers inclusive of appropriate software should be provided.
- A mass measuring unit with hand capturing of data for manual or computerised collation.

In addition, meteorological records should be kept, including rainfall, evaporation, wind, etc.

5.3.4 Auditing

Regular auditing of the site should be carried out during the operation, to ensure that the site design and the development plans are implemented, and that an acceptable standard is adhered to. The audit team should typically consist of the site operator, representatives from Tutuka Power Station and the appropriate environmental authorities. It may also be appropriate to include representatives of the interested and affected public on the audit team. The frequency of the audits must be agreed to by all the parties concerned, but intervals should not exceed 12 months.

5.3.5 Landfill gas monitoring

During routine audits, detection for landfill gas at the landfill should be carried out to determine the need for gas management.

5.4 Water Quality Monitoring

To ensure adequate environmental protection, a long term water quality monitoring programme for both groundwater and surface water is required at the site. This would involve background analyses, routine detection monitoring, investigative monitoring and post closure monitoring.

The objectives of the water quality monitoring system are:

- To indicate any escape of leachate into the environment and to quantify its effect
- To serve as an early warning system so that pollution problems that arise can be timeously identified and rectified.

The water quality monitoring system therefore includes the monitoring of surface water bodies, groundwater, leachate and contaminated water in the pond. Water and leachate samples are to be collected and analysed for the water quality parameters as required in the “Minimum Requirements for Monitoring at Waste Management Facilities” [(2)]. Eskom has appointed specialist groundwater consultants GHT Consulting Scientists for all the water quality monitoring on and around the Tutuka Power Station complex. The details of the water quality monitoring system for the landfill would include the following:

5.4.1 Background analyses

Groundwater samples should be taken from all the monitoring wells installed over the life of the landfill. These include one upstream borehole (DMB35) and 6 downstream boreholes (DMB33, DMB34, DMB86, DMB87, DMB88, DMB89). These samples must be analysed to obtain background water quality data before the construction of the new extended landfill. A complete background analysis of the groundwater should be taken before the construction of the landfill extension.

5.4.2 Surface water

There are three surface water bodies in the vicinity of the site. The monitoring points are in the two dams on the ephemeral stream both upstream and downstream of the landfill site, and the ponded water in the borrow pit to the west of the site. Samples should be taken and analysed four times per year.

5.4.3 Ground water

The monitoring wells installed as part of the plant monitoring programme are to be used for ground water monitoring. Ground water is to be sampled and analysed at three monthly intervals.

5.4.4 Leachate and contaminated water

Leachate in the leachate sump and the existing leachate detection well, as well as water in the contaminated water pond, is to be sampled and analysed for control purposes. Samples are to be taken and analysed at three monthly intervals together with the surface and ground water monitoring.

5.4.5 Reporting

The analyses of all samples should be interpreted to identify any trends or deterioration of water quality that could result from the operations of the waste management facility. The water quality monitoring report should be submitted to Tutuka Power Station environmental management and the relevant regulatory authorities.

5.5 Recycling

If deemed feasible, controlled salvaging may be implemented at the landfill working face, provided that it is carried out in a safe and hygienic manner, and provided that it does not create a litter problem.

5.6 Landfilling operation

Incoming general waste can be discharged directly into the working cell of the landfill. The landfill must, as far as possible, be operated in accordance with the following sanitary landfill operating principles:

- Waste must be spread and compacted in cells, and
- Covered at the end of each day’s operation.

5.6.1 Cell Operation

The landfill operation is based on the construction of a series of cells, which are prepared to receive the waste. The basic landfill unit is thus a cell of compacted solid waste which, when completed at the end of each day, is entirely contained by cover material. The sides may be formed by 1 m high soil or rubble berms, or sloped waste covered by daily cover. The width of the cell is determined by the working face, which is determined by the manoeuvring needs of the vehicles depositing waste. This must be sufficiently wide to avoid traffic congestion, but not so wide that waste is unnecessarily left exposed. There must always be sufficient cell capacity on site to accommodate at least one week's waste.

"End tipping", where waste is pushed over the edge of an advancing face, is not permitted. Waste must be deposited at the bottom of the working face, spread, and worked up a 1 in 3 slope up the working face within the cell. Compaction is best achieved if the waste is spread in layers not exceeding 500mm thick (uncompacted) and passed over a minimum of five times by the landfill compactor or loader.

5.6.2 Cover

The sanitary landfill definition specifies daily or more frequent cover. The material to be used for cover will be excavated and loaded up from the nearby dolerite borrow pit, but may also be imported soil, builders' rubble, or other approved covering. In all cases, a strategic stockpile of cover, enough for at least three days, should be maintained close to the working face for use in emergencies. Suitable equipment and resources must also be available to ensure that there is sufficient cover material, so that no area is left uncovered at the end of the day's operation. In order to facilitate this, incoming cover should be deposited along the top of the cell, either on the completed portion of the current cell, or on the adjacent cell.

Putrescible waste, such as food waste or dead animals, should be deposited and covered immediately with soil. Alternatively, such waste can be deposited at the base of the working face and covered immediately with other waste.

Daily or periodic cover must be sufficient to isolate the waste from the environment. A minimum thickness of 100 mm of compacted soil or other appropriate inert material is usually required. If there is a problem with odours from the landfill, the thickness of the cover might have to be increased. Final cover must be as thick as possible, using construction rubble and gravel.

5.6.3 Wet weather cell

An easily accessible wet weather cell must be constructed close to the haul road, for use under abnormally wet weather conditions. The wet weather cell must have sufficient capacity to accommodate two weeks' waste. The wet weather cell should be constructed in the same manner as the standard cell, except that it should have a well-drained base using construction rubble or similar material to ensure vehicle access in wet weather. As far as possible, the wet weather cell should be operated in the same manner as the standard cell.

5.7 Landfill Drainage

The underlying principles of landfill site drainage are as follows:

- All run-off water must be diverted away from the waste, to prevent water contamination and minimise leachate generation.
- Where contaminated water or leachate does arise on site, it must be managed and kept out of the environment.
- Clean, uncontaminated run-off water must not be permitted to mix with and increase the volumes of contaminated water.

A drainage system which achieves the above is presented in the design section of this report. Once constructed, this system must be maintained. As part of the leachate management procedure, the quality of both leachate and contaminated water should be monitored on a regular basis to determine the suitability for discharge to the sewage treatment plant or other disposal methods.

Detailed on-site drainage at the working faces must continuously be adapted and developed as the landfill develops. Detailed on-site drainage must also be properly managed as follows:

- All clean, uncontaminated water must be allowed to flow off the site into the natural drainage system, under controlled conditions.
- The base of the site at the working face must be so graded that water drains away from the deposited waste.
- All water contaminated by contact with waste must be contained and discharged into the run-off water pond.
- All leachate collected must be discharged into the leachate sump.
- All temporarily and finally covered areas must be graded and maintained to promote run-off and eliminate ponding or standing water.

5.8 Resources

Suitable equipment and resources must be made available to ensure that the waste is properly spread, compacted and covered at the end of each day's operation. The equipment must therefore have the versatility to execute several functions, including grading and shaping, as well as mixing and blending of wastes. Backup plant must also be available in case of breakdowns.

5.8.1 Plant

Normally, a purpose built landfill compactor would be recommended as the main item of plant, together with other items of plant. However, in this case a small tracked loader or TLB with solid tyres would be recommended as the main item of plant, as it is considered to provide more flexibility for cover operations. In addition, there should be access to a second TLB as backup.

Other items of plant would include a small water tanker or trailer for dust control, and a tipper truck for handling cover material.

5.8.2 Staffing

For the operation of the facility, the following staff compliment is recommended to ensure that the site is operated to a high standard:

- One Site Supervisor. This person is responsible for the proper operation of the entire facility. The site supervisor must ensure that all the facility requirements are fully complied with.

- One Plant operator. This person is responsible for operating the waste disposal area and hence the TLB. The plant operator will also be responsible for operating the tractor-trailer, tractor-water cart and other landfill equipment.
- One gate controller to control access and record waste loads during operating hours. The gate controller can also act as the spotter to direct vehicles to the correct tipping area.
- One litter picker and general worker.
- One security guard for general site security.

5.9 Control of Nuisances

In order to control nuisances, sanitary landfilling principles must be used. This is a method of disposing of waste on land without causing nuisances or hazards to public health or safety, by utilising the principles of engineering to compact the waste and to cover it with a layer of soil at the conclusion of each day's operation, or at more frequent intervals as may be necessary.

To ensure that the waste management facility is operated to these standards, environmental management and control of the operation are essential. Some of the common short-term problems associated with landfill operations and their possible solutions, are listed below:

- **Dust:** On-site roads should be wetted in hot dry weather to reduce dust from traffic when necessary.
- **Odours:** Odours are generated as a result of biological degradation of waste. Daily covering of the waste and the maintenance of this cover should ensure that odours from both "fresh" and decomposed waste do not become a problem. Putrescible waste should be covered immediately.
- **Fires:** Burning of waste is prohibited. Compaction and covering of waste minimises the fire risk by minimising oxygen and exposure. Where fires do occur, the burning waste should be exposed, spread, and smothered with cover material. On no account is water to be added.
- **Flies and Rodents:** Immediate compaction and daily covering of waste reduces the likelihood of this becoming a nuisance. Nevertheless, flies are commonly associated with landfill sites and fly traps should be used to control this problem.
- **Litter:** Compaction and covering of the waste reduces the risk of windblown litter. Litter screens can also be used to control litter. All windblown litter should be collected from around the site on a regular basis.
- **Aesthetics:** The rehabilitation of completed areas would improve the general appearance of the site.
- **Health:** Medical waste should not be accepted at the landfill. Other putrescible waste should be covered immediately.
- **Drainage:** Waste deposition should be such that it ensures that water runs away from the waste body, and does not form ponds on top of the waste, from where it might infiltrate.

5.10 Development Plan

The aim of the Development Plan is to develop the landfill site from its constructed state as indicated on the drawings to the intended final landform (see Drawing No 12333/07). The intention is that controlled development should take place, and that all the operating principles in the preceding sections should be implemented and controlled through site audits.

The first aspect of the Development Plan is the site preparation. This includes fencing, gate control, site clearance, and the preparation of the first phase for waste deposition (i.e., cover excavation, stockpiling, and construction of berms). In the landfill, a pioneering layer of waste at least 600 mm thick is to be placed over the constructed liner before any landfilling is to proceed. This is to be carried out by end-tipping and spreading the waste ahead of the equipment, so as to create a bed of waste on which to operate, and so protect the installed liner systems.

The detailed development of the landfill should follow the development plan, and adapted if necessary based on site specific circumstances as they arise.

5.11 Rehabilitation

All final levels and slopes must be in conformance with the landfill design and the end-use plan, with slopes not steeper than 1 in 3. Once the final level is achieved, the area must be capped/covered with the final cover in accordance with the plan. Rehabilitation is to commence as soon as practically possible after the final level has been reached in order to rehabilitate on an ongoing basis and to prevent wind exposure of waste.

5.12 Closure plan

As the landfill approaches final levels, more accurate levels will have to be surveyed to ensure that the final gradients and drainage are correct.

Immediately on completion of an area, final cover must be applied. Completed areas also require ongoing maintenance, including the repair of cracks and areas exposed by wind, and the filling of any settlement depressions. The rehabilitated areas should be controlled by ongoing monitoring after site closure, which should be complemented by water pollution monitoring.

5.13 Discussion

The preliminary Operating Plan outlined above should, if properly implemented, prevent the possible negative impacts normally associated with waste disposal from becoming a nuisance or an environmental threat. It must be stressed, however, that to ensure environmentally acceptable waste disposal, the resources outlined in this plan, such as funds, suitable facilities, equipment and staff, must be made available.

6 CONCLUSIONS

Based on the results of the site investigations undertaken and the content of this report, the following conclusions are drawn regarding the proposed Tutuka landfill facility.

- There is a requirement for a small sized general waste landfill, classified as G:S:B$^-$, with an airspace of approximately 1 014 000 m^3 for the 40 year design life.
- From a consideration of various alternative candidate landfill sites, it was determined that integrating the new waste disposal facility with the closure and rehabilitation of the existing landfill represents the best environmental alternative.
- As the existing landfill has already impacted on the environment (including the groundwater), it would be preferable to address the current environmental impacts of the existing landfill, and extend the landfill, rather than create a new potential environmental impact by developing a new landfill site elsewhere.
- The proximity of the existing landfill site to the Tutuka Power Station, Thuthukani Township and New Denmark Colliery, and its relatively easy access from the main road support its extension and development as a long-term waste disposal facility.
- The existing site has infrastructure such as a gate house, monitoring boreholes, drains and fencing that could be used for the new extended landfill site.
- There is sufficient land available for the proposed extension of the landfill and the natural topography of the area favours the development of a landfill. Due to the dolerite gravel excavation activities on and around the site, it is not pristine and the development of the landfill extension should not impact significantly on flora and fauna.
- The shallow excavatable soils on the site mean that soil for waste covering operations will have to be imported from nearby borrow pits. The black clayey colluvial soils are unsuitable for use in the landfill liner construction, and will have to be removed. The residual dolerite soils are gravelly and sandy and therefore also not suitable for use in the liner construction.
- From a groundwater perspective, the site has a perched aquifer within the fractured/weathered dolerite, and a deeper aquifer beneath the dolerite sill. The aquifer is classified as “low / no significance”, and the geohydrological assessment rates the site as “marginal” to “suitable” for the development of a waste disposal facility.
- The site design is based on developing the following main areas of operation, viz:
  - Extension of the existing landfill to use the full permitted footprint.
  - Raising, shaping and capping the existing landfill with a GCL based “piggy-back” liner.
  - Development of a GCL lined extension of the landfill to the west of the existing landfill, followed by a further extension to the south to achieve the required site life.
  - Construction of a leachate sump and contaminated water pond..
- The landfill is based on sanitary landfilling of general waste in a lined landfill cell.

- In formulating the preliminary design for the Tutuka landfill site, every effort has been made to meet the objectives of landfill design, i.e. to provide a cost effective, environmentally and socially acceptable facility. In addition, the requirements of the Minimum Requirements have been followed and the "Precautionary Principle" has been implemented throughout.
- Whilst the design meets the waste disposal needs of the current users of the Tutuka landfill site, it also addresses all the site specific factors and constraints identified during the site investigations.

7 RECOMMENDATIONS

It is recommended that landfill design report be submitted in support of the landfill licence application to the regulatory authorities.

8 REFERENCES

1. Department of Water Affairs and Forestry, 1998. *Minimum Requirements for Waste Disposal by Landfill.* Waste Management Series - Volume 2, Second edition. Department of Water Affairs and Forestry. CTP Book Printers, Cape.

2. Department of Water Affairs and Forestry, 1998. *Minimum Requirements for Water Monitoring at Waste Management Facilities.* Waste Management Series - Volume 2, Second edition. Department of Water Affairs and Forestry. CTP Book Printers, Cape.

3. Golder Associates Africa, January 2010. *Tutuka Power Station - Classification of New and Current Tutuka Disposal Site.* Report No 12330-9390-1, prepared for Zitholele Consulting.

4. Brink A.B.A., 1983. *Engineering Geology of Southern Africa – Volume 3: The Karoo Sequence.* Building Publications.

5. Peter Legg Consulting, February 2010. *Geotechnical Investigation Report for the Extension of the Tutuka Power Station Landfill Site.* Report No P029-01, prepared for Zitholele Consulting.

6. GHT Consulting Scientists, April 2010. *Proposed Extension Domestic Waste Site, Tutuka Power Station.* Report No RVN574.1/1025, prepared fro Zitholele Consulting.

PETER LEGG CONSULTING

Peter Legg, PrEng

APPENDIX A

WASTE GENERATION AND LANDFILL AIRSPACE REQUIREMENTS

Tutuka Landfill Site

Waste Generation and Landfill Airspace Requirements

	New Denmark Colliery	Power Station Cleaning	Horticul-tural	Contractors	Tutukani	**Total per year**	**IRD**	Cummulative	Airspace	**Airspace incl cover (20%)**
	tonne	tonne	tonne	tonne	tonne	tonne	tonne/day	tonne	m^3	m^3
Growth Rate(%)	3.7	3.7	3.7	3.7	3.7				Landfill density = 1 tonne/m3	
% of total	**19%**	**29%**	**5%**	**35%**	**12%**	**9100**				
2009	1729	2639	455	3185	1092	9100	35	9100	9100	10920
2010	1793	2737	472	3303	1132	9437	36	18537	18537	22244
2011	1859	2838	489	3425	1174	9786	38	28323	28323	33987
2012	1928	2943	507	3552	1218	10148	39	38470	38470	46165
2013	1999	3052	526	3683	1263	10523	40	48994	48994	58793
2014	2073	3165	546	3819	1310	10913	42	59907	59907	71888
2015	2150	3282	566	3961	1358	11317	44	71223	71223	85468
2016	2230	3403	587	4107	1408	11735	45	82958	82958	99550
2017	2312	3529	608	4259	1460	12169	47	95128	95128	114154
2018	2398	3660	631	4417	1514	12620	49	107748	107748	129297
2019	2486	3795	654	4580	1570	13087	50	120834	120834	145001
2020	2578	3936	679	4750	1629	13571	52	134405	134405	161286
2021	2674	4081	704	4926	1689	14073	54	148478	148478	178174
2022	2773	4232	730	5108	1751	14594	56	163072	163072	195686
2023	2875	4389	757	5297	1816	15134	58	178206	178206	213847
2024	2982	4551	785	5493	1883	15694	60	193899	193899	232679
2025	3092	4720	814	5696	1953	16274	63	210173	210173	252208
2026	3207	4894	844	5907	2025	16876	65	227050	227050	272460
2027	3325	5075	875	6125	2100	17501	67	244551	244551	293461
2028	3448	5263	907	6352	2178	18148	70	262699	262699	315239
2029	3576	5458	941	6587	2258	18820	72	281519	281519	337823
2030	3708	5660	976	6831	2342	19516	75	301035	301035	361242
2031	3845	5869	1012	7083	2429	20238	78	321273	321273	385528
2032	3988	6086	1049	7345	2518	20987	81	342261	342261	410713
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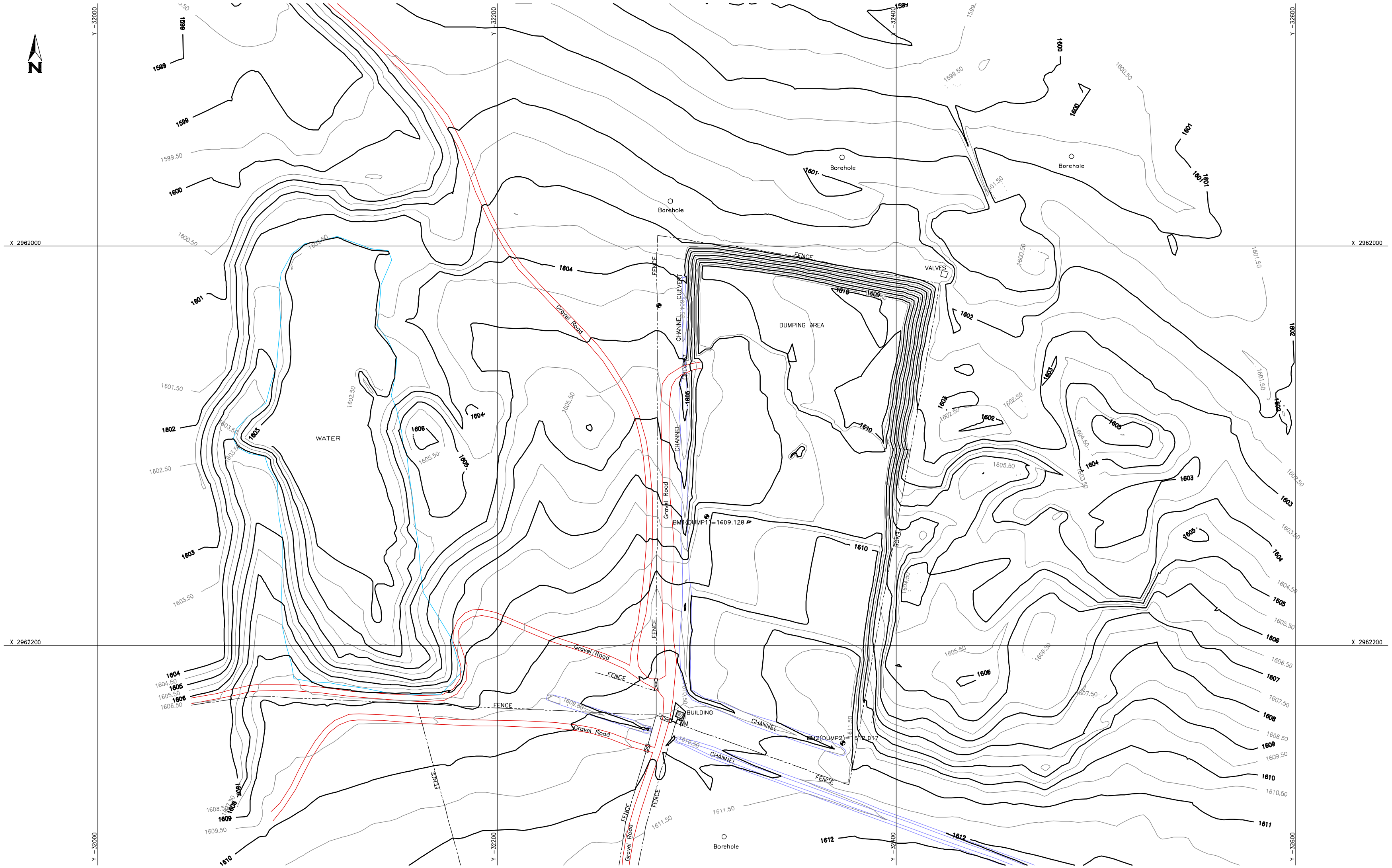
2035	4447	6787	1170	8191	2808	23404	90	409997	409997	491996
2036	4611	7038	1213	8494	2912	24270	93	434267	434267	521120
2037	4782	7299	1258	8809	3020	25168	97	459435	459435	551322
2038	4959	7569	1305	9135	3132	26099	100	485534	485534	582641
2039	5142	7849	1353	9473	3248	27065	104	512599	512599	615118
2040	5333	8139	1403	9823	3368	28066	108	540665	540665	648798
2041	5530	8440	1455	10187	3493	29105	112	569769	569769	683723
2042	5734	8753	1509	10564	3622	30181	116	599951	599951	719941
2043	5947	9076	1565	10954	3756	31298	120	631249	631249	757499
2044	6167	9412	1623	11360	3895	32456	125	663705	663705	796446
2045	6395	9761	1683	11780	4039	33657	129	697362	697362	836835
2046	6631	10122	1745	12216	4188	34902	134	732265	732265	878718
2047	6877	10496	1810	12668	4343	36194	139	768459	768459	922150
2048	7131	10885	1877	13137	4504	37533	144	805992	805992	967190
2049	7395	11287	1946	13623	4671	38922	150	844913	844913	1013896
					MRD (tonne/day)	**150**		**Small**		

APPENDIX B

DRAWINGS

Drawing No	Rev	Title
12333/01	A	Existing Site Survey – September 2009
12333/02	A	Site Survey showing Testpit positions
12333/03	A	Extension of Existing Landfill – Phase 1 - General Arrangement
12333/04	A	Extension of Existing Landfill – Phase 1 – Sections and Details
12333/05	A	Interim Landfill Extension – General Arrangement
12333/06	A	Interim Landfill Extension – Sections and Details
12333/07	A	Extension of Existing Landfill – Development Plan
12333/08	A	Extension of Existing Landfill – Leachate Sump and Contaminated Water Pond – Sections and Details



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REVISION	DESCRIPTION	INITS	DATE	INITS	DATE	REFERENCES
		CHECKED		APPROVED		

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DRAWN	RS
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DRAWING TITLE	EXISTING SITE SURVEY SEPTEMBER 2009
PROJECT No	12333
DRAWING No	12333/01
REVISION	A

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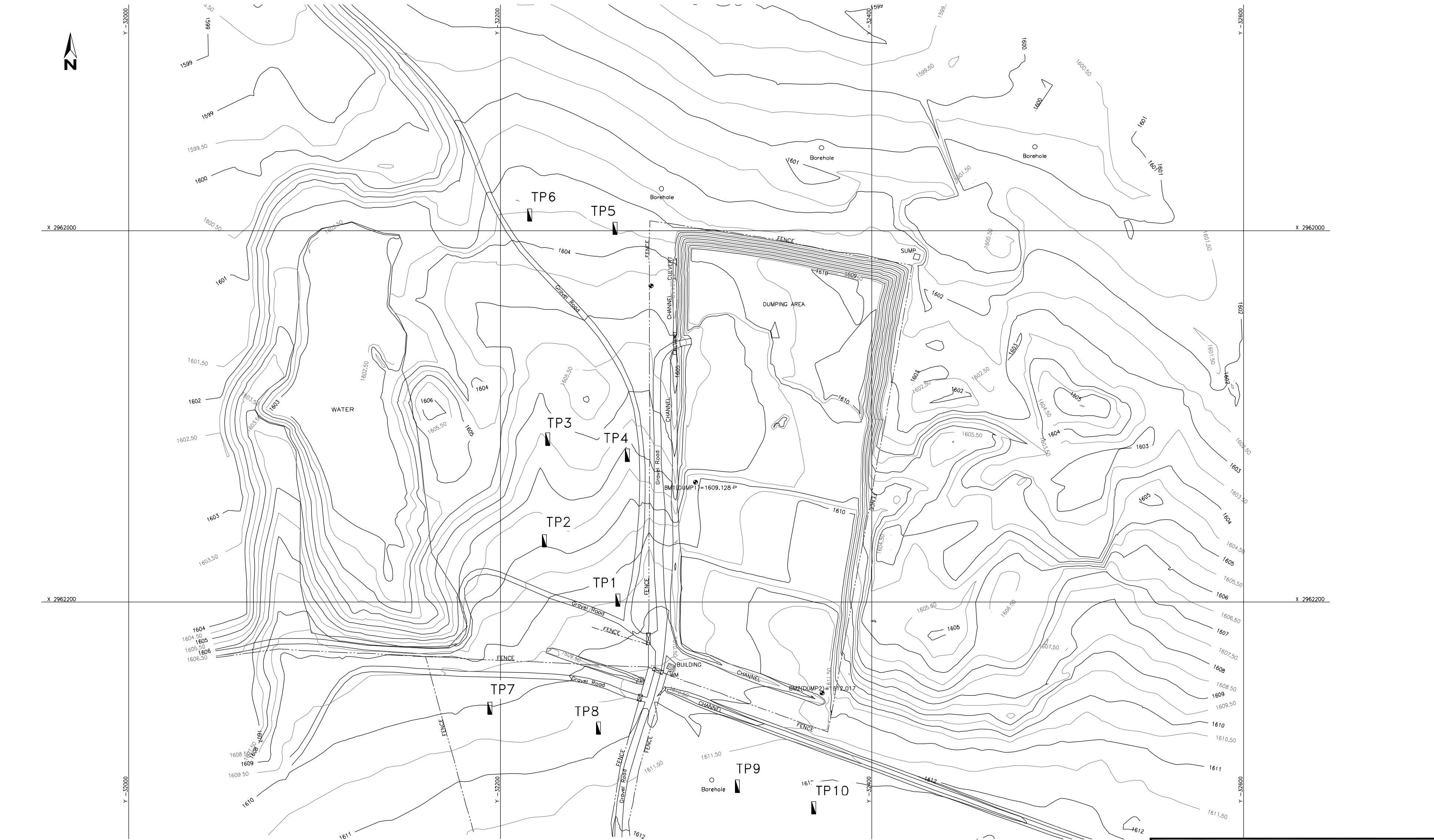

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PROJECT No	12333
DRAWING No	12333/02
REVISION	A

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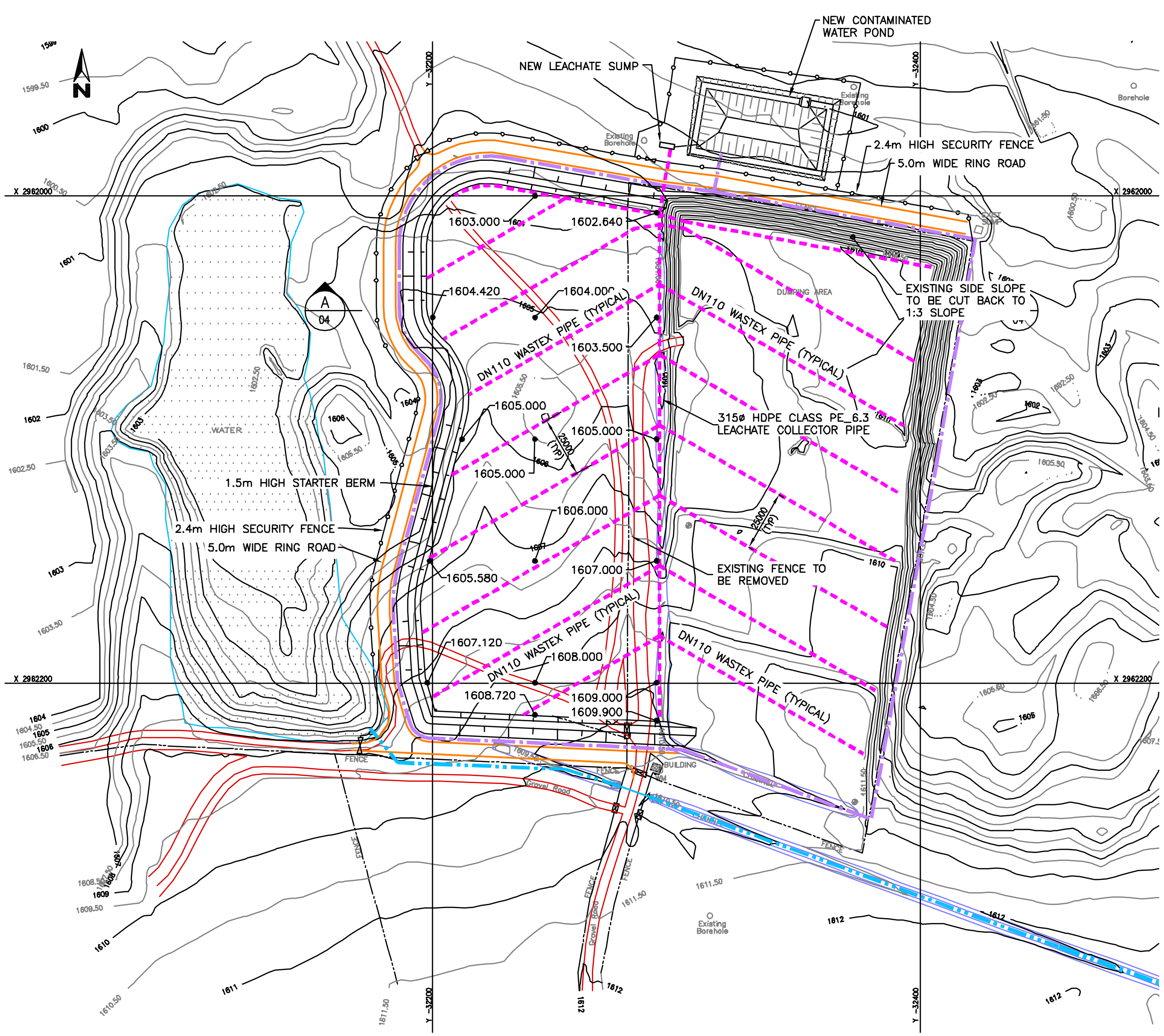

LEGEND

- CLEAN WATER DRAIN
- CONTAMINATED WATER DRAIN
- LEACHATE DRAIN

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LAYOUT

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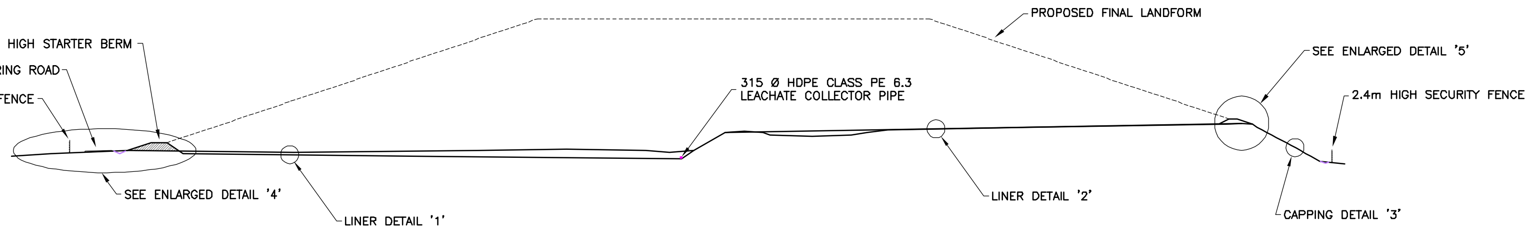

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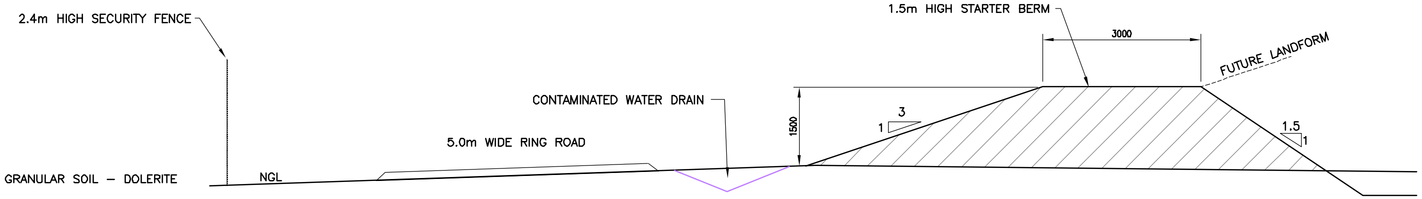

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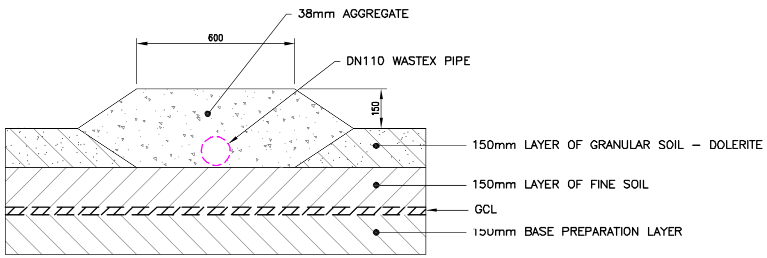

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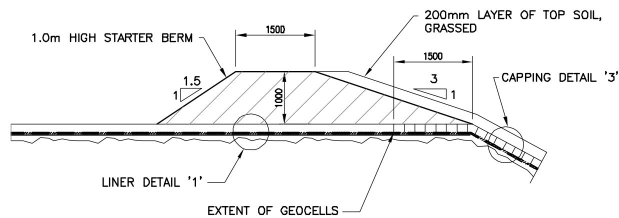

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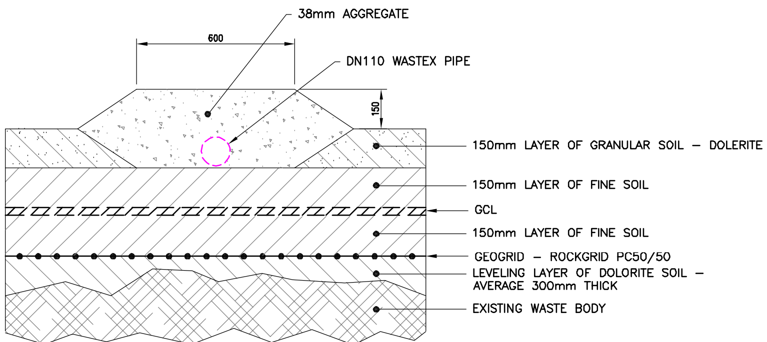

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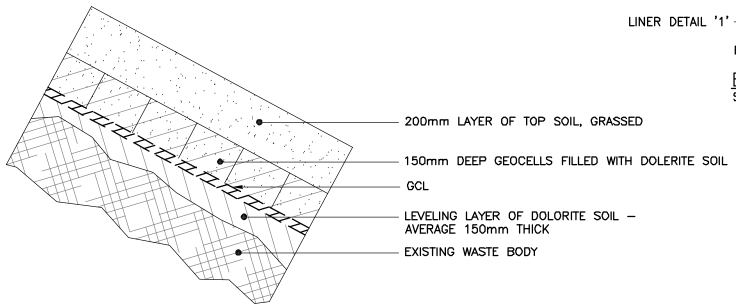

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DESIGNED: PL DATE: 20.4.10 | DESIGN CHECK: DATE:

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DRAWING TITLE: EXTENSION OF EXISTING LANDFILL PHASE 1 SECTIONS & DETAILS

PROJECT No: 12333 | DRAWING No: 12333-04 | REVISION: A

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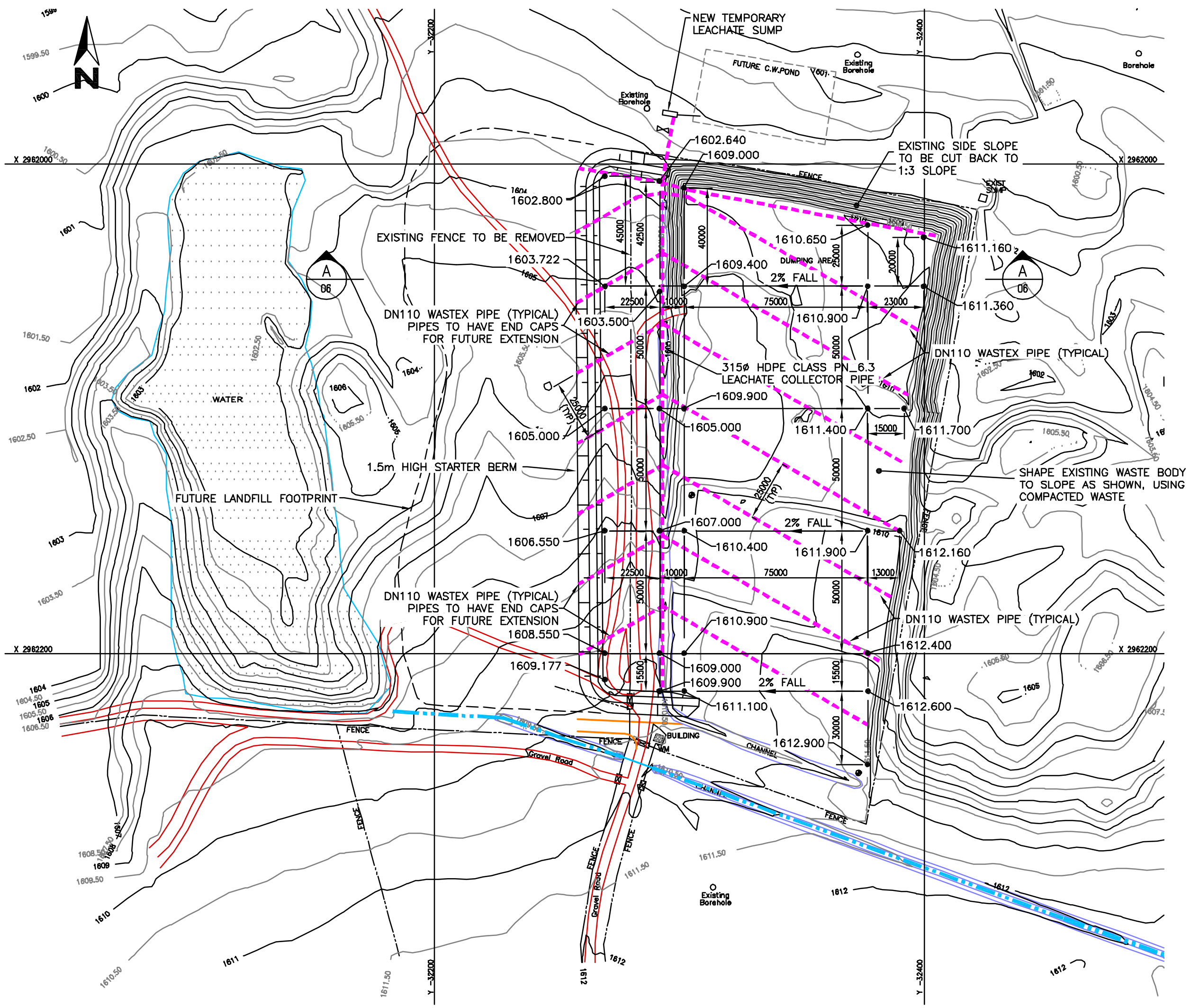
- LEACHATE DRAIN



INTERIM LANDFILL AIRSPACE = 40525m³

LAYOUT
(WITHIN CURRENT PERMIT FOOTPRINT)
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DESIGNED: PL, DATE 20.4.10 | DESIGN CHECK | DATE

AUTHORISED | DATE | SCALE 1:1000

PROJECT: TUTUKA POWER STATION LANDFILL EIA

DRAWING TITLE: EXTENSION OF EXISTING LANDFILL INTERIM LANDFILL EXTENSION GENERAL ARRANGEMENT

PROJECT No 12333 | DRAWING No 12333-05 | REVISION A

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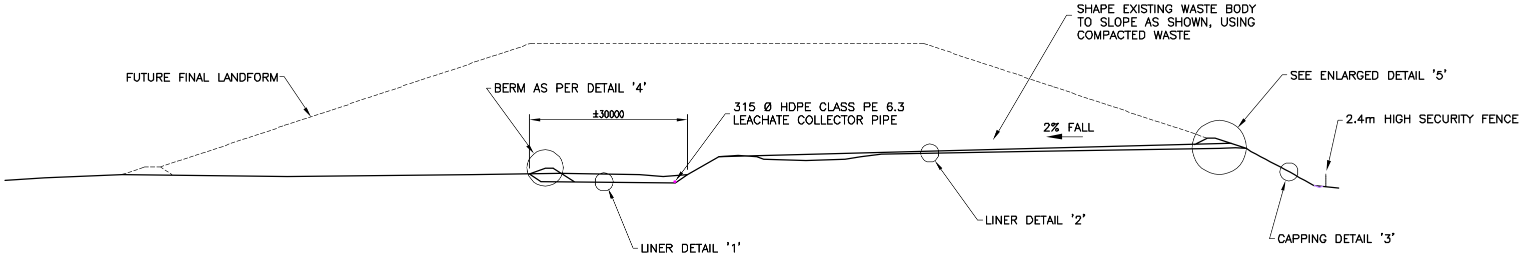

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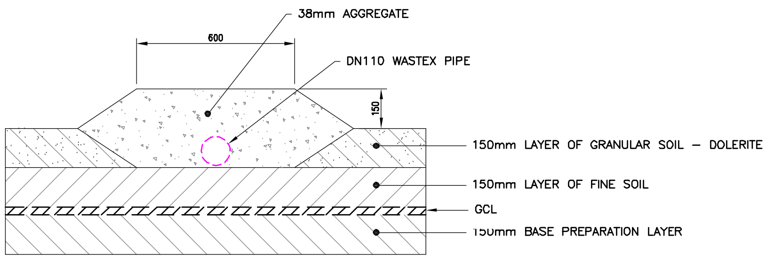

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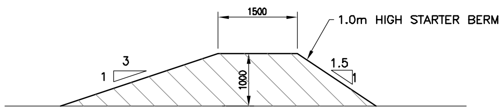

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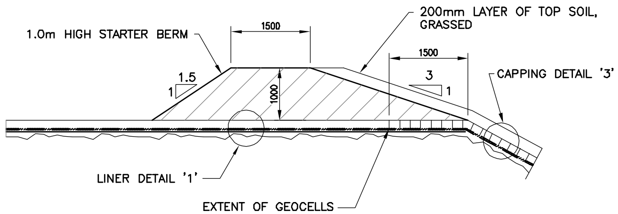
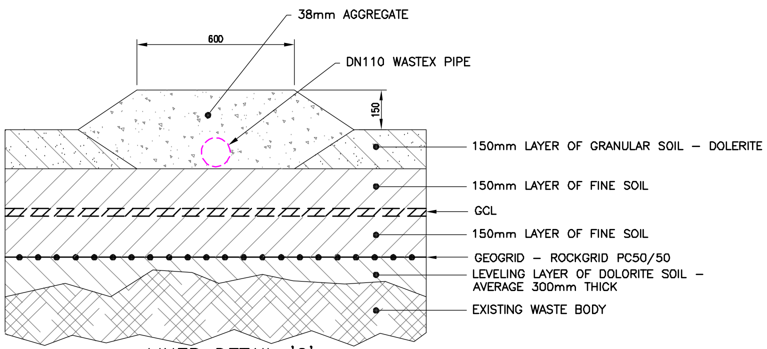
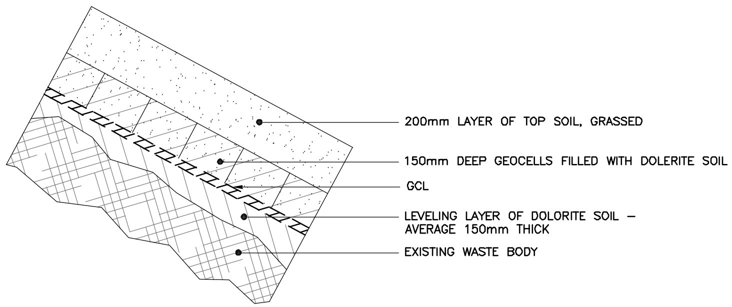


ENLARGED DETAIL '5'
SCALE 1:50



LINER DETAIL '2'
SCALE 1:10



CAPPING DETAIL '3'
SCALE 1:10

NOT FOR CONSTRUCTION

DO NOT SCALE

REVISION	DESCRIPTION	CHECKED INITS	CHECKED DATE	APPROVED INITS	APPROVED DATE	REFERENCES
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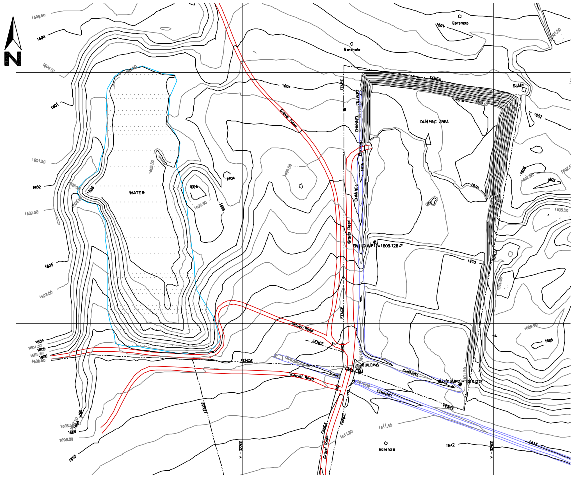
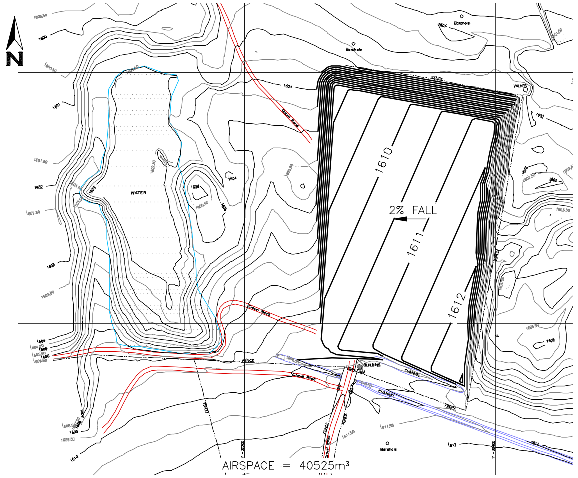
CLIENT	ESKOM
DRAWN	RS — DATE 11.11.09
DRAWING CHECK	DATE
DESIGNED	PL — DATE 20.4.10
DESIGN CHECK	DATE
AUTHORISED	DATE
SCALE	AS SHOWN
PROJECT	TUTUKA POWER STATION LANDFILL EIA
DRAWING TITLE	EXTENSION OF EXISTING LANDFILL INTERIM LANDFILL EXTENSION SECTIONS & DETAILS
PROJECT No	12333
DRAWING No	12333–06
REVISION	A

A1



EXISTING LANDFILL

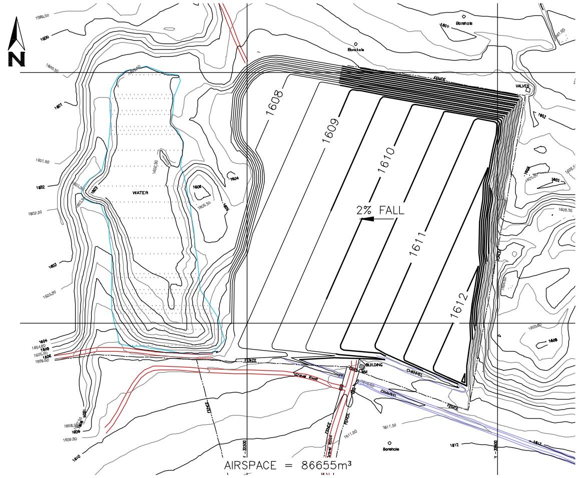
SCALE 1:2000



AIRSPACE = 40525m³

INTERIM DEVELOPMENT PLAN

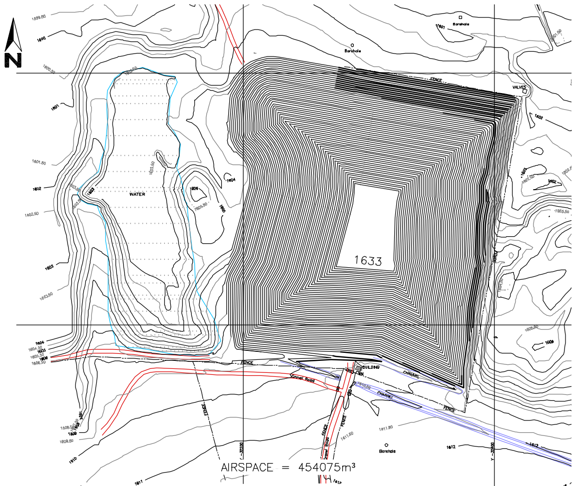
SCALE 1:2000



AIRSPACE = 86655m³

PHASE 1 DEVELOPMENT PLAN

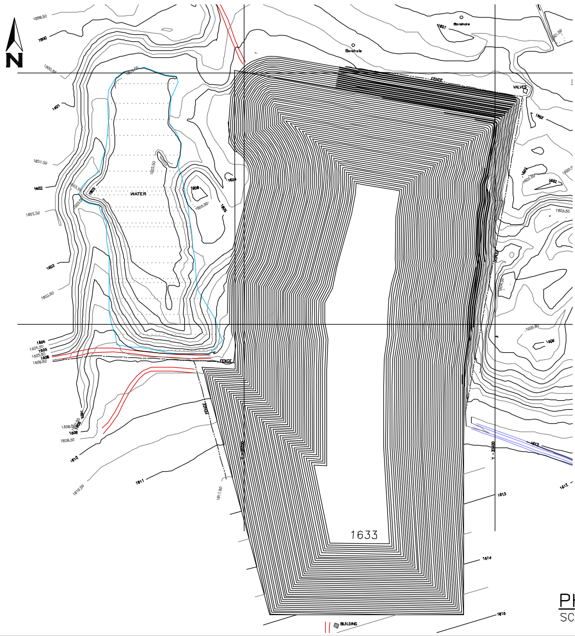
SCALE 1:2000



AIRSPACE = 454075m³

PHASE 2 DEVELOPMENT PLAN

SCALE 1:2000



AIRSPACE = 486825m³

PHASE 3 DEVELOPMENT PLAN

SCALE 1:2000

TOTAL AIRSPACE = 1 068 080m³

REVISION	DESCRIPTION	INITS	DATE	INITS	DATE	REFERENCES
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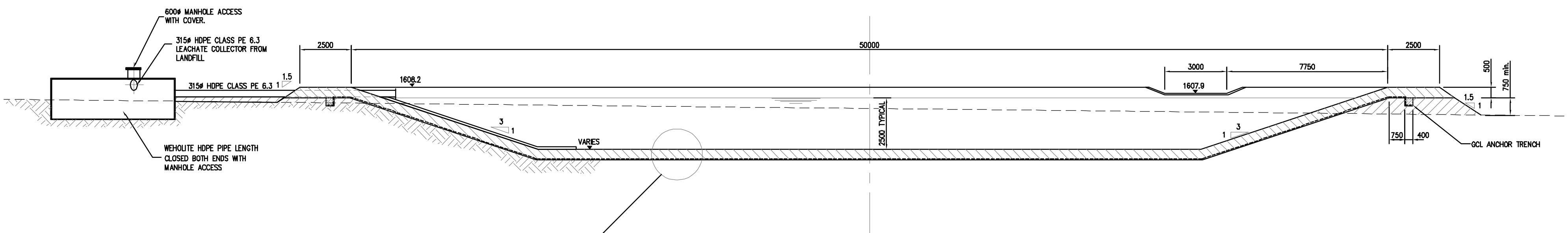
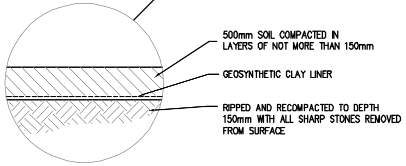
DO NOT SCALE

CLIENT: ESKOM		PROJECT: TUTUKA POWER STATION LANDFILL EIA	
DRAWN: RS	DATE: 06.01.10	DRAWING CHECK	DATE
DESIGNED	DATE	DESIGN CHECK	DATE
AUTHORISED	DATE	SCALE: 1:2000	
DRAWING TITLE: EXTENSION OF EXISTING LANDFILL DEVELOPMENT PLAN			
PROJECT No: 12333	DRAWING No: 12333-07	REVISION: A	A1

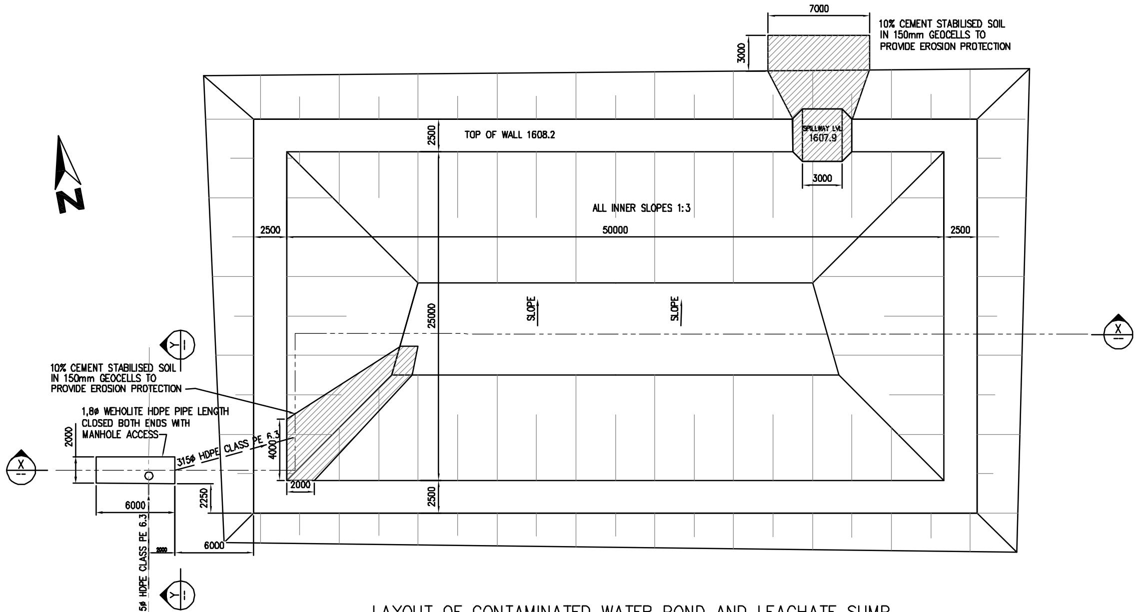


SECTION X–X

1:100

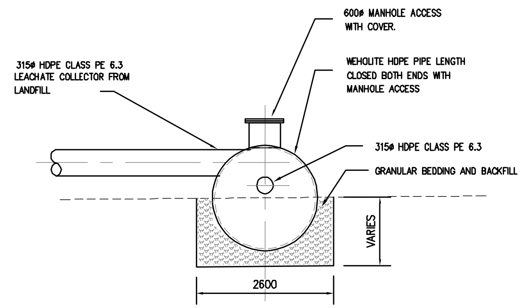


LINER DETAIL



LAYOUT OF CONTAMINATED WATER POND AND LEACHATE SUMP

1:200



SECTION Y–Y

1:50

REVISION	DESCRIPTION	CHECKED INITS	CHECKED DATE	APPROVED INITS	APPROVED DATE	REFERENCES
A	ISSUED FOR APPROVAL	RS	4.10			

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PROJECT: TUTUKA POWER STATION LANDFILL EIA

DRAWN: DM	DATE: 20.4.10	DRAWING CHECK	DATE
DESIGNED: PL	DATE: 20.4.10	DESIGN CHECK	DATE
AUTHORISED	DATE	SCALE: AS SHOWN	

DRAWING TITLE: EXTENSION OF EXISTING LANDFILL LEACHATE SUMP AND CONTAMINATED WATER POND SECTIONS & DETAILS

PROJECT No	DRAWING No	REVISION
12333	12333–08	A

A1