University of Southern Queensland

Faculty of Engineering and Surveying

Design and Documentation of Bairnsdale Regional Landfill - Cell 3

Johnston's Road, Bairnsdale

A dissertation submitted by

Mr Rowan Howarth

In the fulfilment of the requirements of

Courses ENG4111 and 4112 Research Project

Towards the degree of

Bachelor of Engineering (Civil)

Submitted: October 2009

University of Southern Queensland

Faculty of Engineering and Surveying

ENG4111 Research Project Part 1 & ENG4112 Research Project Part 2

Limitations of Use

Frank Bullen

Professor Frank Bullen
Dean
Faculty of Engineering and Surveying

CERTIFICATION

I certify that the ideas, designs and experimental work, results, analyses and conclusions set out in this dissertation are entirely my own effort, except where otherwise indicated and acknowledged.

I further certify that the work is original and has not been previously submitted for assessment in any other course or institution, except where specifically stated.

Rowan Howarth

Student Number: 0050085518

Signature

Date

ABSTRACT

This project was aimed to develop the preliminary design concept for a future landfill cell (Cell 3 of 5) at the Johnston's Road Landfill site, situated on the outskirts of Bairnsdale in East Gippsland, Victoria.

The project was completed on behalf of East Gippsland Shire Council, with the expectation that this project will then form the basis of the complete design and documentation for the landfill cell.

The concept created has an operational capacity of three years, including waste and daily/weekly cover requirements and meets or exceeds the minimum best practice guidelines as set out in the EPA Victoria publication 788, Siting, Design, Operation and Rehabilitation of Landfills.

All elements of the landfill system were examined, these included:

- Siting Conditions and environmental assessment – identification of need, buffer distances, groundwater, surface water, flora and fauna, existing infrastructure, geology and land ownership;
- Site layout – examine suitability of existing and future requirements, as well as existing access issues;

- Landfill liner system – minimum or recommended liner types and methods, sub-base requirements, clay liner, geo-membrane and protection layer and finally, the drainage layer and geo-textile use;
- Water management – Storm water management and existing issues, groundwater management, leachate generation rates and modeling using a HELP package;
- Landfill gas;
- Odour and noise impacts; and;
- Site security and fencing

The landfill Cell was designed as an extension to the previous Cell (Cell 2), and has a the capacity to hold 175,163m^3 of waste, placed in six 2m thick layers, with each layer separated by 0.3m of cover materials. The finished height was designed to match with the previous cells, which allows for a uniform and useful area once landfill activities are complete. The overall footprint of the landfill is approximately 2.2 ha, with a base size of 120m x 84m, and uses 3:1 batters on the Cell walls.

The proposed leachate system utilizes a number of 110mm Class 16 HDPE pipes, spaced at 15m intervals. These pipe diameters were based upon inspection and maintenance access requirements as opposed to flows, as the HELP modeling results indicated that leachate volumes generated were not overly large (0.036 L/sec)

Once the preliminary design concept was established, the focus of the project moved towards preparation of the documentation, namely construction specifications. This specification will eventually form part of the design package sent to the EPA, and selected environmental auditor for approval, prior to advertising a tender for construction of the Cell.

ACKNOWLEDGEMENTS

This research project was carried out under the principal supervision of Dr. Vasantha Aravinthan, and was sponsored by East Gippsland Shire Council, to whom thanks must be given.

Appreciation is goes to Mr. Ron Glasser (Technical Officer, East Gippsland Shire Council) and Mr. George Black (Principal, Black Geotechnical Pty Ltd), for assistance with background research, and for keeping the motivation up when required.

Special thanks must also go to Crowther and Sadler Pty Ltd, for allowing the time and use of surveying equipment in order to obtain relevant survey data.

CONTENTS

Limitations of Use ii

Certification iii

Abstract iv

Acknowledgements vii

Contents viii

Table of Figures xii

List of Tables xiv

Chapter 1 – Introduction .... - 1 -

1.2 Project Objectives .... - 2 -

1.3 Background and Setting .... - 3 -

Chapter 2 – Literature Review .... - 7 -

2.1 Relevant Standards and Guidelines .... - 7 -

2.2 Waste Management Hierarchy .... - 9 -

2.3 Classification of Landfills .... - 10 -

2.4 Best Practice Siting Conditions .... - 12 -

2.4.1 Community needs .... - 13 -

2.4.2 Buffer Distances from features .... - 14 -

- 2.4.3 Groundwater Buffer distances .... - 14 -
- 2.4.4 Surface Water .... - 15 -
- 2.4.5 Flora and Fauna Protection .... - 16 -
- 2.4.6 Capacity of local infrastructure to cater for landfill operations .... - 16 -
- 2.4.7 Geological Setting and Stratigraphy .... - 17 -

2.5 Best Practice - Design .... - 21 -

- 2.5.1 – Environmental Assessment .... - 21 -
- 2.5.2 – Site Layout .... - 22 -
- 2.5.3 – Liner System .... - 23 -
- 2.5.4 Hydrological Evaluation of Landfill Performance (HELP) Model .... - 35 -
- 2.5.4 Water Management .... - 41 -
  - 2.5.4.1 Storm Water Management .... - 41 -
  - 2.5.4.2 Leachate Management .... - 42 -
  - 2.5.4.3 Groundwater Management .... - 44 -
- 2.5.5 Landfill Gas .... - 46 -
- 2.5.6 Odour and Noise Impacts .... - 48 -
- 2.5.7 Site Security and Fencing .... - 49 -

Chapter 3 – Review of Cell 2 Design Deficiencies and Operational Issues ...... - 50 -

3.1 Vehicular Access Issues.. - 51 -

3.2 Storm water Dam Capacity and Surface Water Control .... - 54 -

3.3 Erosion Management .... - 58 -

Chapter 4 – Factors influencing design and site restrictions............................ - 59 -

4.1 License Conditions .... - 59 -

Chapter 5 - Feature Survey .... - 61 -

Chapter 6 – Capacity Requirements and Volume Calculations .... - 64 -

Chapter 7 – Liner System (including HELP model comparison) .... - 68 -

Chapter 8 – Leachate Collection System... - 76 -

Chapter 9 – Summary of Preliminary Design... - 78 -

9.1 Cell Capacity .... - 78 -

9.2 Liner System .... - 79 -

9.3 Leachate Collection System... - 80 -

Chapter 10 – Conclusions and Future Work .... - 80 -

References .... - 83 -

Appendix A – Research Project Specification.. - 86 -

Appendix B – Existing Site Layout .... - 88 -

Appendix C – Current Johnston’s Road Works Approval................................. - 90 -

Appendix D – Proposed Preliminary Cell Layout .... - 104 -

Appendix E – Preliminary Construction Specification .... - 106 -

Appendix F – Site Feature Survey .... - 152 -

Appendix G – Coffey Geotechnical Report .... - 161 -

Appendix H – Visual HELP Output Report... - 210 -

TABLE OF FIGURES

Figure A – East Gippsland Shire Region (VEC 2009).. - 4 -

Figure B – Locality Plan showing Landfill site and surrounds .... - 5 -

Figure C – Landfill Classifications based on Waste Acceptance....................... - 12 -

Figure D – Example of perforated pipe alternative ‘Megaflow’.......................... - 28 -

Figure E – Example of a geonet, ‘Flownet’ by Geofabrics Australia.................. - 28 -

Figure F – Cell 1 Liner System.. - 33 -

Figure G – Cell 2 Liner System.. - 33 -

Figure H –Multi-Layered Liner System.. - 34 -

Figure I – Photo showing example of access roads within the landfill area ...... - 52 -

Figure J – Photo illustrating Cell 2 access track... - 53 -

Figure K – Photo showing some of the remedial action taken on access track leading into cell 2.. .... - 54 -

Figure L – Photo taken from spillway of additional retention dam constructed to allow better surface water control .... - 56 -

Figure M – Photo taken of spillway from additional dam.................................. - 56 -

Figure N – Photo taken of pipe culvert underneath access track from new retention dam spillway .... - 57 -

Figure O – Photo illustrating batter slope erosion .... - 58 -

Figure P – AutoCAD sketch used for cross section calculations....................... - 66 -

Figure Q – ‘HELP’ Model input for Cell 1 Liner System .... - 69 -

Figure R – ‘HELP’ Model input for Cell 2 Liner System.................................... - 70 -

Figure S – ‘HELP’ Model Input for US EPA recommended liner system........... - 70 -

Figure T – Accumulated percolation through base of Cell 1 liner System......... - 72 -

Figure U – Accumulated percolation through base of Cell 2 liner system......... - 73 -

Figure V – Accumulated percolation through base of US EPA recommended liner system .... - 74 -

Figure W – Adopted liner system .... - 76 -

LIST OF TABLES

Table 1 – Required buffer distances from features to Type 2 landfill site.......... - 14 -

Table 2 – Summary of Subsurface Conditions.. - 18 -

Table 3 – Properties of Commonly Used Geo-Membranes .... - 25 -

Table 4 – Layering Rules For Visual HELP... - 37 -

Table 5 – Turbidity Limits For Water Discharged From Site .... - 41 -

Table 6 – Minimum Fencing Requirements .... - 50 -

Table 7 – Average Monthly Precipitation Data for Bairnsdale Aerodrome .... - 71 -

Table 8 – Average Annual Windspeed for Bairnsdale Aerodrome.................... - 71 -

Table 9 – Average Quarterly Humidity for Bairnsdale Aerodrome .... - 71 -

Table 10 – Accumulated percolation through base of Cell 1 liner System .... - 73 -

Table 11 – Accumulated percolation through base of Cell 2 liner system......... - 73 -

Table 12 – Accumulated percolation through base of US EPA recommended liner system .... - 74 -

CHAPTER 1 – INTRODUCTION

This project developed the preliminary design concept for a future landfill cell (Cell 3 of 5) at the Johnston's Road Landfill, situated on the outskirts of Bairnsdale, in East Gippsland, Victoria. The project was completed on behalf of East Gippsland Shire Council, with the expectation that the project will then be continued on, and form the basis of the complete design and documentation for the landfill cell.

The design brief was to design a landfill cell with sufficient capacity (including both waste and daily/weekly cover requirements) for an operational life of three years. It was preferred to have the cell constructed as an extension to the western end of the recently completed cell 2, with both liner systems then able to be connected, and the existing drainage sump and leachate removal pump infrastructure utilised.

The design was required to meet all applicable guidelines and standards, the principal reference being the EPA Victoria 'Publication 788 - Best Practices Guide – Siting, Design, Operation and Rehabilitation of Landfills'. In addition, compliance with the current EPA works approval (license) for the Johnston's Road site was critical.

The design was required to examine some deficiencies with the design and construction of cell 2, and current operational issues at the Johnston's Road site. These issues include:

- Surface water control (or lack thereof);
- Erosion management and minimisation; and
- Vehicular access, including width, grade and surfacing of access tracks.

1.2 PROJECT OBJECTIVES

This project aims to provide the background and preliminary design information for the construction of an additional landfill Cell at the existing Johnston's Road Landfill Site near Bairnsdale, Victoria.

There are seven objectives for this project, these are:

1. Conduct a Literature review of all relevant guidelines, standards and previous research of Landfill/Liner design.
2. Analyse factors influencing design, existing design issues relating to cell 2, current operational issues and requirements as well as site factors/restrictions.
3. Investigate current site conditions such as hydro-geological conditions including groundwater locations, availability and suitability of clays, feature survey, etc. A verification of the Capacity of the existing leachate system may be required. The leachate generation over the life of the cell will be modelled using a Hydrological Evaluation of Landfill Performance (HELP) package.
4. Establish preliminary design requirements regarding site location, required capacity, life span, gas collection, leachate collection and possible treatment etc.

5. Evaluate and model different Liner designs with respect to meeting best practice guidelines and standards, performance and cost.
6. Establish preliminary design, including liner design, leachate collection, gas collection, etc.
7. Submit an academic dissertation on the research and design.

As time permits, it is then proposed to continue to develop the preliminary design into the final drawings and documentation to allow construction of the Landfill cell.

1.3 BACKGROUND AND SETTING

The Johnston's Road Landfill falls within East Gippsland Shire and is situated on the outskirts of Bairnsdale, approximately 280km East of Melbourne. East Gippsland Shire, shown in figure A, is a local government area in Victoria, and was formed in 1994 by the amalgamation of the City of Bairnsdale, Shire of Bairnsdale, Shire of Omeo, Shire of Orbost, Shire of Tambo and parts of the Shire of Rosedale. Encompassing areas such as Bairnsdale, Lakes Entrance, Omeo, Orbost, Mallacoota, Paynesville and Metung, East Gippsland Shire is the largest municipality in Victoria.

The area serviced by the Johnston's Road Landfill site, known as the Bairnsdale Regional SLA had a fixed population of 26,649 and was growing at an annual rate of 1.2% (Monash, 2008), at the 2006 census.

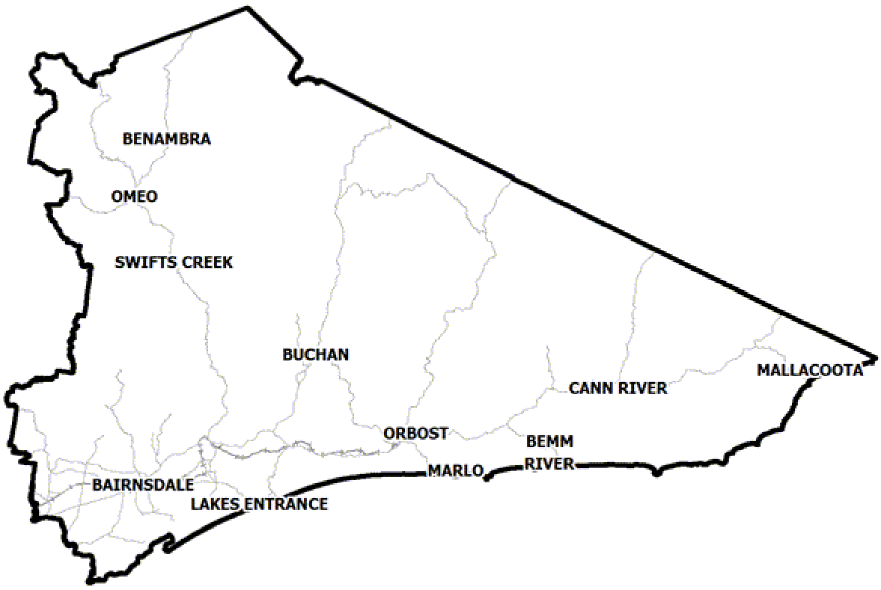


FIGURE A – EAST GIPPSLAND SHIRE REGION (VEC 2009)

The Johnston's Road Landfill is situated approximately 5km South of Bairnsdale and accepts waste from kerbside collections in Bairnsdale, Wy-Yung, Paynesville, Raymond Island and Nicholson. It also accepts the refuse from a number of transfer stations within the area, such as Lindenow. Recently, acceptance of kerbside waste from areas normally serviced by the Lakes Entrance landfill has been occurring, due to the Lakes Entrance site nearing capacity. Figure B shows the location of the Johnston's Road landfill in relation to the Bairnsdale township, and also highlights some key features of the surrounding area (EGSC latitude, 2009).

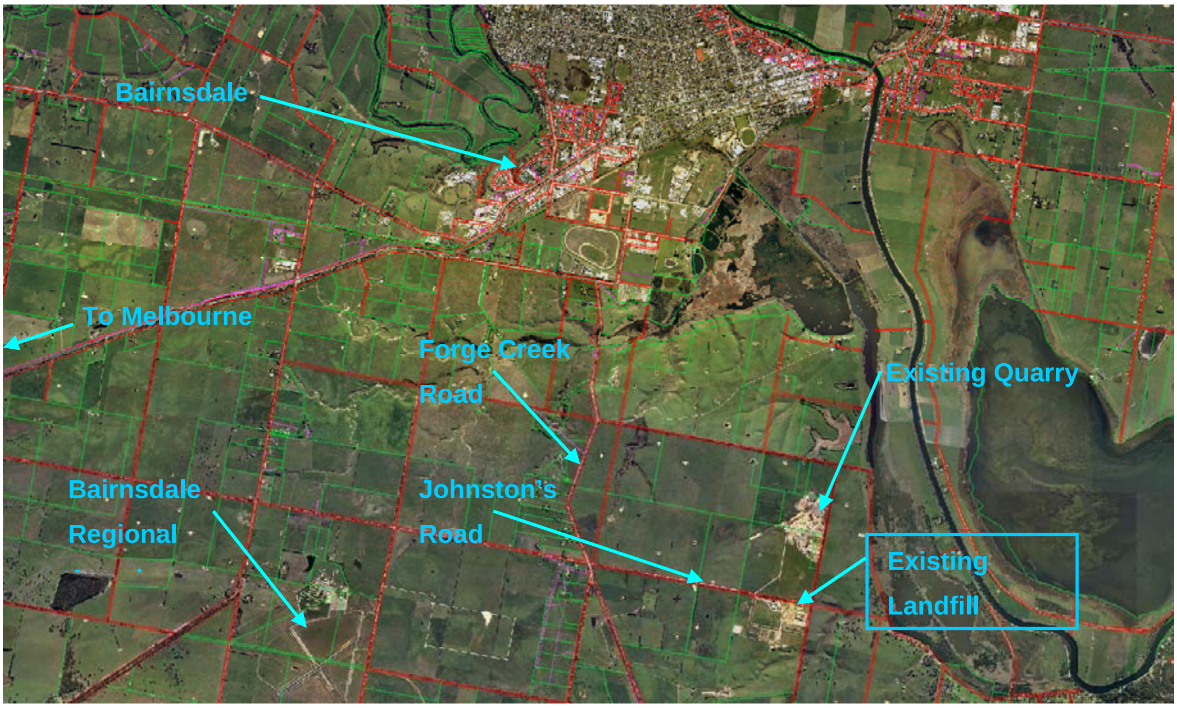


FIGURE B – LOCALITY PLAN SHOWING LANDFILL SITE AND SURROUNDS (EAST GIPPSLAND SHIRE, 2009)

The site was purchased by East Gippsland Shire Council in the late 1990's as part of an overall parcel of some 1700 acres in size, and was previously grazing land, used for both cattle and sheep. Of the overall parcel, approximately 307 acres is currently incorporated into the active landfill/transfer station area (EGSC latitude, 2009)

Three previous landfill cells have been constructed at the site, the first being denoted as Cell 1A, commissioned in late 2003. This was then followed by Cell 1B (an extension at the western end), commissioned within the 2005/2006 financial year. Cell 2 is the most recently constructed cell, with construction having been completed late in 2008, and currently undergoing EPA certification prior to being commissioned.

The Johnston’s Road landfill is the largest operated by East Gippsland Shire Council, and differs from others within the municipality, in that it also features a separate transfer station which was constructed in order to keep the general public away from the dangers posed by an active landfill face (and associated machinery operations), and to maintain better control of the material/types of waste entering the landfill cell. To further aid in the sorting of waste, an enclosed recycling centre, as well as separate green waste separation areas are provided. The existing site layout is provided in appendix B.

With this method of waste sorting, approximately 18000 tonnes of waste enter the landfill cell annually (GWS, 2008). This figure was prior to East Gippsland Shire Council moving from a two bin recycling kerbside system (recyclables, household waste), into a three bin system, which further separates green waste, recyclables and has a smaller bin for household waste. This was aimed at reducing the volume of waste entering the landfill cell by 15%. At this stage, no updated volume figures have become available to gauge whether this has been effective.

CHAPTER 2 – LITERATURE REVIEW

2.1 RELEVANT STANDARDS AND GUIDELINES

All landfill operations need to comply with the Environment Protection Act 1970, its regulations and relevant state environment protection policies (SEPP's). The Environment Protection Act is the 'Principal Legislative Vehicle' (EPA, 2001) for pollution control in Victoria. It regulates the discharge of waste to water, land and air by a system of works approvals and licenses. The SEPP's establish the environmental quality that must be reached and maintained. They typically set out the quantitative, ambient and environmental objectives, as well as specifying measures that must be implemented to minimize the risk of activities causing their ambient standards to be exceeded. The key SEPPs relating specifically to Landfills are:

1. SEPP (Siting and Management of Landfills Receiving Municipal Waste) 1991
2. SEPP (Waters of Victoria) 1988
3. SEPP (Air Quality Management) 2001
4. SEPP (Ambient Air Quality) 1999
5. SEPP (Control of Noise from Commerce, Industry and Trade) No. N-1-1989; and
6. SEPP (Ground waters of Victoria) 1997

The Victorian Environmental Protection Agency has produced a document as part of their 'best practices' series, titled *'Best Practice Environmental Management –*

Siting, Design, Operation and Rehabilitation of Landfills' (Publication number 788). This publication is effectively the 'standard' for landfills constructed within Victoria. It specifies the site selection criteria, minimum standard/specifications required for the various landfill components (such as liner, leachate collection system, etc).

The primary objective of this publication is to provide existing and future operators of landfills, planning authorities and regulating bodies with the information on potential impacts of a landfill on the environment and how this should be assessed, a clear statement of the performance objectives for each part of the environment, and how to avoid or minimise environmental impacts. The publication is intended to be used as a 'default' position for landfill Siting, design, operation and rehabilitation, and gives guidance on how Landfill operators and Designers can meet the objectives of the regulatory framework mentioned above. The design of Cell 3 therefore needs to *'as far as possible'* (EPA, 2001) implement the relevant best practice measures described by this publication.

The final legislative document which must be adhered to is the current operating license for the Johnston's Road site (license number LS52327). An operating license sets outs details such as:

- Waste management practices
    - Specifies which wastes may be deposited and the general requirements under which this may occur.
- Environment improvement plan and operational controls
    - Outlines the requirements for establishment of an 'Environment Improvement Plan' and the review process
    - Specifies operating requirements for good waste management (such as cover requirements, leachate and stormwater controls, etc) that

    - will ensure protection of the environment under both normal and upset operating conditions.
- Monitoring and reporting
    - Specifies the monitoring and reporting requirements of the site and the arrangements for the submission of any reports to the EPA.
- Plan of premises
    - Shows a plan of the premises covered by the operating license.

Compliance with the operating license conditions is critical, and any non-conformance to the conditions within it can result in environmental damage, hazardous conditions and/or significant monetary fines. If such non-conformances led to a cancellation or suspension of the operating license by the EPA it would also result in major waste management headaches and financial implications for East Gippsland Shire Council, as alternative or additional waste services/locations would need to be found.

2.2 WASTE MANAGEMENT HIERARCHY

The EPA utilises a multi-level concept of waste management referred to as the ‘Waste Management Hierarchy’. The basic premise behind the concept is that the initial objective for effective waste management is to avoid producing the waste in the first place, with the last preference being the final disposal of waste. From this waste management hierarchy, waste management should proceed in the following order (EPA, 2001):

1. Avoidance
2. Re-use
3. Recovery of Energy
4. Treatment
5. Containment; and finally,
6. Disposal

East Gippsland Shire Council follows this hierarchy by employing a public education program aimed to introduce people to better waste management and minimization practices. These education programs are directed at all levels of the community, ranging from in-school programs through to mail-outs and advertising campaigns. The transfer from a two bin (both 240L) kerbside collection into a three bin system (with 240L bins for recyclables and green waste, and a smaller 120L bin for household waste) was another method adopted by council to encourage the community to reduce waste generation and better recycling practices (EGSC waste management policy, 2009).

The Johnston's Road site then allows for the final levels of the hierarchy by providing facilities for the sorting and recycling of waste where possible. This ensures that the bare minimum of waste enters the actual landfill cell.

2.3 CLASSIFICATION OF LANDFILLS

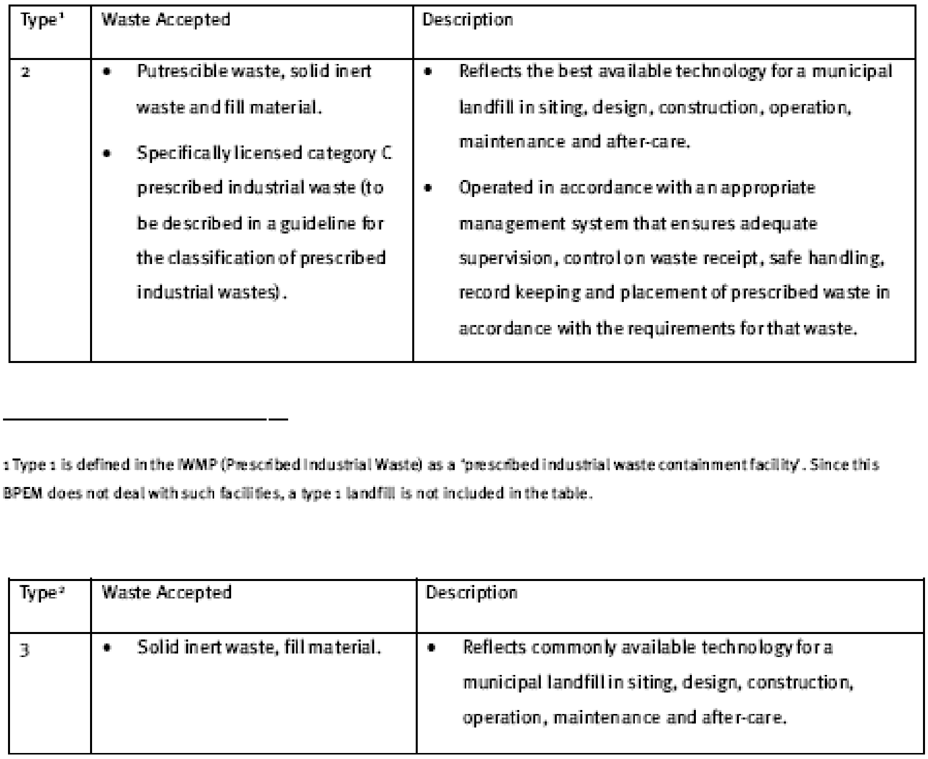
The type of waste that a disposal facility accepts, and the number of people/quantity of waste it is required to serve will have an impact on the way in which the site is operated, the construction methods used, as well as the licensing conditions imposed. The type of waste being accepted is used by the EPA to establish a classification of a landfill, which can then be used to identify the minimum performance levels required throughout the guidelines.

Four types of waste are dealt with in the EPA publication 788, these waste types are (EPA, 2001):

- Municipal waste – consisting of household putrescible waste, street litter, etc;
- Solid inert waste – solid waste which will not break down or cause further chemical reactions or leachate generation (All Earth Group, 2007);
- Category C prescribed industrial waste – industrial wastes which pose a low hazard or only exhibit offensive aesthetic properties (such as treated asbestos, waste washes, etc);
- Fill material – sands, rubble, soils, etc

For other waste types, such as hazardous wastes or oils (both contaminated and uncontaminated), there are additional requirements that are outlined in other guidelines. Sites that accept these types of wastes are specifically licensed and classified by the EPA as ‘Type 1’ Landfills (EPA, 2001).

According to ‘Table 1 – Classification of Landfills’ (EPA, 2001) the Johnston’s Road site and the proposed landfill Cell will be classified as a ‘Type 2’ landfill; Table 1 is reproduced here as figure C. The Cell will be accepting putrescible waste, solid inert waste, as well as some specifically licensed category C industrial waste.



Type[1]	Waste Accepted	Description
2	- Putrescible waste, solid inert waste and fill material. - Specifically licensed category C prescribed industrial waste (to be described in a guideline for the classification of prescribed industrial wastes).	- Reflects the best available technology for a municipal landfill in siting, design, construction, operation, maintenance and after-care. - Operated in accordance with an appropriate management system that ensures adequate supervision, control on waste receipt, safe handling, record keeping and placement of prescribed waste in accordance with the requirements for that waste.

---

[1] Type 1 is defined in the IWMP (Prescribed Industrial Waste) as a 'prescribed industrial waste containment facility'. Since this BPEM does not deal with such facilities, a type 1 landfill is not included in the table.

Type[2]	Waste Accepted	Description
3	- Solid inert waste, fill material.	- Reflects commonly available technology for a municipal landfill in siting, design, construction, operation, maintenance and after-care.

FIGURE C – LANDFILL CLASSIFICATIONS BASED ON WASTE ACCEPTANCE (EPA 2001)

2.4 BEST PRACTICE SITING CONDITIONS

An appropriate siting of a new landfill facility is the *'primary environmental control'* (EPA, 2001). It is for this reason that a number of factors require consideration prior to selecting a landfill site.

This project is focusing on creating additional storage at a current site, as opposed to establishing a completely new ‘green field’ landfill facility, so some consideration of these siting requirements has been previously given.

2.4.1 COMMUNITY NEEDS

A landfill should not be located where it is not needed for the disposal of a communities waste (EPA, 2001).

A review of the waste management facilities within East Gippsland Shire indicates that the next closest landfill site is located at Lakes Entrance (approximately 45km away). The Lakes Entrance landfill is a significantly smaller site, and is nearing capacity. It is likely that it would not be able to handle the influx of additional waste, should the Johnston’s Road site not be extended.

As previously mentioned, the Johnston’s Road Landfill services a fixed population exceeding 26,000 people from a number of nearby areas, as well as accepting the waste from several smaller transfer stations.

Because the site is already an established landfill, a clear community need has been demonstrated.

2.4.2 BUFFER DISTANCES FROM FEATURES

In order to minimize the impact of landfills on the surroundings, the EPA requires landfill sites to have minimum buffer distances to certain nearby features, such as surface water, dwellings and aerodromes. These buffer distances vary depending on the landfill classification. The distances for a ‘Type 2’ landfill are shown in table 1 (EPA, 2001).

TABLE 1 – REQUIRED BUFFER DISTANCES FROM FEATURES TO TYPE 2 LANDFILL SITE

Feature	Buffer Distance
Surface waters	100 metres
Dwellings	500 metres
Aerodrome for piston engine, propeller aircraft.	1500 metres
Aerodrome for jet aircraft	3000 metres

2.4.3 GROUNDWATER BUFFER DISTANCES

Buffer distances are also required from groundwater to the landfill cell itself. This is to provide some separation and additional protection to the groundwater should a leak from the cell develop. The required buffer distance again varies with the type of waste being contained. For a type 2 landfill, a 2m separation is required from waste to groundwater (EPA, 2001).

URS undertook a site audit during 2006, and results of that audit indicated that groundwater was located approximately 15m - 23m below the natural surface in the cell construction areas. This finding was verified within a geotechnical report from Coffey (2004) which indicated that during their site testing groundwater was only encountered in one borehole, at a depth of 2.2m. This borehole was located in the clay borrow pit area, which is significantly lower than the proposed cell area.

A review of the construction logs from Cell 1a, Cell 1b and cell 2 indicate that no groundwater was encountered, and has not proved to be an issue during the landfill operations.

2.4.4 SURFACE WATER

Leachate can be toxic to aquatic organisms and cause eutrophication of waterways (EPA, 2001). Management of leachate and runoff must be managed in such a way as to prevent it escaping into surface waters.

The landfill must be protected from flooding by large rain events, and not located closer than 100m from surface waters.

A desktop study of the Johnston's Road site indicates that the nearest surface water is Macleod Morass, located 800 – 1000m to the East.

2.4.5 FLORA AND FAUNA PROTECTION

Landfill construction and operations is likely to have detrimental impacts on flora and fauna within the area, such as the destruction of vegetation (both through earthworks and via increased traffic flows), removal of wildlife habitat, as well as an increase in pest animals (foxes, feral cats, etc) as they scavenge for food.

Areas identified as sensitive areas, or areas used habitat for threatened or endangered species should be avoided for landfill use. The destruction of vegetation should be avoided, or at least minimized.

As the Johnston's Road site is already an operational landfill, and was previously cleared for grazing land, no major flora and fauna issues should be expected.

2.4.6 CAPACITY OF LOCAL INFRASTRUCTURE TO CATER FOR LANDFILL OPERATIONS

Adjoining infrastructure to a landfill site, such as roads, bridges, etc, must be able to sustain the general landfill operations. Traffic flows on the local network will increase as the general public transport waste to the site. During construction, heavy vehicles are likely to be using the roads for transportation of materials and equipment. Consideration of the ability of the road network to convey this traffic safely, and with a minimum disturbance to the local community needs to be given.

2.4.7 GEOLOGICAL SETTING AND STRATIGRAPHY

The decomposition of waste and the time taken for it to become stable can be several decades (EPA, 2001). For this reason, landfills need to be constructed in geologically stable areas. This enables the integrity of the landfill liner and capping system chosen to be assured and maintained.

The land on which the landfill is to be constructed needs to be capable of supporting the landfill, with or without engineering assistance, including all embankments and slopes. This applies especially when considering sites that have been previously used for underground mining.

The mineralogy of the site is an important factor in site selection, in particular the shrink/swell characteristics of the substrate. This characteristic needs to be examined to ensure that the potential for differential movement of any constructed liner is minimized. The availability of suitable construction materials for landfill components (such as clay liner) is another important consideration when assessing a landfill site, as the importing of suitable materials may become very costly.

Two previous geotechnical assessments have been reviewed. The first (and earliest) of these was a report compiled prior to the design of Cell 1a in 1999. This report was written by MPA Williams and Associates, and focused primarily on the geotechnical conditions underneath what is now the transfer station and cell 1 areas. A small number of test bores were sunk within the clay borrow pit used for liner construction.

The second report was conducted by Coffey Geosciences in 2004, and extended the previous MPA Williams study to the area now underneath Cell 2. Multiple bores and test pits (20 in total) were taken from the clay borrow pit area, and testing undertaken to further gauge its suitability for use in construction of clay liners.

These studies indicated that the regional geology consisted of Quaternary aged paludal deposits comprising silts and clays, and, Quaternary alluvial deposits of gravels, sand and silts (MPA Williams, 1999). A summary of the typical subsurface conditions is given in Table 2 (Coffey, 2004).

TABLE 2 – SUMMARY OF SUBSURFACE CONDITIONS

Interpreted Unit	**Depth to Top of Unit (m)**	**Unit Thickness (m)**	**Description of Materials**
Topsoil	0.0	0.2	SANDY SILT: low plasticity, fine to medium grained sand, dark grey, pale brown, brown. Not observed in pest pit TP20
Alluvium	0.2	Not Penetrated (>3.5m)	SANDY CLAY, CLAYEY SAND, SAND, SILTY CLAY, GRAVELLY SAND: low, medium and high plasticity, fine to medium grained sand, fine to coarse grained gravel, orange, pale grey, red mottles, grey; very stiff or dense to very dense. COBBLES IN SAND MATRIX in test pits TP2, TP14, TP15 and TP20 at depths of 2.5m, 1.6m 0.8m and 0.7m respectively

Weathered Rock	1.7	Not Penetrated	MUDSTONE: slightly weathered, light grey. Observed in test pit TP3 only.

Coffey, 2004, also undertook laboratory testing on the soils at the site to assist in assessing their engineering properties, particularly in regard to permeability and dispersion of the natural clays from the borrow pit area.

A total of four falling head permeability tests were undertaken on remolded soil samples collected within the borrow pit area. These tests resulted in permeability rates of between 3.0x10^{-9} m/sec and 8.8x10^{-11} m/sec (0.2592 mm/day and 0.0076 mm/day). An additional falling head test was conducted using a 2% saline solution instead of distilled water, in order to observe the effects that a saline leachate may have on the permeability of the soil. The results of this test indicated that the saline solution had little or no apparent impact on the permeability of the soil, which recorded a permeability of 1.9x10^{-10} m/sec (0.0164 mm/day).

The soil dispersion characteristics of the soil were assessed using emersion crumb tests. A total of eleven tests were conducted in the laboratory, ten using potable water, and the eleventh again using a 2% saline solution. These test results indicated that the natural clays at the site were mildly dispersive when subjected to potable water, however the sample exposed to a saline solution was found to be only slightly dispersive.

Coffey, 2004 recommends on this basis that the materials encountered in the borrow pit area as being suitable for use as a landfill liner, provided that they be adequately compacted and moisture conditioned. A procedure is recommended as a guide for site preparation and placement of liner materials:

1. The soils exposed after excavation to the design base level should be scarified to a depth of approximately 150mm, moisture conditioned to within ±2% of standard optimum moisture content and then re-compacted to a minimum dry density of 98% standard in accordance with AS1289 5.1.1, 5.4.1 or 5.7.1.
2. Any soft or weak areas identified during the compaction process that do not respond to further compaction should be removed and replaced with suitable site materials in layers not exceeding 250mm in thickness and should be compacted to the above criteria.
3. Subsequent layers of clay liner material should be placed in uniform 250mm loose thickness layers, moisture conditioned and compacted to the above criteria. The final layer of the clay liner should be maintained in a moist condition until covered with a protective layer to prevent drying and cracking.

This construction procedure meets the EPA guidelines (EPA, 2001) in that they require the liner to be constructed in a series of lifts, preferably four to six, and a minimum compacted thickness of one metre.

2.5 BEST PRACTICE - DESIGN

Once a landfill site has been selected, it must be designed so as to ensure it is able to protect the environment. The design of a landfill facility is influenced by a number of factors, such as the natural existing environment, adjacent land uses, available infrastructure, waste to be received and whether there is a need to provide integrated waste management facilities, supplying both disposal and recycling facilities.

A step by step process is generally adopted, looking at each element of the landfill design in turn. The EPA best practice guidelines outline the minimum requirements for each

2.5.1 – ENVIRONMENTAL ASSESSMENT

Prior to conducting design on any of the landfill elements, such as liner system or site layout, a thorough understanding of the existing environment is required. In order to gain this understanding and to develop a sound landfill design, an environmental assessment is required.

An environmental assessment will examine the effect that the landfill will have on the air, groundwater, surface water and noise environments, and should contain meteorological data, such as monthly rainfall and evaporation; hydro-geological data, including existing groundwater conditions and uses; water management practices, including storm water diversion, leachate generation and treatment methods.

As this project is to construct an additional cell at an existing site, much of this assessment data can be reused from previously conducted assessments for Cells 1 and 2.

2.5.2 – SITE LAYOUT

A landfill should be laid out in such a way that minimizes potential environmental impacts and occupational health and safety issues, as well as encouraging effective recycling.

Best practice for a type 2 landfill, as is the case for Johnston’s Road, is to have a gatehouse at the entrance to the site, which cannot be bypassed on the way to the landfill. This gatehouse provides the first active measure to divert recyclables from waste, and ensure that all non-conforming waste (such as industrial waste) does not end up in the landfill cell (EPA, 2001).

A transfer station, along with drop-off points for recyclable materials should be provided so that the public does not have the need to unload vehicles at the active tipping face, thus minimizing safety risks.

The Johnston’s Road site has an existing transfer station and recycling centre in place, and is assumed to be working effectively. As the scope of this project extends only as far as construction of an additional landfill cell, no additional design will be undertaken on the site layout.

2.5.3 – LINER SYSTEM

The primary function of a landfill liner system is to protect groundwater from the impacts of leachate. The liner slows the vertical seepage of leachate and allows its collection and removal via a leachate collection system (EPA, 2001). Several liner construction types have been used and are recommended based on the type of waste being contained, as well as the site conditions (such as soil profiles and groundwater conditions).

Typical liner systems constructed under current guidelines consist of five principal components:

A. Sub – Base

The sub-base forms the foundation for the liner system constructed above. It needs to be well consolidated, with minimal settlement to ensure a firm platform for the clay liner above. A stable sub-base also protects the geo-membrane from excessive strains due to differential settlement, and ensures that the drainage system works effectively throughout the life of the landfill. Peyton and Schroeder also indicate that the sub-base should be able to further attenuate contaminants seeping through the liner.

B. Low-Permeability Clay Liner

Virtually all modern landfill liner systems incorporate a low-permeability clay liner component in their design (Peyton & Shroeder, Unknown year).

As clay has the ability to retard water movement and absorb exchangeable cat ions (Atgun & Met, 2004), it is a suitable natural material to use in the construction of a low-permeability liner.

In order to satisfy minimum requirements of the EPA best practice guidelines, the compacted clay liner component needs to be a minimum of 1m thick and have a hydraulic conductivity not exceeding $1x10^{-9}$ m/sec (0.864 mm/day), when tested with both freshwater and a 50,000 ppm NaCl solution (EPA, 2001). The clay selected to be used in the liner construction should have the following properties (Peyton & Shroeder, Unknown Year):

- No rock or soil clumps greater than 50mm in any direction;
- More than 70% passing through a 19mm sieve;
- More than 30% passing through a 75µm sieve;
- More than 2% passing through a 2µm sieve; and
- A soil plasticity index greater than 10.

The clay liner should be placed and compacted in a minimum of four to six lifts (EPA, 2001). This minimises the risk that preferential flow paths will align and reduce the effectiveness of the liner.

In order to ensure that leachate forming above the liner will drain effectively, and to minimise the risk of damage to any overlaying Geo-membrane, the finished surface of the clay should be as smooth as possible.

C. Geo-membrane and protection layer

With the advent of modern polymer technology, the permeability of a liner system can be further reduced by using installing one or even multiple polymeric membranes over the compacted clay liner.

The type of polymeric membrane to be used must be compatible with the waste type being deposited and be resistant to chemical attack. Table 3, taken from the EPA best practice guidelines, 2001 indicates the most common geo-membranes used and their properties.

TABLE 3 – PROPERTIES OF COMMONLY USED GEO-MEMBRANES (EPA, 2001)

Attribute	**HDPE**	**LLDPE**	**PVC**	**EPDM**	**EIA-R**	**CSPE-R**	**FPP**
General Chemical Exposure	Excellent	Good	Fair	Good	Excellent	Excellent (When Cured)	Excellent
Hydrocarbon Exposure	Good	Good	Fair	Good	Excellent	Good (When Cured)	Good
Weathering (UV Exposure)	Excellent	Fair	Poor	Excellent	Excellent	Excellent (When Cured)	Excellent
Thermal Stability	Poor	Poor	Good	Excellent	Good	Excellent	Good – Excellent when reinforced
Tensile Performance	Good	Good	Good	Good	Excellent	Excellent	Good – Excellent when

							reinforced
Uni-axial elongation performance	Excellent	Excellent	Good	Good	Fair	Good	Excellent
Multi-axial elongation performance	Poor	Excellent	Excellent	Good	Fair	Good	Excellent
Puncture performance	Fair	Excellent	Excellent	Good	Excellent	Good	Good
Installation damage resistance	Fair	Fair	Excellent	Excellent	Good	Good	Excellent
Seaming methods	Thermal - Excellent	Thermal - Excellent	Thermal or Solvent bonding - Good	Tape seams - Good	Thermal - Excellent	Thermal or solvent bonding - Good	Thermal – Excellent
Repair in service	Good	Good	Good	Good	Good	Poor – Requires Adhesives	Excellent
Stress cracking	Fair	Good	Does not occur	Does not occur	Does not occur	Does not occur	Does not occur
Flexibility in detailing	Fair	Excellent	Good	Good	Good	Good	Excellent

Whether a geo-membrane is required depends primarily on the landfill classification, as well as the site properties, such as proximity to groundwater. For landfill sites with a high risk of environmental damage due to leakage, multiple layers of geo-membrane may be used.

The liner system constructed for Cell 1a and 1b does not feature a geo-membrane of any kind, as it was constructed prior to release of the best practice guidelines, however Cell 2 utilises a 2mm HDPE membrane overlaying the compacted clay liner.

D. Drainage layer and leachate collection system

The maximum leachate head on a landfill liner is 300mm (EPA, 2001). In order to meet this requirement, the landfill cell must feature an effective leachate drainage and collection system.

The leachate collection system usually comprises a high permeability drainage material (such as a coarse grained aggregate), through which perforated collection pipes pass, and a sump where collected leachate is extracted from the landfill. A geo-textile is usually placed beneath the aggregate to protect any geo-membrane from damage, and another layer over the top in order to prevent the ingress of fines and solid waste which may clog the drainage aggregate and collection pipe network.

A number of suppliers now manufacture products referred to as ‘geo-nets’, which provide alternatives to standard perforated pipes. These products include such things as ‘Megaflo’ or ‘Flownet’ drainage systems manufactured by Geofabrics Australia Pty Ltd. These are specially designed products for use in landfills, and provide ease of installation and/or higher loading limits than typical polymer pipes.

FIGURE D – EXAMPLE OF PERFORATED PIPE ALTERNATIVE, 'MEGA FLOW' DRAINAGE PRODUCT (GEOFABRICS, 2009)

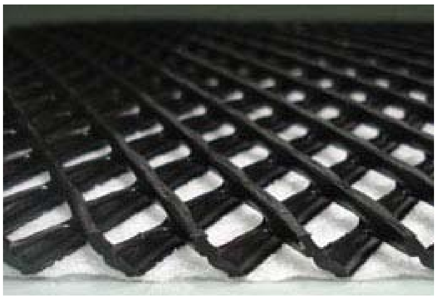


FIGURE E – EXAMPLE OF A GEO-NET, 'FLOWNET' BY GEOFABRICS AUSTRALIA (GEOFABRICS, 2009)

The leachate collection system must be designed to meet a number of objectives (EPA, 2001):

- Able to drain effectively so that leachate head above the liner is minimized (i.e. keep leachate level over liner less than 300mm);
- Appropriately sized to ensure that the estimated volume of leachate generated can be collected and/or stored. Volumes of

leachate generated are predicted using a HELP model, which is discussed in more detail in the following chapters;
- Resistant to chemical attack and to physical, chemical or biological clogging;
- Able to withstand the weight of waste, vehicular traffic and compaction equipment without crushing; and
- Able to be inspected and cleaned by readily available video inspection and pipe-cleaning equipment.

The drainage medium selected should be at least 300mm thick, to ensure that even if some clogging of the drainage pipes occur, leachate will still be able to find its way to the collection sump. The aggregate should be of a rounded shape to reduce the risk of damage to any underlying geo-membrane and selected to maximize drainage of the leachate collection system over the life of the landfill.

Peyton and Schroeder and the EPA guidelines recommend the following properties for the drainage medium:

- D_{85} not less than 40mm;
- D_{10} not less than 20mm;
- Uniformity co-efficient less than 2;
- Fines content less than 1% by weight;
- No limestone or calcareous material that would be subject to chemical attack; and

- The hydraulic conductivity of the drainage layer must be a minimum of 1x10^{-3} m/sec (86,400 mm/day).

Two key factors influence the effectiveness of the leachate collection pipes, pipe spacing and pipe size. By placing the pipes close together, the head above the liner is minimized. The EPA set a maximum pipe spacing of 25m (EPA, 2001). For spacing closer than this, Giroud's equation (Equation 1) can be used to determine the required pipe spacing and liner slope, given the maximum permissible head over liner, and several other parameters (EPA, 2001).

$$L = \frac{T_{Max}\left(2\cos(\beta)\right)}{\sqrt{\tan^2(\beta) + 4 \times \frac{q}{k}} - \tan(\beta)} \text{..}(1)$$

Where

L = spacing between drainage pipes (m)

T_{Max} = maximum leachate head over liner (m)

k = permeability of drainage layer (m/sec)

β = slope of the liner

q = leachate seepage rate into drainage layer (m/sec)

The leachate collection pipes are sized based on expected leachate flow rates within the pipe, as well as the minimum diameter required to allow passage of remote inspection equipment. For determination of the pipe diameter based on flow rate, Manning's equation is used (Equation 2).

$$\mathrm{V} = \frac{1}{\mathrm{n}} \times R^{\frac{2}{3}} \times S_o^{\frac{1}{2}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where; n = Manning's friction co - efficient;

R = Hydraulic Radius (m), given by $\mathrm{R} = \frac{\mathrm{A}}{\mathrm{P}}$;

S_o = Slope of the pipe

The leachate flow rates in landfill cells can be estimated using a ‘Hydrological Evaluation of Landfill Performance’ or HELP model. Further discussion of HELP models is conducted later in this chapter.

E. Geo-textile

Geo-textiles are permeable fabrics which, when used in association with soil, have the ability to separate, filter, reinforce, protect, or drain (Wikipedia, 2009). They are typically used for two purposes in a landfill situation:

a. A layer of geo-textile is placed over the top of the geo-membrane to offer a degree of protection from puncture.
b. A second layer is placed over the top of the drainage medium to minimize the risk of ‘clogging’ caused by drainage aggregate contamination.

Overall, the liner system needs to be designed to ensure that the seepage rate of leachate through the liner does not exceed 10L/ha/day (EPA, 2001).

As previously mentioned, there have been a variety of liner systems adopted throughout the world, with the primary selection criteria being the landfill classification and cost. Construction guidelines are also constantly evolving as new materials become available, which is a primary reason behind the EPA shortening the life of works approval licenses. By forcing the construction of smaller landfill cells and thus reducing their operational life, it gives increased opportunity for revision of construction practices used.

The previous landfill Cells constructed at Johnston’s road have two different liner systems, with Cells 1a and 1b not featuring any type of geo-membrane, instead simply relying on a 1m thick compacted clay liner, and with the drainage pipes cut into trenches in the base of the cell. This was the typical construction practice used in Type 2 landfill construction prior to the release of the best practices series in 2001.

Cell 2 was designed in 2003, and as such was required to meet with the new guidelines, with the minimum recommended construction including a compacted clay liner, and then completely overlain with a geo-membrane (in this case a 2mm HDPE) and the drainage layer. A study of the correspondence between Crossco Pty Ltd (designers of Cell 2) and the EPA revealed that the increased construction requirements and cost caused by this requirement was a particular bone of contention. The debate related to whether adding a geo-membrane into the design would provide any real increase in protection for the groundwater, given that the natural clays well exceeded the permeability requirements, and groundwater was well below the base of liner and the contamination risk considered extremely low.

In order to settle this debate, it was decided that the HELP package would be used to compare both the Cell 1 and Cell 2 liners, and attempt to quantify the performance differences.

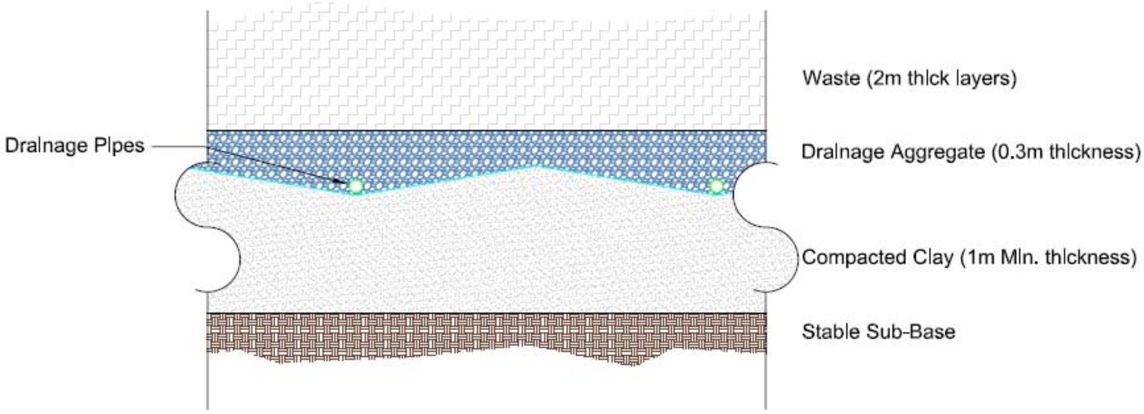


FIGURE F – CELL 1 LINER SYSTEM

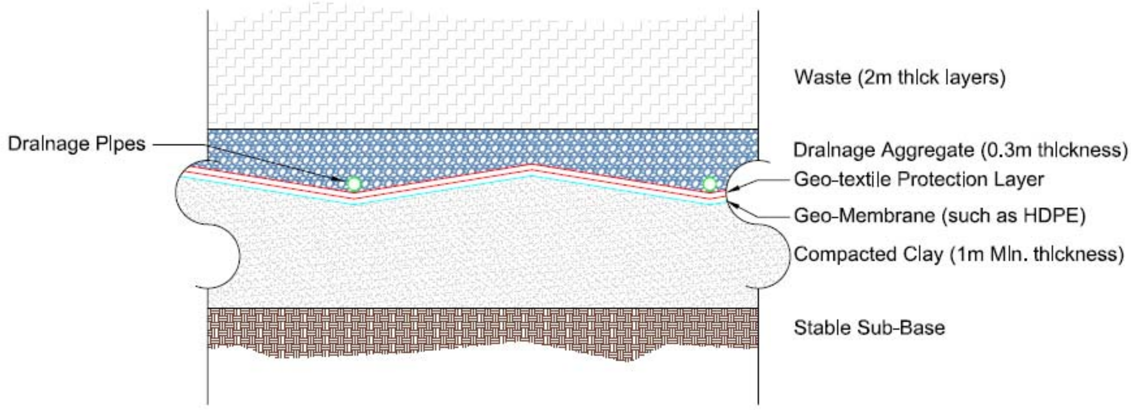


FIGURE G – CELL 2 LINER SYSTEM

A third liner has been commonly used within landfills across Europe and the United States, and involves significantly more construction expense, but also far greater protection. This liner involves the construction of what are effectively two liners, and is indicated in figure H.

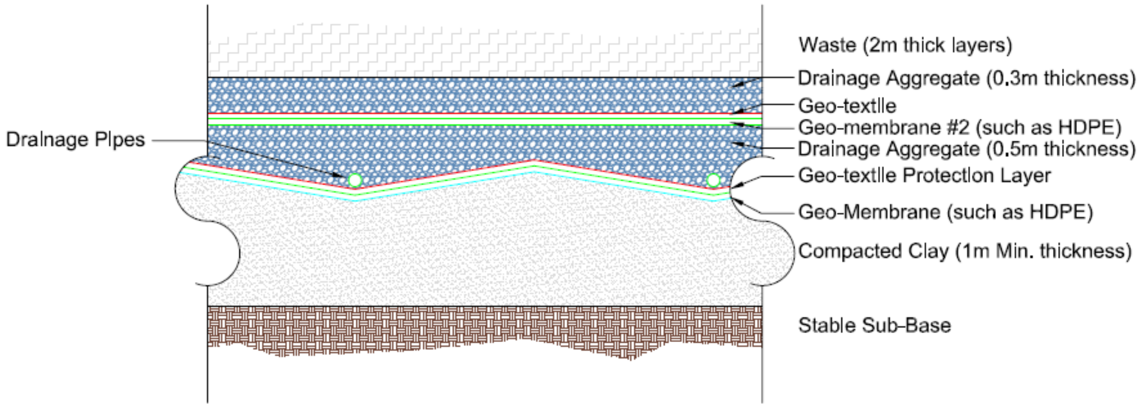


FIGURE H –MULTI-LAYERED LINER SYSTEM (US EPA, 2002)

Because of the primary and secondary layer systems, this liner system can sometimes incorporate ‘leak detection’ infrastructure, which involves constructing an electrical ‘grid’ between the liners. The change in resistance across this grid is then used to monitor any leakage that may occur through the primary liner, and allows the time to capture the leachate and/or repair the defect prior to environmental damage occurring. Because this liner system involves significant more construction outlay, as well as the increased cost associated with the monitoring and installation of the leak detection network, the cost/benefit was not considered adequate for use in this situation. This type of landfill liner would best suited to a Type 1 landfill (hazardous or industrial waste) or those landfill sites deemed to be in a high risk area.

This type of liner will still be modeled within the HELP program in order to examine the performance benefits.

Figure 3 indicates the ‘typical’ liner construction methods for a Type 2 and Type 3 landfill (EPA, 2001). From this, it becomes clear that the Cell 1a and 1b have liners that would meet the minimum guidelines for a Type 3 landfill, whilst Cell 2 meets those for a Type 2.

2.5.4 HYDROLOGICAL EVALUATION OF LANDFILL PERFORMANCE (HELP) MODEL

The ‘Hydrological Evaluation of Landfill Performance’ or HELP model is a hydrologic numerical model initially developed by the United States Army Engineers, in conjunction with the United States EPA.

The model uses a water balance approach to model evapo-transpiration and drainage through soil layers (Wikipedia, 2009), and can be applied to either open or closed landfills (Berger, 2000).

Development of the HELP model began in 1982 by Paul Schroeder and various other collaborators, US Army Waterways Experiment Station, for the US Environmental Protection Agency (Berger, 2000). Version 1 of HELP was released in 1984, version 2 in 1988 and then the latest version 3 in late 1994. The HELP model developed by Schroeder was designed to be run on PC’s under the DOS operating environment. The primary purpose of developing the model was to assist engineers and landfill designers in the comparison of design alternatives.

HELP is a “quasi-two-dimensional” (WHI, 2004) layer model, accepting the following input data:

- Weather (Precipitation, solar radiation, temperature, evapo-transpiration parameters);
- Soil (porosity, field capacity, wilting point and hydraulic conductivity); and
- Engineering design data (liners, leachate and runoff collection systems, and, surface slope).

The profile structure can be multi-layered, consisting of a combination of natural (soil) and artificial materials (waste, geo-membranes) with an option to install horizontal drainage and change the slope of profile parts (e.g. landfill cap, leachate collection and removal systems). The user sets the profile, or cross-section of the landfill or liner system as a sequence of layers, each layer performing a certain task and fitting into one of four categories (Berger, 2000):

- Vertical percolation layer (such as topsoil or waste);
- Lateral drainage layer (such as sand or drainage aggregate above a liner);
- Barrier soil liners (such as the compacted clay liner); and
- Geo-membrane

With the advent of commonplace use of geo-nets and geo-textiles, an additional layer classification was added in version 3 for this type of element.

The layer sequence must follow a specific set of rules, these rules are summarized in table 4 (UHI, 2004).

TABLE 4 – LAYERING RULES FOR VISUAL HELP

Layer Type	**Forbidden Combinations**			**Maximum number of layers in profile**	**Can it be top layer?**
	Above it	Below it	Between		
1. Vertical Percolation Layer	2 and 5 cannot be above 1				Yes
2. Lateral Drainage Layer		1 cannot be below 2			Yes
3. Barrier Soil Layer	cannot be above another 3	cannot be below another 3	cannot be between a 4 and another 4	5	No
4. Geo-membrane Liner	cannot be above another 4	cannot be below another 4	Cannot be between a 3 and another 3	5	No
5. Geo-textiles and Geo-nets		1 cannot be below 5			Yes

HELP models the following processes depending on layer type and in different ways on a daily basis (Berger, 2000):

- Precipitation (input);
- Accumulation of precipitation as snow on the surface; and snow melt;
- surface runoff using the SCS curve–number method (USDA SCS 1972);

- Evapo-transpiration, including potential evapo-transpiration and actual evapo-transpiration;
    - Actual evapo-transpiration consists of three components: evaporation of surface water (usually primarily evaporation of intercepted water, but also evaporation of snow and snow melt), soil evaporation, and plant transpiration;
- Unsaturated vertical percolation;
- Saturated lateral drainage;
- Saturated percolation through barrier soil layers based on Darcy’s law;
- Flow through geo-membranes (through fabrication pinholes and installation defects and by vapour diffusion), and flow through composite liners consisting of a barrier soil layer either overlain or underlain by a geo-membrane; and
- Frozen soil.

HELP is denoted as quasi-two-dimensional because several one-dimensional processes in the vertical and the lateral are combined (vertical: precipitation, infiltration, evapo-transpiration, percolation; lateral surface runoff, lateral drainage), but two-dimensional flow is not actually modeled. Furthermore, vertical flow is modeled in only one way (downward from segment to segment) or in case of the evapo-transpiration as a depth-dependent sideward extraction (output). The lateral flow processes are modeled directly as output (Berger, 2000).

Reviewing the available HELP software available, three readily available versions were found, one free version in the public domain, and two commercial products.

The free version was 3.07, and the published by the US Army Waterway Engineering, as per the original version. Whilst version 3 of the package was a marked improvement over previous versions, particularly in regard to user friendliness (had moved to a menu based operation), it was still based on the PC DOS operating environment.

The first of the commercially available packages examined was an enhanced and ‘corrected’ version that had been modified by Dr Klaus Berger at the University of Hamburg, for German conditions. This package was based on version 3.07 (above) and still utilized the DOS operating environment.

The third and ultimately selected commercial package was produced by Waterloo Hydrologic Incorporated, an American company. The HELP model was included as one of several ‘modules’ within an overall package called ‘Unsat Suite Plus’. Unsat Suite Plus was put together to provide a graphical environment specifically designed for simulating one-dimensional groundwater flow and contaminant transport through the unsaturated zone.

Whilst based on the 3.07 version of HELP, much work had been done in developing a Windows based graphical interface for the model. The module built into Unsat has been titled ‘Visual HELP’ and is version 2.2 of the program (version 1 being based on the earlier versions of the HELP model). As well as being graphical window based, Visual HELP also received a built in weather generator, based upon data from around 2000 weather stations worldwide. This is intended to save the operator significant time in data input.

Other modules built into Unsat Suite Plus are (WHI, 2004):

- PESTAN (**PEST**acide **AN**alytical) model, used to predict the transport of organic solutes through the unsaturated zone to the groundwater table. Commonly used for initial screening assessments to evaluate the potential for groundwater contamination by pesticides used in agricultural applications. Also quite useful for determining potential groundwater impacts from any organic solutes moving through the unsaturated zone.
- SESOIL, which is a popular US EPA model to simultaneously model water transport, sediment transport and pollutant fate.
- VS2DT is a finite difference numerical model for simulating steady state or transient, variably saturated 2D groundwater flow and solute transport. Common applications include determining the fate of agricultural chemicals, landfill leachate, UST leaks and chemical spills, as they move through the unsaturated zone towards the water table.
- VLEACH is a one dimensional finite difference **V**adose zone **LEACH**ing model for predicting the vertical mobilization and migration of organic contaminants in the vadose zone. This model is commonly used to study the impacts on groundwater due to vertical migration of organic contaminants through the unsaturated zone, and to predict sub-surface volatilization of VOC’s.

Because of the advantages of having a windows based graphical interface as opposed to a DOS based text program, and the possible future uses for the additional modules built into the Unsat Suite Plus package, it was decided to purchase one standalone version for $1875 inc GST.

2.5.4 WATER MANAGEMENT

Water management generally refers to three different sources. These sources are:

1. Storm water;
2. Leachate; and
3. Groundwater.

2.5.4.1 STORM WATER MANAGEMENT

Issues with storm water management have led to major issues at the site during construction of Cell 2 and general management, and will be one of the previous design issues examined later in this project.

The EPA guidelines and the license for the site require that consideration of storm water flows be given, and that no water having a turbidity exceeding those of table 5 be allowed to discharge from the site.

TABLE 5 – TURBIDITY LIMITS FOR WATER DISCHARGED FROM SITE

	Maximum NTU	**Median NTU**
Dry Weather	50	25
Storm water Flows	100	50

2.5.4.2 LEACHATE MANAGEMENT

Leachate contains high levels of nutrients and/or salts, and requires treatment prior to being discharged to the environment. Prior to, and during treatment, the leachate needs to be stored and managed onsite in such a way that it will not escape from the site, not cause offensive odours and to ensure that human contact is minimized.

Several leachate management techniques are outlined within the EPA guidelines, these include:

1. Evaporation

   If Evaporation is used as a method of leachate management, it needs to be conducted within a closed system in which no leachate can be escape into the outside environment. Ponds are the usual method of evaporating leachate. The evaporation rate can be enhanced by increasing the evaporation surface using techniques such as micro-sprays in the evaporation pond or devices such as a leachate evaporation pyramid.

   The evaporation pond needs to be designed to ensure that the system can handle the estimated leachate generation throughout the year. The Area of the pond surface can be found using equation 3:

$$A = \frac{1000 \times V}{0.8 \times E - R} \text{..}(3)$$

Where;

$\mathrm{A} = \text{pond surface area} \left(\mathrm{m}^2\right)$

$\mathrm{V} = \text{annual volume of leachate (kL)}$

$\mathrm{E} = \text{median annual evaporation (mm class A pan)}$

$\mathrm{R} = \text{median annual rainfall (mm)}$

The existing system at Johnston’s Road (used for Cell 1 and Cell 2) utilizes this method as part of the Leachate management system.

2. Discharge to Sewer, with or without pre-treatment

   The Leachate can be discharged to the sewer system, with approval from the sewerage authority. This method is not suitable for the Johnston’s Road site because of a lack of reticulated sewer system.

3. Treatment

   Leachate can be treated using a variety of methods, the principal method being the degradation of leachate by aerobic bacteria. The treatment system comprises three main elements:

   - Leachate Collection Pond
   - Treatment Pond
   - Treated Leachate Pond

The leachate at Johnston’s Road is not currently treated. Instead a combination of irrigation and evaporation are used.

4. Surface Irrigation

   Surface irrigation involves the spraying of leachate over land that has not received waste. This method, in combination with evaporation is used as the current leachate management technique at Johnston’s Road.

   Controls are placed on the quality of the liquid used in the irrigation, and must meet the guidelines set out in the EPA publications 168 – ‘Guidelines for wastewater irrigation’ and publication 464 – ‘Guidelines for Wastewater reuse’.

   The design of the leachate spraying system is not part of the project brief, and will not form part of this research.

2.5.4.3 GROUNDWATER MANAGEMENT

The interaction between the landfill and groundwater needs to be considered. Interaction can flow both ways, for example, there may be impacts on the groundwater because of the landfill, such as contamination; or there may be impacts on the landfill due to groundwater, such as a rising watertable.

Issues relating to groundwater that need to be considered are liner uplift and groundwater monitoring bores.

1. Liner Uplift

   Structural failure of a landfill liner can be caused by the upward or outward force of groundwater through the base or sides of a landfill. Until the loading of waste on the liner exceeds that of the upward or outward force of the water, the risk of liner damage needs to be managed.

   Based on the background geotechnical investigation (Coffey, 2004), and the previous construction history at the site, the risk of liner damage due to groundwater inundation is considered low, as the groundwater level is well below the natural surface and the base level of any proposed Cell.

2. Groundwater Monitoring

   Groundwater monitoring is presently conducted at the site. Groundwater monitoring is used to:

   - Establish the groundwater background quality and levels;
   - Groundwater flow direction;
   - Provide early indication that leachate contamination may be occurring

- Ensure compliance with works approval; and
- Give an indication of the downstream groundwater quality

The most recent site audit, undertaken by URS in 2006 noted that the regional water table is located approximately 15 – 23m below the surface and flows towards Macleod Morass, to the East of the site. The base of Cell 2 is approximately 18m AHD, and the water table approximately 3m AHD (URS, 2006).

This report also concluded that existing operations are not currently impacting groundwater, and that direct migration is unlikely, as a number of unsaturated permeable lenses exist above the water table that will control the flow of any escaping leachate (URS, 2006).

No additional bores have been installed at the site since this audit, and as a result, additional boreholes may be required to extend the monitoring network once construction of Cell 3 is complete.

2.5.5 LANDFILL GAS

The degradation of putrescible waste is caused by microbes. As a by-product of this degradation, they also produce what is known as landfill gas. The actual composition of landfill gas varies with the particular stages of decomposition;

however methane and carbon dioxide, both greenhouse gases, are major constituents.

Various technologies exist for the collection and re-use of landfill gas, however such technologies tend to involve significant capital outlay and running expenses, and thus prove cost prohibitive unless large volumes of gas can be captured. As green waste is separated from the waste entering the cell, the gas generation potential of the cell is considered low.

During 2008, a major landfill gas issue became apparent in the Melbourne suburb of Cranbourne, which involved dangerous levels of methane building up within a residential estate, and being sourced back to a previously closed and capped landfill. This widespread publicity has led to the EPA reviewing all landfill gas requirements and monitoring standards.

Until the reviewed standards become available, it is not known whether a permanent landfill gas monitoring and control measures will be required at the Johnston’s Road site. It is not considered likely, as portable monitoring conducted by Lane Piper in 2008 (in the aftermath of the Cranbourne incident) indicated that gas levels were quite low at the site, and green waste (which generates large volumes of gas as it breaks down) is separated from putrescible waste and does not enter the landfill Cell.

The inclusion of a gas mitigation system is not going to have an impact on the landfill liner or general cell design, and will therefore not be examined further within this project.

2.5.6 ODOUR AND NOISE IMPACTS

Odour and noise impacts are identified by the EPA (EPA, 2001) as a *'key consideration in deciding whether a landfill will adversely affect the amenity enjoyed or expected by surrounding neighbours'*.

Unfortunately, even with the best management practices and technology, noise and odour especially tend to come hand in hand with landfill operations. The single most effective and possibly simplest method of reducing the impact on the surrounding population is either to maintain adequate buffer distances from the site, or construct the landfill in areas in which noise or odour is less likely to affect the community (i.e. not in the middle of a residential suburb).

A review of the surrounding area (EGSC latitude, 2009) indicates that the surrounding area is predominately farmland, and an existing operational quarry. The nearest dwelling is approximately 1280m away.

Customer complaints from adjoining neighbours dating back to 1998 (earliest digital records) were examined (EGSC, 2009), and it was found that the most recent previous odour or noise related complaint about the Johnston’s Road site was in 2004, just after opening of the site. Since then, no odour or noise complaints have been recorded.

From this, and from the knowledge that the site has been operational as a landfill for several years, it can be considered that construction of an additional cell is not going to increase the noise or odour impact on the neighbouring area.

2.5.7 SITE SECURITY AND FENCING

Because of the inherent risks associated with an active landfill, such as unstable slopes, hazardous materials, fall from heights and heavy machinery, it is imperative that the site be secured to prevent unauthorized access by people and livestock. In addition, high risk areas, such as leachate ponds and disposal areas need to be clearly signed so as to indicate the dangers posed.

The level of fencing and site security required is dependent on the landfill size (population served) and site topography. Table 6 indicates minimum fencing requirements for landfill sites (EPA, 2001).

TABLE 6 – MINIMUM FENCING REQUIREMENTS (EPA, 2001)

	Population Served			
	< 5000	5000 – 10,000	10,000 – 50,000	More than 50,000
Extractive industry sites	A	A	A	A
Trench and fill	B	B	A or C	A or C
Topography change	B	B	A or C	A or C

A	A wire mesh fence at least 2m high constructed around the landfill site perimeter
B	A stock proof fence constructed around the perimeter of the landfill site, and relocatable litter screens erected near the tipping area
C	A wire mesh fence at least 2m high constructed around the tipping area only, and a stock proof fence around the perimeter of the site

CHAPTER 3 – REVIEW OF CELL 2 DESIGN DEFICIENCIES AND OPERATIONAL ISSUES

One of the objectives of this project was to analyze existing issues relating to the design of Cell 2 and general operational deficiencies at the Johnston's Road landfill site, and either solve the problem, find a method of managing the issue in such a way that the problem is minimized, or at the very least, ensure that the problem is not exacerbated by the construction of the new landfill cell.

As part of this review, some immediate remedial action was recommended and undertaken. Some of these works are outlined later in this chapter.

3.1 VEHICULAR ACCESS ISSUES

The general public does not have access the active tipping face or landfill area; instead they deposit waste using the transfer station and recycling centre. Accessibility to these public areas is considered excellent, with fully constructed and sealed roads, kerb and channel, adequate signage and traffic control measures (such as roundabouts and traffic islands).

Entering the landfill area of the site, these sealed roads immediately become gravel access tracks, and tend be in very poor condition (corrugated, patchy). They have also been noticed to be extremely slippery during wet conditions, due to the high clay content in road materials used (sourced onsite).

FIGURE I – PHOTO SHOWING EXAMPLE OF ACCESS ROADS WITHIN THE LANDFILL AREA

Because the landfill area is primarily entered by heavy vehicles, either transporting kerbside waste, or emptying transfer station waste, these issues can be quite hazardous.

Of particular concern in relation to vehicular access is the suitability of the tracks leading into the landfill cells. The design of Cell 2 featured a quite narrow, one-way gravel access track down to the Cell base, and running alongside the storm water retention basin. The grade of this track was quite steep, with poor sight distances. Concern was expressed by several of the garbage truck drivers that under wet conditions, it may be extremely hazardous and sliding into the storm water dam could be a real possibility. Because of the narrowness of the track, and the poor sight distance, concern was expressed that on occasion two vehicles heading in opposite directions may come across each other in the middle of the track, and with the limited maneuvering room, one would be forced to reverse either up or down a steep grade. This is hardly an ideal or safe situation.

FIGURE J – PHOTO ILLUSTRATING CELL 2 ACCESS TRACK

A review of these issues led to some remedial action being undertaken to minimize the risks, a bund wall has been created around the storm water dam to prevent vehicles sliding off the road in that direction, and the track widened as much as possible to allow additional maneuvering room for two vehicles to pass. A more suitable gravel material (with less clay content) imported from offsite has been placed on the track to increase traction and road stability when wet.

FIGURE K – PHOTO SHOWING SOME OF THE REMEDIAL ACTION TAKEN ON ACCESS TRACK LEADING INTO CELL 2. GRAVEL THAT HAS BEEN PLACED WAS STILL AWAITING FINAL COMPACTION AT THIS POINT, HAS SINCE BEEN COMPLETED. ALSO NOTE THE BUND WALL ON EDGE OF DAM.

Consideration of these issues needs to be given for Cell 3, to ensure that a repeat does not occur. The preference is to provide a two-way vehicular access track.

3.2 STORM WATER DAM CAPACITY AND SURFACE WATER CONTROL

Shortly after construction works at Cell 2 were completed, a reasonably large (1 in 10 ARI) rain event occurred. This led to the lower storm water retention dam above the Cell overflowing and inundating the base of the landfill Cell.

This was a major concern, and the required remedial works such as water removal, and the repair of eroded walls, increased costs substantially (approximately $75k) and delayed the EPA approval of the Cell by nearly 12 months.

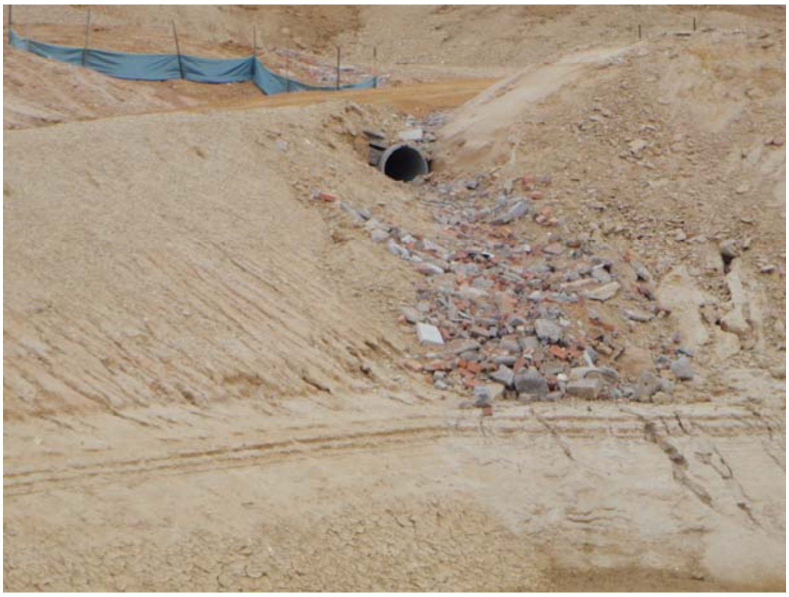
Additional work was conducted to provide better control of surface water through the use of diversion drains, as well as the construction of additional retention basins.

The existing site has a large storm water dam in the North East of the site, and two smaller retention dams above Cell 2 (one originally designed, with the second installed as part of remedial works). Pumps are used to transfer water from the small retention dams across to the main storm water dam, and from there, any excess water is pumped across to an adjacent quarry (operated by Whelan’s Earthmoving) for use in their operations as required.

The overall capacity of the main storm water dam is currently 4.6 ML. A project is currently scheduled within the 2009/2010 Capital Works program to increase this capacity to 14.4 ML (EGSC, 2009)

FIGURE L – PHOTO TAKEN FROM SPILLWAY OF ADDITIONAL RETENTION DAM CONSTRUCTED TO ALLOW BETTER SURFACE WATER CONTROL

FIGURE M – PHOTO TAKEN OF SPILLWAY FROM ADDITIONAL DAM. RUBBLE SOURCED FROM ONSITE WASTE WAS USED AS BEACHING TO MINIMIZE EROSION FLOWS RUN THROUGH A DROP STRUCTURE TO THE SIDE OF ACCESS TRACK, AND THROUGH PIPE CULVERTS INTO THE LOWER (ORIGINAL) RETENTION DAM.



***F**IGURE **N – P**HOTO TAKEN OF PIPE CULVERT UNDERNEATH ACCESS TRACK FROM NEW RETENTION DAM SPILLWAY*

All water entering an active landfill Cell will ultimately become leachate, and with the risks associated with a landfill Cell flooding, it is imperative that the flow of surface water into the Cell be minimized.

Cell 3 should not be subjected to as much surface water runoff as Cell 2 has been, as the natural surface level of the Cell area is above that of Cell 2. In reflection, it would have been a better approach to switch the construction areas for Cell 2 and 3, which would have reduced the surface runoff flowing towards the Cell, and hence the diversion drains, etc that have been required.

3.3 EROSION MANAGEMENT

During the rain event that inundated Cell 2, erosion caused damage that required remedial works in several areas. Of primary concern was damage caused to the batter slopes of the Cell walls. Surface water flows down the Northern, Southern and Eastern batters had eroded the liner protection layer to varying degrees.

FIGURE O – PHOTO ILLUSTRATING BATTER SLOPE EROSION

In order to prevent a recurrence of this problem, the areas above the batters were regraded to fall away from the batter edges. It was also identified that once the disturbed areas above the batters had revegetated then this issue would be further reduced.

The second area of concern for erosion was that of the spoil pile. The design documentation (both specification and drawings) did not indicate a finished shape for the spoil pile of material excavated from Cell 2, and as such it was simply deposited in a large mound to the South of the site. Under rain events, the slopes of this pile erode away and turbid runoff leaves the site, which is in violation of the EPA license.

Once again, the erosion issue from the spoil pile will reduce as vegetation grows back, however for a spoil pile created from Cell 3, clauses will be entered in the specification that provide a requirement for slopes to be as shallow as possible and revegetation to occur as soon as practical.

CHAPTER 4 – FACTORS INFLUENCING DESIGN AND SITE RESTRICTIONS

4.1 LICENSE CONDITIONS

The license agreement for Johnston's Road has several conditions that will affect the design of the next landfill Cell. These conditions relate to waste cover requirements, and the leachate and storm water management.

Taken from the EPA works approval (License):

‘2.4 All wastes must be deposited and compacted in layers not exceeding a vertical height of two metres.

2.5 Putrescible waste must be immediately covered by earth or other EPA approved material after deposition.

2.6 At the end of each days operation all waste must be covered by a layer of earth or other EPA approved material

2.7 By the end of each week, all wastes must be covered by a layer of earth or other EPA approved material not less than 300mm in thickness.

2.8 Adequate material for at least one month’s operation must be readily available on the premises’

These requirements will increase the required capacity of the cell, in order that the three year operational life required can be maintained.

Also relevant for the design of Cell 3 are the following conditions:

‘2.9 All surface drainage must be diverted from those portions of the premises which are or have been used for waste deposit

2.10 Leachate must be extracted from the landfill such that the depth of leachate above the lowest point of the drainage layer does not exceed 300mm.

2.11 Leachate or water must not be permitted to pond on the surface of the landfill

2.12 All leachate and contaminated storm water must only be discharged from the leachate storage pond system in accordance with the following:

- *To irrigation in accordance with the conditions of this license; or*
- *By tanker to an approved sewerage authority works in accordance with the conditions of this license; or*
- *For emergency use on the premises to suppress a fire on the premises'*

These requirements will affect the sizing of leachate collection pipes and storm water diversion techniques.

CHAPTER 5 - FEATURE SURVEY

A feature survey of the site was conducted in order to not only to identify any features that may have been missed on a desktop study, but also so that a digital model of the site could be prepared. It was also decide that establishment of additional survey control points would be advantageous for future construction at the site.

A Topcon GPT-7500 series total station was used to conduct the survey. To simplify the management of the survey, the site was broken up into seven key areas, and tackled in smaller surveys as time permitted. These areas are indicated as part of Appendix F, and included:

1. Gatehouse/transfer station area

   This area was surveyed as an electronic ‘as-built’ plan of the layout could not be located. Sufficient information was gathered to establish the location of all buildings, roads, fence lines/property boundaries and services.

   As no work is proposed within this area, a focus on obtaining natural surface shots for construction of a digital terrain model (DTM) was not required.

   Two additional bench marks were established in the area to allow for future expansion of the survey, or set out of buildings should the need arise.

2. Leachate pond and storm water dam

   This area was surveyed to establish whether the as constructed area did in fact match the construction drawings, and hence verify the leachate dam storage capacity. As there is also a Capital Works project for the enlargement of the storm water dam, it was considered sensible to ‘kill two birds with one stone’ and survey the area whilst onsite.

   Features picked up included things such as access roads, fence lines, services, and sufficient natural surface data to allow creation of an accurate DTM.

3. Cell 1 (including Cell 1a and Cell 1b)

Sufficient survey was required to allow creation of an accurate DTM, as well as locating features such as access tracks, drainage infrastructure, fence lines, etc. This data will be used to locate Cell 3, and possible future uses include airspace calculations for finding the space remaining in the cell.

4. Cell 2

   An ‘as built’ survey was considered advantageous, as it would provide a base point from which future waste volumes in the cell could be calculated, as well as providing a real world model to tie Cell 3 construction drawings into. Sufficient data was collected to create an accurate DTM, as well as locate all relevant features, such as access tracks and drainage infrastructure (some of which formed part of remedial works, and as such did not appear on the construction drawings).

   The locations of Temporary Bench Marks were verified, and two additional marks installed for future use.

5. Proposed Cell 3 Area

   Obviously, the existing terrain and features in the area proposed to be Cell 3 was required. Sufficient data was collected in order to create a DTM. The locations of fences, services and other features were also collected.

6. Spoil Area / Stockpile

   Because of the erosion and runoff issues with the Cell 2 spoil pile, some reshaping and removal may be done in the near future. Survey data was collected to enable a DTM to be created, as well as perform any volume calculations or the like that may be required.

   This area also extends down into the natural gully known as Skeen’s Creek, which is the direction that all runoff flows.

7. Borrow pit

   This is the area in which clay liner material for Cells 1 and 2 have been previously excavated, and is the area in which the clay for Cell 3 construction will also come from. No survey of the area could be found, so sufficient survey data was collected to create a DTM. This will allow volume calculations and haul road locations to be assessed.

CHAPTER 6 – CAPACITY REQUIREMENTS AND VOLUME CALCULATIONS

Prior to be licensed, each new landfill Cell is required to undergo an audit process by both the EPA, and by an EPA approved environmental auditor. This audit process is a two stage process, first examining and approving the construction documentation (including specification, design drawings and quality assurance systems) and then reviewing the construction practices used, test results, any issues that may have appeared during construction. If all is satisfactory, approval is then given for the landfill to become operational.

The EPA prefers that all new landfill cells be designed to have an operational life of 3 years, with an absolute maximum of 5 years. This allows them the opportunity to amend preferred construction practices and minimum guidelines as new technology becomes available, and helps to ensure that active landfill cells are as close to the best practice methods as possible. For this reason, the project brief called for an operational life for Cell 3 of three years, including capacity for both waste and daily cover requirements.

Waste volume reports from the site established that 18,000 tonnes of waste enter the landfill cell annually. The literature review also indicated that population serviced by the site had an annual growth rate of 1.2%. A review of the compaction processes used in current landfill operations, and the previous waste reports (GWS, 2008), a compacted density of 312 kg/m^3 was adopted.

The required volume within the cell for waste was then calculated:

$$\begin{aligned}
\text{Year 1 Waste Volume} &= 18000 \text{ Tonnes} \\
\text{Year 2 Waste Volume} &= 18000 \times 0.012 = 18216 \text{ Tonnes} \\
\text{Year 3 Waste Volume} &= 18216 \times 0.012 = 18435 \text{ Tonnes}
\end{aligned}$$

$$\begin{aligned}
\text{Total Waste Volume} &= 18000 + 18216 + 18435 \\
&= 54651 \text{ Tonnes}
\end{aligned}$$

$$\begin{aligned}
&\text{Converting to Volume:} \\
&\quad \text{Volume of Waste} = \frac{54651}{0.321} \\
&\qquad = 175163 \text{ m}^3
\end{aligned}$$

The site license requires that the waste be covered daily, and then be covered by 300mm of approved cover material weekly. Waste layers are required to be placed in layers not exceeding 2m in height.

The preference was to construct Cell 3 as an extension to the Western end of Cell 2. This means that the general geometry of the Cell, such as the finished base RL and batter slopes need to match into that of Cell 2. A review of the as built levels and geometry indicate the base level is approximately 18.5m AHD, with the final contour of Cell 1 being around 34m AHD. Batter slopes are 3:1.

The landfill capping layer is outside the scope of this project, but previous capping methods used have involved placing a 1m thick compacted clay layer, overlain with 0.5m of topsoil. For the purpose of calculating volumes, it will be assumed that this will again be the method used, and adequate space below the final landform height will be left.

A simple cross – section was drawn in AutoCAD to reflect the geometry, based upon a similar base width as Cell 2 (84m) (Crossco, 2007), and separated into several 2m thick layers of waste, overlain with a 0.3m layer of cover materials. The waste/cover material layers were repeated, until the final layer approached the underside of the capping layers. An extract of this sketch, with the relevant RL's is shown in figure P

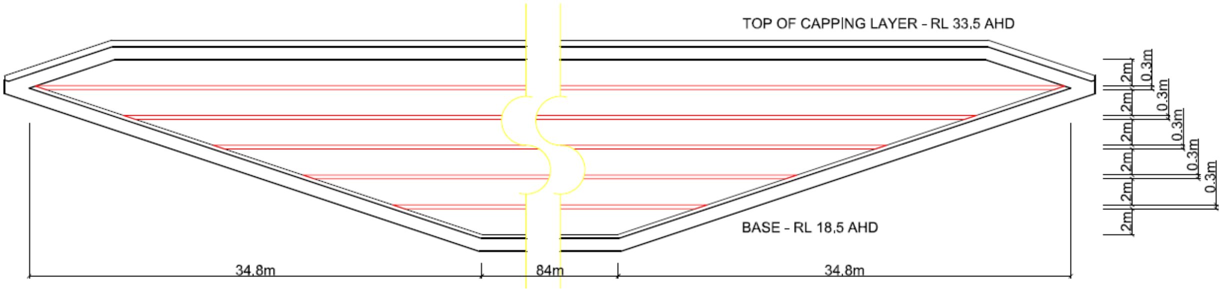


FIGURE P – AUTOCAD SKETCH USED FOR CROSS SECTION CALCULATIONS

The total internal area of the cell cross section is 1702.85m^2. Separating this into waste and cover categories, this is broken down into 1469m^2 of waste, and 233.85m^2 of cover material.

The required length of the cell was then calculated.

$$
\begin{aligned}
&\text{Length of Cell } 3 = \frac{175163\text{m}^3}{1469} \\
&= 119.24\text{m} \\
&\approx 120\text{m}
\end{aligned}
$$

This geometry assumes that the Western batter of the Cell will be vertical, which is not the real life case. A similar autoCAD based approach was used to estimate the volume gained by utilising a 3:1 batter on the Western end, which equated to an additional 314m^3. It was decided to disregard this small additional volume, as it would equate to shortening the proposed Cell geometry by less than 1m. Because the waste being deposited is going to be inherently variable in density, some slight extra volume would be beneficial.

In summary, from these calculations, the adopted cell will have a base RL of 18.5 AHD, an upper finished surface RL of 33.5, and a base size of 84m x 120m, with 3:1 batters on all sides. A sketch of the proposed Cell is included as appendix D.

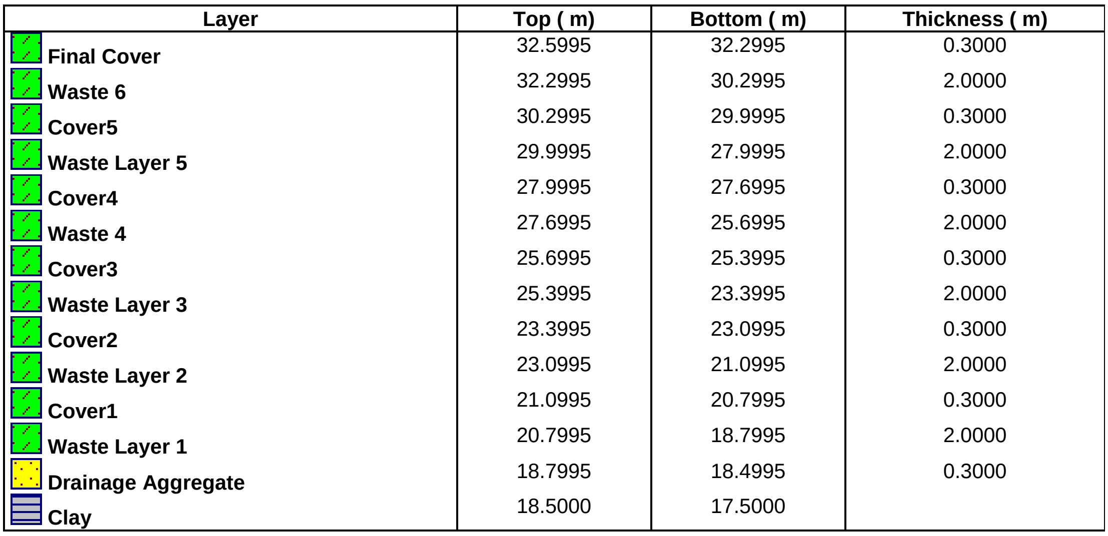
CHAPTER 7 – LINER SYSTEM (INCLUDING HELP MODEL COMPARISON)

As mentioned in the literature review, many different liner systems have been used across the world. Most of these systems were adopted based on the specific site conditions or availability of natural materials (such as clays). During the design and audit stage of Cell 2, much debate took place between EPA Victoria and the designer on whether the use of a geo-membrane layer in the Cell 2 liner system would substantially reduce the environmental risk, and offer enough of a performance gain to warrant the additional expense.

To gain an understanding of the performance increases that the geo-membrane offered, three liner systems were selected to be modeled and compared. These liner systems were:

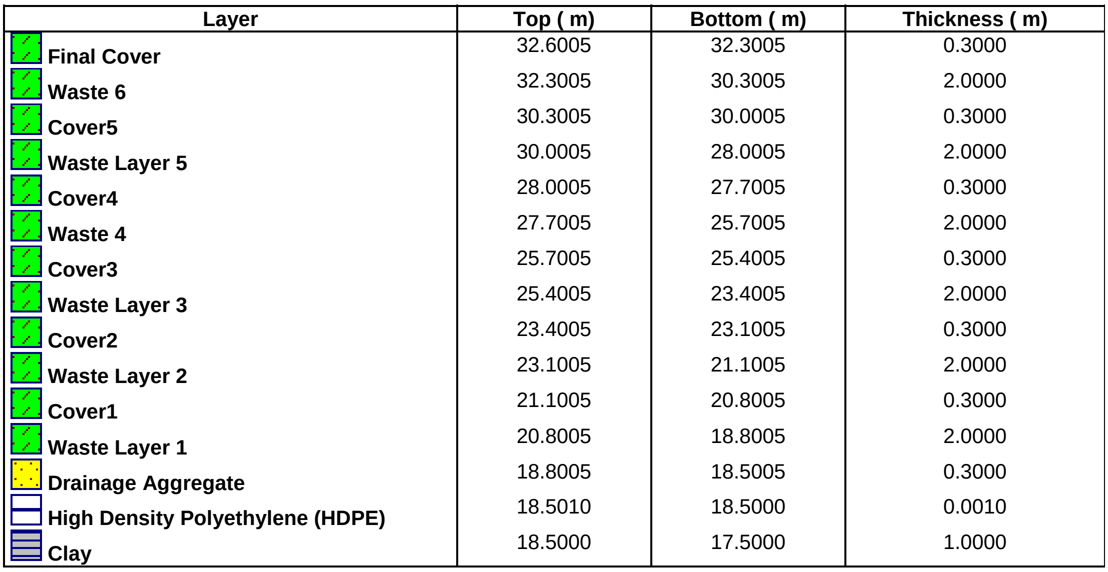
1. Cell 1 liner system – 1m thick compacted clay liner (CCL), with overlaying 300mm drainage aggregate.
2. Cell 2 liner system – 1m compacted clay liner, overlain with a 2mm HDPE geo-membrane and then 300mm of drainage aggregate.
3. US EPA recommended system – A multiple geo-membrane system, which utilizes a 1m thick compacted clay liner, overlain with a butyl rubber geo-membrane, and then a 0.5m thick drainage layer. This is then overtopped by an additional HDPE geo-membrane, a geo-textile protection layer and then finally by a secondary 0.3m thick drainage aggregate.

Each of these liner systems were setup within Visual HELP, with a three year simulation time selected to reflect the life of the landfill. Municipal waste at 312kg/m^3 was added in 2m thick layers, separated by 300mm soil layers, as per the volume design indicated within chapter 6. No final cap layer was included, as the nearly full, still active landfill would represent the worst case for leachate generation. Figures Q, R and S indicate the visual HELP input layers setup for the three liner systems.



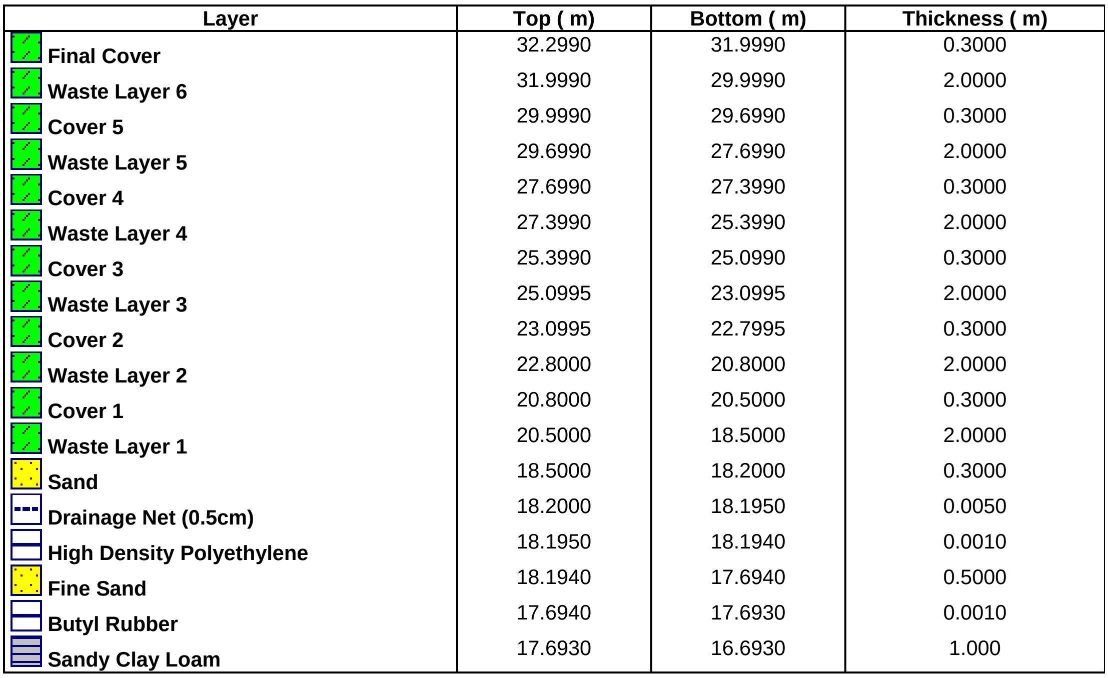
Layer	Top (m)	Bottom (m)	Thickness (m)
🟩 **Final Cover**	32.5995	32.2995	0.3000
🟩 **Waste 6**	32.2995	30.2995	2.0000
🟩 **Cover5**	30.2995	29.9995	0.3000
🟩 **Waste Layer 5**	29.9995	27.9995	2.0000
🟩 **Cover4**	27.9995	27.6995	0.3000
🟩 **Waste 4**	27.6995	25.6995	2.0000
🟩 **Cover3**	25.6995	25.3995	0.3000
🟩 **Waste Layer 3**	25.3995	23.3995	2.0000
🟩 **Cover2**	23.3995	23.0995	0.3000
🟩 **Waste Layer 2**	23.0995	21.0995	2.0000
🟩 **Cover1**	21.0995	20.7995	0.3000
🟩 **Waste Layer 1**	20.7995	18.7995	2.0000
🟨 **Drainage Aggregate**	18.7995	18.4995	0.3000
▤ **Clay**	18.5000	17.5000	

Figure Q – 'HELP' Model input for Cell 1 Liner System



Layer	Top (m)	Bottom (m)	Thickness (m)
🟩 **Final Cover**	32.6005	32.3005	0.3000
🟩 **Waste 6**	32.3005	30.3005	2.0000
🟩 **Cover5**	30.3005	30.0005	0.3000
🟩 **Waste Layer 5**	30.0005	28.0005	2.0000
🟩 **Cover4**	28.0005	27.7005	0.3000
🟩 **Waste 4**	27.7005	25.7005	2.0000
🟩 **Cover3**	25.7005	25.4005	0.3000
🟩 **Waste Layer 3**	25.4005	23.4005	2.0000
🟩 **Cover2**	23.4005	23.1005	0.3000
🟩 **Waste Layer 2**	23.1005	21.1005	2.0000
🟩 **Cover1**	21.1005	20.8005	0.3000
🟩 **Waste Layer 1**	20.8005	18.8005	2.0000
🟨 **Drainage Aggregate**	18.8005	18.5005	0.3000
☐ **High Density Polyethylene (HDPE)**	18.5010	18.5000	0.0010
▤ **Clay**	18.5000	17.5000	1.0000

Figure R – 'HELP' Model input for Cell 2 Liner System



Layer	Top (m)	Bottom (m)	Thickness (m)
🟩 **Final Cover**	32.2990	31.9990	0.3000
🟩 **Waste Layer 6**	31.9990	29.9990	2.0000
🟩 **Cover 5**	29.9990	29.6990	0.3000
🟩 **Waste Layer 5**	29.6990	27.6990	2.0000
🟩 **Cover 4**	27.6990	27.3990	0.3000
🟩 **Waste Layer 4**	27.3990	25.3990	2.0000
🟩 **Cover 3**	25.3990	25.0990	0.3000
🟩 **Waste Layer 3**	25.0995	23.0995	2.0000
🟩 **Cover 2**	23.0995	22.7995	0.3000
🟩 **Waste Layer 2**	22.8000	20.8000	2.0000
🟩 **Cover 1**	20.8000	20.5000	0.3000
🟩 **Waste Layer 1**	20.5000	18.5000	2.0000
🟨 **Sand**	18.5000	18.2000	0.3000
Drainage Net (0.5cm)	18.2000	18.1950	0.0050
High Density Polyethylene	18.1950	18.1940	0.0010
🟨 **Fine Sand**	18.1940	17.6940	0.5000
Butyl Rubber	17.6940	17.6930	0.0010
▤ **Sandy Clay Loam**	17.6930	16.6930	1.000

Figure S – 'HELP' Model Input for US EPA recommended liner system

Geo-membrane installation quality was assumed to be rated 'good', with 2 defects per hectare and with an additional 2 pin hole defects per hectare due to manufacturing faults.

It was noted that the weather data automatically generated by the software package did not accurately reflect the weather station data obtained from the Bairnsdale aerodrome. The precipitation and evaporation rates are critical within the HELP model to obtain accurate results, and whilst more time consuming, the decision was made to manually enter the weather data for each simulation. Tables 7, 8 and 9 provide the updated weather data used within the model, obtained from the weather station at the Bairnsdale Aerodrome (BOM, 2009).

Table 7 – Average Monthly Precipitation Data for Bairnsdale Aerodrome (1943 – 2009) (BOM, 2009)

Climate				
	Rainfall (mm)	**Rainfall (in)**	**Temp (Celsius)**	**Temp (F)**
January	50.5	**2.02**	25.7	**78.3**
February	48.3	**1.932**	25.4	**77.7**
March	40.2	**1.608**	23.8	**74.8**
April	57.7	**2.308**	20.6	**69.1**
May	46.1	**1.844**	17.5	**63.5**
June	59	**2.36**	15.1	**59.2**
July	51	**2.04**	14.5	**58.1**
August	35.6	**1.424**	15.7	**60.3**
September	54.7	**2.188**	17.6	**63.7**
October	58.3	**2.332**	19.7	**67.5**
November	83.3	**3.332**	21.5	**70.7**
December	59.4	**2.376**	23.4	**74.1**

Table 8 – Average Annual Windspeed for Bairnsdale Aerodrome (1943 – 2009) (BOM, 2009)

Windspeed		
	km/h	**miles/hr**
Wind Speed	18.1	11.222

Table 9 – Average Quarterly Humidity for Bairnsdale Aerodrome (1943 – 2009) BOM, 2009)

Humidity				
	Month 1	**Month 2**	**Month 3**	**Avge**
1st Quarter	53	53	53	**53.00**
2nd Quarter	58	62	64	**61.33**
3rd Quarter	61	57	59	**59.00**
4th Quarter	58	58	56	**57.33**

In order to compare the effectiveness of the landfill liner system, the total volume of leachate that seeped through the base layer (compacted clay) of each liner, across the entire three year model life were compared.

Figures S through U are graphical outputs of the visual HELP model, and table 9, 10 and 11 are a tabular form of these plots. These results indicate that the US EPA recommended liner is the most effective, whilst the stand alone clay liner used in Cell 1 performed quite badly, allowing far more seepage through the liner base than either of the geo-membrane inclusive liner systems.

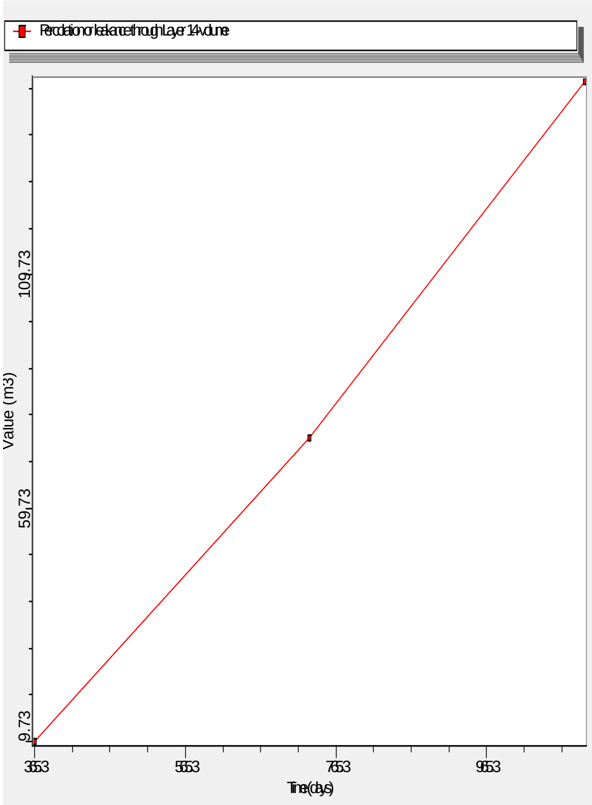


Figure T – Accumulated percolation through base of Cell 1 liner System (3 year simulation time)

TABLE 10 – ACCUMULATED PERCOLATION THROUGH BASE OF CELL 1 LINER SYSTEM (3 YEAR SIMULATION TIME)

	Year 1 (m^3)	**Year 2 (m^3)**	**Year 3 (m^3)**
Percolation or leakance through Layer 14 (m^3)	9.7342	74.751	151.24

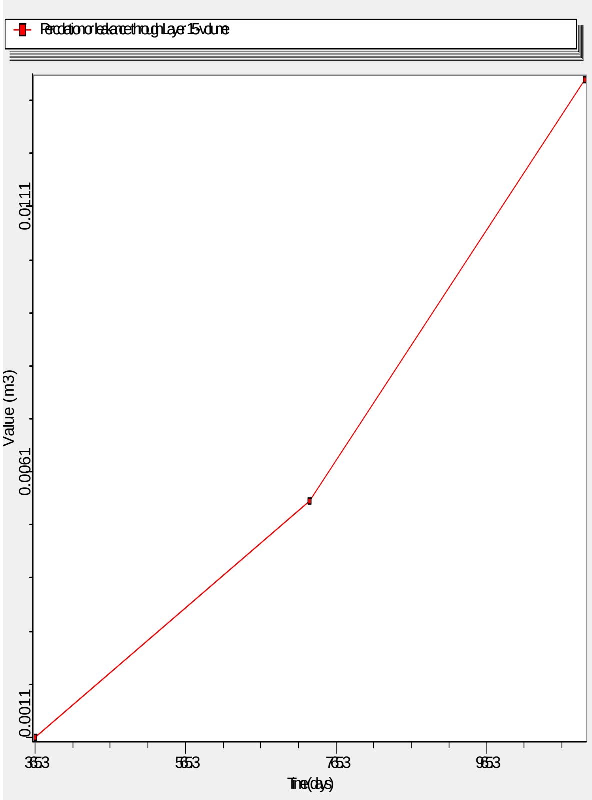


FIGURE U – ACCUMULATED PERCOLATION THROUGH BASE OF CELL 2 LINER SYSTEM (3 YEAR SIMULATION TIME)

TABLE 11 – ACCUMULATED PERCOLATION THROUGH BASE OF CELL 2 LINER SYSTEM (3 YEAR SIMULATION TIME)

	Year 1 (m^3)	**Year 2 (m^3)**	**Year 3 (m^3)**
Percolation or leakance through Layer 15 (m^3)	1.0956×10^{-3}	5.5440×10^{-3}	1.3489×10^{-2}

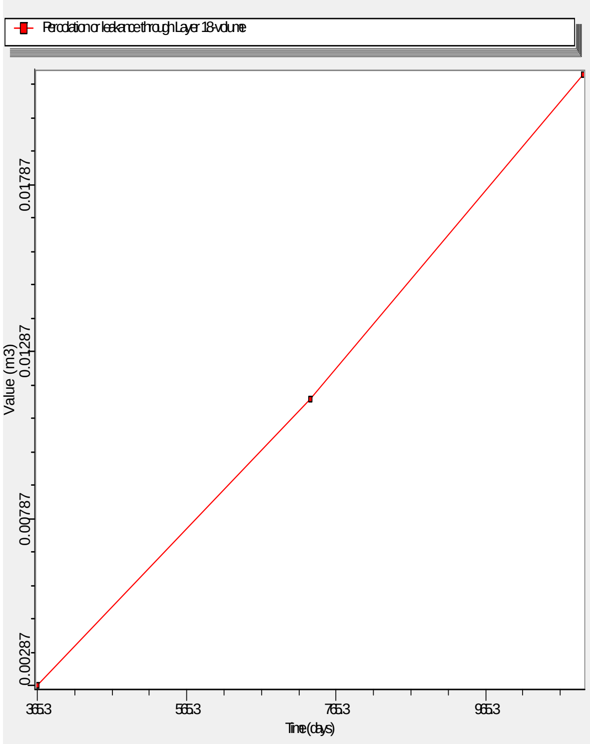


FIGURE V – ACCUMULATED PERCOLATION THROUGH BASE OF US EPA RECOMMENDED LINER SYSTEM (3 YEAR SIMULATION TIME)

TABLE 12 – ACCUMULATED PERCOLATION THROUGH BASE OF US EPA RECOMMENDED LINER SYSTEM (3 YEAR SIMULATION TIME)

	Year 1 (m3)	**Year 2 (m3)**	**Year 3 (m3)**
Percolation or leakance through Layer 18 (m^3)	2.8692 x 10^{-3}	1.1455 x 10^{-2}	2.1170 x 10^{-2}

Comparing the results of the model, it becomes obvious that the liner systems featuring a geo-membrane are far superior to that of the simple compacted clay liner used in Cell 1. Seepage rates through the liner system of Cell 1 are far greater than that of Cell 2. This would seem to settle the debate as to whether the inclusion of a geo-membrane would provide a greater margin of groundwater protection, and be worth the increased construction costs.

Having proved that the use of a geo-membrane was a very efficient way of reducing leachate seepage, the simple compacted clay liner system was ruled out as an option.

The final two remaining options had very low seepage rates. The multi-membrane system recommended by the US EPA did not indicate the lowest percolation rate, as had been expected, a revisiting of the permeability rates of the butyl rubber layer used will be done at a later stage. The volumes involved in both cases were considered quite low (0.0134m^3 over three years).

Because of the additional construction requirements and cost associated with installing additional geo-membranes, the decision was made to use a liner system similar to that of Cell 2. Figure V indicates the adopted liner system.

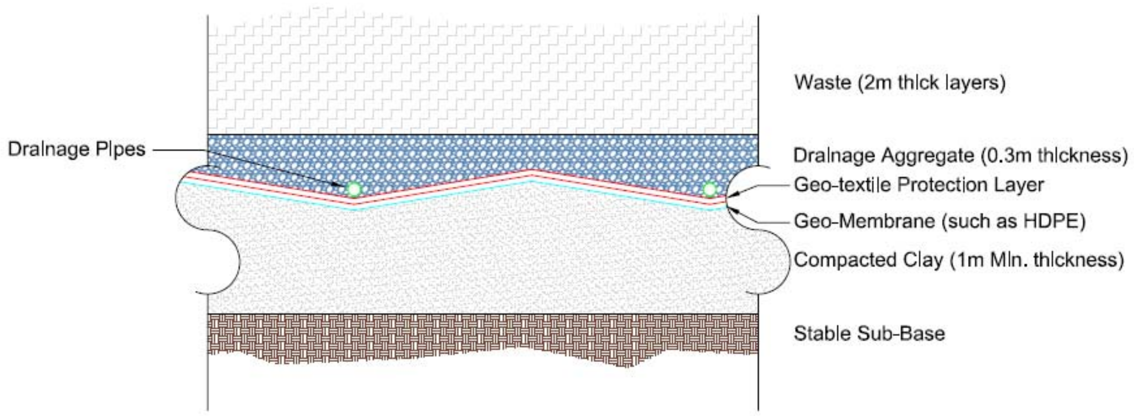


FIGURE W – ADOPTED LINER SYSTEM

CHAPTER 8 – LEACHATE COLLECTION SYSTEM

It is required that the level of leachate within the landfill Cell never exceeds 0.3m of head above the landfill liner system. In order to maintain leachate at low levels, drainage pipes need to be sized and spaced to cater for the leachate volumes generated.

The leachate pipes spacing is calculated using Giroud's Equation, as outlined earlier (section 2.5.3). Gregory, Richardson and Giroud (2002) recommend *'that, in non arid regions, the design rate of fluid supply be taken as the permeability of the layer overlaying the lateral drainage layer'.*

In this instance, the permeability of the lower waste layer will be adopted as the value for ‘q’.

$$L = \frac{T_{Max}\left(2\cos(\beta)\right)}{\sqrt{\tan^2(\beta) + 4\times\frac{q}{k} - \tan(\beta)}}$$

Where

L = spacing between drainage pipes (m)

T_{Max} = maximum leachate head over liner (m) = 0.3

k = permeability of drainage layer (m/sec) = 1×10^{-3}

β = slope of the liner = 4% = 2.29°

q = leachate seepage rate into drainage layer (m/sec) = 1×10^{-5} (permeability of waste layer above)

$$\mathrm{L} = \frac{0.3\times\left(2\times\cos(2.29)\right)}{\sqrt{\tan^2(2.29) + \left(4\times\frac{1\times10^{-5}}{1\times10^{-3}}\right) - \tan(2.29)}}$$

$$= 14.98m$$

$$\approx 15m$$

This pipe spacing is less than the maximum of 25m allowed within the EPA guidelines, and will hence be adopted.

With a proposed Cell base length of 120m; 8 drainage pipe runs will be required.

From the HELP model, the peak daily flow rate from the drainage layer is 2.07x10^{-4} m^3 (0.207 Litres). If this flow is spread evenly over the eight required drainage pipes (calculated above), it immediately becomes apparent that the flow in each pipe will be very small, and sizing will therefore be governed by the need to have sufficient diameter for remote inspection equipment to be passed through, as opposed to flowing full. The minimum diameter required for inspection by remote equipment available locally is 100mm.

High Density Poly Ethylene (HDPE) has a high chemical resistance, and is well suited to welding. This chemical resistance makes it ideal for use in a landfill leachate collection system. Structurally, the drainage pipes must be able to withstand crushing by vehicular traffic and compaction activities on the waste layers above. HDPE pipe comes in several classes, each of differing structural strengths. Class 16 HDPE has the highest structural strength, and will therefore be adopted.

In summary, the leachate system will comprise 8/110mm Class 16 HDPE pipe runs, with a liner base slope of 4%.

CHAPTER 9 – SUMMARY OF PRELIMINARY DESIGN

9.1 CELL CAPACITY

The project brief required the landfill cell to have an operational life of three years, and be constructed as an extension to the Western end of Cell 2.

This equated to a waste volume of just over 175,000m^3.

In order to allow the new Cell to be constructed as an extension to Cell 2, it made sense to follow a similar geometry in regard to Cell base width and batter slopes. Cell base levels and finished surface levels of capped waste were also taken from Cell 2, and Cell 1 respectively.

For this reason, a cell base size of 120m x 84m was adopted, with 3:1 batter slopes on three sides, with the fourth (Eastern) end being previously excavated as Cell 2.

9.2 LINER SYSTEM

From the HELP modeling, and a review of the existing design data, a liner system based upon that used in Cell 2 has been adopted. This liner features a 1m thick compacted clay liner, overlain with a 2mm thick high density poly-ethylene (HDPE) geo-membrane. A drainage layer consisting of a 0.3m thick drainage aggregate, through with 110mm diameter, class 16 HDPE pipes are run through.

The compacted clay layer is to be placed in 4 x 250mm thick lifts. The clay can be obtained from the existing borrow pit area, and must be moisture conditioned and blended prior to placement. Moisture content should be monitored and maintained close to the OMC during construction to ensure that compaction is maintained within at least 98% of the standard maximum dry density.

9.3 LEACHATE COLLECTION SYSTEM

The leachate collection system is located in the uppermost area of the liner system. It consists of 8 runs of 110mm, class 16 HDPE pipe (running North – South) spaced at 15m intervals along the base of the cell. These pipes will then connect into the drainage sump previously built into Cell 2. The slope on the base of the liner has been set at a 4% grade.

The pipe network runs through the 300mm thick drainage aggregate layer. This aggregate is required to be free of organic material, sticks, roots, sharp objects or debris of any kind. Particle size of the aggregate screened from the excavated material shall be between 20mm and 75mm with a fines content of less than 1%.

CHAPTER 10 – CONCLUSIONS AND FUTURE WORK

Preliminary computations regarding the Cell capacity have indicated that a volume of 175,163m^3 of waste will enter the landfill Cell over a three year life. This does not allow for the expected reduction in waste generation due to the shift to a three bin kerbside collection system (which was aimed to reduce waste by 15%). An annual population growth of 1.2% was allowed for, as was indicated at the 2006 census.

In order to cater for these volumes, a landfill Cell having a base size of 84m x 120m was adopted, with 3:1 batter slopes on all sides except the Cell 2 (Eastern) end. Allowance was made to place waste in six 2m thick layers, with each layer being overlain with 0.3m of approved cover material (such as soil).

Three different liner systems were modeled using a program called ‘Visual HELP’, which provided seepage rates through the base of each liner case. It was found that the use of a geo-membrane layer within a liner significantly reduced the amount of leachate leaking through the liner base and being able to enter groundwater. A liner type similar to that used for the construction of Cell 2 was adopted.

The Leachate system contains 8 pipe runs, spaced along the cell at 15m intervals, and connected into the existing drainage sump constructed in Cell 2. Based on expected leachate generation rates from the HELP model, these pipes were sized not on discharge, but on the requirement to provide access for remote inspection equipment and maintenance tasks. Leachate pipes were therefore nominated as 110mm diameter, Class 16 HDPE pipes.

Details of the proposed Cell are included as a concept sketch in Appendix D.

The existing issues associated with Cell 2, and the general operational issues have been identified. Avoiding a repeat of the majority of these issues can be avoided by better rehabilitation of disturbed areas post construction, consideration of the final spoil pile shape during construction, and the use of more suitable materials on access routes. Some detail will be added into the project specifications in order to make the construction contractor aware of these increased responsibilities.

The access issues identified will be resolved upon completion of the final drawings. These include items such as the provision of two way access into the new Cell, and at a suitable grade for heavy vehicles. The surface water management issues will also be addressed at final drawing stage, although it is noted that surface water should not be as much of an issue for this Cell, as the location selected is at a higher level than that of Cell 2.

In order to finalize this design, some work still needs to be completed. This work involves the preparation of final drawings, schedule of quantities, as well as the final preparation of contract documents.

A revisit of the HELP model profile setup for the US EPA liner system is warranted. A check needs to be done of the applied permeability rates of the various layers involved. A profile could also be setup to investigate the performance of the system if an alternative to Butyl Rubber (such as a second HDPE layer) is used.

A draft specification has been prepared, and is attached in Appendix E.

REFERENCES

1. All Earth Group, 2007, *Recycling your green and inert waste*, viewed 17th August 2009, Green Earth Group, Maddington, NSW <http://www.allearth.com.au/go/for-your-home/recycling-your-green-and-insert-waste>

2. Berger K, 2000, ‘Validation of the hydrologic evaluation of landfill performance (HELP) model for simulating the water balance of cover systems’, *Environmental Geology*, Vol 39, Issue 11, p 1261 – 1274

3. Coffey Geosciences Pty Ltd, 2004, *Geotechnical Assessment Report of Bairnsdale Regional Landfill – Stage 2, Bairnsdale, Victoria*, Coffey Geoscience Australia, Albury

4. Crossco Pty Ltd, 2007, *Bairnsdale Regional Landfill – Cell 3, Construction Drawings*, Crossco Pty Ltd, Bairnsdale, Victoria

5. Environmental Protection Agency – Victoria, 2001*, Siting, Design, Operation and Rehabilitation of Landfills*, Publication #788, EPA, Southbank, Victoria

6. Environmental Earth Sciences Vic, 2009, *Environmental Audit Report, Construction of Cell 2, Bairnsdale Regional Landfill, 200 Johnston’s Road, Bairnsdale, Victoria*, Environmental Earth Sciences, Footscray, Victoria

7. East Gippsland Shire Council, *Customer Service History – Precis Search ‘Johnston’s Road Landfill, Bairnsdale’*, search conducted 12th August 2009

8. East Gippsland Shire Council, 2009, ‘Latitude GIS Package’, utilised throughout project March 2009 – October 2009

9. Faculty of Engineering and Surveying, 2009, *ENG4111/4112 Research Project – Project Reference Book,* University of Southern Queensland, Toowoomba, QLD

10. Fleenor W, 1995, ‘Defining limitations for use of the HELP model’, *High Level Radioactive Waste Management – Proceedings of the annual international conference*, p 185 – 187

11. Gippsland Waste Services Pty Ltd, 2008, *Annual Operational Report – 2008*, Gippsland Waste Services, Bairnsdale

12. MPA Williams and Associates Pty Ltd, 1999, *Geotechnical Investigation for Johnston’s Road Landfill, Bairnsdale South*, Printed by MPA Williams and Associates, Bonbeach

13. Schroeder, P. et al, 1994, *The Hydrologic Evaluation of Landfill Performance (HELP) Model: Engineering Documentation for Version 3*, U.S. Environmental Protection Agency - Office of Research and Development, Washington, DC.

14. Schroeder P, 1998, *Hydrologic Evaluation of Landfill Performance (HELP) computer program for Landfill and Confined Disposal Facility (CDF) design*, US Army Corps of Engineers, Accessed 15th October 2009 <http://el.erdc.usace.army.mil/elmodels/helpinfo.html >

15. State of Ohio EPA, 2005, Using the HELP model to design the leachate collection and management system, Ohio EPA, viewed 15th October 2009 <http://www.epa.state.oh.us/portals/34/document/guidance/gd_528.pdf >

16. Waterloo Hydrogeologic Incorporated, November 2004, *User’s manual for WHI Unsat Suite (includes Visual HELP) – the intuitive unsaturated zone analysis package*, Waterloo Hydrogeologic Incorporated, Ontario

17. Waterloo Hydrogeologic Incorporated, November 2004, *WHI Unsat Suite Tutorial – Visual HELP lab exercises,* Waterloo Hydrogeologic Incorporated, Ontario

18. West, T, 1995, *Geology Applied to Engineering*, Prentice Hall, Upper Saddle River, NJ

19. Wikipedia, 2009, *Geo-textiles*, viewed 16th September 2009 <http://en.wikipedia.org/wiki/Geotextile>

20. Wikipedia, 2009, *Hydrological Evaluation of Landfill Performance*, viewed 16th September 2009 <http://en.wikipedia.org/wiki/Hydrologic_Evaluation_of_Landfill_Performance>

APPENDIX A – RESEARCH PROJECT SPECIFICATION

Appendix A

University of Southern Queensland

FACULTY OF ENGINEERING AND SURVEYING

ENG4111/4112 Research Project
PROJECT SPECIFICATION

FOR: **Rowan Alistair HOWARTH**

TOPIC: INVESTIGATION, DESIGN AND DOCUMENTATION OF PROPOSED CELL 3, JOHNSTONS ROAD LANDFILL

SUPERVISORS: Dr Vasantha Aravinthan
Mr. Ron Glasser (Project Officer, EGSC)
Mr. George Black (Principal, Black Geotechnical)

SPONSERSHIP: East Gippsland Shire Council

PROJECT AIM: This project aims to investigate current operational issues and to then develop a design that will address these issues, for the next landfill cell (Cell 3 of 5) at the Johnstons Road Landfill site, Bairnsdale.

PROGRAMME: (Issue C, 19 March 2009)

1. Conduct a Literature review of all relevant guidelines, standards and previous research of Landfill/Liner design.
2. Analyze factors influencing design, existing design issues relating to cell 2, current operational issues and requirements as well as site factors/restrictions.
3. Investigate current site conditions such as hydro-geological conditions including groundwater locations, availability and suitability of clays, feature survey, etc
4. Establish preliminary design requirements regarding site location, required capacity, life span, gas collection, leachate collection and possible treatment etc.
5. Evaluate and model different Liner designs with respect to meeting best practice guidelines and standards, performance and cost.
6. Establish preliminary design, including liner design, leachate collection, gas collection? etc.
7. Submit an academic dissertation on the research and design.

As time permits:

8. Finalize design and establish final drawings and specification

AGREED: ____________________ (student) ____________________ (supervisor)
Date: ___/___/09 Date: ___/___/09

APPENDIX B – EXISTING SITE LAYOUT

BORROW PIT AREA NOTES:

1. STRIP APPROX. 200mm DEPTH OF TOPSOIL FROM BORROW PIT AREA AS SPECIFIED IN GEOTECHNICAL REPORT AND STOCKPILE.
2. THE BORROW PIT SHALL NOT ALLOW EGRESS OF STORMWATER.
3. BATTER SLOPES SHALL BE LEFT AT A SLOPE NO GREATER THAN 1.5:1 (1.5 HORIZ. TO 1 VERT.) AT COMPLETION OF WORKS.
4. STORMWATER ACCUMULATING IN THE BORROW PIT SHALL BE PUMPED TO THE SEDIMENTATION DAM ONCE WATER QUALITY MEETS EPA GUIDELINES.
5. PLACE 100mm THICK LAYER OF TOPSOIL FROM STOCKPILE OVER BATTER SLOPES AND SEED AND FERTILISE WITH A MIXTURE SUITABLE FOR DRYLAND GRAZING AS RECOMMENDED BY SUPPLIER WHEN CELL CONSTRUCTION IS COMPLETED.

TEST PIT NOTE:

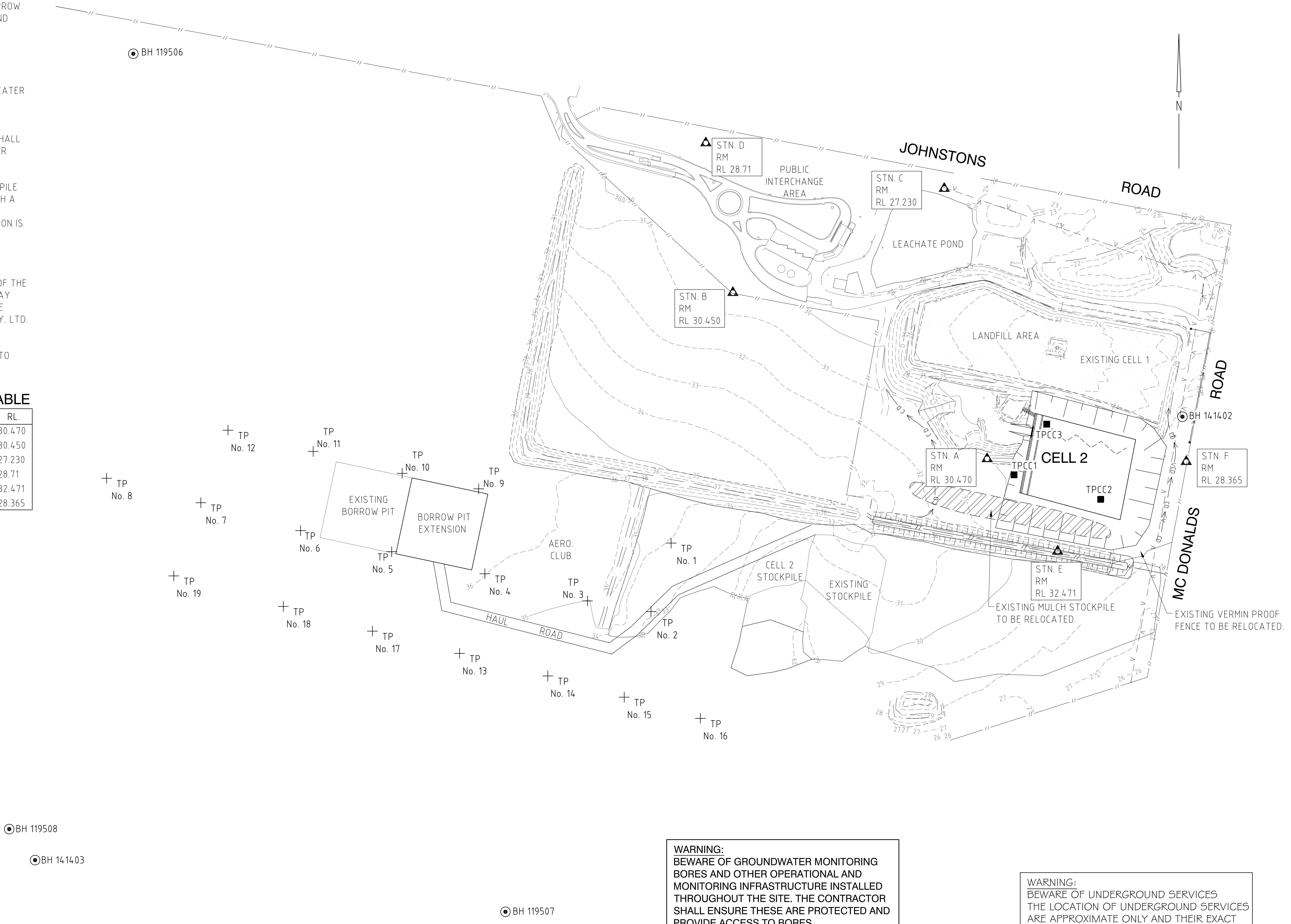
1. T.P. REFERS TO GEOTECHNICAL TEST PITS. DETAILS OF THE SOILS LOGGED FROM THESE TEST PITS INCLUDING CLAY PERMEABILITY TEST RESULTS ARE CONTAINED IN THE GEOTECHNICAL REPORT BY COFFEY GEOSCIENCES PTY. LTD. REFER TO SPECIFICATION.
2. FOR EXCAVATION LOGS FOR TPCC1 TO TPCC3 REFER TO APPENDIX 1 OF THE SPECIFICATION.

STATION CO-ORDINATE SET OUT TABLE

POINT No.	DESCRIPTION	EASTING	NORTHING	RL.
STN. A	RM	555345.903	5806818.140	30.470
STN. B	RM	555099.978	5806978.876	30.450
STN. C	RM	555304.438	5807079.584	27.230
STN. D	RM	555073.796	5807123.698	28.71
STN. E	RM	555414.129	5806728.663	32.471
STN. F	RM	555538.499	5806815.397	28.365

LEGEND:

+ TP No. 12	GEOTECHNICAL TEST PITS
■ TPCC2	EXCAVATION LOGS
⊙ BH 119507	GROUNDWATER MONITORING BORE (PROTECTION REQUIRED)



WARNING:
BEWARE OF GROUNDWATER MONITORING BORES AND OTHER OPERATIONAL AND MONITORING INFRASTRUCTURE INSTALLED THROUGHOUT THE SITE. THE CONTRACTOR SHALL ENSURE THESE ARE PROTECTED AND PROVIDE ACCESS TO BORES.

WARNING:
BEWARE OF UNDERGROUND SERVICES
THE LOCATION OF UNDERGROUND SERVICES ARE APPROXIMATE ONLY AND THEIR EXACT POSITION SHOULD BE PROVEN ON SITE.
NO GUARANTEE IS GIVEN THAT ALL EXISTING SERVICES ARE SHOWN.

Rv.	APPR.	DATE	REVISIONS
C	A.C.C.	14.08.2007	DESIGN AUDIT AMENDMENT
B	A.C.C.	07.06.2007	SIZE OF LANDFILL AMENDED
A	A.C.C.	01.03.2007	ORIGINAL ISSUE

EAST GIPPSLAND
SHIRE COUNCIL

Crossco Consulting Pty Ltd
ABN: 88 135 548 110
154 Macleod St
P.O. Box 858
Bairnsdale Vic 3875
Tel:(03) 51526298
Fax (03) 51527222
Email: consult@crossco.net.au

CROSSCo
ENGINEERING & ENVIRONMENTAL CONSULTANTS

Quality System
Quality Endorsed Company
ISO 9001
LIC. 2178
DLIQ

DESIGNED: A.G.
DRAWN: L.W.S.
CHECKED: A.C.C.
APPROVED: A.C.C.
SCALE: 1 : 2000
A1
DATUM: A.H.D.
SURVEY REF: -
PLAN No: -
XREF ATTACHED: R:\00001388 Bairnsdale Landfill Cell 2\ACAD\Xref\1388-Title Block.dwg
CAD FILE NAME: R:\00001388 Bairnsdale Landfill Cell 2\ACAD\Drgs\1388-1001.dwg

EAST GIPPSLAND SHIRE COUNCIL

BAIRNSDALE REGIONAL LANDFILL
CELL 2

EXISTING CONDITIONS AND CLAY
LINER BORROW PIT AREA DETAILS

DATE: MARCH 2007
SHEET 2 OF 12
DRAWING No: 1388/1001
Rv. C

APPENDIX C – CURRENT JOHNSTON'S ROAD WORKS APPROVAL

EPA
VICTORIA

LICENCE

issued under Section 20 of the Environment Protection Act 1970

This licence allows the licence holder to deposit waste to land at the premises subject to the attached conditions.

LICENCE HOLDER:	EAST GIPPSLAND SHIRE COUNCIL
REGISTERED ADDRESS:	273 MAIN STREET BAIRNSDALE VIC 3875
PREMISES ADDRESS:	JOHNSTON ROAD BAIRNSDALE SOUTH
LICENCE NUMBER:	LS52327
DATE OF ISSUE:	15 JULY 2003

....

MICHAEL ROBERT TONTA

ENVIRONMENT PROTECTION AUTHORITY

40 CITY ROAD SOUTHBANK MELBOURNE VICTORIA 3006 GPO BOX 4395QQ MELBOURNE VICTORIA 3001
TEL: (03) 9695 2700 FAX: (03) 9695 2710
www.epa.vic.gov.au

Plant Activities

This licence applies to a premises where municipal waste is deposited to land.

Licence Objectives

The licence holder shall adopt the following objectives for the protection of the environment:

- meet environmental quality requirements for all segments of the environment. This includes meeting the general provisions of the *Environment Protection Act (1970)*, State environment protection policies, and Industrial waste management policies. In particular,
  - *State environment protection policy (Waters of Victoria);*
  - *State environment protection policy (Groundwaters of Victoria);*
  - *State environment protection policy (Air Quality Management);*
  - *State environment protection policy (Siting and Management of Landfills receiving Municipal Wastes)*
- operate in accordance with good environmental practice at all times, including the provisions of EPA Publication No 788 *Siting, Design, Operation and Rehabilitation of Landfills*; and
- take opportunities to minimise waste and continuously improve environmental performance.

Licence Structure

The licence consists of the following parts.

1. *Waste Management*
   - specifies which wastes may be deposited and the general requirements under which this may occur.
2. *Environment Improvement Plan and Operational Controls*
   - may require an Environment Improvement Plan to be produced and regularly reviewed; and
   - may include operating requirements for good waste management to ensure protection of the environment under both normal and upset conditions.
3. *Monitoring and Reporting*
   - specifies the monitoring requirements and the arrangements for submission of reports to EPA.
4. *Plan of Premises*
   - plan of the premises covered by this licence.

DEFINITIONS

For the purposes of this licence the following interpretations apply:

"EPA" means the Environment Protection Authority

"Municipal waste" includes putrescible wastes and solid inert wastes from manufacturing, commercial, processing and services industries and waste generated within residential dwellings, but does not include liquid wastes, night-soil or grease trap wastes.

1. WASTE MANAGEMENT

Waste Discharge Components

1.1. Only the following wastes may be deposited at the premises:

a) municipal waste, both putrescible and solid inert fractions / only solid inert fractions; and

b) pneumatic automotive tyres shredded into pieces less than 250 millimetres in all dimensions.

Waste Discharge Location

1.2. Waste may only be deposited in that area described as the tipping area on the Plan of Premises.

1.3. Wastes, including litter, must not be:

a) deposited or allowed to accumulate in waters or leachate dams;

b) discharged beyond the boundaries of the premises; or

c) burned.

1.4. Leachate, or any water containing leachate, must not be discharged to the environment beyond the boundary of the premises.

1.5. Seepage of waste to groundwater at the premises must not cause any groundwater quality objective, as specified in State environment protection policy (*Groundwaters of Victoria*), to be exceeded.

Odours

1.6. Odours offensive to the senses of human beings must not be discharged beyond the boundaries of the premises.

Future Landfill Cells and Areas

1.7. At least 3 months prior to the commencement of construction of a new landfill cell, the licence holder must submit to EPA for approval, plans and specifications for the design and construction of the cell liner and leachate[4] collection system.

1.8. Prior to the commencement of construction of any landfill cell, the licence holder must engage an environmental auditor appointed under the Environment Protection Act 1970 to prepare an environmental audit report.

1.9. The environmental audit report referred to in Condition 1.8 must confirm that the cell has been constructed in accordance with the Authority approved plans and specifications as required by Condition 1.7 and be submitted to the Authority.

1.10. In preparing the environmental audit report referred to in Condition 1.8 above, the environmental auditor must:

a. review the approved plans and specifications including the Construction Quality Assurance Plan;

b. review all reports, measurements and other data provided in the context of the Construction Quality Assurance Plan;

c. review all other records and/ or management systems relevant to the construction of the landfill cell;

---

[4] "Leachate" means water that has become contaminated by being in contact with landfill wastes

d. collect and review all other data or information which the relevant environmental auditor considers relevant;

e. undertake one or more inspections of the site; and

f. assess the risk of any possible harm or detriment to the groundwater environment caused by the manner in which the cell has been constructed.

Financial Assurance

1.11. By 1 September 2003 the licence holder must submit a financial assurance in accordance with section 67B of the Environment Protection Act to EPA and the financial assurance proposal accepted by the Authority.

2. ENVIRONMENT IMPROVEMENT PLAN AND OPERATIONAL CONTROLS

Environment Improvement Plan

2.1. By 1 October 2003 the licence holder must submit a revised Environment Improvement Plan (EIP) to EPA for approval.

2.2. The licence holder must operate the landfill in accordance with the latest version of the Environment Improvement Plan approved by EPA.

Tipping and Cover

2.3. The tipping area must be supervised at all times when the landfill is open for the reception of wastes.

2.4. All wastes must be deposited and compacted in layers not exceeding a vertical height of two metres.

2.5. Putrescible wastes must be immediately covered by earth or other EPA approved material after deposition.

2.6. At the end of each day's operation all waste must be covered by a layer of earth or other EPA approved material.

2.7. By the end of each week, all wastes must be covered by a layer of earth or other EPA approved material not less than 300 millimetres in thickness.

2.8. Adequate cover material for at least one month's operation must be readily available on the premises.

Leachate and Stormwater Management

2.9. All surface drainage must be diverted from those portions of the premises which are or have been used for waste deposit.

2.10. Leachate must be extracted from the landfill such that the depth of leachate above the lowest point of the drainage layer does not exceed 300 millimetres.

2.11. Leachate or water must not be permitted to pond on the surface of the landfill.

2.12. All leachate and contaminated stormwater run-off must be collected and directed to the leachate treatment and disposal pond system.

2.13. Leachate and contaminated stormwater must only be discharged from the leachate pond system in accordance with the following:

a) to irrigation in accordance with the conditions of this licence; or

b) by tanker to an approved sewerage authority works in accordance with the conditions of this licence; or

c) for emergency use on the premises to suppress a fire on the premises.

Irrigation of Leachate within the Premises

2.14. Leachate may only be irrigated over that portion of the premises identified as a leachate irrigation area as shown on the attached plan of premises.

2.15. Irrigation must only take place between the hours of 8:00 am and 5:00 pm, except with the approval of EPA.

2.16. Irrigation must not commence or continue during weather conditions which may reasonably be expected to cause spray drift or run-off beyond the boundaries of the premises.

2.17. Irrigation must not cause run-off, ponding or seepage to surface downslope.

2.18. The supply of wastewater to the emitters must be manually controlled by an operator who must remain on the premises during the whole of the irrigation cycle.

2.19. The licence holder must inform EPA of all modifications or additions to the irrigation system, associated works or equipment.

Disposal of Leachate from the Premises

2.20. Liquid waste in the leachate treatment and disposal system must be tankered to an approved disposal site whenever the level in pond reaches a level where the freeboard is reduced below 500 mm and irrigation is not permitted by this licence.

2.21. No discharge of leachate to a sewer shall occur unless approval to discharge to a sewerage system has been obtained from the appropriate authority.

2.22. All leachate transported from the premises must be in accordance with the Environment Protection (Prescribed Waste) Regulations 1998.

Abutting Roads

2.23. The licence holder must ensure that vehicles exiting the premises do not deposit waste, sand, soil, clay or stones on the abutting roads.

2.24. The licence holder must ensure that all vehicles use the wheel cleaning facility when vehicles are likely to take mud off-site.

Site Screening

2.25. A screen of suitable trees and shrubs must be maintained around the northern, western and southern perimeters of the Stage 1 tipping areas, as shown on the plan of premises.

2.26. Tree screening plantations must be maintained and extended as necessary during the life of the landfill by the replacement or infill planting such that the screening remains effective.

Fires

2.27. A water supply and a means of distribution must be readily available to enable the extinguishment of a fire at any part of the premises.

2.28. In the event of a fire breaking out, the licence holder must take immediate action to extinguish the fire.

Signs and Fences

2.29. Signs must be prominently displayed at the premises indicating:

a) EPA waste discharge licence number;

b) the hours of opening of the premises;

c) the types of wastes which may be deposited;

d) that fires must not be lit on the premises;
e) the types of wastes which may be recycled;
f) where wastes may be deposited; and
g) emergency contact phone numbers.

2.30. All fences and gates surrounding the premises must be:
  a) at least 1.8 metres in height;
  b) maintained to prevent uncontrolled access by livestock or people; and
  c) kept clean and litter-free.

Landfill Gas Management

2.31. Landfill gas must be managed in accordance with the latest version of the landfill gas management plan for the premises approved by EPA.

722?

Progressive Premises Rehabilitation

2.32. The landfill must be progressively rehabilitated in accordance with the latest version of the premises rehabilitation plan for the premises approved by EPA.

Environment Management Review Committee

2.33. The licence holder must establish and facilitate the continued operation of an Environment Management Review Committee to review the development and management of the landfill, the implementation of the EIP and report to EPA.

2.34. The Environment Management Review Committee shall be chaired by a representative of the licence holder, and invite representative(s) of stakeholders with an interest in the management and operation of the facility.

2.35. The objectives and function of the Environment Management Review Committee must be:
  a) to receive reports on the progress and development of the landfill;
  b) to review the development and operation of the landfill;
  c) to identify and address local concerns;
  d) to act as a forum for the exchange of information between the operator and the community on issues relating to refuse collection and disposal;
  e) to coordinate information to the public on litter, recycling and waste management issues;
  f) to review the groundwater monitoring data; and
  g) to report to EPA.

3. MONITORING AND REPORTING

Groundwater Monitoring Program

3.1. The licence holder must maintain five groundwater monitoring bores ('the bores') at the locations shown on the attached plan of premises.

3.2. The bores must be reasonably accessible at all times to any Authorised Officer of EPA or any Authorised Officer under the Water Act 1989.

3.3. Standing water level in the bores must be measured and recorded on each occasion that samples are obtained in accordance with condition number 3.4. This measurement must be:

a) carried out prior to any disturbance by sampling;

b) measured relative to ground level; and

c) referenced to Australian Height Datum.

3.4. Samples of water must be taken from the bores at least once every 6 months, and analysed or tested for:

a) electrical conductivity

b) pH

c) redox potential

d) total dissolved solids

e) total kjeldahl nitrogen

f) ammonia nitrogen

g) nitrate nitrogen

h) bicarbonate (as bicarbonate)

i) chloride

j) sulfate

k) sodium

l) potassium

m) calcium

n) magnesium

o) total iron

p) manganese

q) total organic carbon

r) chemical oxygen demand

3.5. The licence holder must forward to the Project Manager - Groundwater, Department of Natural Resources and Environment, Groundwater Database, PO Box 500, East Melbourne 3002 a copy of all groundwater analyses, measurements and observations within 28 days of the completion of analyses for each sampling occasion referred to in condition 3.4.

Leachate Monitoring Program

3.6. Standing leachate levels in the leachate collection sumps must be measured and reported on every occasion that samples are obtained in accordance with condition 3.7 such that it is:

a) carried out prior to any disturbance by sampling;

b) measured relative to ground level;

c) referenced to Australian Height Datum; and

d) reported as metres above the lowest point of the top of the landfill liner.

3.7. The licence holder must take a sample from the leachate collection sump on at least one occasion in every period of 6 months and have the sample analysed or tested for:

a) electrical conductivity
b) pH
c) redox potential
d) total dissolved solids
e) ammonia nitrogen
f) bicarbonate (as bicarbonate)
g) chloride
h) sulfate
i) sodium
j) potassium
k) calcium
l) magnesium
m) total iron
n) manganese
o) total organic carbon
p) volatile fatty acids (C_{2-6})

Sampling and Analysis Procedure

3.8. The licence holder must ensure that all samples required by conditions 3.4 and 3.7 are:

a) collected, preserved and analysed as specified in the most recent edition of EPA Publication number 441*, "A Guide to the Sampling and Analysis of Waters, Wastewater, Soils and Wastes",* or by other methods approved by EPA;

b) sampled, in the case of groundwater, consistent with the most recent edition of EPA Publication number 669, "*Groundwater Sampling Guidelines*" or other methods approved by EPA;

c) submitted to an analytical laboratory accredited by the National Association of Testing Authorities (NATA) to undertake the analyses specified in this licence unless prior agreement to do otherwise has been obtained from EPA; and

d) the results of the analysis are submitted to EPA in a NATA endorsed test report unless prior agreement to do otherwise has been obtained from EPA.

Greenhouse Gas Action Plan

3.9. By 30 November 2003, the licence holder must submit a Greenhouse Gas Action Plan to EPA for written approval in accordance with EPA Protocol for Environmental Management (PEM), *Greenhouse Gas Emissions and Energy Efficiency in Industry*.

824

National Pollutant Inventory

3.10. By the 30 September each year, the licence holder must submit a National Pollutant Inventory report using the NPI Emission Estimation Technique Manual, *Municipal Solid Inert Landfills*, for the licence holder's previous year's NPI Reporting Period to EPA.

Premises Rehabilitation Plan

3.11. On or before 1 October 2003, the licence holder must submit a revised premises rehabilitation plan to EPA for approval.

3.12. The premises rehabilitation plan required by condition 3.11 must include consideration of, and designs for, the following provisions where applicable:

a) proposed timetable for the progressive rehabilitation of the current and previous tipping areas;

b) anticipated timetable for the closure and rehabilitation of the premises;

c) after-use options, including the preferred option;

d) final contour plan of the premises at the completion of waste filling;

e) final contour plan after capping and rehabilitation of the premises (allowing for settlement);

f) capping design and specifications for cap installation;

g) surface water drainage system;

h) landfill gas management system;

i) leachate collection and disposal after landfill closure;

j) provision for irrigation measures to promote vegetation on the final surface;

k) proposed cap protection measures and settlement monitoring program; and

l) anticipated period of and provisions for after-care of the premises.

Complaints

3.13. The licence holder must keep a written record of all complaints received concerning the environmental impact of the premises which includes:

a) name and address of complainant;

b) date and time of complaint;

c) location from which complaint arose;

d) general description of the nature of the complaint;

e) approximate wind direction and temperature at the time of the complaint;

f) the likely source of the cause of the complaint; and

g) action taken by licence holder.

Annual Reporting

3.14. By 1 October each year the licence holder must submit a report to EPA on the operations at the premises during the previous financial year which includes:

a) the results of the groundwater monitoring program required by conditions 3.1 to 3.4 with monitoring bores identified by their Groundwater Database Number;

b) assessment by an appropriately qualified and experienced hydrogeologist of the results of the groundwater monitoring including trends in quality and potential impacts on beneficial uses of groundwater and a review of the basis for forward leachate behaviour and groundwater impact;

c) certification by an appropriately qualified and experienced hydrogeologist that groundwater quality objectives as specified in State environment protection policy (Groundwaters of Victoria) are not being exceeded;

d) leachate management report including:

i) volume extracted from the landfill;

ii) results of leachate monitoring program required by conditions 3.6 to 3.7;

iii) program/method for preventing odours; and

iv) method and volume of leachate disposed;

e) summary of number, nature and action taken in regard to any environmental complaints;

f) a contour plan of the premises as at the end of the previous financial year;

g) the remaining air space at the landfill and projected landfill life;

h) a review of the progressive premises rehabilitation plan and any proposed changes; and

i) a review of performance against the measures specified in the Environment Improvement Plan and identify any proposed changes to the plan.

Groundwater Audit Report

3.15. By no later than 1 October each year, the licence holder must submit to the Authority an environmental audit report prepared by an environmental auditor appointed under the *Environment Protection Act* 1970 in relation to the risk of any possible harm or detriment to groundwaters caused by the activities of the licence holder on the premises as determined by:

a) the review of any relevant data including but not limited to the leachate management records and the results of any sampling and analysis from relevant groundwater monitoring bores and leachate sumps;

b) an inspection of any relevant activity on the site as the auditor sees fit; and

c) the taking of any sample, measurement, reading or test as the auditor sees fit;

that are relevant to the impact of the landfill's operations on the quality of local groundwater.

3.16. Specifically, the environmental audit report referred to in Condition 3.15 shall confirm:

a) that groundwater quality objectives as specified in State environment protection policy (Groundwaters of Victoria):

(i) are being met at the premises; or

(ii) are not being met at the premises and recommend measures, including an implementation timetable, necessary to ensure groundwater quality objectives will be met; or

b) that the status of groundwater quality objectives at the premises can not be determined and recommend measures necessary, including an implementation timetable, to ensure that the status of the groundwater quality will be able to be determined.

Landfill Levy

3.17. The licence holder must submit a landfill levy statement and accompanying payment quarterly as follows:

a) July-September quarter – paid on or before 31 December;

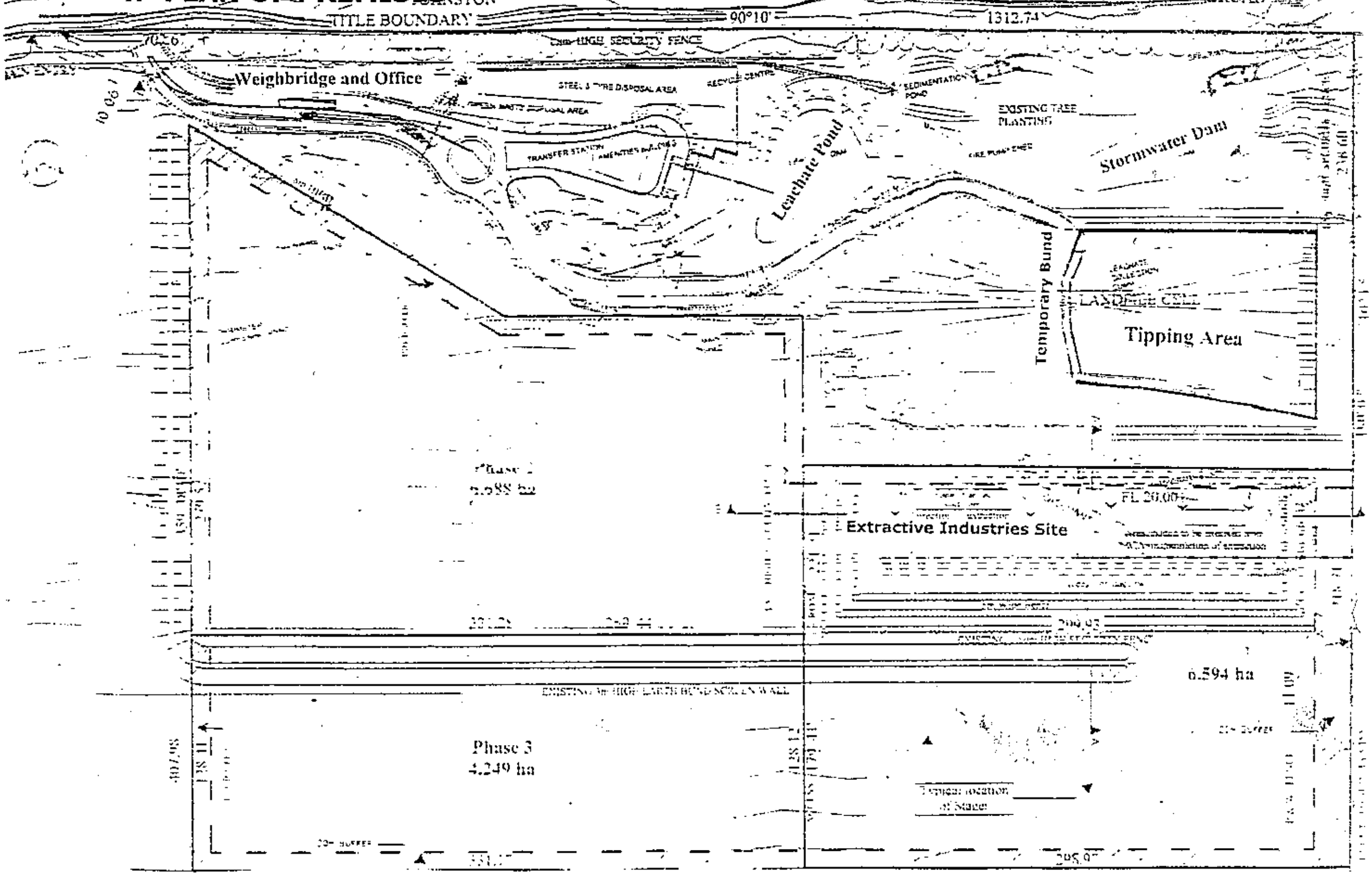
b) October-December quarter – paid on or before 31 March;

c) January-March quarter – paid on or before 30 June; and

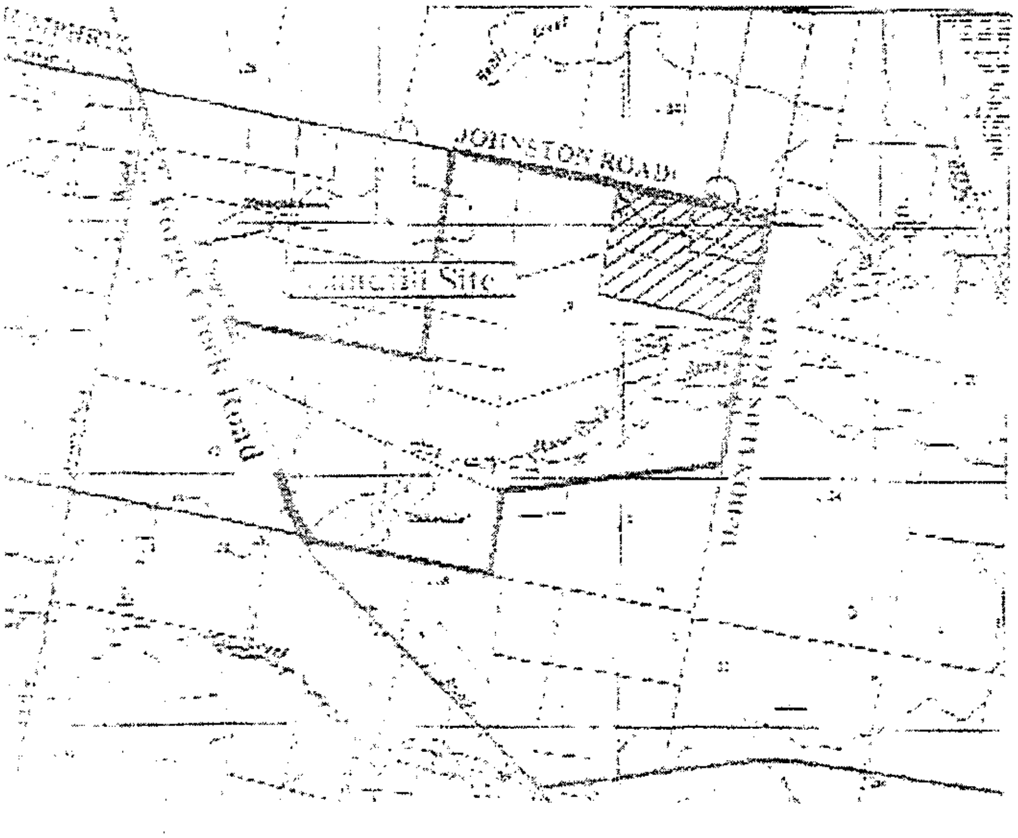
d) April-June quarter – paid on or before 30 September to reconcile previous quarterly payments with the amount of levy payable in respect of waste deposited during that financial year.

3.18. The statement referred to in condition 3.17 must be supported by accurate records detailing the quantity of municipal waste received and cover material used during each quarter.

4. PLAN OF PREMISES

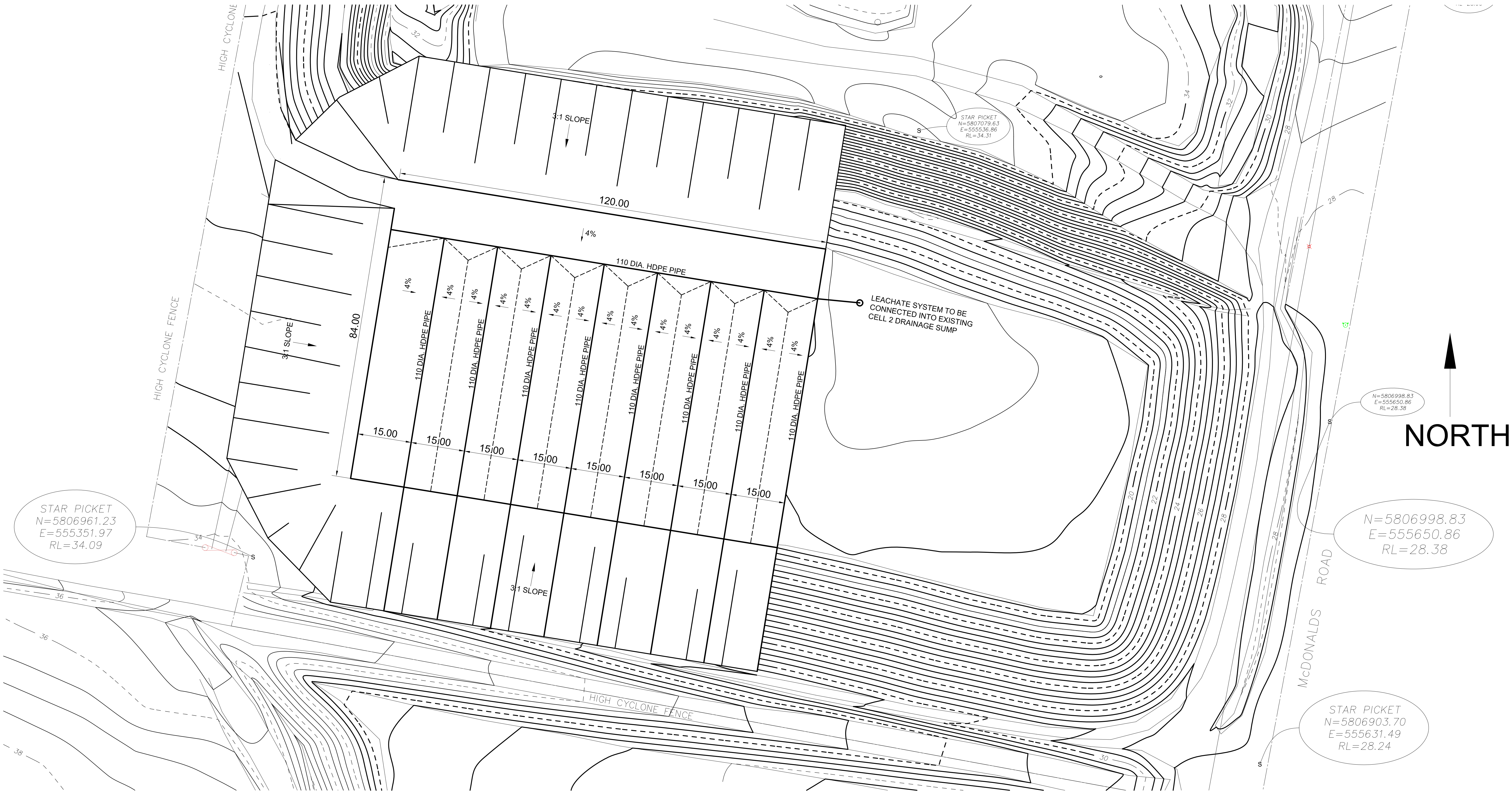


Plan of Premises



Locality Plan

APPENDIX D – PROPOSED PRELIMINARY CELL LAYOUT

HIGH CYCLONE
HIGH CYCLONE FENCE
HIGH CYCLONE FENCE
3:1 SLOPE
3:1 SLOPE
3:1 SLOPE
120.00
84.00
4%
110 DIA. HDPE PIPE
110 DIA. HDPE PIPE
4%
LEACHATE SYSTEM TO BE CONNECTED INTO EXISTING CELL 2 DRAINAGE SUMP
15.00
15.00
15.00
15.00
15.00
15.00
15.00
15.00
STAR PICKET
N=5807079.63
E=555536.86
RL=34.31
N=5806998.83
E=555650.86
RL=28.38
N=5806998.83
E=555650.86
RL=28.38
STAR PICKET
N=5806961.23
E=555351.97
RL=34.09
STAR PICKET
N=5806903.70
E=555631.49
RL=28.24
McDONALDS ROAD
NORTH
S
32
34
32
30
28
28
20
22
24
26
28
28
34
36
36
38
30

APPENDIX E – PRELIMINARY CONSTRUCTION SPECIFICATION

EAST GIPPSLAND
SHIRE COUNCIL

SPECIFICATIONS

CONTRACT NO. XXX/XXX

CONSTRUCTION OF CELL 3
BAIRNSDALE REGIONAL LANDFILL
JOHNSONS ROAD, BAIRNSDALE

Closing Date: XXXXXXXXXXXXXXXXXXXXXXX

Our Vision, Our Values

OUR VISION

The East Gippsland Shire will provide strong and inclusive leadership and, through a shared commitment with our diverse communities, nurture our healthy lifestyle and environment, supporting a sustainable economy

OUR VALUES

- Transparency and accountability
- Decision making framework that considers financial, environmental and social consequences
- Community engagement
- Professionalism and commitment
- Teamwork
- Innovation and excellence
- Responsible financial management

Contents

Contents 1
SECTION 3 - SPECIFICATION 4
1 General 4
1.1 Drawings 4
1.2 General 4
1.3 Scope of Work 4
1.4 Contract Times 4
1.5 Adverse Weather Conditions 5
1.6 Contractor's Establishment 5
1.7 Time and Performance Schedule 6
1.8 Site Conditions 6
1.9 Covering Letter 6
1.10 Definitions 6
1.11 Standard Specification 6
1.12 Trade-Named Items 7
1.13 Co-Operation With Other Contractors 7
1.14 Fires 7
1.15 Measurement Of Quantities 7
1.16 Testing Of Works 8
1.17 Provision Sum 8
1.18 Provisional Quantities 8
1.19 Instructions 8
1.20 Variations On Contract 9
1.21 Hours Of Work 9
1.22 Safety Of Contractor Personnel 9
1.23 First Aid 10
1.24 Safety Of The Public And Protection Of Works 10
1.25 Injury To Persons 10
1.26 Liability Of Contractor For Actions, Suits, Claims, Etc. 10
1.27 Temporary Storage And Amenities 10
1.28 Datum Marks 10
1.29 Setting Out The Works 11
1.30 Use of Public Roads 12
1.31 Structures to Drainage Works 12
1.32 Existing Services, Structures And Property Of The Principal 12
1.33 Removal of Existing Structures 12
1.34 Trenches To Be Timbered 12
1.35 Explosives 13

1.36 Maintenance – During Construction 13
1.37 Clearing Up On Completion 13
1.38 Maintenance - After Completion 14
1.39 "As Constructed" Drawings 14
1.40 Practical Completion Of Works 14
1.41 Defects Liability Period 15
1.42 Final Acceptance Of Works 15
1.43 Environmental Controls 15
1.44 Dust Suppression 15
1.45 Control Of Soil Erosion 15
1.46 Surface Drainage During Site Operations 16
1.47 Industrial Matters 16
1.48 Co-Ordination Meetings 16

2 Earthworks 18

2.1 Scope 18
2.2 Nature of the Ground 18
2.3 Testing 18
2.4 Safety of Earthworks 19
2.5 Clearing, Grubbing and Topsoil Stripping 19
2.6 Landfill Site Earthworks 19
2.7 Compaction Plant 20
2.8 Borrow Area and Management of Materials 21
2.9 Other Site Earthworks 27
2.10 Topsoiling and Grassing 27

3 HDPE Liner Supply & Installation 29

3.1 General 29
3.2 Trimming & Compaction 29
3.3 Anchor Trench 29
3.4 Area To Be Lined 29
3.5 Experience 30
3.6 Material Specifications 30
3.7 Factory Quality Control 30
3.8 Subgrade Preparation 31
3.9 Liner Installation 31
3.10 Field Seams 32
3.11 Field Seam Testing 32
3.12 Quality Assurance Certificates and Records 32
3.13 Protection of Works 33
3.14 Warranty 33

4 CONCRETE 34

4.1 General 34

4.2 Standards 34
4.3 Materials 34
4.4 Storage of Materials 34
4.5 Mixture 35
4.6 Pre-Mixed Concrete 35
4.7 Mixed On-Site Concrete 35
4.8 Cement Mortar 35
4.9 Additives 35
4.10 Consistency 35
4.11 Concrete Strength 36
4.12 Standard Tests For Material and Concrete 36
4.13 Formwork 36
4.14 Reinforcement 36
4.15 Inspection prior to placement of concrete 36
4.16 Placing of Concrete 36
4.17 Compaction of Concrete 37
4.18 Curing 37
4.19 Defective Concrete 37
5 Leachate Pipes and Fittings 38
5.1 Scope 38
5.2 Materials 38
5.3 Handling and Delivery of Pipes and Fittings 39
5.4 Construction 39
6 Quality System 41
6.1 General 41
6.2 Construction Quality Assurance Plan 41
6.3 Environmental Management Plan (Construction) 41
6.4 Environmental Audit 43
6.5 Occupational Health and Safety 43
6.6 Construction Program 43
SECTION 4 – GEOTECHNICAL REPORT .... Error! Bookmark not defined.

SECTION 3 - SPECIFICATION

1 General

1.1 Drawings

The following drawings shall be used in conjunction with this Specification and will form part of the Contract Documents.

Drawing No.	**Title**

INSERT DRAWING NUMBERS AND TITLES

1.2 General

The works of this Contract shall be carried out in accordance with this Specification, the accompanying drawings and General Conditions of Contract AS2124-1992. An extract of Annexure A of AS2124-1992 is attached.

1.3 Scope of Work

The works under this Contract comprise the supply of all labour, materials and equipment necessary for construction and testing of all works associated with the development of Cell 3 of the Landfill located at the Bairnsdale Regional Waste Management Facility, Johnston's Road, Forge Creek.

The works will include, but are not limited to:

- Preliminary works including relocation of vermin proof fence and mulch stockpile and stripping of topsoil.
- Bulk earthworks to create the Cell 3 void to the design sub-grade line and levels
- Screening and stockpiling material from the bulk earthworks to obtain sufficient material for placement of a drainage filter over the clay liner.
- Development of a clay borrow pit and placement of a compacted clay liner, including haul road and erosion control.
- Installation of a 2mm thick HDPE liner and geo-textile to the base and sides of Cell 3.
- Placement of leachate collection pipes, and drainage filter blanket on top of the liner, and connection into the drainage sump located within Cell 2.
- Other miscellaneous works.

The whole of the works will be carried out in strict accordance with and to the true intent and purpose of the accompanying drawings and specifications and under the supervision of the Superintendent.

1.4 Contract Times

a) Time for Commencement

The works under this contract shall commence within fourteen (14) days from the date of notification of acceptance of tender.

b) Time for Completion of Contract

The whole of the works shall be completed within Thirty (30) weeks from the date of Notification of Acceptance of Tender, inclusive of all public and industry holidays. This time also includes a provision time of six (6) working days for time lost during or as a consequence of adverse weather conditions.

The Principal shall be entitled to deduct or set off as and by way of liquidated damages, the sums noted in Annexure A of the General Conditions of Contract for any delay in the completion of works beyond the stated time of completion.

1.5 Adverse Weather Conditions

Time lost due to adverse weather conditions is defined for the purpose of this contract as time lost due to wet weather or excessively hot or dusty conditions and to the effects of these adverse conditions, eg. wet site conditions following rain.

The Contractor's site representative shall notify the Superintendent immediately of any time lost due to adverse weather conditions and shall confirm such notification in writing within 7 days. This confirmation shall provide details of the nature and extent of delays and the construction activities affected. The Superintendent, if satisfied that the Contractor has taken reasonable steps to minimise the period of delay, will certify within 7 days an appropriate period of time lost. The Superintendent will only certify time lost during customary working hours as defined in the General Conditions of Contract. The maximum period of time, which will be certified on any working day, will be eight hours.

Only delays affecting critical activities included in the approved construction program shall be considered as time lost due to adverse weather conditions.

If, subject to the above, the total period of time certified exceeds the total allowance for the Contract the Superintendent will, in accordance with General Conditions of Contract, grant an extension of time for completion on the basis of one (1) working day for each eight (8) hours of certified time in excess. No extension of time will be granted until the total excess period equals eight (8) hours or a multiple thereof. Periods of less than eight (8) hours duration shall accrue to form part of a subsequent extension of one working day when the total excess equals the next successive multiple of eight (8) hours.

No payment of any kind will be made for the granting of extension of time due to adverse weather conditions.

1.6 Contractor's Establishment

The Contractor shall erect his site establishment adjacent to the area of the Works at a location approved by the Superintendent.

Upon receipt of notice to remove his site establishment at the completion of the Contract, the Contractor shall immediately remove all sheds, temporary fencing, buildings, equipment, surplus materials, etc., and restore the area used to its original condition to the satisfaction of the Superintendent.

The Contractor shall at his own expense provide any necessary temporary access facilities to this site establishment and remove these at the completion of the works of the Contract, restoring the site to its original condition and to the satisfaction of the Superintendent.

1.7 Time and Performance Schedule

Within seven (7) days of the Date of Letter of Acceptance of Contract, the Contractor shall prepare and submit to the Superintendent a construction program for the orderly completion of the works.

During the initial preparation of the construction program the Contractor shall confer with the Superintendent to ensure that agreement is reached regarding layout and conventions.

At fortnightly intervals during the construction period the Contractor shall lodge with the Superintendent two (2) copies of the time and progress schedule showing the percentage of progress made in each section of the work.

1.8 Site Conditions

The Contractor must satisfy himself as to the different sub-surface, ground and groundwater conditions likely to be encountered during construction and shall be deemed to have made full allowance for contingencies arising there from in the tendered price.

A Geotechnical report by Coffey Geosciences is attached to this specification as information only.

It shall be the responsibility of the Tenderer to ascertain the ground conditions to the full extent of the proposed excavation.

The associated tender amount shall remain firm irrespective of the type of material or excavation conditions actually encountered during construction.

1.9 Covering Letter

If the Tenderer deems it necessary to submit qualifying conditions or exceptions with his Tender, then all these qualifying conditions and exceptions shall be contained in a single covering letter, giving where possible the sums of money which would be required in lieu of these qualifying conditions and exceptions.

1.10 Definitions

References to "the Engineer" herein shall refer to the Superintendent except where it is intended to refer to the Municipal Engineer. The Municipal Engineer is the Manager, Projects of the East Gippsland Shire Council. The Municipality is the East Gippsland Shire Council or its Authorised Representative.

Where the word 'approved' is used in this Specification, it shall mean approved by the Superintendent.

1.11 Standard Specification

All materials, equipment and fittings supplied under this Contract shall be new and in accordance with the requirements of the relevant Australian Standard Specifications where such exist or, in their absence, with the relevant British Standard Specifications or American Society for Testing and Materials (ASTM) Specifications.

If any requirements of this Specification conflict with the Standard requirements, then the specified requirements shall apply.

Wherever a Standard Specification or Code is specified herein, it shall mean the latest edition and/or amendment of that Specification or Code at the date of calling of tenders for this Contract.

1.12 Trade-Named Items

Trade names, brands and catalogue numbers specified herein are intended as an indication of the quality, appearance, type, finish, and/or method of construction which will meet the approval of the Superintendent.

Any alternative offered by the Contractor must be equivalent to that specified and to the approval of the Superintendent.

An alternative item to a specified item will be approved by the Superintendent provided the alternative item can be shown to:

a. be at least equal in quality, durability, appearance, strength and design to the specified item; and

b. perform at least equally the specific function imposed by the general design; and

c. conform substantially even with deviations to the detailed requirements for the item in the Specification; and

d. have at least an equal operational performance record.

1.13 Co-Operation With Other Contractors

During the progress of this Contract, work may be undertaken by others in the vicinity of the works. Access to the existing landfill cell must be maintained at all times between 8am to 5pm daily for waste contractors.

It is expected that the Contractor will liaise with others concerning access, construction schedules, etc. and should at all times co-operate with other personnel in the execution of their work.

The Contractor shall avoid interference with the work being carried out by others in the vicinity of the site and shall co-operate in order to prevent any delays to the progress of the project. Should the Contractor damage any adjacent work being carried out by others, he shall at his own expense make good such damage as directed by the Superintendent.

1.14 Fires

No fires shall be lit for any purpose in connection with this Contract unless authorised in writing by the Superintendent and not forbidden by any current Government Regulations. The Contractor shall give occupiers of adjoining properties and other contractors forty-eight (48) hours' notice of his intention to burn.

The Contractor shall be responsible for all damage to fences, grass cultivation, buildings or other property occasioned by fires lit for any purpose in connection with this Contract.

1.15 Measurement Of Quantities

All quantities are to be measured in accordance with the AS1181-1971 "Measurement of Civil Engineering Quantities".

a) Volume

Each quantity relating to volume shall be defined as being the volume, which it occupies or will occupy in the present proposed location. All volumes stated in the schedule refer to solid volumes; no allowance is made for bulking or compaction.

b) Area

Each quantity relating to area shall be defined as being the plan area for the item being measured except for:

i) Surface treatment of concrete or masonry surfaces other than those directly associated with excavation or earthworks, and

ii) Any other items which the Superintendent considers reasonable.

All of which shall have their areas measured in the plane of the item being considered.

Payment for all earthworks items shall be made based on as constructed survey results received from the contractor's licensed surveyor. Measurement of quantities shall be undertaken utilising the Superintendent's mathematical and computing tools.

1.16 Testing Of Works

All materials, equipment, installation and workmanship included in the works of this Contract, if so requested by the Superintendent, shall be tested and inspected to provide compliance with the Contract requirements.

Tests and inspections, unless otherwise specified or accepted, shall be in accordance with the relevant standards of the Australian Standards Association or those of the British Standard Institution or American Society for Testing and Materials.

At all times when tests are in progress, the Contractor shall have at least one qualified and approved representative present. In the case of tests on works of Sub-Contractors a qualified and approved representative of the Sub-Contractor shall also be present for the duration of the tests.

Testing of all earthworks shall be undertaken by the Contractor in accordance with Section 2.3 of this specification

In the event that any tests fail and additional retesting is required, then the cost of this additional retesting shall be borne by the Contractor.

1.17 Provision Sum

The provision sum specified in this clause shall be added by the Contractor and included in a schedule and in his Tender amount. The whole, part or no part of any provision sum may be expended, as the Superintendent may, at his discretion deem advisable. The Contractor will be paid only for work actually ordered in writing and carried out and the Contractor will have no claim in respect of any provision sum except as to the portion of it actually expended under written order by the Superintendent.

1.18 Provisional Quantities

Any provisional quantities specified in this clause shall be added by the Contractor and included in a schedule and in his Tender amount.

More than or the whole, part or no part of any provisional quantity may be ordered as the Superintendent may, at his discretion, deem advisable. The Contractor will have no claim in respect of any provisional quantity, except as to the amount actually authorised under a written order by the Superintendent.

1.19 Instructions

The Contractor shall at all times give immediate effect to the Superintendent's instructions, whether written or verbal. The Superintendent shall be in sole control of the Contract. He shall define the order or work or the program of construction which the Contractor shall strictly observe.

In reply to the Superintendent's absence, the Contractor shall fulfil the instructions of the Superintendent's nominated representative.

At his discretion and at no additional cost to the Principal the Superintendent can order one portion of the Contract to be proceeded with before another part is completed. The Superintendent has power to amend the designed layout and Contract Drawings, as he may deem necessary on the site. The order of the work can be amended by the Superintendent if he deems it will quicken the completion of the Contract or is necessary in the interest of completing the other contracts.

1.20 Variations On Contract

No extra work shall be done by the Contractor and no section of the works omitted, without a written direction from the Superintendent being first obtained. Such direction shall be on the Superintendent's Variation Order form. The Contractor shall check the quantities shown on such orders and shall ensure that they are correct before commencing any extras ordered. Payment shall not be made for any extras performed in excess of those ordered.

1.21 Hours Of Work

The hours of work shall be restricted to 7:00am to 6:00pm, Monday to Saturday inclusive. Should the Contractor wish to perform any work, including plant maintenance, outside these hours he shall first obtain the permission of the Superintendent to do so.

The Superintendent reserves the right to restrict the Contractor's use of public roads during hours of peak traffic flows. Such restrictions will not be unnecessarily imposed.

The time for Practical Completion is inclusive of all industry Rostered Days off and Public Holidays. Should the Contractor wish to work on these days, he shall first obtain the permission of the Superintendent.

When construction works are carried out on industry Rostered Days Off and Public Holidays, it may be necessary, at the Superintendents discretion, for the Contractor to pay to Council or the Superintendent the cost of supervision at the current rates which can be obtained from the Superintendent.

In this regard the Contractor will-be required to give 48 hours notice of this intention to work so that the necessary arrangement of staff may be carried out.

No payment of any kind will be made for overtime rates or site allowances.

1.22 Safety Of Contractor Personnel

It is the Contractors responsibility to be informed of the provisions of the Occupational Health and Safety Act 2004. The duties and all other obligations that the Act placed on an employer shall be properly discharged by the Contractor.

The Contractor shall take all necessary precautions to ensure the safety of personnel employed on the works site and shall bear sole responsibility for giving effect to such precautions and for any damage or injury to personnel. Contractor personnel employed in excavations or required to work within the operating radius of a crane, backhoe or excavator shall be equipped with safety helmets.

The Contractor shall be required to provide the Superintendent with a detailed Occupational Health and Safety Plan prepared by a registered Occupational Hygienist which addresses the provisions of the Occupational Health and Safety Act 2004. In particular, the Contractor shall be required to provide details of procedures which comply Section 21 of the Act: Duties of Employers, and evidence of compliance with these procedures. The Superintendent will conduct random checks to confirm compliance with the Health and Safety Plan.

The Contractor shall ensure that all employees on site wear approved safety footwear and high visibility clothing at all times.

The Contractor shall take all precautions considered necessary by the Superintendent, to prevent the entry of unauthorised persons into the construction areas.

1.23 First Aid

The Contractor shall provide, equip and maintain an adequate first aid treatment centre on the site and shall have an experienced first aider available at all times when work is in progress.

1.24 Safety Of The Public And Protection Of Works

The Contractor shall, to the satisfaction of the Superintendent, erect and maintain all necessary warning signs, barricades and lights and take all necessary precaution for the safety of the public and protection of the works.

All works adjacent to access roads shall be cordoned off and appropriately lit to the satisfaction of the Superintendent.

1.25 Injury To Persons

The Contractor shall be solely liable for and shall indemnify the Principal in reply to respect of and shall insure against any liability, loss, claim or proceedings whatsoever arising under any statute (other than as provided in the previous clause dealing with Worksafe) or at Common Law in respect of personal injury to or death of any person whomsoever arising out of or in the course of or caused by the execution of the works.

1.26 Liability Of Contractor For Actions, Suits, Claims, Etc.

The Contractor shall be liable for and shall indemnify the Principal against all liability, loss, actions, suits, claims and demands whatsoever directly or indirectly arising out of or in respect of any accident to or damage suffered by any person in consequence of any works carried out under this contract or upon the site of such works whether or not such accident or damage were caused by the negligence of the Contractor or of any of his servants, agents, sub-contractors, or of any other person whatsoever including the Principal, its officers, servants or agents.

The Contractor shall take out and maintain insurance policies in accordance with the Conditions of Contract (and Annexures).

1.27 Temporary Storage And Amenities

The Principal will make a suitable area available for the Contractor to provide temporary building and storage. The Contractor shall not occupy an area outside the limits set down by the Superintendent. In addition to facilities required for his own use, the Contractor is not required to provide facilities for use by the Superintendent.

The Contractor shall provide all statutory and necessary amenities and sanitary facilities for personnel and other persons lawfully upon the site and remove on completion of the Works.

The Contractor at his own expense shall provide for any temporary electrical power supply, telephone and other necessary requirements.

1.28 Datum Marks

The Contractor shall carefully preserve all datum marks at all times. Should any become disturbed by the Contractor's operations, these must be immediately replaced by a Licensed Surveyor approved by the Superintendent and at the Contractor's expense.

1.29 Setting Out The Works

The Contractor shall set out the works and be responsible for the accuracy of such setting out as provided in the General Conditions of Contract, at his expense.

The Contractor shall provide a suitably qualified and experienced licensed surveyor to set out and check the work during construction and to supply an accurate record of the locations and levels of all works as constructed.

The Contractor shall arrange for the licensed surveyor to survey the site and verify the accuracy of the existing survey details.

Should the Contractor discover any error or discrepancy in the lines of levels, or the plans, or the site, he shall immediately notify the Superintendent before proceeding with the work.

The cost of re-pegging or additional survey as a result of discrepancies or error made by the Contractor shall also be paid for by the Contractor.

A series of temporary benchmarks shall be pegged by the Principal's surveyor prior to the commencement of works. Any re-pegging for any reasons whatsoever that is required by the Contractor during the period of the Contract shall be undertaken by the Principal's surveyor or by a licensed surveyor approved in writing by the Superintendent and the costs so incurred by these works shall be wholly met by the Contractor.

The costs associated with any title survey re-establishment, which was brought about by the Contractor's negligence or failure to take adequate precautions, shall be met by the Contractor.

The Contractor shall also supply and maintain on the works approved straight edges, levels, templates, ranging rods, survey tapes and other equipment and instruments to enable Contractor personnel to set out the work accurately and those instruments and templates in particular shall be used throughout as the work proceeds.

The Contractor shall see that the work is accurately done in all respects by the use of such templates and other instruments and shall correct any errors or inaccuracies before other work is done.

The Contractor shall, when required by the Superintendent or his representative, either personally or by his representative test the accuracy of the work and if necessary, retest the same when any adjustments have been made.

The Contractor shall take adequate precautions to protect all survey pegs and marks and shall not disturb any such without prior consent of the Superintendent.

The benchmarks to be used for the setting out of levels shall be as indicated on the drawings.

The work of additional setting out shall be kept at least two days ahead of the work done or being done.

The Contractor shall arrange at his cost for a licensed surveyor to undertaken a level survey prior to:

i) **Commencement of work in cell and borrow area;**

ii) **Completion of subgrade before placement of the clay liner; and**

iii) **Immediately after the liner is completed and borrow area.**

iv) **The surveyor will provide a contour plan for each condition to the Superintendent in both hardcopy and digital form.**

1.30 Use of Public Roads

Access to the site shall be via Johnston’s Road. The Contractor shall be responsible for cleaning up to the satisfaction of the Superintendent any material spilled by him or his subcontractors on the works, on access and public roads. All costs associated with the above requirements shall be deemed to be included in the contract rates and the work shall be carried out immediately such spillage occurs.

The Contractor shall be responsible for the maintenance of all access / haul roads for the duration of the Contract. The cost of this above work shall be deemed to be included in the Contract Sum.

1.31 Structures to Drainage Works

Structures on or to drainage works shall be installed as the construction of the drain proceeds and completed immediately and erosion protection devices installed to prevent soil and silt entering existing drainage systems.

1.32 Existing Services, Structures And Property Of The Principal

The Contractor shall make himself fully conversant with all existing services, structures and property of the Principal within and adjacent to the site of the works and shall be responsible for the continuous maintenance of these services during the currency of the Contract.

The locations of the various underground and overhead structures and services or other property shown on the plans and dimensions of such are believed to be correct by reference to the various authorities, but cannot be guaranteed to be exactly so. These have been plotted for the information of the Contractor and information so given is not to be construed as being complete and accurate. The Contractor shall check with the Principal's staff and other statutory authorities to ascertain the exact location of all existing services and assets.

In the event of damage by the Contractor or any Sub-Contractor to any services, structures or property of the Principal, the Contractor shall effect immediate repair of same, which shall be carried out at no cost to the Principal.

1.33 Removal of Existing Structures

Except where relocation and extension of fencing is specified in these works , perimeter fences are to be maintained in their present condition for the duration of the Contract.

Any fence requiring removal to allow construction to progress shall only be removed with the Superintendents permission and such fences shall be replaced with fences of equal quality and condition as that which existed.

The Contractor is responsible for damage to all fences within the scope of works over the duration of the Contract.

1.34 Trenches To Be Timbered

Whenever and wherever it is necessary that the sides of any trench or other excavation be held up by timbering or means to ensure the safety of the public of adjoining ground or property, the Contractor shall, as the work proceeds, carry out such shoring up and timbering and other works required for the purpose indicated as part of this contract and without any special or extra payment for the same and shall maintain such timbering, shoring up or other works in a safe and secure condition until they can be removed without the safety of the public or the stability of the adjoining ground or property being prejudiced by such removal.

The Contractor shall keep sufficient timber on the job to meet any emergency.

Where ordered by the Superintendent, the Contractor shall leave timbering in position. Such timbering shall be cut off 0.60 metres below the surface. The timber (including that cut off) shall be paid for at the market price fixed by the Superintendent, less 10%.

1.35 Explosives

The Contractor shall not use any explosives in the execution of the works except where, when and under such conditions as shall be previously approved by the Superintendent. The Contractor shall provide himself with the necessary licence from the appropriate authority and shall conform to all Government regulations and instructions, relating to the transport, storage, handling and use of explosives.

The Contractor shall be liable for any accident, damage or injury to any person or thing resulting from the use of explosives.

The Contractor shall notify the Superintendent and other relevant authorities in writing of his intention to use explosives at least 48 hours prior to commencement of any works involving explosives.

1.36 Maintenance – During Construction

The Contractor and Sub-Contractors shall keep the site of the works clean and tidy at all times and pay continuous attention to the removal of litter and waste materials.

Under no circumstances will the Contractor or Sub-Contractors dispose of any material or goods, construction debris, rubbish or like material on or about the site.

During the progress of the work until the date of certification by the Superintendent that the work is complete, the Contractor shall maintain the works for the time being, in a careful and workmanlike manner so that the excavations, fills, formations, sub-grades, sub-base and base always present a smooth, even surface.

All subsidence and failures shall be filled, made good and compacted as hereinafter specified by the Contractor at his own expense.

All drains shall be kept clear at all times so that no obstruction or impediment is presented to the flow of water.

The road pavement and site formations shall be maintained in such a condition that it is well drained at all times. No ruts, waves or soft spots shall be allowed to remain and the Contractor shall keep the formations trimmed to the required level and grade by constant use of an approved grader.

1.37 Clearing Up On Completion

The Contractor shall ensure that all works of the contract, including works of all sub-contractors, be absolutely complete immediately prior to the date of expiry of the contract time.

The Contractor shall remove all debris from the site and any material he may have stored conveniently adjacent to the site, and leave the area tidy to the satisfaction of the Superintendent i.e.

- Removal and disposal of all dead trees. Grading up of site to ensure it is free draining.
- Removal and disposal of all rubbish, e.g. building materials, dead wood, rocks, foundations etc.
- Topsoiling and grassing of all disturbed areas.

1.38 Maintenance - After Completion

As each section of the work as determined by Superintendent is accepted and taken over, it shall be efficiently maintained by the Contractor for a period as nominated in Annexure A from the date of certification by the Superintendent that the work or section of the work is complete.

All ruts and subsidences shall be filled and all drains shall be cleaned out on completion. All pavement failures *shall* be reinstated and road surfaces shall be true to alignment, level and left in a perfect condition.

1.39 "As Constructed" Drawings

Prior to the issuing of the Certificate of Practical Completion the Contractor shall furnish to the Superintendent "as constructed" details of the works as executed.

This requirement applies also to Sub-Contractors. Such amendments as are necessary to depict in detail the as-built condition shall be carefully and accurately prepared by competent draft persons. Where an as-built condition requires a drawing to be amended all related drawings influenced by this amendment shall be similarly amended.

Upon completion of all amendments three (3) copies of each drawing prepared pursuant to the requirements of this Contract, each clearly marked adjacent to the title block "Work-as-Executed Drawing" and a digital copy shall be delivered to the Superintendent prior to the issue of the Certificate of Practical Completion.

The Contractor shall also provide survey plans prepared by a Licensed Surveyor, showing "As Constructed" levels for the landfill and leachate pond;

- prepared foundation (pre and post) for bulk earthworks volumes,
- clay base and side liner
- filter material won from on site

This information shall be provided in AutoCAD, 12D or similar format (on disk) together with an accompanying hard copy, prior to filling with the next layer of material.

The cost of preparing and printing the above work-as-executed drawings, notwithstanding that some amendments may have been required as the result of instructions issued by the Superintendent, shall be deemed to be included in the Contract Sum.

1.40 Practical Completion Of Works

When the Contractor has carried out all the work, including testing and submission of "as built" drawings and, in the Contractor's opinion, the works are practically completed, he shall so advise the Superintendent in writing and, within a reasonable time but not exceeding 14 days of receipt of such advice, the Superintendent shall:

(a) If satisfied that the works are practically complete, issue to the Contractor a Certificate of Practical Completion in accordance with the General Conditions of Contract; or

(b) If not reasonably satisfied that the works are practically completed, give to the Contractor written notice that the Certificate of Practical Completion will not be issued until the Contractor has completed such further works and/or attained satisfactory performance results as are necessary for practical completion of the works.

The Contractor shall within 14 days of such notice issued under (b) above proceed with such further works as necessary to achieve practical completion of the works, and shall advise the Superintendent when he has completed such works and, within seven (7) days of such advice, the Superintendent shall:

i) if satisfied that the works are practically completed, issue the Certificate of Practical Completion; or

ii) if not satisfied that the works are practically completed, issue to the Contractor a further notice or notices. The Contractor shall then comply with the notice and advice the Superintendent when he has so complied until the Superintendent is satisfied that a Certificate of Practical Completion may be issued.

1.41 Defects Liability Period

The Defects Liability Period shall be for the period stated in the Annexure A of the General Conditions of Contract.

1.42 Final Acceptance Of Works

At the end of the Defects Liability Period and provided all defects notified to the Contractor by the Superintendent have been satisfactorily completed, the Contractor shall notify the Superintendent in writing of the completion of the work.

The Superintendent will promptly, by inspection, satisfy himself as to the actual completion of the work in accordance with the terms of the Contract and shall, if in agreement, issue a Final Certificate in accordance with the General Conditions of Contract.

The Final Certificate will not be issued until the Superintendent is satisfied that the performance of the works is in conformity with all requirements of this Specification and with all performance guarantees tendered by the Contractor.

The Contractor may during the Defects Liability Period be called upon to further amend the Works-as-Executed drawings should it be found necessary for the Superintendent to order modifications to the work.

1.43 Environmental Controls

It is the Contractors responsibility to be informed of the provisions of the Environment Protection Act 1970 and any associated regulations and policies, and to carry out all works under the contract in accordance with the requirements of the Act and any associated regulations and policies.

The Contractor shall submit with his tender a proposed Environmental Management Plan, refer to Section 6.3 for specific requirements of this plan.

1.44 Dust Suppression

The Contractor shall take all necessary measures to keep airborne dust to a minimum by watering.

The Superintendent may direct the suspension of work at any time where that work in the Superintendent's opinion creates a dust hazard or nuisance to the public, personnel working on the site or property such as crops, stock and houses in the vicinity of the work. Where the Superintendent has directed a suspension of work and considers that the Contractor could not have been expected to have adequately controlled the dust, the Superintendent may consider an extension of time due to adverse weather conditions. No claim for increased costs due to such suspension will be considered.

1.45 Control Of Soil Erosion

The Contractor shall take all measures necessary to control soil erosion and to minimise the siltation of watercourses and water storages and ensure no offsite impact. Areas that may need soil erosion control protection include but not limited to; the access track from the borrow pit, stormwater drain discharge points to existing drainage and surface systems. Such measures shall be deemed to have been included in the lump sum and scheduled rates.

When directed by the Superintendent, temporary control works shall be removed and the area reinstated to the satisfaction of the Superintendent.

1.46 Surface Drainage During Site Operations

It is the Contractor's responsibility to undertake and maintain all works necessary, and as approved by the Superintendent, to ensure the area of works remains free from stormwater and runoff from other areas do not enter the site.

1.47 Industrial Matters

The Contractor shall keep the Superintendent informed concerning any industrial matter, which could affect the progress of the work under the Contract.

The Contractor shall inform the Superintendent immediately if bans are applied to the work under the Contract or if work under the Contract ceases due to industrial action, and shall also inform the Superintendent of measures being taken to resolve such action.

The Contractor shall make no claim against the Principal for increased labour costs, or for additional costs, loss or damage arising from increased labour costs, incurred by or as a result of:

(a) any variation to any Award of the Australian Conciliation and Arbitration Commission or to any Award of the State Industrial Relations Commission, whether by consent or by formal arbitration;

(b) any agreement, award, settlement, fee or like payment made by the Contractor or any organisation or any person acting on behalf of the Contractor with any union or any other body or any person;

(c) any industrial action through which occurs a strike, work stoppage, work ban or work limitation of any kind;

(d) any site allowance claim lodged by unions in respect of the works.

Provided that any industrial action causing lost time does not arise from factors within the control of the Contractor, the Contractor may be granted an extension of time for completion pursuant to the General Conditions of Contract, however will receive no payment of any kind for such extension.

1.48 Co-Ordination Meetings

At intervals not exceeding two weeks, the Contractor and the Superintendent shall together review the progress of the work under the Contract in comparison with the construction program. Where required by the Superintendent, such review will be conducted as a site meeting between representatives of the Principal and the Contractor held weekly or at intervals decided by the Superintendent. Site meetings will be chaired by the Superintendent and minutes will be prepared by the Superintendent and distributed to the Principal and the Contractor not later than two days prior to the next site meeting.

The Superintendent may at any time require the Contractor to submit in writing within 14 days:

(a) an explanation of delays in execution of the work under the Contract in comparison with the construction program;

(b) an amended construction program.

Where no current construction program has been supplied and the Superintendent at any time considers that the rate of progress is insufficient to ensure completion of the whole or any separable part of the Works by the relevant Date of Practical Completion, the Superintendent may direct the Contractor to submit within 14 days written details of the intended procedure for the execution of the remainder of the work under the Contract.

2 Earthworks

2.1 Scope

The Contractor shall provide all labour, materials and equipment necessary to clear, excavate, fill, backfill, compact and trim to grade for all earthworks included in this Contract.

2.2 Nature of the Ground

The Contractor must satisfy himself as to the different subsurface, ground and groundwater conditions likely to be encountered during construction and shall be deemed to have made full allowance for contingencies arising there form in this tendered price.

The Geotechnical report contains factual data conducted at the site and should be read in conjunction with this Specification.

The document is entitled:

- Geotechnical Assessment Report, Bairnsdale Landfill Stage 2, 25 September 2004. Author: Coffey Geoscience Pty. Ltd.

The Geotechnical report appended to this Specification provides details on clay depths at the nominated borrow area and clay permeability of the various clay layers. In addition to the geotechnical report. Two (3) test pit logs have been provided down to a depth of 4 metres in the existing excavation, and from the undisturbed ground. The location of the Coffey Geoscience test pits and these additional test pits are shown in the drawings.

2.3 Testing

Geotechnical testing required by this Specification shall be to AS1289 test methods, as set out in Table 1.

Table 1 List of Tests

Abbreviation	Description	Australian Standard
LL	Liquid Limit	1289.3.1.1/1289.3.1.2
PL	Plastic Limit	1289.3.2.1
PI	Plasticity Index	1289.3.3.1
% fines	Percent by weight passing 75um sieve	1289.3.6.1
K	Permeability - Constant head method - Falling head method	1289.6.7.1 1289.6.7.2
	Standard Compaction	1289.5.1.1
	Dry Density Ratio	1289.5.4.1
	Hilf Density Ration	1289.5.7.1
	Field Wet Density – Sand Replacement Method	1289.5.3.1
	Field Wet Density – Nuclear Density Gauge Method	1289.5.8.1

Sampling and in-situ density testing of fill material shall be performed by a NATA Accredited Testing Authority appointed (and managed) by the Contractor. Density tests will be carried out not later than 24 hours after compaction has been completed.

Test results shall be made available to the Superintendent in writing not later than 24 hours after the completion of the test.

The Contractor shall be responsible for giving notice to the Superintendent that areas are ready for testing, and he shall allow free and safe access for persons carrying out tests.

No additional filling or compaction shall be carried out in an area that has been tested before the Contractor is advised by the Superintendent that the test results in this area are satisfactory.

The Contractor shall allow for delays resulting from the taking of tests and shall accept the interpretation of the results by the Superintendent and the resulting directions.

In the event of failed or unsatisfactory results from the tests performed by the Geotechnical Subconsultant then all subsequent re-working and re-testing shall be at the Contractor's expense.

2.4 Safety of Earthworks

The Contractor shall be solely responsible for the security of all excavations and earthworks. The Contractor shall comply with the provisions of the Mines (Trenches) Regulations and shall submit to the Victorian Workcover Authority, a completed copy of the form "Notice of Intention to Commence Operation in Trenches, Shafts, Tunnels or other Excavations" should any proposed trench depth exceed 1.50 metres.

All excavations shall be carried out in such a manner that the surrounding materials receive the minimum amount of disturbance. Any damage or disturbance caused to materials, whether or not within the area of operations, will be made good by the Contractor at his own expense, in accordance with the Superintendent’s instructions.

Excavations shall be timbered or supported as necessary so as to ensure minimum disturbance to the surrounding ground and to ensure the safety of personnel, adjacent structures and the Works. The sides of excavations may be battered if approved or directed.

If, in the opinion of the Superintendent, the Contractor's method of support of an excavation is inadequate then the Contractor shall alter or increase the support at his own expense as directed. Any direction so given will in no way relieve the Contractor of his responsibilities under the Contract.

2.5 Clearing, Grubbing and Topsoil Stripping

Prior to the commencement of any earthworks, the limit of such earthworks shall be cleared of all vegetation, refuse and obstructions, and stripped of all topsoil to a nominal depth of 200 mm. Hard waste materials such as rock shall be disposed of on-site as directed by the Superintendent.

All vegetation such as trees, shrubs or grasses shall be cleared and grubbed and removed from site.

The Superintendent may direct that any designated tree or shrub shall be retained.

2.6 Landfill Site Earthworks

2.6.1 Preamble

The Contractor should note that the base and side liner of the landfill must be constructed so as to ensure that the permeability achieved is not greater than 1 x 10^{-9} metres per second and a minimum clay liner thickness of 1.0m shall be maintained throughout the cell.

To ensure that the technical requirements for the base and side liner of the landfill are satisfied the Contractor is to seek the specialist advice of a Geotechnical Subconsultant to monitor the placement of the clay base and side liner. The subconsultant's role will comprise density and compaction testing of each progressively placed clay layer to ensure the specified standards are met. Also ensuring that the mixing of clay from the borrow pit retains a permeability not greater than 1 x 10^{-9}m/s. Any clay placed in the liner that does not meet the permeability test standard shall be removed and replaced with suitable clay at the contractors cost. The overall responsibilities in the supervision of the works covered by this Specification are however, retained by the Contractor.

2.6.2 Testing and Certification

All testing of earthworks shall be undertaken in accordance with the specification and included in the applicable rates for each item of work.

The Contractor shall obtain the specialist advice of an independent Geotechnical Subconsultant to monitor all earthworks. The Contractor shall submit with his tender, details of the proposed Geotechnical Subconsultant together with a proposed Construction Quality Assurance Plan. This plan shall include details of the nature and frequency of proposed testing.

The Construction Quality Assurance Plan shall conform to the requirements described herein with regard to compliance testing, inspection and reporting procedures.

The Contractor shall nominate in the Quality Plan a suitably qualified and experienced Geotechnical Subconsultant who shall be responsible for the independent certification of each part of the works as appropriate, as part of the quality assurance program.

The Geotechnical Subconsultant inspections shall include, but are not limited to, the following stages of the Works:-

i) completion of stripping for foundation preparation, but prior to or during compaction,

ii) completion of side wall trimming before placement of liner,

iii) construction of the base and side wall liner.

Once the Construction Quality Assurance Plan has been reviewed and approved by the Superintendent, the Contractor shall carry out all earthworks strictly in accordance with the Plan, unless otherwise directed by the Superintendent in writing.

At the completion of works, the Contractor shall provide the Superintendent with three (3) copies of a report from the Geotechnical Subconsultant certifying that earthworks have been constructed to the standard nominated in this specification. All test results must be appended to the report which clearly identified the location of the test performed. The subconsultant shall undertake sufficient testing throughout construction to enable such certification to be made. This report should form part of the Construction Quality Assurance Report required under section 6.2.

The Contract Price shall include allowances for possible time delays while samples are being collected and tested. No additional payment will be made or extension of time granted for any completed work requiring removal and/or repair as deemed by the results of any tests.

At the direction of the Superintendent, independent testing may be undertaken by the Principal's Geotechnical Subconsultant. The Contractor shall provide at his expense, all labour, materials and equipment necessary to prepare areas and assist testing. Such testing shall be at the expense of the Principal, and shall not exclude the Contractor from his testing responsibilities under the Contract.

2.7 Compaction Plant

The Contractor shall be entirely responsible for providing plant of adequate type, capacity and availability to carry out the works in accordance with the Specification.

2.8 Borrow Area and Management of Materials

2.8.1 Borrow Area

The area designated as the source of materials for the construction of the liner, known as the Borrow Area, is shown in the Drawings. The area boundaries are indicative only, and represent the region indicated by the site investigation as likely to contain material conforming to the liner specification.

Clay materials suitable for use in the liner directly underlie the topsoil to an average depth of 2.7 m below the stripped surface. Below this, material particle sizes become predominantly sand and gravel-sized, and are generally not suitable for use. This depth is indicative only, and details are provided in the test pit logs of the geotechnical report. Confirmation of the actual depth of suitable material in a particular area is the responsibility of the Contractor.

The Contractor shall make maximum use of all material to be obtained from the designated borrow area and any other suitable material clay from the cell excavation, so as to produce a sufficient quantity of material necessary for the completion of the Works.

2.8.1.1 Borrow Material

Borrow material for use as a liner in the base and side walls of the landfill shall be low permeability, essentially fine grained material and shall conform to the soil classification outlined in the geotechnical report and as specified.

2.8.1.2 Borrow Pit Configuration

Borrow pit configurations shall comply with the drawings.

The Contractor shall be responsible for providing suitable access to the borrow pits. The location of access roads should be maintained on existing, or proposed access track alignments, or otherwise within the limits of existing clearing unless otherwise approved by the Superintendent

2.8.1.3 Clearing, Grubbing and Topsoil Stripping

The Contractor shall clear and grub all vegetation, and strip all topsoil to a nominal depth of 200 mm the designated borrow area. Vegetation shall be disposed of as directed by the Superintendent. Topsoil shall be stockpiled in area(s) designated by the Superintendent.

2.8.1.4 Borrow of Construction Materials

The Contractor shall excavate, and blend if necessary, material within the borrow pits to achieve uniform material for liner construction complying with the requirements of this Specification.

The Contractor shall, at whatever location, depth and by whatever method, perform all mixing and other conditioning processes, including the addition or removal of water as necessary, to produce the required materials.

If required, moisture shall be introduced into the material at the borrow area. Watering in the borrow area shall be carried out sufficiently far in advance of excavation operations to ensure uniformity of moisture content. This time shall be at least 24 hours.

If at the borrow location there is excessive moisture, the Contractor shall make selective excavation to secure materials of suitable moisture content and shall excavate drainage channels, rip, work or aerate the material, or perform such other work as may be necessary to reduce the moisture content of the material.

2.8.1.5 Unsuitable Material

For the purposes of this Contract, the Superintendent shall have power to classify material (other than topsoil or overburden) which is excavated or taken from stockpile as unsuitable for incorporation in any particular part of the works. Such material may consist of silty deposits or excessively sandy soils and shall be designated "unsuitable material", transported to designated spoil areas; taken for use in another particular part of the works, or stockpiled for later use, as the Superintendent may direct.

2.8.1.6 Management of Materials

While the Contractor is responsible for proper management of all materials so as to enable all the required works under the Contract to be constructed within the time required, he shall recognise that particular problems of this kind will inevitably present themselves. The constraints of space, time and the order in which materials will be excavated coupled with the requirement for moisture conditioning, may require multiple handling of materials and the use of temporary stockpiles. The Contractor shall allow for the time and work requirements to meet these needs in his construction program. Materials shall be stockpiled only in areas designated by the Superintendent.

2.8.2 Dewatering

The landfill base and borrow areas shall be kept free from water and the Contractor shall make all necessary arrangements to dispose of any water which enters the excavations. Any flow or seepage of water into excavations shall be properly diverted, pumped, drained or otherwise disposed of to the satisfaction of the Superintendent, in accordance with the EMP.

The Contractor shall, at all times, take adequate precautions and provide suitable equipment to keep all excavations dewatered and dry. Should water be allowed to accumulate on the works during construction, as a consequence of which work previously accepted as suitable are rendered unsuitable, then the Superintendent shall direct the Contractor to remove and replace at his own expense any works which have become so affected.

2.8.3 Preparation of Base liner and Side Liner Foundation

2.8.3.1 General

The base and side liner foundation shall be excavated to the profiles and levels as indicated on the Drawings and as directed on-site by the Superintendent. Where the foundation is considered by the Superintendent to be soft, wet or unstable, this material should be excavated.

2.8.3.2 Areas to be Lined

Cell areas to be lined include existing undisturbed regions as well as those areas which have been disturbed during previous quarrying and landfill activities.

Surface preparation shall involve the clearing and grubbing of all vegetation, and stripping of all topsoil to a nominal depth stated in the geotechnical report. The area shall be excavated to the profile and levels shown on the drawings. Areas undergoing preparation for final subgrade level shall be inspected by the Superintendent, who may instigate remedial works on any soft or loose areas revealed during the works.

2.8.3.3 Removal of Unsuitable Material

All unsuitable material including soft clay soil and any other foreign matter shall be removed from the base and side wall areas to the satisfaction of the Superintendent and the levels and gradings shown on the Drawings. Removal of this material shall be performed under the supervision of the Superintendent to ensure that the base and/or side walls are not damaged.

The remedial treatment used may vary depending upon conditions encountered and may consist of hard rockfill, geotextiles, geogrids and drainage geotextiles.

Payment for remedial works shall be in accordance with rates quoted in the Schedule of Prices or where no rate is given, as agreed with the Superintendent.

All removed unsuitable material shall be disposed of at the disposal area as directed by the Superintendent.

2.8.3.4 Excavation and Filling

Prior to placement of the clay liner, the existing surface shall be regraded to the grades and elevations in accordance with the formation surface levels shown on the drawings.

Where fill is placed to raise the existing surface to the formation level, such material shall be placed in layers not exceeding 250 mm loose layer thickness. Layers of soil fill shall be compacted to achieve a minimum dry density ratio of 98% Standard at optimum moisture content ± 2% in accordance with AS1289.5.1.1 and 5.4.1. A greater loose layer thickness may only be placed if it can be demonstrated that uniform compaction can be achieved over the total layer thickness.

Should the Contractor excavate to depths greater than required, the excess excavation shall be backfilled at the Contractor's expense to the correct lines and levels with approved material and compacted to the satisfaction of the Superintendent.

Material removed during the preparation of the base and side walls shall be used to form the perimeter bunds or stockpiled at a location approved by the Superintendent, for possible subsequent reuse, or disposed of within the site in a carefully controlled manner approved, and as directed, by the Superintendent should excessive deleterious material be present.

2.8.3.5 Subgrade Preparation

The subgrade material exposed after excavation (or filling) to the design subgrade level shall be scarified to a depth of approximately 150mm and moisture conditioned to within ±2% of Standard Optimum Moisture Content, and then re-compacted to a minimum dry density of 98% Standard in accordance with AS1289 5.1.1, 5.4.1 or 5.7.1. Compaction testing of the subgrade is not required unless requested by the Superintendent.

Following compaction of the subgrade and prior to the placement of the clay liner, the Contractor shall prepare the subgrade surface such that it is smooth and hard in preparation for proof rolling. The proof roll shall be conducted in the presence of the Superintendent with a 10 tonne equivalent smooth wheeled roller or loaded truck with an intensity of contact pressure on the rear wheels of not less than 6 tonne per metre, without visible deformation.

Any soft or weak areas encountered during proof rolling that do not respond to further compaction shall be removed and replaced with suitable site material in layers not exceeding 250mm thickness (loose), and compacted and re-tested to the above criteria.

Following rolling, the Superintendent shall inspect and approve the prepared surface prior to the clay liner being placed. The Superintendent shall satisfy himself that no deflection of the subgrade is visible during proof rolling, and may direct further rolling of the formation surface to be undertaken at the expense of the Contractor.

The Contractor shall arrange for a detailed feature survey of the prepared surface to be undertaken by an independent licensed surveyor following the completion of proof rolling and prior to the placement of the clay liner.

2.8.4 Construction of Base and Side Liner

2.8.4.1 Liner Compaction Requirements

The required compaction for lining material shall be a Dry Density Ratio of not less than 98% of the standard maximum dry density (AS1289.5.4.1) or a Hilf Density Ratio of not less than 98% (Standard Compaction) (AS1289.5.7.1). The moisture variation (w_0-w_f) shall be maintained in the range ± 2% of optimum moisture content. The clay must achieve a permeability of 1 x 10^{-9} m/s or better. Clay material is to be tested for permeability in accordance with (AS1289.6.7.1 & 2).

2.8.4.2 Preparation of Trial Liners

The contractor must win at least 40 cu.m of clay won from the cell excavation and from at least 6-8 different locations in the borrow pit area. The trial liners must be representative of the full depth of clay determined in the borrow pit area. The clays must be mixed, moisture conditioned, spread in 200mm thick layers and compacted until a 1.0m thick liner depth is achieved.

The Geotechnical Subconsultant is required to ensure sufficient representative clay has been sourced for the trials and undertake appropriate moisture, density and permeability samples and tests in accordance with the Specification and Australian Standards. The Geotechnical Subconsultant is required to certify all results and submit a report to the Superintendent for approval. The Contractor shall not commence placement of the clay liner until such approval in writing has been obtained from the Superintendent. Between two and four trial liners are recommended so that a number of clay mixture and compaction level options can be analysed, providing the Contractor with more flexibility during the construction of the compacted clay liner. Provision for four (4) permeability tests on the trial liners has been included in the Bill of Quantities.

When the mixture(s) of clay identified as passing the permeability requirement have been established and approved by the Superintendent, the Contractor and Geotechnical Subconsultant shall ensure that all clay being used to construct the liner is at least of equivalent quality.

2.8.4.3 Placement

i) The clay lining material to form the base and side wall liners shall be constructed to the lines, levels, grades and cross-sections as shown on the Drawings.

ii) Before placing lining material, the surface of the previously compacted layer shall be scarified to a depth of at least 50 mm. If the surface has dried out and/or cracked, it shall be ripped or disc-ploughed to at least 50 mm below the depth of drying or cracking, then watered and mixed, lining material shall not be placed on a surface on which free water has ponded.

iii) The lining material shall be placed in near horizontal layers which are longitudinally and transversely continuous. The layers shall be of uniform loose thickness not greater than 250 mm. Rolling shall be conducted in at least two different directions for the base liner, and in a direction parallel to the longitudinal axis of the side wall liner. The liner shall be placed to the cross falls and levels specified on the Drawings.

iv) At the completion of each day's work, or if adverse weather conditions are imminent and the Contractor intends to suspend operations, the surface shall be graded to a self shedding profile and sealed with a smooth drum roller or equivalent.

v) If the required density and moisture is not achieved the compacted material shall be reworked in accordance with the standard to meet the density and moisture content requirements. If the density and moisture content requirements again cannot be achieved, the failed lift shall be removed at the Superintendent's direction for either moisture conditioning in a borrow area before reuse or stockpiled if still considered unsuitable.

vi) The Superintendent may order trafficked sections to be ripped and recompacted if he deems that the quality of these sections has deteriorated due to construction traffic.

vii) The Contractor shall arrange with their Geotechnical Subconsultant to take clay liner samples for permeability testing. Results are to be forwarded to the Superintendent. Areas of the clay liner that fail to meet 1×10^{-9} m/s permeability have to be reworked or removed and suitable clay placed as specified and retested at the Contractors expense.

2.8.4.4 Moisture Conditioning

The Contractor's attention is drawn to the fact that meeting the specified moisture condition of this Specification is equally as important a compaction requirement as the specified Density Ratio.

Tests at the time of the site investigation (September 2004) showed that the in-situ moisture contents of liner borrow materials were generally between ± 2% of optimum moisture content. Water addition or drying out that may be required in excess of this shall be carried out in the borrow area or at a temporary stockpile. After such moisture content adjustment in the borrow area or at a temporary stockpile, the lining material shall be stockpiled and allowed to cure for 24 hours prior to placement.

The compacted surface of each layer of the liner should be kept moist by frequent watering until subsequent layers or the HDPE Liner is placed.

2.8.4.5 Filter Blanket

The entire exposed surface area of the clay liner base and sides is to be lined with a 2mm thick HDPE liner covered by a geotextile fabric (refer section 3). The base of the cell shall be protected by the placement of a minimum thickness of 300mm filter blanket, being a aggregate free of organic material, sticks, roots, sharp objects or debris of any kind. Particle size of the aggregate screened from the excavated material shall be between 20mm and 75mm with a fines content of less than 1%.

Previous screening of material from the site has indicated that between 20 to 25% of material screened would meet the required aggregate size. A second screening of the filter blanket stockpile is normally required to ensure the 1% or less of fines is achieved.

2.8.4.6 Protection Cover

The entire exposed surface area of the HDPE and geotextile side wall liner and top of batter shall be protected by the placement of a minimum thickness of 300mm road gravel (by-product of screening filter blanket material) as protective cover (measured normal to the exposed surface) as specified in the construction drawings.

2.8.5 Placement of Leachate Collection System

The Contractor shall, at all times, take adequate precautions during the laying of the leachate pipe to prevent damage to the base. A minimum of 50mm of bedding material will be placed on the geotextile–covered HDPE Liner directly beneath the HDPE collection pipe. Further bedding material will be place around and above the pipe to ensure that a minimum of 100mm surrounds the top and sides of the pipe. The sides shall be haunched with care to ensure crushing of the pipe is avoided. The pipe may need to be sandbagged to prevent it from moving during placement of filter medium. If, in the opinion of the Superintendent, the compacted clay liner or HDPE liner has been damaged during excavation, remedial work shall be carried out to the satisfaction of the Superintendent by the Contractor at his own expense.

The Superintendent shall inspect all installed leachate collection pipes prior to placement of the filter medium.

2.8.6 Temporary Earthen Banks

The Contractor shall construct temporary earthen banks to the lines, levels and grades shown on the Drawings and shall construct associated stormwater drains.

Spoil from the excavation of the temporary stormwater drains which, in the opinion of the Superintendent, is unsuitable for the construction of the bank shall be disposed of on site as directed.

Prior to the placement of fill material, the surface of the liner base on which the bank is to be constructed, shall be thoroughly scarified. The fill material shall be placed in uniform 250mm loose thickness layers and compacted in successive layers to the requirements specified in 2.8.4.1

2.8.7 Acceptance Testing

The Contractor shall test for compliance with the requirements of Clause 2.8.4.1 herein strictly in accordance with the approved Construction Quality Assurance Plan.

Notwithstanding the above, the following criteria for acceptance shall be taken as minimum requirements:

i) Base and Side Wall liner compaction/moisture content testing frequency:

- The minimum overall frequency for testing shall be one test per 1,000m^3,
- Two tests per 250mm thick (loose) layer (if the compacted volume of a layer is less than 2,000m^3

ii) Each test location shall be selected by the contractors geotechnical sub-consultant. Should a test fail to meet the specified density or moisture content then remedial action shall be carried out *as* described in Table 2. The Superintendent may select a test location at his discretion.

iii) Should the Superintendent consider the depth of non conforming material to be greater than can be effectively compacted from the surface, material shall be removed to a depth at which compaction is satisfactory and replaced and compacted in layers.

Table 2 – Remedial Action for Compacted Fill

Category	**Density Ratio Result**	**Moisture Result**	**Remedial Action**
A	Fail by less than 1%	Pass	RE-roll (no. of passes to be specified by the Superintendent – max. 3)
B	Fail by 1% or more	Pass, but not more than 1% wet of OMC	Rip, re-water, re-roll and re-test
D	Fail by 1% or more	Pass by 1% or more wet of OMC	Rip, re-roll and re-test
E	Pass	Fail, but no more than 2% dry of OMC	Rip, water re-roll and re-test
F	Fail	Fail: more than 2% dry or more than 3% wet of OMC	Remove fill, replace and re-test

In addition to the compaction testing described above, routine compliance testing with regard to the criteria specified shall be conducted on samples taken for compaction testing, in accordance with the approved Construction Quality Assurance Plan, but not less than the following:

Testing frequency - 1 group of compliance testing per 5,000m^3 (minimum number for Cell 2 shall be 4).

Required tests (other than compaction test)
- % fines (Grading Analysis)
- Plasticity Index (PI)
- Permeability (k)

Permeability compliance testing shall be carried out on samples prepared at a Dry Density Ratio and Moisture Content equivalent to that which was obtained from the compaction test for that sample.

Notwithstanding the compliance testing described above, the Superintendent reserves the right to reject incoming material based upon a field assessment of sand content (% fines) or silt content (PI).

The Superintendent may authorise the nominated Testing Authority to perform % fines and/or PI testing on selected samples. When such testing is being carried out the requirements of Section 2.3 and Clause 2.6.2 shall be followed.

2.9 Other Site Earthworks

Material for the construction of general filling layers shall be sourced, as far as practical, from on site, or other area on site as directed by the Superintendent. The material shall be clean well graded material, unless notified otherwise by the Superintendent in writing. The materials used shall be free of stones larger than 20mm, rock, cobbles, boulders, roots, sticks or any sharp objects or debris of any kind.

Any material which fails to comply with these requirements, or is otherwise considered unsuitable by the Superintendent, shall be reused elsewhere on site or disposed of on site as directed by the Superintendent at the Contractor's expense.

2.10 Topsoiling and Grassing

2.10.1 Scope

This section covers the requirements for topsoiling and grassing, including the control of weeds and erosion and promotion of grass cover.

The Contractor shall topsoil and grass all disturbed areas within the limit of works. Topsoil stripped as part of the works shall be stockpiled and reused as part of these works in the first instance. The written approval of the Superintendent is required prior to the importation of topsoil. Imported topsoil will only be considered if there is a deficiency of available topsoil from within the site.

The Contractor shall provide all labour, materials and equipment necessary to undertake the works detailed in this section.

2.10.2 Topsoiling

2.10.2.1 Materials

All topsoil shall be free from perennial weeds and their roots, stone or rubble, clods of subsoil and other extraneous material.

2.10.2.2 Ground Preparation

Prior to the placement of topsoil, the surface for topsoiling shall be lightly cultivated across the slope to achieve a coarse surface texture which will assist in retaining topsoil on sloping ground.

2.10.2.3 Spreading of Topsoil

Topsoil shall be spread:
Where petrol, oil, lime or other harmful materials have been spilt on the subgrade or topsoil, the affected material shall be excavated and removed from site.

Finished surface levels of topsoiled areas shall be graded evenly toward drainage structures, and shall be finished flush with paved surfaces and kerbs. Following spreading and grading, the surface of topsoiled areas shall be tine harrowed across the slope.

Grassing Scope

All topsoiled areas, drainage channels and open drains shall be grassed. This includes:

- Final preparation of seed bed as required.
- Sowing by broadcasting
- Protection and maintenance.

2.10.2.4 Seed Bed Preparation

Ensure areas to be seed have been brought to a suitable tilth before sowing and is free of major weed infestations.

Soil shall not be worked under unfavourable moisture conditions that may not allow proper cultivation or that may damage the soil structure. Final cultivation shall be by tine harrow across the slope of the land, ie. along the contours.

2.10.2.5 Seed Mix

All grass seed shall be a prepared mix of:

- Valda Hard Fescue
- MX86 Sheeps Fescue
- Delaware Dwarf Fine Rye Grass

Sow Valda and MX86 as a 50/50 mix at 50kg per hectare and Delaware Rye at 70kg per hectare, (total rate 120kg per hectare).

2.10.2.6 Sowing and Subsequent Treatment

Sow only on a calm day and do not sow when seed bed is in a muddy condition. Seeding shall be carried out only at times of the year when a good result can be reasonably expected, ie. The months of April, May, September and October.

For sowing outside these times as may be required for surface stabilisation seed shall be sown by machine in two equal sowing in a transverse direction.

Protect newly-grassed areas against traffic or stock access.

Re-seed all areas where grass fails to germinate within one month of the original seeding.

3 HDPE Liner Supply & Installation

3.1 General

The area to be lined is the internal surface of Cell 3. The cell base shall be lined with 2mm thick smooth HDPE and the permanent cell walls shall be lined with 2mm thick textured HDPE. After installation the liner will be completely covered with a non-woven needle punched geotextile (Bidim A24 or approved equivalent). A 300mm thick drainage aggregate will be placed on the base of the cell, and a 300mm thick protective gravel cover layer will be placed on the sides.

The contractor shall examine drawings provided and submit with the tender details of any design amendments required to suit the HDPE membrane lining. In particular, details affecting the surface finish under the liner, slope transitions and anchoring should be considered.

3.2 Trimming & Compaction

The Contractor shall trim the floor and embankments of the cell to the lines and levels indicated on the drawings and compact with a smooth flat drum roller to provide a smooth dense finish.

Embankment tops are to be trimmed prior to construction of anchor trench to ensure minimum fall of 1:30 towards the outside batter slope.

3.3 Anchor Trench

The Contractor is to excavate the anchor trench on the outside embankments and temporary bund to the lines and levels indicated on the drawings.

Following the installation of the HDPE membrane liner the anchor trench shall backfill and compacted with approved material.

The backfill material shall be placed in layers not exceeding 200mm loose depth. Each layer shall be compacted by means of mechanical compactor to achieve 90% Standard Dry Density.

3.4 Area To Be Lined

The area to be lined consists of the base and sides of the cell. The true areas of the lined areas are represented in the Bill of Quantities, meaning that the contractor does not need to allow additional area for the 1 in 3 slope on the walls or the peaks and troughs of the floor.

The schedule does NOT make allowance for the following:

- Joints, overlaps and expansion or contraction of material;
- Edge treatment required beyond the 2.1m wide strip specified for anchor trenches on top of the embankments.

Contractors are to make their own assessment of the quantity of liner required, based on the drawings attached to this Specification.

3.5 Experience

The Contractor shall provide with their tender, evidence of their (or their subcontractor's) ability and experience to supply and install HDPE membrane lining. A minimum of five years continuous experience in the manufacture and installation of HDPE membrane lining is required.

A list of similar past projects including relevant details of each installation and a Client contact is to be provided.

3.6 Material Specifications

The liner shall be a premium grade High Density Polyethylene and shall be manufactured of new, first quality products designed and manufactured specifically for the purpose of liquid containment in hydraulic structures and landfills.

The liner shall have nominal thickness of 2mm minimum.

The liner shall be free of surface striations or roughness (apart from those inherent in the textured liner), holes, blisters, undispersed raw materials, bubbles or any sign of contamination by foreign matter.

The lining materials shall be provided in rolls of a minimum width of 6.0 metres and each roll shall be labelled identifying the following data:

- Name of Manufacturer
- Product Identification;
- Material thickness;
- Roll Length, Width and Weight;
- Year of Production and manufacturer's roll number.

There shall be no factory seams.

Contractors may offer an equivalent to the 2mm HDPE liner for assessment by the Principal. Details of the alternative offer including any supporting technical literature is to be included in the tender.

3.7 Factory Quality Control

3.7.1 Raw Material

Prior to the production of the liner, the liner manufacturer shall test the raw material batches to certify the raw material suppliers test results and entity of the singular resin.

The liner manufacturer shall provide certification and all test results for raw materials prior to the delivery of materials to site.

3.7.2 Manufactured Material

The manufacturing process must provide for the continuous monitoring of thickness and sheet quality.

Details of testing methods shall be provided with each roll delivered to the site and shall include the following information and test results:

- Thickness (ASTM D 1593)
- Tensile Properties (ASTM D 638)
- Tensile Strength at Yield and Break
- Elongation at Yield and Break
- Tear Resistance (ASTM D 1004, Die C)
- Puncture Resistance (FTMS 101C 2031/FTMS 101C 2065)
- Carbon Black Content (ASTM D 1603)
- Density (ASTM 1505)
- Melt Index (ASTM D 1238)
- Brittleness (ASTM D 746)

The Superintendent and the Contractor shall jointly inspect any material rejected on site by the Superintendent. If required, the material shall be tested at the Contractors expense. If the material fails to meet the Specification, the Contractor at his cost shall replace it.

3.8 Subgrade Preparation

The surfaces to be lined shall be smooth and free of all rocks, stones, sticks, roots, sharp objects, or debris of any kind. The surface should provide a firm, unyielding foundation for the membrane with no sudden, sharp or abrupt change or break in grade. No standing water or excessive moisture shall be allowed. The Contractor shall certify in writing the surface on which the membrane is to be installed is acceptable before commencing works. The Contractor's Quality Assurance Program shall allow for submission of the certification to the Superintendent prior to laying the liner. The Superintendent shall also inspect the entire subgrade surface area of the cell prior to commencement of liner placement.

3.9 Liner Installation

The liner shall be placed in a manner, which minimises handling and wrinkling of the liner. Due allowance shall be made for shrinkage and thermal expansion and contraction of the liners. The membrane panel layout is the responsibility of the Contractor.

The liner shall be terminated with anchor trenches as shown in the drawings. The anchor trench shall be continuous around the perimeter of the cell. Once the membrane liners are in place the anchor trench shall be backfilled and suitably compacted to prevent slippage of the liner. The contractor is to make allowance for any temporary ballasting required to hold the liner in place in the anchor trench prior to backfilling the anchor trench.

The full cost of this joint or edge treatment including excavation and backfilling of the anchor trenches shall be deemed to be included in the Contract Sum.

The Contractor shall allow for any works required to hold the installed liners in position against the action of wind prior to placement of the leachate collection system, filter blanket aggregate and protective gravel cover.

The Contractor shall ensure that no vehicles or mobile equipment is permitted on the liner until the full depth (300mm) of protective cover or filter blanket has been placed.

The Contractor shall be responsible for making allowance considered necessary to accommodate variations in temperature and weather conditions.

3.10 Field Seams

Seams are to be orientated down the slope, not across it. The layout of the liner will be such to minimise the number and length of seams.

All welds require a minimum of 100mm overlap.

Two types of welds shall be used, Hot Wedge Welding and Extrusion Welding.

Extrusion Welding shall be kept to a minimum and should only be used in 'non stressed' locations.

Extreme care shall be taken by the installer in the preparation of the areas to be welded. The area to be welded shall be cleaned and prepared according to the procedures laid down by the material manufacturer.

The welding equipment used shall be capable of continuously monitoring and controlling the temperatures in the zone of contact when the machine is actually fusing the lining material so as to ensure changes in environmental conditions will not affect the integrity of the weld.

The Contractor shall submit his weld procedure as part of the Quality Assurance/Quality Control Program before any welding is commenced.

3.11 Field Seam Testing

On site physical non destruction testing shall be conducted on ail welds by air pressure testing and/o vacuum box. The testing methods shall be included in the Quality Control program submission.

Any area showing a defect shall be marked and repaired in accordance with HDPE repair procedures at the Contractor's expense.

Prior to the beginning of each weld period, trial welds, shall be made on fragment pieces of membrane. Destructive seam tests will be carried out on these samples. Additional destructive seam tests will be performed at random selected locations during installation. These tests are conducted to confirm and evaluate seam strength and continuity during the field seaming.

In the event of failure, all prior welds shall be tested back to the last test which passed. All repairs necessary to make good the seams to the Principal's satisfaction, including additional testing shall be carried out by the Contractor at his own expense.

3.12 Quality Assurance Certificates and Records

The Contractor shall provide the Superintendent with the following listed Test certificates and records prior, during and at the completion of the works as each report and record is required:

- Certification & Test Results of Raw Materials from Raw Material Supplier
- Certification & Test Results of Raw Materials from Membrane Manufacturer
- Roll Test Date Reports, for Each Roll of Material
- HDPE Welding Granulate Test Reports
- Daily Installation Reports for each welder and technician:
  - Trial Test Weld Record
  - Wedge Weld Records

  - Surface Extrusion Weld Records
  - Weld Peel & Tensile Test Records
  - Wedge Air Tunnel Pressure Test Records
  - Vacuum Box Test Records
  - Repair Records
- Completed As Built Drawing, including roll numbers, panel layout, seam locations and repair locations.

3.13 Protection of Works

As soon as possible after installation of the liner, the Contractor shall provide protection of the liner by placement of the specified geotextile (Bidim A24 or equivalent) protective cover material and drainage aggregate. If a crusher run filter blanket material is used, the geotextile grade shall be increase to Bidum A34 or equivalent to provide greater protection to the HDPE liner.

Extreme care must be taken at all times to avoid damage to the liner.

No equipment is permitted to operate on the unprotected liner. Personnel walking on the liner should be kept to a minimum, and footwear must be checked prior to accessing the liner to ensure rocks or other sharp objects are not embedded in the sole.

Formwork for the sump slab shall be pre-fabricated in a location external to the lined cell and assembled at the location site. The formwork may only be held in place with screened filter blanket material placed around its perimeter. Under no circumstance should the formwork be staked to the ground. Bar chairs used in the slab construction shall be of a flat based plastic type so as to not damage the HDPE liner.

3.14 Warranty

The Contractor shall provide a written 10 year warranty for the liner material. The warranty shall include all labour and materials required to effect any repair under warranty.

4 CONCRETE

4.1 General

This section specifies concrete for use in the Leachate Collection Sump.

4.2 Standards

The latest editions of the following Australian Standard shall form part of this specification:-

AS 3600	Concrete structures.
AS 3972	Portland and blended cements
AS 2758.1	Aggregates and rock for engineering purposes - Concrete aggregates
AS 1012	Methods of testing concrete.
AS 1379	Specification and supply of concrete
AS 1303	Steel reinforcing wire for concrete
AS 1302	Steel Reinforcing bars for concrete
AS 1304	Welded wire reinforcing fabric for concrete

4.3 Materials

(a) Portland Cement

Portland Cement shall comply with the requirements of Australian Standard AS 3972.

(b) Fine Aggregate

Fine aggregate for concrete shall be sand or fine gravel from an approved source to be thoroughly clean and free from clay, loam or organic impurity and shall comply with the Australian Standard AS 2758.

(c) Course Aggregate

Course aggregate for concrete shall be gravel or screenings from an approved source and shall comply with the Australian Standard AS 2758.

(d) Water

All water shall be free of matter harmful to concrete and its reinforcing.

(e) Reinforcing

Steel reinforcement shall comply with the respective Australian Standards AS 1302, AS 1303 and AS 1304.

4.4 Storage of Materials

Any material that has deteriorated or has been damaged shall not be used for construction purposes. Cement and aggregates shall be stored separately in a manner such as will prevent deterioration and the inclusion of foreign materials.

4.5 Mixture

The concrete shall consist of a mixture of cement, fine aggregate,

course aggregate and water, mixed in such proportions necessary to produce concrete complying with the requirements of this Specification.

The proportion of fine aggregate to course aggregate will depend on the grading of the materials, but the amount of fine aggregate shall always be the minimum which, when combined with cement, will produce only sufficient mortar to fill the voids in the course aggregate and leave a slight excess for finishing.

The proportions of the mix will be determined by the Superintendent and shall be strictly adhered to by the Contractor.

4.6 Pre-Mixed Concrete

All concrete used on the Contract Works shall be premixed concrete, from sources approved by the Superintendent, mixed at a central mixing plant, delivered and placed in strict accordance with Australian Standards AS 1379.

It is the responsibility of the Contractor, not the concrete supplier, to ensure that requirements of this Specification are met. The concrete must be delivered to the site of the works and placed in its final position before initial set takes place and the addition of water or other retempering of the concrete before placing will not be permitted.

4.7 Mixed On-Site Concrete

Mixed on-site concrete shall not be used except when specifically approved by the Superintendent where small quantities of concrete are required. When required and approved, mixed on-site concrete shall be hand or machine mixed as specified by the Superintendent, to produce concrete complying with the requirements of this Specification.

4.8 Cement Mortar

All cement mortar shall consist of:-

One (1) part cement

One and one quarter (1 and 1/4) parts sand

One and one quarter (1 and 1/4) parts screened bluestone dust.

The materials shall be thoroughly mixed with a proper quantity of water, by a method and to a consistency approved by the Superintendent.

4.9 Additives

Additives shall not be permitted.

4.10 Consistency

The concrete to be placed in the work shall be of such consistency that it can be readily placed and compacted in the forms without causing segregation of the materials or excess free water to collect on the surface.

The consistency of the concrete shall be determined by a slump test in accordance with Australian Standard AS 1012.

The maximum slump allowable for concrete used in the works shall be 75mm.

4.11 Concrete Strength

Concrete shall develop minimum compression strength at seven (7) days of 14 Megapascals and at 28 days of 40 Megapascals.

4.12 Standard Tests For Material and Concrete

The materials and concrete will be tested as and when directed by the Superintendent in accordance with Australian Standard AS 1012.

Test cylinders shall be prepared by the Contractor when directed by the Superintendent and shall be numbered and marked with dates. The Contractor shall keep a register of such test cylinders, which shall also show the dimensions and changes of the various concrete works executed on every day and in particular those executed on the day on which the samples were taken.

The Contractor shall be responsible for having the samples tested at an approved Laboratory.

Three cylinders will be prepared and disposed of as follows:-

No.1 Tested for 7 days strength, 14 megapascals.

No.2 Tested for 28 days strength, 40 megapascals.

In the event of No.2 not reaching the required standard, No.3 will be tested. The result of this test will be binding and final on the Contractor and the Superintendent. The Contractor is to take immediate steps to remove and reconstruct any work condemned by reason of this section of the Specification.

4.13 Formwork

Formwork and framing for concrete shall be in accordance with the provision of Australian Standard AS 3600.

The forms shall be to the shape, lines and dimensions required by the Contract Drawings.

Forms shall be properly supported and braced to maintain position during and after the placing of concrete and shall not be stripped until the concrete has hardened and obtained sufficient strength to support its own weight and any construction loads, without injury to the concrete.

In no case shall the forms be removed before 12 hours after placing of the concrete.

4.14 Reinforcement

Where detailed, reinforcement shall be accurately fixed in accordance with the accompanying drawings and the provisions of Australian Standard AS 3600.

Reinforcement shall be thoroughly cleaned of all loose scale, rust and other detrimental coatings and shall be accurately placed, secured and maintained in position until incorporated in the concrete.

4.15 Inspection prior to placement of concrete

No concrete shall be placed before the formwork reinforcement and bedding, in place, have been inspected by the Superintendent.

4.16 Placing of Concrete

After mixing, concrete shall be conveyed to the place of final deposit, without delay, and placed into its final position as rapidly as possible by methods which prevent the loss or segregation of materials.

Dropping concrete a greater height than one (1) metre, depositing large quantities at any point and moving or working it along the forms will not be permitted. A plastic surface shall be maintained until the completion of the unit.

Concrete placing shall be carried on continuously up to the construction points as shown on the drawings, or as directed by the Superintendent.

Wherever the work of placing concrete is delayed until the concrete shall have taken its initial set, the point of stopping shall be deemed a construction joint. The location of construction joints shall be planned in advance and shall be made only when approved by the Superintendent. The placing of concrete shall be carried on continuously from joint to joint. These joints shall be perpendicular to the principal lines of stress and in general, shall be located at points of minimum shear.

Before placing new concrete on or against concrete which has set, the form shall be re-tightened and the surface of the set concrete shall be roughened as required by the Superintendent, thoroughly cleaned of foreign matter, laitance and loose or porous material, and saturated with water. The surface shall be then covered with a thin coat of stiff, neat cement to ensure bond and concreting shall then proceed immediately.

Precautions shall be taken in placing concrete when air temperatures are above 30^{o}C and below 5^{o}C. No concrete is to be placed under water unless methods used are approved by the Superintendent.

4.17 Compaction of Concrete

The concrete shall be thoroughly compacted to the satisfaction of the Superintendent, whilst it is being placed in the works. Compaction shall be by means of continuous tamping, spading and vibration with approved vibrators.

Care shall be taken to fill every part of the forms, to force the concrete under and around the reinforcement without displacing it, to work back coarse aggregate from the face and to remove all air bubbles and voids.

4.18 Curing

Concrete and rendering shall be cured so as to prevent excessive loss of moisture from the surface for at least seven (7) days continuously, following the time of placing.

In hot weather the Superintendent may direct the curing period to extend up to fourteen (14) days.

Curing shall be accomplished by one or more of the following methods:-

(a) Covering with Hessian, plastic sheeting or similar material maintained in a wet condition.

(b) Covering with at least 25mm thickness of sand or earth maintained in a damp condition.

(c) Coating with approved curing compound.

(d) New surfaces shall be effectively protected from rain until hard set has occurred.

4.19 Defective Concrete

The Contractor shall be fully responsible for employing effective methods of mixing, placing, protecting and curing concrete; and for the adequacy of falsework and forms. Approval of any such work or methods by the Superintendent will be tentative only and shall not relieve the Contractor of this responsibility. Concrete which is not placed and completed in accordance with this Specification or which is, in the opinion of the Superintendent, defective, shall be removed within the limits assigned by the Superintendent and replaced to his satisfaction.

5 Leachate Pipes and Fittings

5.1 Scope

The Contractor shall provide all materials, labour and equipment necessary to supply, install and test all pipes, fittings and valves, and all associated structural work as shown on the Drawings and as specified herein, and as required to make the work complete and operable.

5.2 Materials

5.2.1 General

The Contractor shall give the Superintendent sufficient notice to enable him to inspect any material or article that is delivered on the site of the works and all materials and articles shall be stacked in such a manner as will facilitate inspection. Materials and articles will be inspected before their use in the works of the Contract, but may be ultimately rejected if defects of any kind referred to or implied in this Specification be found before the completion of the Contract.

Samples and materials and/or articles supplied, which fail to meet the requirements of this Specification, whether definitely stated or implied, shall together with all materials and/or articles represented by such samples, be subject to rejection, and if rejected shall be replaced by the contractor at his own cost by materials and/or articles fully in accordance with such requirements of this Specification. The Contractor shall have no claim for extra payment or extension of time in respect of any such replacements.

The Superintendent may, at his discretion, require the Contractor to submit samples of any materials or articles to any test which he may prescribe for the purpose of determining whether or not they are in accordance with the requirements of this Specification. The cost of providing such samples shall be borne by the Contractor if the material is found to be unsatisfactory.

5.2.2 Leachate Pipes and Fittings

The leachate collection pipe shall be slotted 110mm nominal diameter (as specified in the drawings) Vinidex PE80B polyethylene pipe (class PN16) and fittings, or equivalent approved by the Superintendent in writing, manufactured in accordance with AS 4310.

Slots are to be 4mm x 100mm in length, with three slots staggered around the circumference of the pipe. Slots are at 300mm centres along the length of the pipe.

A filter sock is not to be fitted over the pipe.

Pipe work is to be connected to the sump within Cell 2 as per the construction drawings. Pipe ends shall protrude 50mm into the sump. Pipe penetrations shall be neatly constructed and rendered.

The Contractor shall not damage the flexible membrane liner. Any damage caused to the liner system must be repaired immediately to the satisfaction of the Superintendent.

Connections at pipe intersection shall be achieved using a single piece HDPE, Fabricated Tee constructed with an appropriate offset so as to maintain a constant pipe invert level across the transition. Alternate connection methods may only be used with the approval of the Superintendent.

5.2.3 Drainage Aggregate

Drainage aggregate for the area immediately surrounding leachate collection pipes trenches shall be 14 mm size rock of uniform grade.

Drainage aggregate for the filter blanket shall meet the requirements of clause 2.8.4.5.

Representative samples of drainage aggregate shall be provided to the Superintendent for approval, prior to material being brought to site.

5.3 Handling and Delivery of Pipes and Fittings

5.3.1 Transport and Unloading

Pipes shall be transported by an approved method which shall safeguard their condition.

Prior to commencement of deliveries, the proposed method of unloading at the site shall be in accordance with manufacturers specifications and approval by the Superintendent and no alteration of the approved method will be permitted without the further approval of the Superintendent.

When delivered all pipes are to be secured from rolling and be spaced so that free access can be obtained around them. Particular care shall be taken to avoid damage due to incorrect use of slings and pipe handling.

5.3.2 Acceptance After Delivery

Pipes and fittings will be subjected to inspection at the point of delivery and items which fail to meet the requirements of this Specification, independent of physical tests, will be rejected. Any item that is damaged beyond repair shall be removed immediately by the contractor and replaced by him at his expense.

After pipes and fittings have been delivered, unloaded, stacked and finally inspected, a Certificate of Acceptance shall be issued by the Superintendent for all items accepted, and forwarded to the Contractor. However, if the Superintendent is not satisfied that items have been delivered in accordance with this Specification, written notification of the reasons for non-acceptance will be given to the Contractor, who shall carry out forthwith such further works as are necessary for acceptance by the Superintendent.

The Superintendent may permit the repair of minor damage to the items at the delivery site if he is satisfied that the damage is superficial; otherwise the Contractor shall return the item to the factory for replacement.

Notwithstanding prior acceptance, any item which cannot be jointed properly will be rejected and shall be replaced by the Contractor at his expense.

5.4 Construction

5.4.1 General

For the purpose of this Section the term pipework shall be deemed to include all appurtenances built into or fixed on to the pipelines.

It shall be the Contractor's responsibility to ensure proper fit of all pipework. Dimensions and levels shown on the Drawings are to be retained unless such dimensions or levels result in a misfit or interference of the pipework with other pipework, structures or objects, or the dimensions given are not compatible with equipment items to be installed under this Contract, in which case the Contractor shall advise the Superintendent of changes he wishes to make to ensure proper fit and seek the Superintendent's approval to such changes. Approval to so modify such dimensions or pipework arrangements shall not constitute a Contract variation and such modifications shall be deemed to be part of the work of this Contract.

5.4.2 Leachate Collection Pipes

Before laying pipe, all dirt shall and foreign matter, etc. shall be removed from inside the pipe.

Unless otherwise approved by the Superintendent, laying shall commence at the low points of the pipeline and proceed upgrade. All pipelines shall be laid to the lines, levels and grades shown on the Drawings. Pipes must be seated on the geofabric and ballasted (commonly with sandbags) to prevent movement when aggregate is applied.

Angular changes in pipe alignment such as those required to enter the leachate sump, and transition from the base to the wall of the cell shall be achieve using the allowable bending radius of the pipe. The minimum allowable radius of a bend in HDPE pipe is 33 times the outside diameter of the pipe.

5.4.2.1 Jointing of Leachate Collection Pipes

All jointing of HDPE pipes shall be achieved by butt welding. Flanged, Victaulic, and compression fitting shall not be used without the written authority of the Superintendent. All procedures specified by the manufacturer must be followed; in particular:

- The pipe ends must be trimmed square to allow uniform pressure build up. The jointing ends must be free from dirt, grease and contamination to prevent foreign material being trapped inside the weld section.
- The heating time must not be reduced from that specified by the manufacturer and in windy or wet conditions the welding machine must be protected to prevent uneven heating or cooling around the pipe surface.
- The heating plate temperatures must not be changed from the recommended levels to ensure adequate heating and to prevent oxidation of the jointing surfaces.
- The temperature of the welding plate must be checked during the heating cycle.
- The trimmed and heated ends must be held for the appropriate time, depending on the pipe diameter and class.
- The zone must be kept under compression for the nominated period to prevent stresses being built into the joint and reducing the strength of the weld.
- The weld zone must be allowed to cool under ambient conditions and cooling by water spray should not be attempted.
- Weld beads may be left in place providing they are smooth and do not place significant pressure on the HDPE liner beneath.

The Contractor shall provide evidence in the appropriate schedule, of the experience of the pipe welding subcontractor.

Jointing may take place on the HDPE liner, providing adequate steps are taken to ensure that no damage occurs to the HDPE Liner. In the event of such damage the Contractor shall undertake repairs to the satisfaction of the Superintendent at no cost to the Principal.

After laying, jointing and inspection of the pipework, drainage stone shall be placed around the pipework as indicated on the Drawings. Approved 14 mm nominal sized drainage aggregate shall be mounded over the pipework to the cross-sections shown on the Drawings.

5.4.3 Excavation of Open Drains

The open drains shall be excavated to the lines, levels, grades and cross-sections as shown on the Drawings.

Should the Contractor excavate to depths greater than required, the excess excavation shall be backfilled at the Contractor's expense to the correct levels with approved material and compacted and tested to the satisfaction of the Superintendent.

Excavated material shall be stockpiled for possible subsequent use and placed on site as directed by the Superintendent.

6 Quality System

6.1 General

The Contractor shall for all works, plan, develop, document and implement a Quality System based on the principles and practices specified in the AS/NZS ISO 9000 series.

The Quality System shall include development and implementation of:

- Landfill Construction Quality Assurance Plan
- Environmental Management Plan (Construction Management Plan)
- Occupational Health & Safety Plan
- Construction Program

6.2 Construction Quality Assurance Plan

The Contractor/shall submit with his tender details of a proposed Construction Quality Assurance Plan (CQAP) for the landfill works. This plan shall include details of the nature and frequency of proposed testing.

The Construction Quality Assurance Plan shall conform to the geotechnical testing requirements described in Section 5 with consideration to EPA Best Practice Environmental Management (Landfills) Publication No. 788.

Once the Construction Quality Assurance Plan has been reviewed and approved by the Superintendent, the Contractor shall carry out all earthworks strictly in accordance with the Plan, unless otherwise directed by the Superintendent in writing.

The Contractor shall be deemed to have made full allowances for compliance with the approved CQAP and any contingencies arising there from in his tendered price.

The CQAP shall include preparation of a Construction Quality Assurance Report at the completion of works to the satisfaction of the Superintendent. This report will provide documentary evidence and certification that the works have been constructed in accordance with the drawings, specifications and CQAP. The report will include at least the following:

- Survey data/plans confirming compacted clay liner thickness
- Survey data/plans confirming correct pipe and liner grades and levels
- Results of the trial clay liners (including compaction and permeability test results)
- Compacted clay liner density, moisture content and permeability test results and evidence of frequency and locations of tests
- Test results and quality assurance certification of the HDPE liner manufacture and installation

6.3 Environmental Management Plan (Construction)

During construction, control of drainage flows along drainage lines, erosion and sediment transportation must be controlled by the Contractor to acceptable levels.

For this reason the Contractor shall submit with his tender a proposed Environmental Management Plan (EMP) which details how all the works under the Contract are to be carried out in accordance with the requirements of the Environment Protection Act 1970 and associated regulations and policies. The Plan (EMP) shall be applied throughout the project, commencing prior to the start of construction and being maintained until the end of the maintenance period.

The EMP shall be prepared by the Contractor and submitted to the Superintendent for approval within 7 days of the notification of acceptance of tender. The Contractor shall not be given possession of the site to commence works until the Superintendent has approved the EMP.

Once the EMP has been reviewed and approved by the Superintendent, the Contractor shall carry out all works strictly in accordance with the Plan, unless otherwise directed by the Superintendent in writing.

The Contractor shall be deemed to have made full allowances for compliance with the approved EMP and any contingencies arising there from in his tendered price.

The EMP should also be prepared in accordance with the Environment Protection Authority Publications "Construction Techniques for Sediment Pollution Control" (publication 275), "Environmental Guidelines for Major Construction Sites" (publication 480), and “Siting, Design, Operation and Rehabilitation of Landfills” (publication 788) copies of which are available for viewing at the Council offices or from the Victorian EPA website www.epa.vic.gov.au.

Items to be addressed in the EMP include, but are not limited to, the following:

- Establishing a practical sequence for construction of drains to divert drainage flows around the works or take other measures as appropriate to convey drainage flows during the period of works. Existing drainage sumps and pumping capacity installed for the current landfill operation may only be used by the contractor with permission of the landfill operator.

- Turbidity testing of water in dams adjoining the construction site, daily from the date when construction commences on site. In accordance with Table 6 of EPA publication 788, the following stormwater turbidity limits shall apply. Stormwater exceeding these limits must be retained on site for either reuse or treatment prior to discharge

	Maximum NTU	Median NTU
Dry weather	50	25
Stormwater flows	100	50

- Minimising effects of runoff from upstream surfaces by locating stockpiles on flat areas, away from flowpaths and constructing perimeter diversion banks around the site boundary and stockpiles to intercept upstream flows and direct them to stable drainage routes.

- Maintaining stability of stockpiles by limiting stockpile height and side slopes.

- Trapping sediment at source by constructing silt fencing around lower edge of stockpiles or by installing other alternative types of sediment traps.

- Establishing a practical construction sequence which traps sediment and prevents it from entering drainage lines.

- Reducing lengths of exposed slopes into non-erosive segments by constructing berms at regular intervals.

- Trapping of sediment on site at strategic locations along drainage lines by installation of sediment controls such as silt fences and traps.

- Protection of soil surface from rain and runoff by early establishment of vegetation, eg.: hydroseeding.

- Reducing dust from haul roads by watering or gravelling.
- Conveyance of concentrated flows down slopes without causing erosion by installing appropriate energy dissipaters and constructing a stabilised/lined base for drainage lines.
- Minimising area of works and disturbance of soil.
- Limiting construction equipment movement by fencing off critical areas.

The Contractor's adherence to the EMP shall be monitored throughout the course of the contract. If appropriate, the approved EMP shall be amended by agreement between the Superintendent and Contractor in order to better meet the objectives of the EMP.

At his discretion, the Superintendent may instruct the Contractor, at no additional cost to the Principal, to install additional control measures in areas where sediment control is not being satisfactorily achieved. Long term treatment of these areas will then be subject to amendment of the EMP as detailed above.

The EMP shall remain in force until the issue of the Final Certificate.

6.4 Environmental Audit

As required under the conditions of the EPA Waste Discharge Licence for the landfill, the Principal shall engage the services of an Environmental Auditor to prepare an Environmental Audit Report. The Superintendent shall provide the Environmental Auditor with a copy of the CQAP, the EMP and any other data, records or details of management systems relevant to the construction of the landfill. The Contractor shall co-operate with the provision of such items if requested. The Environmental Auditor is also required to undertake one or more inspections of the site during construction.

6.5 Occupational Health and Safety

The Contractor shall submit for consideration by the Superintendent an Occupational Health and Safety Plan covering the management of occupational health and safety in accordance with the Occupational Health and Safety Act 2000. Refer to Clause **Error! Reference source not found.** for further details of the Contractors responsibility regarding Occupational Health and Safety and the OH&S Plan.

The Plan shall provide for the prompt notification to the Superintendent of any accident or injury occurring at the site.

The Contractor and the Contractor's agents shall, so far as is practicable, provide and maintain for employees and agents of the Principal and the Superintendent who, in the course of their work for the Principal, enter the site, an environment that is safe and without risks to health.

6.6 Construction Program

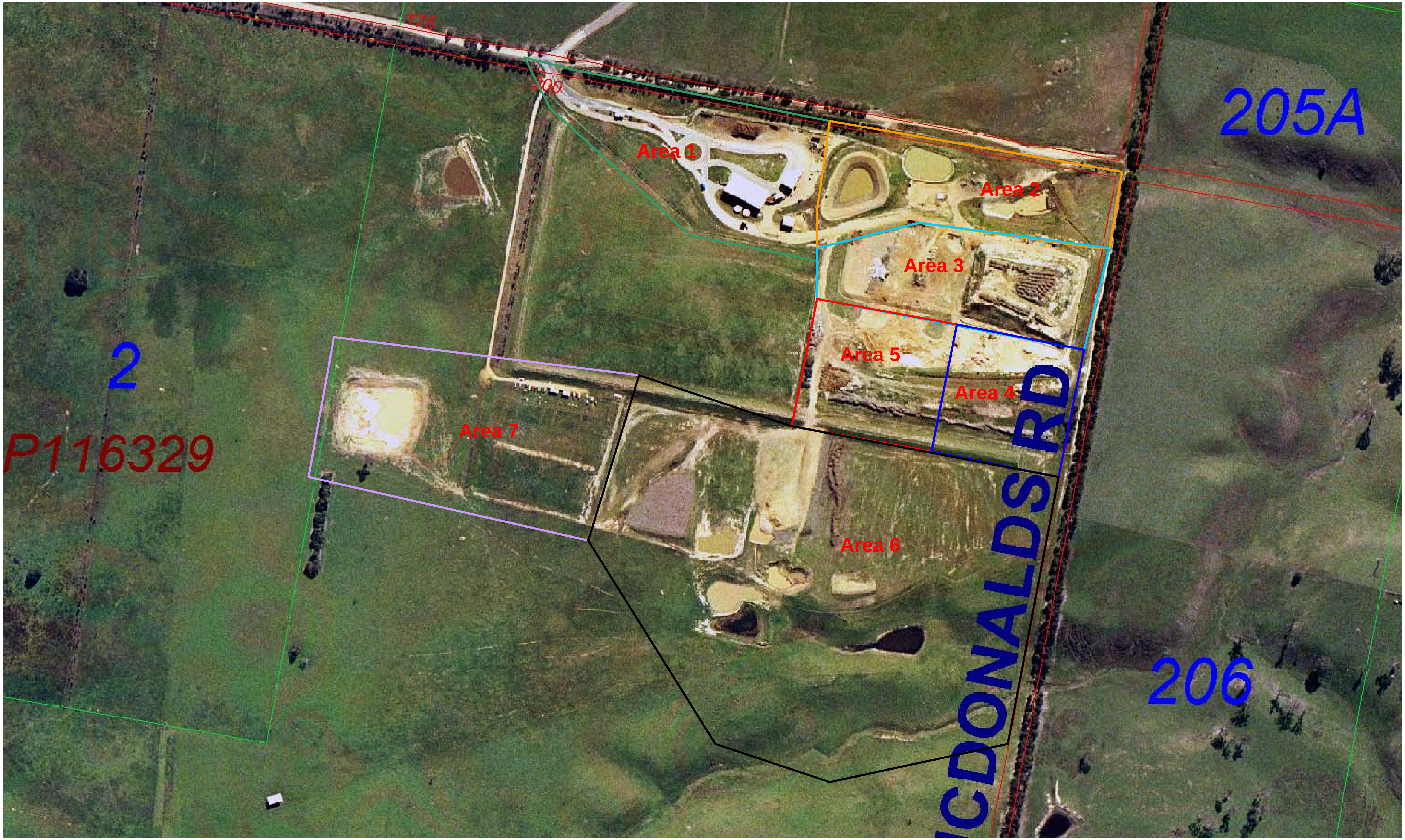
Within fourteen (14) days of the Date of Letter of Acceptance of Contract, the Contractor shall prepare and submit to the Superintendent a construction program for the orderly completion of the works.

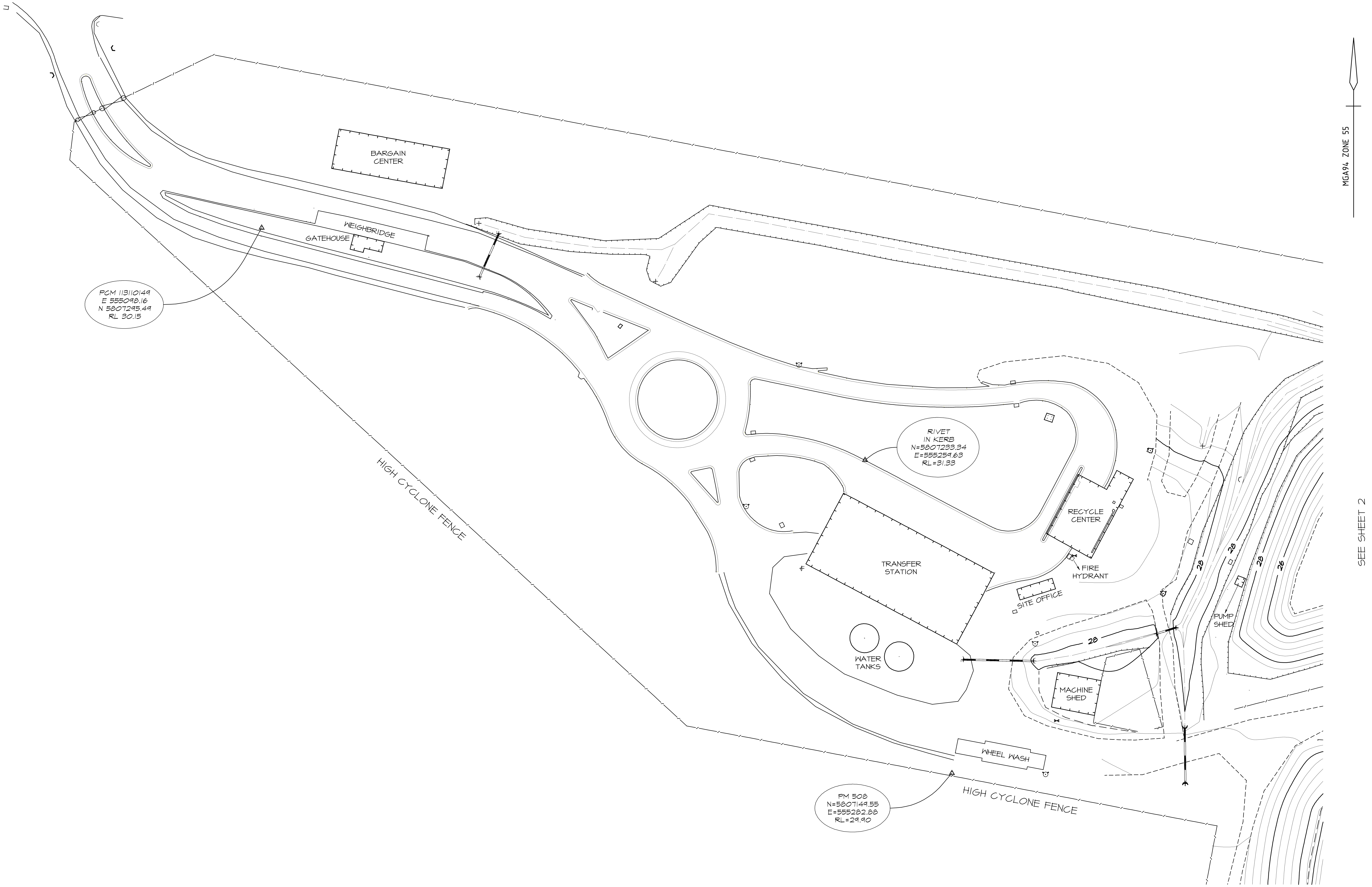
During the initial preparation of the construction program the Contractor shall confer with the Superintendent to ensure that agreement is reached regarding layout and conventions.

The diagrams submitted shall be revised and resubmitted as required, until the Contractor's programmed sequence of operations, construction procedures and use of labour, materials and equipment is, in the opinion of the Superintendent, such as to ensure satisfactory progress for completion of the works within the times specified and in accordance with the requirements of the Contract. All revisions required under this sub-clause shall be completed within four (4) calendar weeks of the Date of Letter of Acceptance of Contract.

The program shall be subject to review and acceptance by the Superintendent.

APPENDIX F – SITE FEATURE SURVEY


175
200
205A
Area 1
Area 2
Area 3
Area 5
Area 4
2
P116329
Area 7
Area 6
CDONALDS RD
206



NOTATIONS

CO-ORDINATE DATUM IS MGA94
HEIGHT DATUM IS AHD

CONTOUR INTERVAL IS 0.5m

DATE OF SURVEY : JULY 2009

Crowther&Sadler Pty.Ltd.
LICENSED SURVEYORS & TOWN PLANNERS
152 MACLEOD STREET, BAIRNSDALE, VIC., 3875
TELEPHONE (03) 5152 5011

SURVEYORS REF.	SCALE
13679	1 : 500

N:\DATA 2009\13601-13700\13679 E.G Shire\13679 merged data.pro

Legend of Features

- Ⓔ Electricity Pit
- ⋈ Stop Valve
- 🅃 Telecom Pit
- ¤ Electricity Pole
- Ⓢ Sewerage Manhole
- △ Water Meter
- ▣ Fire Plug
- △ Tap
- ⊙ Fire Hydrant

PLAN OF FEATURES

PARISH OF BAIRNSDALE
CROWN ALLOTMENTS H, 88 & 258

JOHNSTONS ROAD LANDFILL, BAIRNSDALE
AREA 1 : GATEHOUSE/TRANSFER STATION

EAST GIPPSLAND SHIRE COUNCIL

SHEET 1 OF 7

NOTATIONS

CO-ORDINATE DATUM IS MGA94
HEIGHT DATUM IS AHD

CONTOUR INTERVAL IS 0.5m

DATE OF SURVEY : JULY 2009

Crowther&Sadler Pty.Ltd.
LICENSED SURVEYORS & TOWN PLANNERS
152 MACLEOD STREET, BAIRNSDALE, VIC., 3875
TELEPHONE (03) 5152 5011

SURVEYORS REF.	SCALE
13679	1 : 500

N:\DATA 2009\13601-13700\13679 E.G Shire\13679 merged data.pro

Legend of Features

- Ⓔ Electricity Pit
- ⋈ Stop Valve
- 🅃 Telecom Pit
- ¤ Electricity Pole
- Ⓢ Sewerage Manhole
- △ Water Meter
- ▣ Fire Plug
- △ Tap
- ☉ Fire Hydrant

PLAN OF FEATURES

PARISH OF BAIRNSDALE
CROWN ALLOTMENTS H, 88 & 258

JOHNSTONS ROAD LANDFILL, BAIRNSDALE
AREA 2 : LEACHATE POND & STORMWATER DAM

EAST GIPPSLAND SHIRE COUNCIL

SHEET 2 OF 7

SEE SHEET 2

SEE SHEET 4

NOTATIONS

CO-ORDINATE DATUM IS MGA94
HEIGHT DATUM IS AHD

CONTOUR INTERVAL IS 0.5m

DATE OF SURVEY : JULY 2009

Crowther&Sadler Pty.Ltd.
LICENSED SURVEYORS & TOWN PLANNERS
152 MACLEOD STREET, BAIRNSDALE, VIC., 3875
TELEPHONE (03) 5152 5011

SURVEYORS REF.	SCALE
13679	1 : 500

N:\DATA 2009\13601-13700\13679 E.G Shire\13679 merged data.pro

Legend of Features

- Ⓔ Electricity Pit
- ⋈ Stop Valve
- 🅃 Telecom Pit
- ⌧ Electricity Pole
- Ⓢ Sewerage Manhole
- △ Water Meter
- ▣ Fire Plug
- △ Tap
- ⊙ Fire Hydrant

PLAN OF FEATURES

PARISH OF BAIRNSDALE
CROWN ALLOTMENTS H, 88 & 258

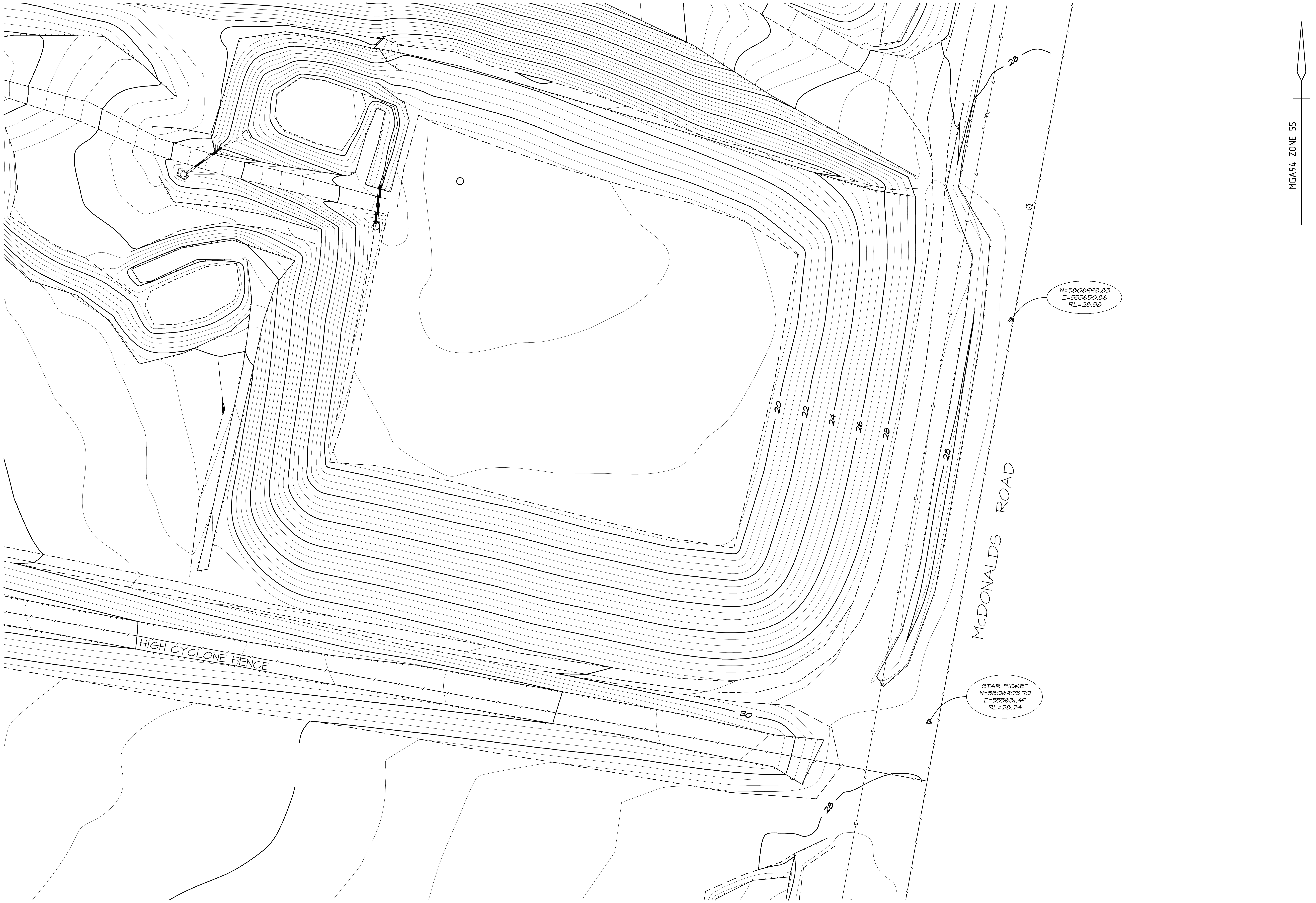
JOHNSTONS ROAD LANDFILL, BAIRNSDALE
AREA 3 : CELL 1

EAST GIPPSLAND SHIRE COUNCIL

SHEET 3 OF 7

SEE SHEET 3

SEE SHEET 5



SEE SHEET 6

NOTATIONS

CO-ORDINATE DATUM IS MGA94
HEIGHT DATUM IS AHD

CONTOUR INTERVAL IS 0.5m

DATE OF SURVEY : JULY 2009

Crowther&Sadler Pty.Ltd.
LICENSED SURVEYORS & TOWN PLANNERS
152 MACLEOD STREET, BAIRNSDALE, VIC., 3875
TELEPHONE (03) 5152 5011

SURVEYORS REF.	SCALE
13679	1 : 500

N:\DATA 2009\13601-13700\13679 E.G Shire\13679 merged data.pro

Legend of Features

- Ⓔ Electricity Pit
- ⋈ Stop Valve
- 🅃 Telecom Pit
- ¤ Electricity Pole
- Ⓢ Sewerage Manhole
- △ Water Meter
- ■ Fire Plug
- △ Tap
- ⊙ Fire Hydrant

PLAN OF FEATURES

PARISH OF BAIRNSDALE
CROWN ALLOTMENTS H, 88 & 258

JOHNSTONS ROAD LANDFILL, BAIRNSDALE
AREA 4 : CELL 2

EAST GIPPSLAND SHIRE COUNCIL

SHEET 4 OF 7

NOTATIONS

CO-ORDINATE DATUM IS MGA94
HEIGHT DATUM IS AHD

CONTOUR INTERVAL IS 0.5m

DATE OF SURVEY : JULY 2009

Crowther&Sadler Pty.Ltd.
LICENSED SURVEYORS & TOWN PLANNERS
152 MACLEOD STREET, BAIRNSDALE, VIC., 3875
TELEPHONE (03) 5152 5011

SURVEYORS REF.	SCALE
13679	1 : 500

N:\DATA 2009\13601-13700\13679 E.G Shire\13679 merged data.pro

Legend of Features

- Ⓔ Electricity Pit
- ⋈ Stop Valve
- 🅃 Telecom Pit
- ¤ Electricity Pole
- Ⓢ Sewerage Manhole
- △ Water Meter
- ▣ Fire Plug
- △ Tap
- ⏰ Fire Hydrant

PLAN OF FEATURES

PARISH OF BAIRNSDALE
CROWN ALLOTMENTS H, 88 & 258

JOHNSTONS ROAD LANDFILL, BAIRNSDALE
AREA 5 : FUTURE CELL 3

EAST GIPPSLAND SHIRE COUNCIL

SHEET 5 OF 7

PLAN OF FEATURES

PARISH OF BAIRNSDALE
CROWN ALLOTMENTS H, 88 & 258

JOHNSTONS ROAD LANDFILL, BAIRNSDALE
AREA 6 : SPOIL AREA / STOCKPILE

EAST GIPPSLAND SHIRE COUNCIL

SHEET 6 OF 7

NOTATIONS

CO-ORDINATE DATUM IS MGA94
HEIGHT DATUM IS AHD

CONTOUR INTERVAL IS 0.5m

DATE OF SURVEY : JULY 2009

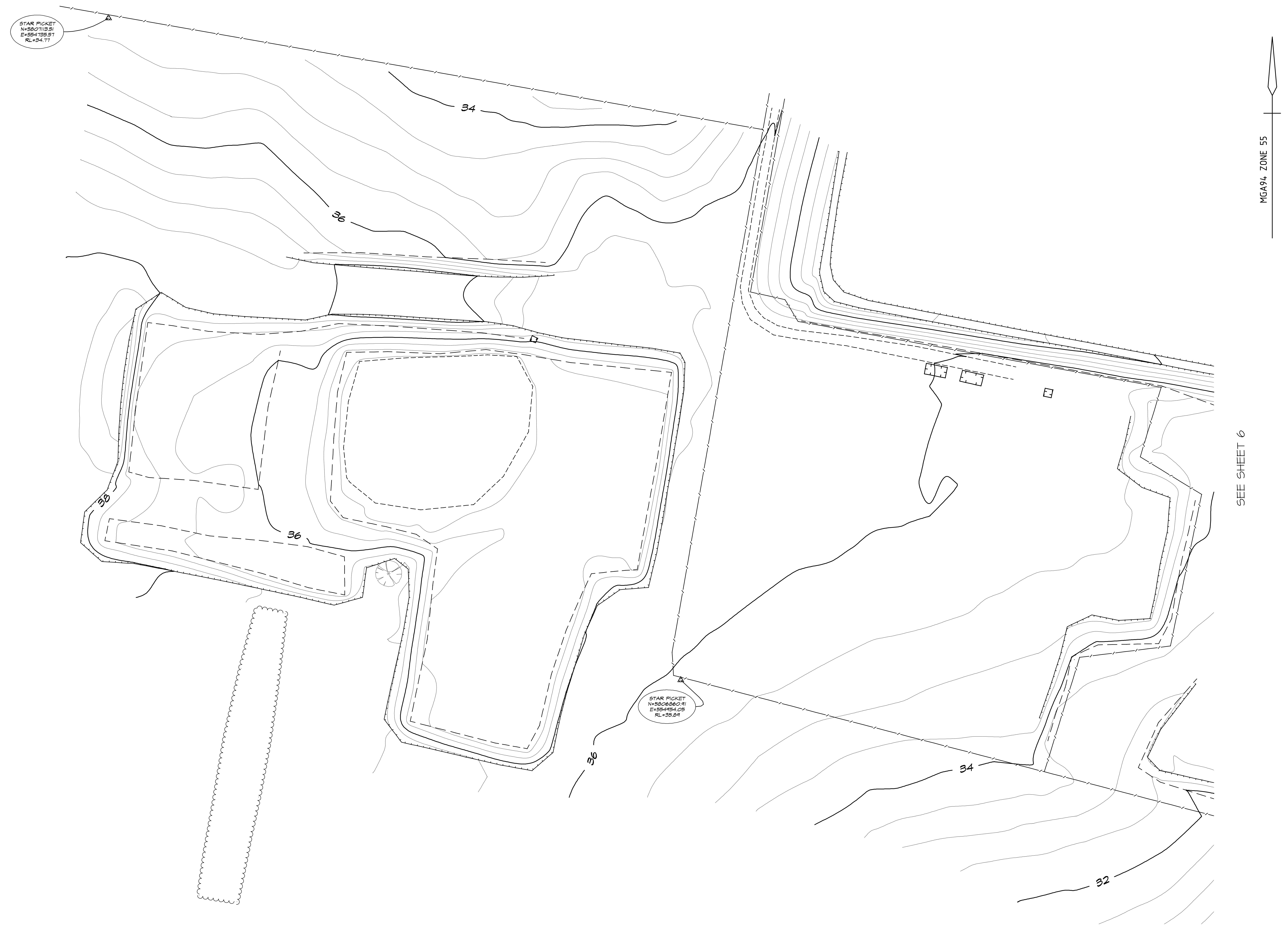
Legend of Features

- Ⓔ Electricity Pit
- ⋈ Stop Valve
- 🅃 Telecom Pit
- ¤ Electricity Pole
- Ⓢ Sewerage Manhole
- △ Water Meter
- ■ Fire Plug
- △ Tap
- ⊙ Fire Hydrant

Crowther&Sadler Pty. Ltd.
LICENSED SURVEYORS & TOWN PLANNERS
152 MACLEOD STREET, BAIRNSDALE, VIC., 3875
TELEPHONE (03) 5152 5011

SURVEYORS REF.	SCALE
13679	1 : 1000

N:\DATA 2009\13601-13700\13679 E.G Shire\13679 merged data.pro



NOTATIONS

CO-ORDINATE DATUM IS MGA94
HEIGHT DATUM IS AHD

CONTOUR INTERVAL IS 0.5m

DATE OF SURVEY : JULY 2009

Crowther&Sadler Pty.Ltd.
LICENSED SURVEYORS & TOWN PLANNERS
152 MACLEOD STREET, BAIRNSDALE, VIC., 3875
TELEPHONE (03) 5152 5011

SURVEYORS REF.	SCALE
13679	1 : 800

N:\DATA 2009\13601-13700\13679 E.G Shire\13679 merged data.pro

Legend of Features

- Ⓔ Electricity Pit
- ⋈ Stop Valve
- 🅃 Telecom Pit
- ⊗ Electricity Pole
- Ⓢ Sewerage Manhole
- △ Water Meter
- ■ Fire Plug
- △ Tap
- ⊙ Fire Hydrant

PLAN OF FEATURES

PARISH OF BAIRNSDALE
CROWN ALLOTMENTS H, 88 & 258

JOHNSTONS ROAD LANDFILL, BAIRNSDALE
AREA 7 : BORROW PIT AREA

EAST GIPPSLAND SHIRE COUNCIL

SHEET7 OF 7

APPENDIX G – COFFEY GEOTECHNICAL REPORT

INFRASTRUCTURE SOLUTIONS PTY LTD

GEOTECHNICAL ASSESSMENT REPORT
BAIRNSDALE LANDFILL - STAGE 2
BAIRNSDALE VIC

AW1781.1AC

25th September 2004

AW1781.1ABC AE
25th September 2004

Infrastructure Solutions Pty Ltd
1 Orchard Court
SHEPPARTON VIC 3632

Attention: Mr Trevor Woodcock

Dear Sir,

RE: GEOTECHNICAL ASSESSMENT REPORT
BAIRNSDALE LANDFILL - STAGE 2
BAIRNSDALE VIC

We have pleasure in submitting our geotechnical assessment report for the sourcing of clay material to construct an engineered clay liner at the above site. Three copies of the report are provided for your information.

We trust this report meets your current requirements for the design of the above project. Please contact the undersigned, or Mr. Bojan Knezevic at this office on (02) 6023 3799 for any queries regarding this report or further assistance.

For and on behalf of
COFFEY GEOSCIENCES PTY LTD

TONY EDWARDS - PRINCIPAL

Distribution:

3 copies	Infrastructure Solutions Pty Ltd
1 copy	Coffey Geosciences Pty Ltd Library
Original	Held by Coffey Geosciences Pty Ltd

1/314 Kiewa Street
Albury NSW 2640 Australia
PO Box 803 Albury
NSW 2640 Australia
Telephone +61 2 **6023 3799**
Facsimile +61 2 6023 3644
Email albury@coffey.com.au

Coffey Geosciences Pty Ltd ACN 056 335 516

TABLE OF CONTENTS

1. INTRODUCTION I

2. FIELDWORK I

3. LABORATORY TESTING I

4. SITE CONDITIONS II
4.1 Regional Geology ii
4.2 Subsurface Conditions ii
4.3 Groundwater ii

5. GEOTECHNICAL ASSESSMENT III
5.1 Investigation Finding. iii
5.1.1 Soil Permeability iii
5.1.2 Soil Dispersion iii
5.1.3 Liner Materials iii
5.2 Earthworks iii
5.2.1 Excavation Conditions iii
5.2.2 Fill Placement iii

6. APPLICABILITY IV

IMPORTANT INFORMATION ABOUT YOUR COFFEY REPORT

Table 2. Extraction Zones for Clay Liner Materials

Figure

1 Field Investigation Plan

Appendix

A Results of Field Investigation

B Results of Laboratory Tests

1. INTRODUCTION

This report presents a geotechnical assessment for the source of clay material to construct an engineered clay liner at the Bairnsdale Landfill – Stage 2, Bairnsdale VIC. Coffey Geosciences Pty Ltd (Coffey) carried out the geotechnical assessment that was commissioned by Mr Trevor Woodcock of Infrastructure Solutions Pty Ltd in accordance with our proposal (AW1781/1-PAA, dated 07 June 2004).

The objectives of the assessment were to determine the suitable soil from the available soil sourcing area, for use as a clay liner at the proposed landfill extension.

The scope of the work carried out to meet the above objectives included:

- Fieldwork involving the excavation and logging of 20 test pits;
- Assessment of subsurface conditions, including groundwater conditions;
- Laboratory testing including five Falling Head Permeability and eleven Emerson Crumb tests;
- Recommendations for suitable earthworks, and
- Preparation of this geotechnical report.

2. FIELDWORK

The fieldwork was carried out on 26 August 2004 and comprised excavation of twenty test pits to depths ranging from 1.8 to 3.5m below the ground level.

A geotechnician from Coffey observed the excavation of the test pits and logged the encountered subsurface soils and conditions within the test pits. Disturbed and bulk soil samples were collected from the test pits and returned to our laboratory for further assessment and testing.

Engineering excavation logs, together with explanation sheets outlining the terms and symbols used in their preparation, are presented in Appendix A.

3. LABORATORY TESTING

The following geotechnical laboratory tests were undertaken to assist in assessing the engineering properties of the soils at the site:

- 4 No. Falling Head Permeability Tests using distilled water;
- 1 No. Falling Head Permeability Test using saline solution;
- 10 No. Emerson *Crumb* Tests using distilled water, and
- 1 No. Emerson Crumb Test using saline solution.

The laboratory testing was performed in Coffey's NATA accredited laboratories in Melbourne and Sydney. The results of the tests are included in Appendix B of this report.

4. SITE CONDITIONS

4.1 Regional Geology

The published map 'Geological Survey of Victoria, Bairnsdale sheet, 1:250,000" indicates that the near surface geology of the site as:

- Quaternary aged Paludal lagoon deposits comprising silts and clays;
- Quaternary Fluvial deposits comprising gravels, sands and silts, and
- Tertiary deposits of Seaspray and Sale groups.

The results of our fieldwork indicate the presence of alluvial soils generally below a thin layer of topsoil at the site.

4.2 Subsurface Conditions

The subsurface conditions encountered within the test pits at the site during our fieldwork are summarised in Table 1.

TABLE 1: SUMMARY OF SUBSURFACE CONDITIONS

Interpreted Unit	Depth to Top of Unit (m)	Unit Thickness (m)	Description of Materials
Topsoil	0.0	0.2	SANDY SILT: low plasticity, fine to medium grained sand, dark grey, pale brown, brown. Not observed in test pit TP20.
Alluvium	0.2	Not Penetrated (>3.5m)	SANDY CLAY, CLAYEY SAND, SAND, SILTY CLAY, GRAVELLY SAND: low, medium and high plasticity, fine to medium grained sand, fine to course grained gravel, orange, pale grey, red mottles, grey; very stiff or dense to very dense. COBBLES IN SAND MATRIX in test pits TP2, TP14, TP15 and TP20 at depths of 2.5m, 1.6m, 0.8m and 0.7m, respectively.
Weathered Rock	1.7	Not Penetrated	MUDSTONE: slightly weathered, light grey. Observed in test pit TP3 only.

4.3 Groundwater

Standing groundwater was observed within the test pit TP15 only at depth of 2.2m below existing ground level at the time of our investigation. Fluctuations in groundwater level and seepage could occur due to rainfall, change in temperature and other factors.

5. GEOTECHNICAL ASSESSMENT

5.1 Investigation Finding.

5.1.1 Soil Permeability

Four Falling Head Permeability tests were carried out on remoulded soil samples collected from the test pits and resulted in permeability rates of between 3.0×10^{-9}m/sec and 8.8×10^{-11}m/sec using distilled water.

One additional Falling Head Permeability test was carried out on a remoulded Silty Clay sample of high plasticity, using 2% saline solution instead of distilled water in order to observe the effects that a saline, landfill leachate may have on the permeability of the soil. The results of the test using the saline solution indicated little or no apparent impact on the permeability of the sample, which recorded a permeability of 1.9×10^{-10}m/sec.

The laboratory soil samples used in all permeability tests were remoulded to a dry density ratio of approximately 95% Standard within a moisture ratio of ±2% of Standard Optimum Moisture Content (SOMC) and test results are presented in Appendix B of this report.

5.1.2 Soil Dispersion

A total of eleven Emerson Crumb tests were carried out in our laboratory in order to assess the dispersion characteristics of the soils. Ten of the tests were performed using potable water and one duplicate test using saline solution of 2%.

On the basis of the Emerson Crumb testing it was apparent that most of the Clayey soils are mildly dispersive when subject to potable water however the duplicate sample tested with saline solution was only slightly dispersive. Given the leachate from municipal landfills is commonly of a saline nature we assess the dispersion of the clays will not be significant in the application as a liner.

5.1.3 Liner Materials

On the basis of the field observations and the results of the laboratory tests we recommend the materials encountered in the test pits and as shown in Table 2 following the text of this report as being suitable for use as a liner for the landfill if adequately compacted and moisture conditioned. We have included in the chart some mixing of materials in adjoining layers that on the basis of the laboratory testing are expected to meet the specified criteria provided they are adequately mixed. Because of the variable nature of the soils across the site we recommend that the potential liner materials should be excavated and mixed under direction of a geotechnical practitioner, then stockpiled, sampled and tested for permeability compliance prior to placement.

5.2 Earthworks

5.2.1 Excavation Conditions

Excavation of the alluvial soils should be achievable using conventional earthmoving equipment such as excavators and scrappers. Minor water inflows are likely to be encountered if excavation is extended in to the more granular materials such as where encountered in TP15 particularly following extended rainfall periods.

5.2.2 Fill Placement

The new Clay liner material should be placed and compacted to an engineering specification in general accordance with recommendations outlined in AS3798-1996, 'Guidelines for Commercial and Residential

Developments'.

The following procedure is recommended as a guide for site preparation and the placement of controlled fill.

- The soils exposed after excavation to the design base level should be scarified to a depth of about 150mm, moisture conditioned to within ±2% of Standard Optimum Moisture Content (SOMC) and then re-compacted to a minimum dry density of 98% Standard in accordance with AS1289 5.1.1, 5.4.1 or 5.7.1.
- Any soft or weak areas identified during the compaction process that do not respond to further compaction should be removed and replaced with suitable site materials in layers not exceeding 250mm thickness and should be compacted to the above criteria.
- Subsequent layers of general fill or the Clay liner material fill should be placed in uniform 250mm loose thickness layers, moisture conditioned and compacted to the above criteria. The final layer of the Clay liner should be maintained in a moist condition until covered with a protective layer to prevent drying and cracking

Earthworks should be carried out during dry weather conditions, if possible. Provision should be made for effective diversion of surface water from outside the site. The surface runoff from the site should be treated to remove excess sediments before discharge.

6. APPLICABILITY

Recommendations and opinions contained in this report are based on the interpretation of subsurface conditions from the investigation test pits and information from published geological maps. The nature and continuity of the subsoil away from the test locations are inferred, but it must be appreciated that actual conditions could vary from the assumed geotechnical model. If conditions other than those described are encountered, Coffey should be engaged to assess whether the recommendations should be revised.

The attached "Important Information about Your Coffey Report" provides additional information in the uses and limitations of this report.

For and on behalf of
COFFEY GEOSCIENCES PTY LTD

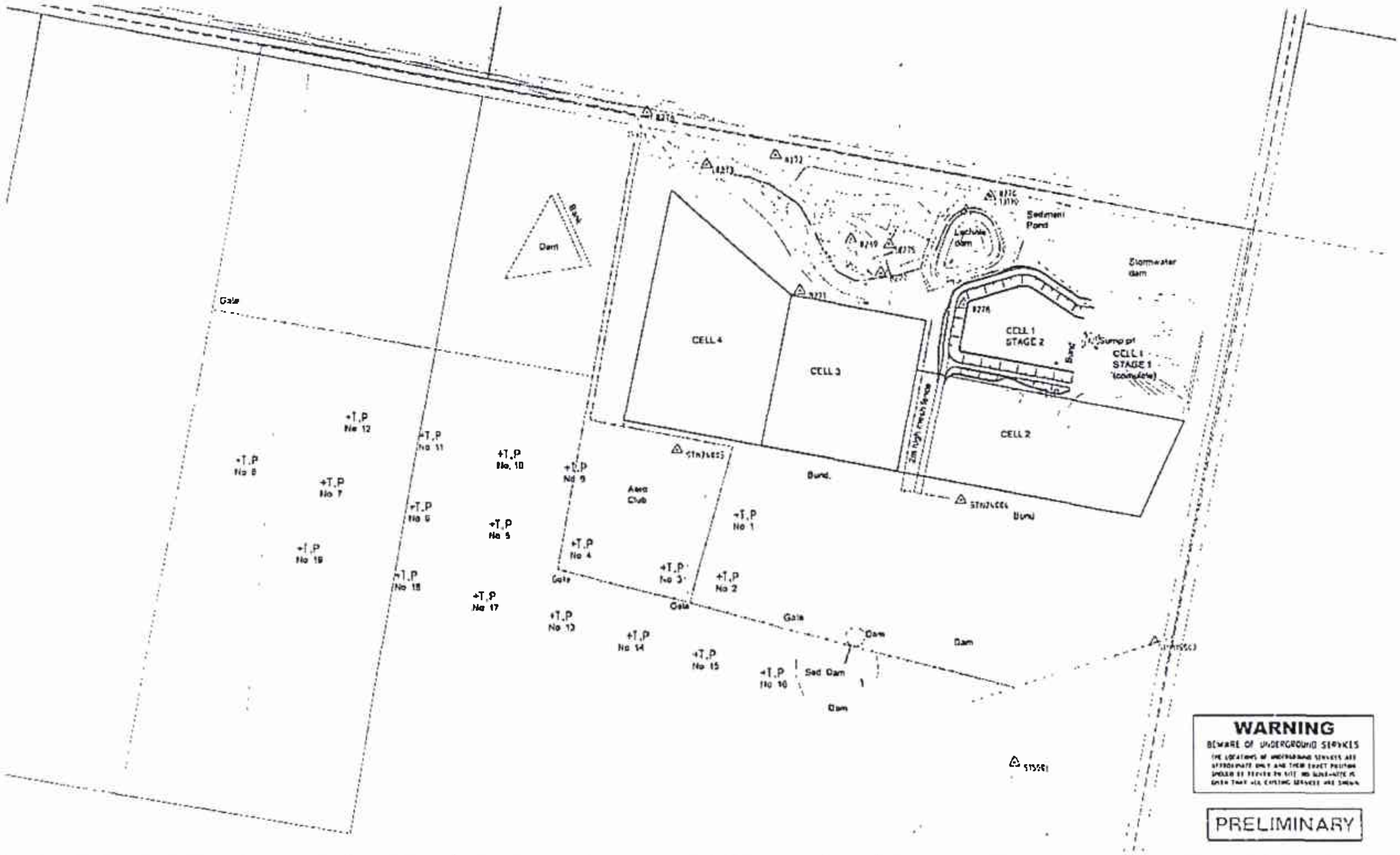
Tony Edwards - Principal

Table 2. Extraction Zones for Clay Liner Materials

Test Pit No.	Depth (m)	Material	Comments
1	0.2 – 1.0	Sandy Clay, medium plasticity.	-
2	0.2 – 0.8	Silty Clay, medium plasticity.	-
3	0.2 – 1.7	Silty Clay, high plasticity and Sandy Clay, medium plasticity.	Mixed layers
4	0.4 – 3.0	Silty Clay, medium & high plasticity	Mixed layers
5	0.2 – 3.0	Silty Clay & Sandy Clay, medium & high plasticity.	Mixed layers
6	0.2 – 3.0	Silty Clay & Sandy Clay, medium & high plasticity.	Mixed layers
7	0.2 – 2.2	Silty Clay, high plasticity	-
8	0.2 – 3.0	Silty Clay & Sandy Clay, medium & high plasticity	Mixed layers
9	0.2 – 2.1	Silty Clay, medium & high plasticity	Mixed layers
10	0.2 – 1.5	Silty Clay, medium & high plasticity	Mixed layers
11	0.2 – 3.4	Silty clay, medium & high plasticity	Mixed layers
12	0.2 – 3.0	Silty Clay, medium & high plasticity	Mixed layers
13	0.2 – 3.0	Silty Clay, medium & high plasticity	Mixed layers
16	0.2 – 2.5	Silty Clay, medium plasticity.	-
17	0.2 – 3.1	Silty Clay, medium & high plasticity	Mixed layers
18	0.2 – 1.7	Silty Clay, medium & high plasticity	Mixed layers
19	0.2 – 1.6	Silty Clay, medium & high plasticity	Mixed layers

Materials from TP's, 14, 15 & 20 not assessed as suitable for liner use.

Refer to figure 1 for test pit locations.



Notes:

LEGEND

✦ T.P Denotes approximate location of Test Pit.

Coffey Geosciences Pty Ltd ACN 056 335 516

Geotechnical | **Resources** | Environmental | **Technical** | Project Management

Drawn	RK
Approved	
Date	18.10.2004
Scale	N.T.S

INFRASTRUCTURE SOLUTIONS PTY LTD
BAIRNSDALE LANDFILL, STAGE 2,
BAIRNSDALE VIC
FIELD INVESTIGATION PLAN

Figure No:
1

Job No.
AW1781/1-AB

Information

Important information about your **Coffey** Report

As a client of Coffey you should know that site subsurface conditions cause more construction problems than any other factor. These notes have been prepared by Coffey to help you interpret and understand the limitations of your report.

Your report is based on project specific criteria

Your report has been developed on the basis of your unique project specific requirements as understood by Coffey and applies only to the site investigated. Project criteria typically include the general nature of the project; its size and configuration; the location of any structures on the site; other site improvements; the presence of underground utilities; and the additional risk imposed by scope-of-service limitations imposed by the client. Your report should not be used if there are any changes to the project without first asking Coffey to assess how factors that changed subsequent to the date of the report affect the report's recommendations. Coffey cannot accept responsibility for problems that may occur due to changed factors if they are not consulted.

Subsurface conditions can change

Subsurface conditions are created by natural processes and the activity of man. For example, water levels can vary with time, fill may be placed on a site and pollutants may migrate with time. Because a report is based on conditions which existed at the time of the subsurface exploration, decisions should not be based on a report whose adequacy may have been affected by time. Consult Coffey to be advised how time may have impacted on the project.

Interpretation of factual data

Site assessment identifies actual subsurface conditions only at those points where samples are taken and when they are taken. Data derived from literature and external data source review, sampling and subsequent laboratory testing are interpreted by geologists, engineers or scientists to provide an opinion about overall site conditions, their likely impact on the proposed development and recommended actions. Actual conditions may differ from those inferred to exist, because no professional, no matter how qualified, can reveal what is hidden by earth, rock and time. The actual interface between materials may be far more gradual or abrupt than assumed based on the facts obtained. Nothing can be done to change the actual site conditions which exist, but steps can be taken to reduce the impact of unexpected conditions. For this reason, owners should retain the services of Coffey through the development stage, to identify variances, conduct additional tests if required, and recommend solutions to problems encountered on site.

Your report will only give preliminary recommendations

Your report is based on the assumption that the site conditions as revealed through selective point sampling are indicative of actual conditions throughout an area. This assumption cannot be substantiated until project implementation has commenced and therefore your report recommendations can only be regarded as preliminary. Only Coffey, who prepared the report, is fully familiar with the background information needed to assess whether or not the report's recommendations are valid and whether or not changes should be considered as the project develops. If another party undertakes the implementation of the recommendations of this report there is a risk that the report will be misinterpreted and Coffey cannot be held responsible for such misinterpretation.

Your report is prepared for specific purposes and persons

To avoid misuse of the information contained in your report it is recommended that you confer with Coffey before passing your report on to another party who may not be familiar with the background and the purpose of the report. Your report should not be applied to any project other than that originally specified at the time the report was issued.

Interpretation by other design professionals

Costly problems can occur when other design professionals develop their plans based on misinterpretations of a report. To help avoid misinterpretations, retain Coffey to work with other project design professionals who are affected by the report. Have Coffey explain the report implications to design professionals affected by them and then review plans and specifications produced to see how they have incorporated the report findings.

Data should not be separated from the report*

The report as a whole presents the findings of the site assessment and the report should not be copied in part or altered in any way.

Logs, figures, drawings etc. are customarily included in our reports and are developed by scientists, engineers or geologists based on their interpretation of field logs (assembled by field personnel) and laboratory evaluation of field samples. These logs etc. should not under any circumstances be redrawn for inclusion in other documents or separated from the report in any way.

Geoenvironmental concerns are not at issue

Your report is not likely to relate any findings, conclusions, or recommendations about the potential for hazardous materials existing at the site unless specifically required to do so by the client. Specialist equipment, techniques, and personnel are used to perform a geoenvironmental assessment. Contamination can create major health, safety and environmental risks. If you have no information about the potential for your site to be contaminated or create an environmental hazard, you are advised to contact Coffey for information relating to geoenvironmental issues.

Rely on Coffey for additional assistance

Coffey is familiar with a variety of techniques and approaches that can be used to help reduce risks for all parties to a project, from design to construction. It is common that not all approaches will be necessarily dealt with in your site assessment report due to concepts proposed at that time. As the project progresses through design toward construction, speak with Coffey to develop alternative approaches to problems that may be of genuine benefit both in time and cost.

Responsibility

Reporting relies on interpretation of factual information based on judgement and opinion and has a level of uncertainty attached to it, which is far less exact than the design disciplines. This has often resulted in claims being lodged against consultants, which are unfounded. To help prevent this problem, a number of clauses have been developed for use in contracts, reports and other documents. Responsibility clauses do not transfer appropriate liabilities from Coffey to other parties but are included to identify where Coffey's responsibilities begin and end. Their use is intended to help all parties involved to recognise their individual responsibilities. Read all documents from Coffey closely and do not hesitate to ask any questions you may have.

** For further information on this aspect reference should be made to "Guidelines for the Provision of Geotechnical Information in Construction Contracts" published by the Institution of Engineers Australia, National Headquarters, Canberra, 1987.*

APPENDIX A

Results of Field Investigation

Explanation Sheets

Engineering Logs

Soil Description

Explanation Sheet (1 of 2)

DEFINITION:

In engineering terms soil includes every type of uncemented or partially cemented inorganic or organic material found in the ground. In practice, if the material can be remoulded or disintegrated by hand in its field condition or in water it is described as a soil.

Other materials are described using rock description terms.

CLASSIFICATION SYMBOL & SOIL NAME

Soils are described in accordance with the Unified Soil Classification (UCS) as shown in the table on Sheet 2.

PARTICLE SIZE DESCRIPTIVE TERMS

NAME	SUBDIVISION	SIZE
Boulders		>200 mm
Cobbles		63 mm to 200 mm
Gravel	coarse	20 mm to 63 mm
	medium	6 mm to 20 mm
	fine	2.36 mm to 6 mm
Sand	coarse	600 μm to 2.36 mm
	medium	200 μm to 600μm
	fine	75 μm to 200 μm

MOISTURE CONDITION

Dry	Looks and feels dry. Cohesive and cemented soils are hard, friable or powdery. Uncemented granular soils run freely through hands.
Moist	Soil feels cool and darkened in colour. Cohesive soils can be moulded. Granular soils tend to cohere.
Wet	As for moist but with free water forming on hands when handled.

CONSISTENCY OF COHESIVE SOILS

TERM	UNDRAINED STRENGTH s_u (kPa)	FIELD GUIDE
Very Soft	<12	A finger can be pushed well into the soil with little effort.
Soft	12 - 25	A finger can be pushed into the soil to about 25mm depth.
Firm	25 - 50	The soil can be indented about 5mm with the thumb, but not penetrated.
Stiff	50 - 100	The surface of the soil can be indented with the thumb, but not penetrated.
Very Stiff	100 - 200	The surface of the soil can be marked, but not indented with thumb pressure.
Hard	>200	The surface of the soil can be marked only with the thumbnail.
Friable	-	Crumbles or powders when scraped by thumbnail.

DENSITY OF GRANULAR SOILS

TERM	DENSITY INDEX (%)
Very loose	Less than 15
Loose	15 - 35
Medium Dense	35 - 65
Dense	65 — 85
Very Dense	Greater than 85

MINOR COMPONENTS

TERM	ASSESSMENT GUIDE	PROPORTION OF MINOR COMPONENT IN:
Trace of	Presence just detectable by feel or eye, but soil properties little or no different to general properties of primary component.	Coarse grained soils: < 5% Fine grained soils: <15%
With some	Presence easily detected by feel or eye, soil properties little different to general properties of primary component.	Coarse grained soils: 5 - 12% Fine grained soils: 15 - 30%

SOIL STRUCTURE

ZONING		CEMENTING	
Layers	Continuous across exposure or sample.	Weakly cemented	Easily broken up by hand in air or water.
Lenses	Discontinuous layers of lenticular shape.	Moderately cemented	Effort is required to break up the soil by hand in air or water.
Pockets	Irregular inclusions of different material.		

GEOLOGICAL ORIGIN

WEATHERED IN PLACE SOILS

Extremely weathered material	Structure and fabric of parent rock visible.
Residual soil	Structure and fabric of parent rock not visible.

TRANSPORTED SOILS

Aeolian soil	Deposited by wind.
Alluvial soil	Deposited by streams and rivers.
Colluvial soil	Deposited on slopes (transported downslope by gravity).
Fill	Man made deposit. Fill may be significantly more variable between tested locations than naturally occurring soils.
Lacustrine soil	Deposited by lakes.
Marine soil	Deposited in ocean basins, bays, beaches and estuaries.

Explanation Sheet (2 of 2) – Soil Description

SOIL CLASSIFICATION INCLUDING IDENTIFICATION AND DESCRIPTION

<table>
<tr><th colspan="6">FIELD IDENTIFICATION PROCEDURES
(Excluding particles larger than 60 mm and basing fractions on estimated mass)</th><th>USC</th><th>PRIMARY NAME</th></tr>
<tr><td rowspan="8">COARSE GRAINED SOILS
More than 50% of material less than 63 mm is larger than 0.075 mm</td><td rowspan="16">(A 0.075 mm particle is about the smallest particle visible to the naked eye)</td><td rowspan="4">GRAVELS
More than half of coarse fraction is larger than 2.0 mm</td><td rowspan="2">CLEAN GRAVELS
(Little or no fines)</td><td colspan="2">Wide range in grain size and substantial amounts of all intermediate particle sizes</td><td>GW</td><td>GRAVEL</td></tr>
<tr><td colspan="2">Predominantly one size or a range of sizes with more intermediate sizes missing</td><td>GP</td><td>GRAVEL</td></tr>
<tr><td rowspan="2">GRAVELS WITH FINES
(Appreciable amount of fines)</td><td colspan="2">Non-plastic fines (for identification procedures see ML below)</td><td>GM</td><td>SILTY GRAVEL</td></tr>
<tr><td colspan="2">Plastic fines (for identification procedures see CL below)</td><td>GC</td><td>CLAYEY GRAVEL</td></tr>
<tr><td rowspan="4">SANDS
More than half of coarse fraction is smaller than 2.0 mm</td><td rowspan="2">CLEAN SANDS
(Little or no fines)</td><td colspan="2">Wide range in grain sizes and substantial amounts of all intermediate sizes missing</td><td>SW</td><td>SAND</td></tr>
<tr><td colspan="2">Predominantly one size or a range of sizes with some intermediate sizes missing</td><td>SP</td><td>SAND</td></tr>
<tr><td rowspan="2">SANDS WITH FINES
(Appreciable amount of fines)</td><td colspan="2">Non-plastic fines (for identification procedures see ML below)</td><td>SM</td><td>SILTY SAND</td></tr>
<tr><td colspan="2">Plastic fines (for identification procedures see CL below)</td><td>SC</td><td>CLAYEY SAND</td></tr>
<tr><td rowspan="8">FINE GRAINED SOILS
More than 50% of material less than 63 mm is smaller than 0.075 mm</td><td></td><td colspan="3">IDENTIFICATION PROCEDURES ON FRACTIONS <0.2 mm</td><td></td><td></td></tr>
<tr><td></td><td>DRY STRENGTH</td><td>DILATANCY</td><td>TOUGHNESS</td><td></td><td></td></tr>
<tr><td rowspan="3">SILTS & CLAYS
Liquid limit less than 50</td><td>None to Low</td><td>Quick to slow</td><td>None</td><td>ML</td><td>SILT</td></tr>
<tr><td>Medium to High</td><td>None</td><td>Medium</td><td>CL</td><td>CLAY</td></tr>
<tr><td>Low to medium</td><td>Slow to very slow</td><td>Low</td><td>OL</td><td>ORGANIC SILT</td></tr>
<tr><td rowspan="3">SILTS & CLAYS
Liquid limit greater than 50</td><td>Low to medium</td><td>Slow to very slow</td><td>Low to medium</td><td>MH</td><td>SILT</td></tr>
<tr><td>High</td><td>None</td><td>High</td><td>CH</td><td>CLAY</td></tr>
<tr><td>Medium to high</td><td>None</td><td>Low to medium</td><td>OH</td><td>ORGANIC CLAY</td></tr>
<tr><td colspan="3">HIGHLY ORGANIC SOILS</td><td colspan="3">Readily identified by colour, odour, spongy feel and frequently by fibrous texture</td><td>Pt</td><td>PEAT</td></tr>
<tr><td colspan="8">• Low plasticity - Liquid Limit W_L less than 35% • Medium plasticity - W_L between 35% and 50%</td></tr>
</table>

COMMON DEFECTS IN SOIL

TERM	DEFINITION	DIAGRAM
PARTING	A surface or crack across which the soil has little or no tensile strength. Parallel or sub parallel to layering (eg bedding). May be open or closed.	
JOINT	A surface or crack across which the soil has little or no tensile strength but which is not parallel or sub parallel to layering. May be open or closed. The term 'fissure' may be used for irregular joints <0.2m in length.	
SHEARED ZONE	Zone in clayey soil with roughly parallel near planar, curved or undulating boundaries containing closely spaced, smooth or slickensided, curved intersecting joints which divide the mass into lenticular or wedge shaped blocks.	
SHEARED SURFACE	A near planar curved or undulating, smooth, polished or slickensided surface in clayey soil. The polished or slickensided surface indicates that movement (in many cases very little) has occurred along the defect.	

TERM	DEFINITION	DIAGRAM
SOFTENED ZONE	A zone in clayey soil, usually adjacent to a defect in which the soil has a higher moisture content than elsewhere.	
TUBE	Tubular cavity. May occur singly or as one of a large number of separate or inter-connected tubes. Walls often coated with clay or strengthened by denser packing of grains. May contain organic matter.	
TUBE CAST	Roughly cylindrical elongated body of soil different from the soil mass in which it occurs. In some cases the soil which makes up the tube cast is cemented.	
INFILLED SEAM	Sheet or wall like body of soil substance or mass with roughly planar to irregular near parallel boundaries which cuts through a soil mass. Formed by infilling of open joints.	

Coffey Geosciences Pty Ltd ACN 056 335 516

Engineering log - Excavation

Excavation No. *TP01*
Sheet 1 of 1
Office Job No.: *AW1781/1*

Client: *Infrastructure Solutions Pty Ltd*
Principal:
Project: *Bairnsdale Landfill - Stage 2*
Test pit location: *Refer to Figure 1*

Date started: *12.8.2004*
Date completed: *12.8.2004*
Logged by: *MFT*
Checked by: RAL

equipment type and model: Backhoe
Pit Orientation:
Easting: m
R.L. Surface: Not Measured
excavation dimensions: 5m long 0.8m wide
Northing: m
datum:

excavation information							material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
BH		N	None Observed					ML	**SANDY SILT:** low plasticity, dark grey, fine to medium grained sand	D	F		Topsoil
						0.5		CL	**SANDY CLAY:** medium plasticity, orange to pale grey, fine to medium grained sand	M	VSt		Alluvial
				Bs								×	
						1.0							
								SC	**CLAYEY SAND:** fine to medium grained, orange, low plasticity clay		D		
						1.5			with red staining				
						2.0							
								SP	**SAND:** fine to medium grained, orange				
						2.5							
						3.0							
									Test pit TP01 terminated at 3m				
						3.5							
						4.0							

Sketch

method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator

support

S shoring N nil

penetration

water

water level on date shown
water inflow
water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Coffey Geosciences Pty Ltd ACN 056 335 516

Engineering log - Excavation

Excavation No. *TP02*
Sheet 1 of 1
Office Job No.: *AW1781/1*

Client: *Infrastructure Solutions Pty Ltd*
Principal:
Project: *Bairnsdale Landfill - Stage 2*
Test pit location: *Refer to Figure 1*

Date started: *12.8.2004*
Date completed: *12.8.2004*
Logged by: *MFT*
Checked by:

equipment type and model:	Backhoe	Pit Orientation:	Easting: m	R.L. Surface:	Not Measured
excavation dimensions:	5m long 0.8m wide		Northing: m	datum:	

excavation information							material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
BH		N	None Observed					ML	**SANDY SILT:** low plasticity, brown to pale grey, fine to medium grained sand	M	F		Topsoil
								CL	**SILTY CLAY:** medium plasticity, orange		VSt	600	Alluvial
				D		0.5							
								SP	**SAND:** fine to medium grained, orange with red mottles		D		
						1.0							
									becoming orange to pale grey in colour				
						1.5							
						2.0							
									with some cobbles up to 200mm in diameter		VD		
						2.5							
									COBBLES IN A SAND MATRIXupto 200mm in diameter, rounded, fine to coarse grained orange sand, with some fine to coarse grained gravel				
						3.0			Test pit TP02 terminated at 3m				
						3.5							
						4.0							

Sketch

method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator

support

S shoring N nil

penetration

1 2 3 4 no resistance ranging to refusal

water

▼ water level on date shown

► water inflow

◄ water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description
based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Coffey Geosciences Pty Ltd ACN 056 335 516

Engineering log - Excavation

Excavation No.	*TP03*
Sheet	1 of 1
Office Job No.:	*AW1781/1*
Client:	*Infrastructure Solutions Pty Ltd*
Principal:	
Project:	*Bairnsdale Landfill - Stage 2*
Test pit location:	*Refer to Figure 1*
Date started:	*12.8.2004*
Date completed:	*12.8.2004*
Logged by:	*MFT*
Checked by:	

equipment type and model:	Backhoe	Pit Orientation:		Easting:	m	R.L. Surface:	Not Measured
excavation dimensions:	5m long 0.8m wide			Northing:	m	datum:	

excavation information							material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
BH		N	None Observed					SM	**SILTY SAND:** fine to medium grained, grey	D	MD		Topsoil
						0.5		CH	**SILTY CLAY:** high plasticity, orange to pale grey	M	VSt	×	Alluvial
				Bs		1.0							
						1.5		CL	**SANDY CLAY:** medium plasticity, orange to pale grey with red mottles, fine grained sand			×	
				D					**MUDSTONE:** low strength, slightly weathered, light grey				
						2.0			Refusal Test pit TP03 terminated at 1.8m				
						2.5							
						3.0							
						3.5							
						4.0							

Sketch

method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator

support

S	shoring	N	nil

penetration

1 2 3 4 no resistance ranging to refusal

water

▼	water level on date shown
▶—	water inflow
◀—	water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Coffey Geosciences Pty Ltd ACN 056 335 516

Engineering log - Excavation

Excavation No. *TP04*
Sheet 1 of 1
Office Job No.: *AW1781/1*

Client: *Infrastructure Solutions Pty Ltd*
Principal:
Project: *Bairnsdale Landfill - Stage 2*
Test pit location: *Refer to Figure 1*

Date started: *12.8.2004*
Date completed: *12.8.2004*
Logged by: *MFT*
Checked by: BAR.

equipment type and model: Backhoe
Pit Orientation:
Easting: m
R.L. Surface: Not Measured
excavation dimensions: 5m long 0.8m wide
Northing: m
datum:

excavation information							material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
BH		N	None Observed					ML	**SANDY SILT:** low plasticity, brown, fine to medium grained sand	M	F	×	Topsoil
								CL	**SANDY CLAY:** low plasticity, brown, fine to medium grained sand		VSt		Alluvial
						0.5		CH	**SILTY CLAY:** high plasticity, orange with black mottles				
						1.0						×	
						1.5						×	
								CL	**SILTY CLAY:** medium plasticity, orange to pale brown				
				D		2.0							
				Bs		2.5							
						3.0			Test pit TP04 terminated at 3m				
						3.5							
						4.0							

Sketch

method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator

support

S shoring N nil

penetration

1 2 3 4 no resistance ranging to refusal

water

▼ water level on date shown
▶ water inflow
◀ water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Coffey Geosciences Pty Ltd ACN 056 335 516

Engineering log - Excavation

Excavation No. *TP05*

Sheet 1 of 1

Office Job No.: *AW1781/1*

Client: *Infrastructure Solutions Pty Ltd*

Principal:

Project: *Bairnsdale Landfill - Stage 2*

Test pit location: *Refer to Figure 1*

Date started: *12.8.2004*

Date completed: *12.8.2004*

Logged by: *MFT*

Checked by:

equipment type and model: Backhoe

Pit Orientation:

Easting: m

R.L. Surface: Not Measured

excavation dimensions: 5m long 0.8m wide

Northing: m

datum:

excavation information							material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
BH		N	None Observed					ML	**SANDY SILT:** low plasticity, brown, fine to medium grained sand	M	D		Topsoil
						0.5	▨	CH	**SILTY CLAY:** high plasticity, orange		VSt	x	Alluvial
						1.0 1.5	▨	CL	**SANDY CLAY:** medium plasticity, orange to pale grey, fine grained sand			600 x	
						2.0 2.5 3.0	▨	CL	**SILTY CLAY:** medium plasticity, orange to pale grey with red mottles				
						3.5 4.0			Test pit TP05 terminated at 3m				

Sketch

method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator

support

S shoring N nil

penetration

1 2 3 4 no resistance ranging to refusal

water

▼ water level on date shown

► water inflow

◄ water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Coffey Geosciences Pty Ltd ACN 056 335 516

Engineering log - Excavation

Excavation No.	*TP06*
Sheet	1 of 1
Office Job No.:	*AW1781/1*
Client:	*Infrastructure Solutions Pty Ltd*
Principal:	
Project:	*Bairnsdale Landfill - Stage 2*
Test pit location:	*Refer to Figure 1*
Date started:	*12.8.2004*
Date completed:	*12.8.2004*
Logged by:	*MFT*
Checked by:	RBK

equipment type and model:	Backhoe	Pit Orientation:		Easting:	m	R.L. Surface:	Not Measured
excavation dimensions:	5m long 0.8m wide			Northing:	m	datum:	

excavation information							material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
BH		N	None Observed					ML	**SANDY SILT:** low plasticity, brown, fine to medium grained sand	M	D		Topsoil
							▨	CH	**SILTY CLAY:** high plasticity, orange		VSt	x	Alluvial
						0.5	▨						
				Bs			▨						
						1.0	▨						
							▨		becoming orange to pale grey in colour, with red mottles				
						1.5	▨	CL	**SANDY CLAY:** medium plasticity, orange to pale grey with red mottles, fine grained sand				
						2.0	▨					x	
						2.5	▨						
				Bs			▨						
						3.0			Test pit TP06 terminated at 3m				
						3.5							
						4.0							

Sketch

method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator

support

S shoring N nil

penetration

1 2 3 4 no resistance ranging to refusal

water

▼ water level on date shown

► water inflow

◄ water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Coffey Geosciences Pty Ltd ACN 056 335 516

Engineering log - Excavation

Excavation No. **TP07**
Sheet 1 of 1
Office Job No.: **AW1781/1**

Client:	*Infrastructure Solutions Pty Ltd*
Principal:	
Project:	*Bairnsdale Landfill - Stage 2*
Test pit location:	*Refer to Figure 1*
Date started:	*12.8.2004*
Date completed:	*12.8.2004*
Logged by:	*MFT*
Checked by:	

equipment type and model:	Backhoe	Pit Orientation:	Easting: m	R.L. Surface:	Not Measured
excavation dimensions:	5m long 0.8m wide		Northing: m	datum:	

excavation information / **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
BH		N	None Observed					ML	**SANDY SILT:** low plasticity, grey, fine to medium grained sand	M	F		Topsoil
						0.5 1.0 1.5 2.0		CH	**SILTY CLAY:** high plasticity, orange, with some fine to medium grained SAND becoming orange to pale grey with red mottles in colour with some cobbles up to 200mm in diameter		VSt	x	Alluvial
						2.5		SP	**GRAVELLY SAND:** fine to medium grained, orange, fine to coarse grained gravel, with some cobbles up to 200mm in diameter		VD		
						3.0 3.5 4.0			Test pit TP07 terminated at 2.7m				

Sketch

method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator

support

S shoring N nil

penetration

1 2 3 4 no resistance ranging to refusal

water

▼ water level on date shown

► water inflow

◄ water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description
based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Coffey Geosciences Pty Ltd ACN 056 335 516

Engineering log - Excavation

Excavation No. ***TP08***
Sheet 1 of 1
Office Job No.: ***AW1781/1***

Client: ***Infrastructure Solutions Pty Ltd***
Principal:
Project: ***Bairnsdale Landfill - Stage 2***
Test pit location: ***Refer to Figure 1***

Date started: ***12.8.2004***
Date completed: ***12.8.2004***
Logged by: ***MFT***
Checked by: BR

equipment type and model:	Backhoe	Pit Orientation:		Easting:	m	R.L. Surface:	Not Measured
excavation dimensions:	5m long 0.8m wide			Northing:	m	datum:	

excavation information / **material substance**

method	penetration 1 2 3	support	water	**notes** samples, tests, etc	RL	depth metres	graphic log	classification symbol	**material** soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	**structure and additional observations**
BH		N	None Observed					ML	**SANDY SILT:** low plasticity, brown, fine to medium grained sand	M	F		Topsoil
						0.5 1.0 1.5	▨	CH	**SILTY CLAY:** high plasticity, orange to pale grey, with red mottles		VSt	×	Alluvial
						2.0	▨	CL	**SANDY CLAY:** medium plasticity, orange tp pale grey, fine grained sand				
						2.5 3.0	▨	CL	**SILTY CLAY:** medium plasticity, orange to pale grey			600×	
						3.5 4.0			Test pit TP08 terminated at 3m				

Sketch

method

N	natural exposure
X	*existing excavation*
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator

support

S shoring N nil

penetration

1 2 3 4 no resistance ranging to refusal

water

▼ water level on date shown

► water inflow

◄ water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Coffey Geosciences Pty Ltd ACN 056 335 516

Engineering log - Excavation

Excavation No. *TP09*
Sheet 1 of 1
Office Job No.: *AW1781/1*

Client: *Infrastructure Solutions Pty Ltd*
Principal:
Project: *Bairnsdale Landfill - Stage 2*
Test pit location: *Refer to Figure 1*

Date started: *13.8.2004*
Date completed: *13.8.2004*
Logged by: *MFT*
Checked by:

equipment type and model:	Backhoe	Pit Orientation:	Easting: m	R.L. Surface:	Not Measured
excavation dimensions:	5m long 0.8m wide		Northing: m	datum:	

excavation information							material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/density index	pocket penetrometer kPa 100 200 300 400	structure and additional observations
BH		N	None Observed					ML	**SANDY SILT:** low plasticity, brown, fine to medium grained sand	M	F		Topsoil
								CH	**SILTY CLAY:** high plasticity, brownish orange		VSt		Alluvial
						0.5						x	
						1.0							
								CL	**SILTY CLAY:**medium plasticity, orange to pale grey				
						1.5							
				Bs				CL	**SANDY CLAY:** medium plasticity, orange to pale brown, fine grained sand				
						2.0							
								SC	**CLAYEY SAND:**fine to medium grained, orange		VD		
						2.5							
						3.0							
									Test pit TP09 terminated at 3m				
						3.5							
						4.0							

Sketch

TESTPIT AW1781.1.GPJ COFFEY.GDT 15.09.04

method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator

support

S shoring N nil

penetration

1 2 3 4
no resistance ranging to refusal

water

water level on date shown
water inflow
water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description
based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Form GEO 5.2 Issue 3 Rev.2

Coffey Geosciences Pty Ltd ACN 056 335 516

Excavation No. *TP10*

Engineering log - Excavation

Sheet 1 of 1
Office Job No.: *AW1781/1*

Client:	*Infrastructure Solutions Pty Ltd*	Date started:	*13.8.2004*
Principal:		Date completed:	*13.8.2004*
Project:	*Bairnsdale Landfill - Stage 2*	Logged by:	*MFT*
Test pit location:	*Refer to Figure 1*	Checked by:	

equipment type and model:	Backhoe	Pit Orientation:		Easting:	m	R.L. Surface:	Not Measured
excavation dimensions:	5m long 0.8m wide			Northing:	m	datum:	

excavation information / **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetrometer kPa 100 200 300 400	structure and additional observations
BH		N	None Observed					ML	**SANDY SILT:** low plasticity, brown, fine to medium grained sand	M	F		Topsoil
						0.5		CH	**SILTY CLAY:** high plasticity, brownish orange		VSt	x	Alluvial
						1.0		CL	**SILTY CLAY:**medium plasticity, orange to pale brown				
						1.5 2.0 2.5		SC	**CLAYEY SAND:** fine to medium grained, orange		VD		
						3.0 3.5 4.0			Test pit TP10 terminated at 3m				

Sketch

method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator

support

S shoring N nil

penetration

1 2 3 4 no resistance ranging to refusal

water

▼ water level on date shown

► water inflow

◄ water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Coffey Geosciences Pty Ltd ACN 056 335 516

Engineering log - Excavation

Excavation No. *TP11*
Sheet 1 of 1
Office Job No.: *AW1781/1*

Client: *Infrastructure Solutions Pty Ltd*
Principal:
Project: *Bairnsdale Landfill - Stage 2*
Test pit location: *Refer to Figure 1*

Date started: *13.8.2004*
Date completed: *13.8.2004*
Logged by: *MFT*
Checked by: BU

equipment type and model: Backhoe
Pit Orientation:
Easting: m
R.L. Surface: Not Measured
excavation dimensions: 5m long 0.8m wide
Northing: m
datum:

excavation information / material substance

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
BH		N	None Observed					ML	**SANDY SILT:** low plasticity, brown, fine to medium grained sand	M	F	600	Topsoil
							▨	CH	**SILTY CLAY:** high plasticity, orange		VSt		Alluvial
						0.5	▨						
							▨	CL	**SILTY CLAY:** medium plasticity, orange to pale grey with red mottles			x	
						1.0	▨						
						1.5	▨						
						2.0	▨						
						2.5	▨		becoming orange to pale grey with with black mottles in colour				
						3.0	▨						
						3.5			Test pit TP11 terminated at 3.4m				
						4.0							

Sketch

method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator

support

S shoring N nil

penetration

1 2 3 4 no resistance ranging to refusal

water

▼ water level on date shown
► water inflow
◄ water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

TESTPIT AW1781.1.GPJ COFFEY.GDT 15.09.04

Form GEO 5.2 Issue 3 Rev.2

Coffey Geosciences Pty Ltd ACN 056 335 516

Engineering log - Excavation

Excavation No. *TP12*
Sheet 1 of 1
Office Job No.: *AW1781/1*

Client: *Infrastructure Solutions Pty Ltd*
Principal:
Project: *Bairnsdale Landfill - Stage 2*
Test pit location: *Refer to Figure 1*

Date started: *13.8.2004*
Date completed: *13.8.2004*
Logged by: *MFT*
Checked by:

equipment type and model: Backhoe
Pit Orientation:
Easting: m
R.L. Surface: Not Measured
excavation dimensions: 5m long 0.8m wide
Northing: m
datum:

excavation information							material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
BH		N	None Observed					ML	**SANDY SILT:** low plasticity, brown, fine to medium grained sand	M	F		Topsoil
							▨	CH	**SILTY CLAY:** high plasticity, orange, with some fine grained sand		VSt		Alluvial
						0.5	▨					×	
						1.0	▨						
							▨	CL	**SILTY CLAY:** medium plasticity, orange to pale grey with red mottles			×	
						1.5	▨						
				Bs			▨						
						2.0	▨						
						2.5	▨						
						3.0	▨						
									Test pit TP12 terminated at 3m				
						3.5							
						4.0							

Sketch

method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator

support
S shoring N nil

penetration
1 2 3 4
no resistance ranging to refusal

water
water level on date shown
water inflow
water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description
based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Coffey Geosciences Pty Ltd ACN 056 335 516

Engineering log - Excavation

Excavation No. *TP13*
Sheet 1 of 1
Office Job No.: *AW1781/1*

Client: *Infrastructure Solutions Pty Ltd*
Principal:
Project: *Bairnsdale Landfill - Stage 2*
Test pit location: *Refer to Figure 1*

Date started: *13.8.2004*
Date completed: *13.8.2004*
Logged by: *MFT*
Checked by:

equipment type and model: Backhoe
Pit Orientation:
Easting: m
R.L. Surface: Not Measured
excavation dimensions: 5m long 0.8m wide
Northing: m
datum:

excavation information							material substance							
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
BH		N	None Observed					ML	**SANDY SILT:** low plasticity, brown, fine to medium grained sand	M	F		Topsoil
							▨	CH	**SILTY CLAY:** high plasticity, orange		VSt	x	Alluvial
						0.5	▨						
						1.0	▨						
							▨		becoming orange to pale grey with red mottles in colour				
						1.5	▨	CL	**SILTY CLAY:** medium plasticity, orange to pale grey with red mottles				
						2.0	▨						
						2.5	▨						
						3.0			Test pit TP13 terminated at 3m				
						3.5							
						4.0							

Sketch

method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator

support

S shoring N nil

penetration

1 2 3 4 no resistance ranging to refusal

water

▼ water level on date shown

► water inflow

◄ water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description
based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Coffey Geosciences Pty Ltd ACN 056 335 516

Engineering log - Excavation

Excavation No.	*TP14*
Sheet	1 of 1
Office Job No.:	*AW1781/1*
Client:	*Infrastructure Solutions Pty Ltd*
Principal:	
Project:	*Bairnsdale Landfill - Stage 2*
Test pit location:	*Refer to Figure 1*
Date started:	*13.8.2004*
Date completed:	*13.8.2004*
Logged by:	*MFT*
Checked by:	

equipment type and model:	Backhoe	Pit Orientation:		Easting:	m	R.L. Surface:	Not Measured
excavation dimensions:	5m long 0.8m wide			Northing:	m	datum:	

excavation information							material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
BH		N	None Observed				▥	ML	**SANDY SILT:** low plasticity, brown, fine to medium grained sand	M	F		Topsoil
				Bs		0.5	▨	CL	**SANDY CLAY:** medium plasticity, orange to pale grey, fine grained sand		VSt	x	Alluvial
						1.0 1.5	▨	SC	**CLAYEY SAND:** fine to medium grained, orange		VD		
						2.0 2.5 3.0	▨		**COBBLES IN A SAND MATRIX**upto 200mm in diameter, rounded, fine to coarse grained orange sand, with some fine to coarse grained gravel				
						3.5 4.0			Test pit TP14 terminated at 3m				

Sketch

method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator

support

S shoring N nil

penetration

1 2 3 4 no resistance ranging to refusal

water

▼ water level on date shown

► water inflow

◄ water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Coffey Geosciences Pty Ltd ACN 056 335 516

Engineering log - Excavation

Excavation No. *TP15*
Sheet 1 of 1
Office Job No.: *AW1781/1*

Client: *Infrastructure Solutions Pty Ltd*
Principal:
Project: *Bairnsdale Landfill - Stage 2*
Test pit location: *Refer to Figure 1*

Date started: *13.8.2004*
Date completed: *13.8.2004*
Logged by: *MFT*
Checked by:

Coffey

equipment type and model: Backhoe
Pit Orientation:
Easting: m
R.L. Surface: Not Measured
excavation dimensions: 5m long 0.8m wide
Northing: m
datum:

excavation information							material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
BH		N						ML	**SANDY SILT:** low plasticity, brown, fine to medium grained sand	M	F		Topsoil
								SM	**SILTY SAND:** fine to medium grained, brownish orange		VD		Alluvial
						0.5							
						1.0			**COBBLES IN A SAND MATRIX**upto 200mm in diameter, rounded, fine to coarse grained orange sand, with some fine to coarse grained gravel				
			Observed Water Level			1.5			becoming orange to pale grey in colour				
			▼			2.0			becoming medium to coarse grained sand	W			
						2.5							
						3.0		SC	**CLAYEY SAND:** medium to coarse grained, pale grey, with some cobbles up to 100mm in diameter				
									Test pit TP15 terminated at 3m				
						3.5							
						4.0							

Sketch

method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator

support

S	shoring	N	nil

penetration
1 2 3 4
no resistance ranging to refusal

water

▼	water level on date shown
▶	water inflow
◀	water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description
based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Coffey Geosciences Pty Ltd ACN 056 335 516

Engineering log - Excavation

Excavation No.	*TP16*
Sheet	1 of 1
Office Job No.:	*AW1781/1*
Client:	*Infrastructure Solutions Pty Ltd*
Principal:	
Project:	*Bairnsdale Landfill - Stage 2*
Test pit location:	*Refer to Figure 1*
Date started:	*13.8.2004*
Date completed:	*13.8.2004*
Logged by:	*MFT*
Checked by:	BVZ

equipment type and model:	Backhoe	Pit Orientation:		Easting:	m	R.L. Surface:	Not Measured
excavation dimensions:	5m long 0.8m wide			Northing:	m	datum:	

excavation information							material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetrometer kPa 100 200 300 400	structure and additional observations
BH		N	None Observed				|||	ML	**SANDY SILT:** low plasticity, brown, fine to medium grained sand	M	F		Topsoil
							▨	CL	**SILTY CLAY:** medium plasticity, orange to pale grey		VSt	x	Alluvial
						0.5	▨						
						1.0	▨						
							▨					600x	
						1.5	▨						
						2.0	▨						
						2.5	▨					600x	
				Bs & D			|||	ML	**SILT:** low plasticity, pale grey				
							░	SP	**SAND:** fine to medium grained, orange		VD		
						3.0			Test pit TP16 terminated at 3m				
						3.5							
						4.0							

Sketch

TESTPIT AW1781.1.GPJ COFFEY.GDT 15.09.04

method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator

support

S shoring N nil

penetration

1 2 3 4

no resistance ranging to refusal

water

▼ water level on date shown

► water inflow

◄ water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Form GEO 5.2 Issue 3 Rev.2

Coffey Geosciences Pty Ltd ACN 056 335 516

Engineering log - Excavation

Excavation No. *TP17*

Sheet 1 of 1

Office Job No.: *AW1781/1*

Client: *Infrastructure Solutions Pty Ltd*

Principal:

Project: *Bairnsdale Landfill - Stage 2*

Test pit location: *Refer to Figure 1*

Date started: *13.8.2004*

Date completed: *13.8.2004*

Logged by: *MFT*

Checked by:

Coffey

equipment type and model: Backhoe

Pit Orientation:

Easting: m

R.L. Surface: Not Measured

excavation dimensions: 5m long 0.8m wide

Northing: m

datum:

excavation information / material substance

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	structure and additional observations
BH		N	None Observed				ML	**SANDY SILT:** low plasticity, brown, fine to medium grained sand	M	F	Topsoil
							CH	**SILTY CLAY:** high plasticity, orange		VSt	Alluvial
						0.5					
						1.0		becoming orange to pale grey with red mottles in colour			
						1.5					
							CL	**SILTY CLAY:** medium plasticity, orange to pale grey with red mottles			
						2.0		becoming orange to pale grey with black mottles in colour			
				Bs		2.5					
						3.0					
								Test pit TP17 terminated at 3.1m			
						3.5					
						4.0					

pocket penetrometer kPa: 100 200 300 400

Sketch

TESTPIT AW1781.1.GPJ COFFEY.GDT 15.09.04

method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator

support

S shoring N nil

penetration

1 2 3 4

no resistance ranging to refusal

water

▼ water level on date shown

► water inflow

◄ water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Coffey Geosciences Pty Ltd ACN 056 335 516

Coffey

Engineering log - Excavation

Excavation No.	*TP18*		
Sheet	1 of 1		
Office Job No.:	*AW1781/1*		
Client:	*Infrastructure Solutions Pty Ltd*	Date started:	*13.8.2004*
Principal:		Date completed:	*13.8.2004*
Project:	*Bairnsdale Landfill - Stage 2*	Logged by:	*MFT*
Test pit location:	*Refer to Figure 1*	Checked by:	

equipment type and model:	Backhoe	Pit Orientation:		Easting:	m	R.L. Surface:	Not Measured
excavation dimensions:	5m long 0.8m wide			Northing:	m	datum:	

excavation information							material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
BH		N	None Observed					ML	**SANDY SILT:** low plasticity, brown, fine to medium grained sand	M	F		Topsoil
						0.5		CH	**SILTY CLAY:** high plasticity, orange with red mottles		VSt	x	Alluvial
						1.0							
						1.5		CL	**SILTY CLAY:** medium plasticity, orange to pale grey with red mottles, with some fine to medium grained sand and cobbles up to 200mm in diameter				
						2.0		SC	**CLAYEY SAND:** fine to coarse grained, orange to pale grey with some cobbles up to 200mm in diameter		VD		
						2.5			Refusal Test pit TP18 terminated at 2.4m				
						3.0							
						3.5							
						4.0							

Sketch

TESTPIT AW1781.1.GPJ COFFEY.GDT 15.09.04

method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator

support

S	shoring	N	nil

penetration

1 2 3 4

no resistance ranging to refusal

water

water level on date shown

water inflow

water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Form GEO 5.2 Issue 3 Rev.2

Coffey Geosciences Pty Ltd ACN 056 335 516

Engineering log - Excavation

Excavation No. *TP19*

Sheet 1 of 1

Office Job No.: *AW1781/1*

Client: *Infrastructure Solutions Pty Ltd*

Principal:

Project: *Bairnsdale Landfill - Stage 2*

Test pit location: *Refer to Figure 1*

Date started: *13.8.2004*

Date completed: *13.8.2004*

Logged by: *MFT*

Checked by:

equipment type and model: Backhoe

excavation dimensions: 5m long 0.8m wide

Pit Orientation:

Easting: m

Northing: m

R.L. Surface: Not Measured

datum:

excavation information							material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
BH		N	None Observed					ML	**SANDY SILT:** low plasticity, brown, fine to medium grained sand	M	F		Topsoil
								CH	**SILTY CLAY:** high plasticity, orange, trace cobbles up to 100mm in diameter		VSt	×	Alluvial
						0.5							
						1.0							
				Bs		1.5		CL	**SILTY CLAY:** medium plasticity, orange to pale grey with red mottles and trace cobbles up to 100mm in diameter				
								CL	**SANDY CLAY:** medium plasticity, orange to pale grey with red mottles, fine grained sand, with some cobbles up to 200mm in diameter				
				Bs		2.0							
								SC	**CLAYEY SAND:** fine to medium grained, orange to pale grey		VD		
						2.5							
						3.0			Test pit TP19 terminated at 3m				
						3.5							
						4.0							

Sketch

method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator

support

S shoring N nil

penetration

1 2 3 4 no resistance ranging to refusal

water

water level on date shown

water inflow

water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

TESTPIT AW1781.1.GPJ COFFEY.GDT 15.09.04

Form GEO 5.2 Issue 3 Rev.2

Coffey Geosciences Pty Ltd ACN 056 335 516

Coffey

Engineering log - Excavation

Excavation No. *TP20*

Sheet 1 of 1

Office Job No.: *AW1781/1*

Client: *Infrastructure Solutions Pty Ltd*

Principal:

Project: *Bairnsdale Landfill - Stage 2*

Test pit location: *Refer to Figure 1*

Date started: *13.8.2004*

Date completed: *13.8.2004*

Logged by: *MFT*

Checked by: RL

equipment type and model: Backhoe

Pit Orientation:

Easting: m

R.L. Surface: Not Measured

excavation dimensions: 5m long 0.8m wide

Northing: m

datum:

excavation information							material substance							
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
BH		N	None Observed						**COBBLES IN A SAND MATRIX**upto 200mm in diameter, rounded, medium to coarse grained orange sand	D	VD		Alluvial
						0.5							
						1.0							
						1.5							
						2.0							
						2.5				becoming orange to pale grey in colour			
						3.0							
						3.5							
									Test pit TP20 terminated at 3.5m				
						4.0							

Sketch

TESTPIT AW1781.1.GPJ COFFEY.GDT 15.09.04

Form GEO 5.2 Issue 3 Rev.2

method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator

support

S shoring N nil

penetration

1 2 3 4 no resistance ranging to refusal

water

water level on date shown

water inflow

water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

APPENDIX B

Results of Laboratory Tests

Coffey Geosciences Pty Ltd A.C.N.0 56 335 516

Geotechnical | **Resources** | Environmental | **Technical** | Project Management

Unit 8, 12 Mars Road, Lane Cove West,NSW,2066
Ph:(02) 9911 1000 Fax (02) 9911 1001

test results

client : *INFRASTRUCTURE SOLUTIONS PTY LTD*

job no : *AW1781/1*

principal :

laboratory : *SYDNEY*

project : *BAIRNSDALE LANDFILL - STAGE 2*

report date : *17 September, 2004*

location : *JOHNSTONS ROAD, BAIRNSDALE*

test report : -

test procedure : *AS 1289.6.7.2*
AS 1289.2.1.1

test date : *07/09/04 to 17/09/04*

Sample Identification	REMOULDED DRY DENSITY	REMOULDED MOISTURE CONTENT	REMOULDED FALLING HEAD PERMEABILITY	REMOULDED FALLING HEAD PERMEABILITY
	t/m^3	%	cm/sec	m/sec
TP 6 0.5 - 0.8m	*1.46*	*26.6*	1.9×10^{-8}	1.9×10^{-10}

Notes:- 1.Specimen remoulded to 95% of Standard Maximum Dry Density and at Standard Optimum Moisture Content.

2.Tested with 2% saline solution.

3.Sample and Compaction Data received from CG-(Albury) on the 31/08/04.

4. 0% Percenatge of material retained on 19mm sieve.

5.5 0 kPa pressure was applied to the sample.

remarks : *Samples suplied by CG (Albury) on the 31/08/04*

The tests, calibrations or measurements covered by this documenth ave been performed in accordance with NATA requirements whichi nclude the requirements of ISO/IEC 17025 and are traceable to national standards of measurement. This document shall not be reproduced except in full.

NATA Accredited Laboratory
No.4 31

Date : *September 17, 2004*

Authorised Signature:

James Russell
Laboratory Manager

Russell

Coffey Geosciences Pty Ltd A.C.N. 056 335 516

Geotechnical Resources Environmental Technical Project Management
16 Church Street, Hawthorn, Vic, 3122
Ph: (03) 9853 3396, Fax: (03) 9853 0189

Coffey

test results

client : *INFRASTRUCTURE SOLUTIONS PTY LTD*
principal :
project : *BAIRNSDALE LANDFILL - STAGE 2*
location : *JOHNSTONS ROAD, BAIRNSDALE*

job no : *AW1781/1*
laboratory : *MELBOURNE*
date : *31/08/04*
test report : *AA*

test procedure. : *AS1289 5.1.1 2.1.1*

test date : *17 - 26/08/2004*

		MAXIMUM DRY DENSITY t/m3	OPTIMUM MOISTURE CONTENT %	FIELD MOISTURE CONTENT %
TP3	*0.80 - 1.00m*	*1.61*	*23.5*	*25.3*
TP4	*2.60 - 2.80m*	*1.80*	*15.5*	*15.1*
TP6	*0.50 - 0.80m*	*1.54*	*26.0*	*27.0*
TP6	*2.50 - 2.70m*	*1.94*	*11.0*	*9.5*
TP9	*1.50 - 1.60m*	*1.85*	*14.0*	*12.6*
TP14	*0.50 - 0.60m*	*1.96*	*11.5*	*12.2*
TP16	*2.50 - 2.60m*	*1.71*	*18.5*	*20.1*
TP17	*2.30 - 2.50m*	*1.81*	*15.5*	*14.8*
TP19	*1.40 - 1.50m*	*1.73*	*18.0*	*19.2*
TP19	*2.00 - 2.10m*	*1.97*	*10.5*	*10.7*

remarks :

NATA

Authorised Signature

NATA Accredited Laboratory
No. 431

A Catton

ALASTAIR CATTON

Coffey Geosciences Pty Ltd A.C.N. 056 335 516

Geotechnical **Resources** Environmental **Technical** Project Management
16 Church Street, Hawthorn, Vic, 3122
Ph: (03) 9853 3396, Fax: (03) 9853 0189

Coffey

test results

client : *INFRASTRUCTURE SOLUTIONS PTY LTD*
principal :
project : *BAIRNSDALE LANDFILL - STAGE 2*
location : *JOHNSTONS ROAD, BAIRNSDALE*

job no : *AW1781/1*
laboratory : *MELBOURNE*
date : *31/08/04*
test report : *AB*

test procedure : *AS1289 6.7.2 (Falling Head Permeability)*
AS1289 5.1.1 2.1.1

test date : *19 - 27/08/2004*

		TP3 0.80 - 1.00m	TP4 2.60 - 2.80m	TP9 1.50 - 1.60m	TP17 2.30 - 2.50m
Maximum Dry Density	*t/m^3*	*1.61*	*1.80*	*1.85*	*1.81*
Optimum Moisture Content	*%*	*23.5*	*15.5*	*14.0*	*15.5*
Field Moisture Content	*%*	*25.3*	*15.1*	*12.6*	*14.8*
Moisture Variation		*+ 1.8*	*- 0.4*	*- 1.4*	*- 0.7*
Target Density Ratio		*95*	*95*	*95*	*95*
Actual Density Ratio		*95.0*	*95.0*	*94.6*	*95.0*
Moisture Ratio of sample		*100.4*	*100.0*	*102.1*	*100.0*
PERMEABILITY	*m/s*	*5.2 E -10*	*3.0 E -9*	*1.2 E -9*	*8.8 E -11*
Water Type		*potable*	*potable*	*potable*	*potable*
Sample Description		*SANDY CLAY* *medium plastcty* *orange*	*CLAYEY SILT* *medium plasticity* *orange*	*CLAYEY SAND* *fine to coarse* *orange*	*SILTY CLAY* *high plasticity* *brown*

remarks :

NATA

This laboratory is accredited by the National Association of Testing Authorities, Australia. The test(s) reported herein have been performed in accordance with the terms of accreditation. This document shall not be reproduced except in full.

Authorised Signature
NATA Accredited Laboratory
No. 431

ALASTAIR CATTON

Coffey Geosciences Pty Ltd A.C.N. 056 335 516

Geotechnical Resources Environmental Technical Project Management
16 Church Street, Hawthorn, Vic, 3122
Ph: (03) 9853 3396, Fax: (03) 9853 0189

determination of emerson class number

client : *INFRASTRUCTURE SOLUTIONS PTY LTD*
principal :
project : *BAIRNSDALE LANDFILL - STAGE 2*
location : *JOHNSTONS ROAD, BAIRNSDALE*

job no : *AW1781/1*
laboratory : *MELBOURNE*
date : *31/08/04*
test report : *AC*

test procedure : *AS12893 .8.1*
sample identification: *TP3 0.80 - 1.00m*

test data

air dried crumbs

time start of test: *11.12 19/08/04*

time dispersion commences: *15:15 19/08/04*

time dispersion completed: *16:30 19/08/04*

remoulded material

time start of test:

time dispersion commences:

time dispersion completed:

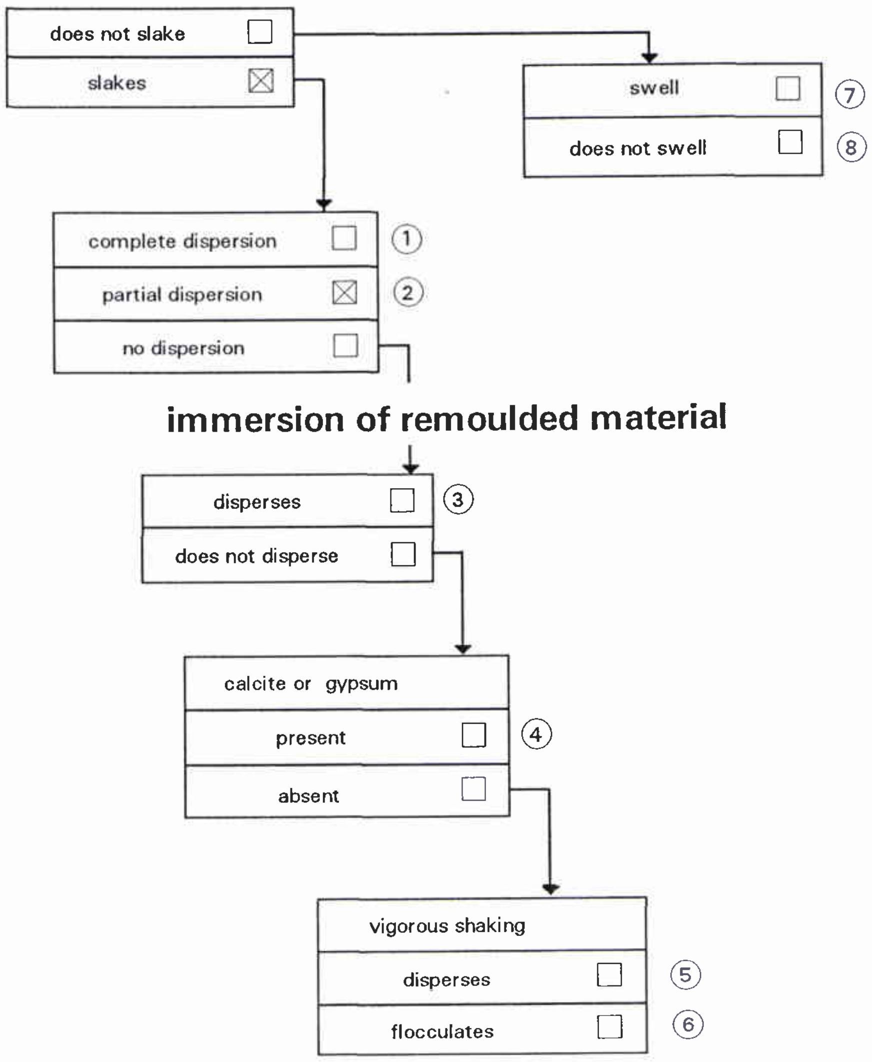
material description

SANDY CLAY, medium plasticity, orange

type of water used: *distilled*

water temperature: *19° C*

immersion of air dried crumbs



does not slake ☐
slakes ☒

swell ☐ ⑦
does not swell ☐ ⑧

complete dispersion ☐ ①
partial dispersion ☒ ②
no dispersion ☐

immersion of remoulded material

disperses ☐ ③
does not disperse ☐

calcite or gypsum
present ☐ ④
absent ☐

vigorous shaking
disperses ☐ ⑤
flocculates ☐ ⑥

Emerson class number *2*

This laboratory is accredited by the National Association of Testing Authorities, Australia. The test(s) reported herein have been performed in accordance with the terms of accreditation. This documents hall not be reproduced except in full.

Authorised Signature

NATA Accredited Laboratory
No. 431

ALASTAIR CATTON

Form Number L4.8R1 Version 4.0

Coffey Geosciences Pty Ltd A.C.N. 056 335 516

Geotechnical Resources Environmental Technical Project Management
16 Church Street, Hawthorn, Vic, 3122
Ph: (03) 9853 3396, Fax: (03) 9853 0189

Coffey

determination of emerson class number

client : *INFRASTRUCTURE SOLUTIONS PTY LTD*
principal :
project : *BAIRNSDALE LANDFILL - STAGE 2*
location : *JOHNSTONS ROAD, BAIRNSDALE*

job no : *AW1781/1*
laboratory : *MELBOURNE*
date : *31/08/04*
test report : *AD*

test procedure : *AS12893 .8.1*
sample identification: *TP4 2.60 - 2.80m*

test data

air dried crumbs

time start of test: *11.12 19/08/04*

time dispersion commences: *11.30 19/08/04*

time dispersion completed: *12:30 19/08/04*

remoulded material

time start of test:

time dispersion commences:

time dispersion completed:

material description

CLAYEY SILT, medium plasticty, orange

type of water used: *distilled*

water temperature: *19° C*

immersion of air dried crumbs

- does not slake ☐
  - swell ☐ ⑦
  - does not swell ☐ ⑧
- slakes ☒
  - complete dispersion ☐ ①
  - partial dispersion ☒ ②
  - no dispersion ☐

immersion of remoulded material

- disperses ☐ ③
- does not disperse ☐
  - calcite or gypsum
    - present ☐ ④
    - absent ☐
      - vigorous shaking
        - disperses ☐ ⑤
        - flocculates ☐ ⑥

Emerson class number *2*

This laboratory is accredited by the National Association of Testing Authorities, Australia. The test(s) reported herein have been performed in accordance with the terms of accreditation. This documents hall not be reproduced except in full.

Authorised Signature

NATA Accredited Laboratory No. 431

ALASTAIR CATTON

Coffey Geosciences Pty Ltd A.C.N. 056 335 516

Geotechnical **Resources** Environmental **Technical** Project Management
16 Church Street, Hawthorn, Vic, 3122
Ph: (03) 9853 3396, Fax: (03) 9853 0189

Coffey

determination of emerson class number

client : *INFRASTRUCTURE SOLUTIONS PTY LTD*
principal :
project : *BAIRNSDALE LANDFILL - STAGE 2*
location : *JOHNSTONS ROAD, BAIRNSDALE*

job no : *AW1781/1*
laboratory : *MELBOURNE*
date : *1/09/04*
test report : *AM*

test procedure : *AS1289 3.8.1*
sample identification: *TP 4 2.60 - 2.80m*

test data

air dried crumbs

time start of test: *11:25 31/08/04*

time dispersion commences:

time dispersion completed:

remoulded material

time start of test: *8:25 1/09/04*

time dispersion commences:

time dispersion completed:

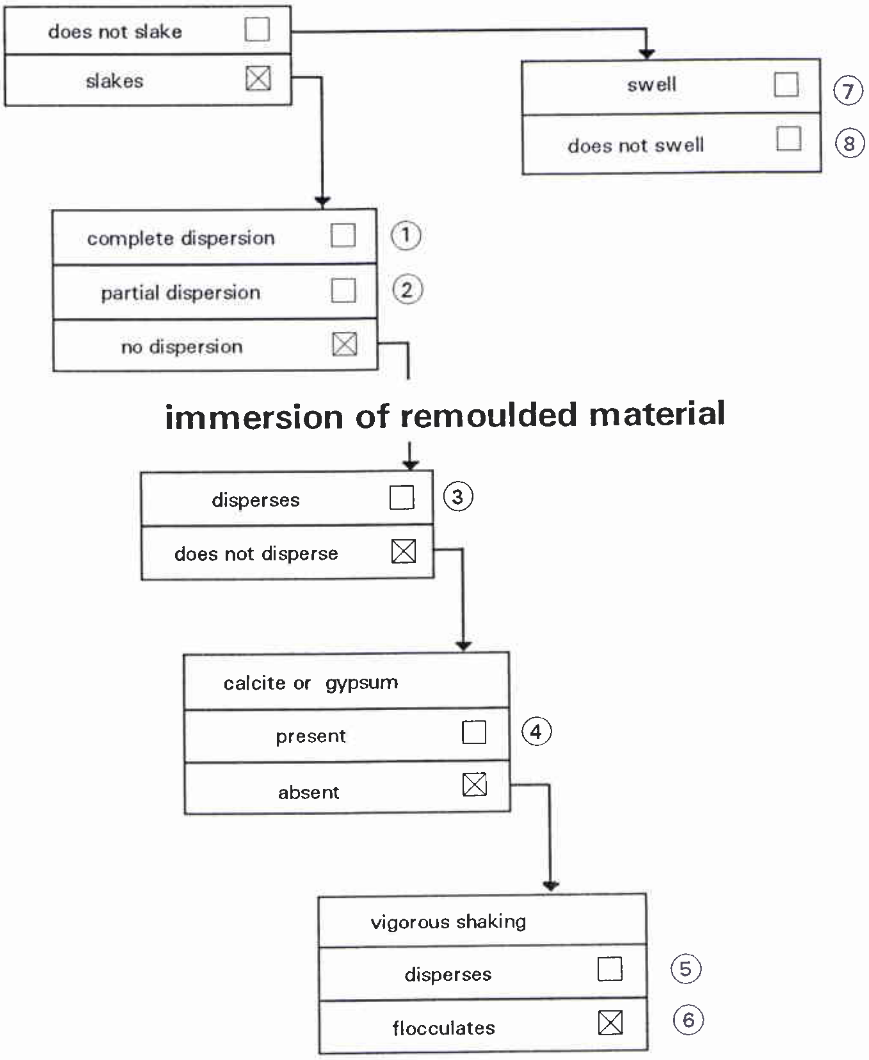
material description

CLAYEY SILT, medium plasticty, orange

type of water used: *1% saline*

water temperature: *20° C*

immersion of air dried crumbs



does not slake ☐
slakes ☒

swell ☐ ⑦
does not swell ☐ ⑧

complete dispersion ☐ ①
partial dispersion ☐ ②
no dispersion ☒

immersion of remoulded material

disperses ☐ ③
does not disperse ☒

calcite or gypsum
present ☐ ④
absent ☒

vigorous shaking
disperses ☐ ⑤
flocculates ☒ ⑥

Emerson class number	*6*

This laboratory is accredited by the National Association of Testing Authorities, Australia. The test(s) reported herein have been performed in accordance with the terms of accreditation. This documents hall not be reproduced except in full.

Authorised Signature

NATA Accredited Laboratory
No. 431

A Catton
ALASTAIR CATTON

Form Number L4.8R1 Version 4.0

Coffey Geosciences Pty Ltd A.C.N. 056 335 516
Geotechnical Resources Environmental Technical Project Management
16 Church Street, Hawthorn, Vic, 3122
Ph: (03) 9853 3396, Fax: (03) 9853 0189
Coffey

determination of emerson class number

client : *INFRASTRUCTURE SOLUTIONS PTY LTD*
principal :
project : *BAIRNSDALE LANDFILL - STAGE 2*
location : *JOHNSTONS ROAD, BAIRNSDALE*

job no : *AW1781/1*
laboratory : *MELBOURNE*
date : *1/09/04*
test report : *AE*

test procedure : *AS1289 3.8.1*
sample identification: *TP6 0.50 - 0.80m*

test data

air dried crumbs

time start of test: *8:55 31/08/04*

time dispersion commences:

time dispersion completed:

remoulded material

time start of test: *8:25 1/09/04*

time dispersion commences: *11:30 1/09/04*

time dispersion completed: *13:00 1/09/04*

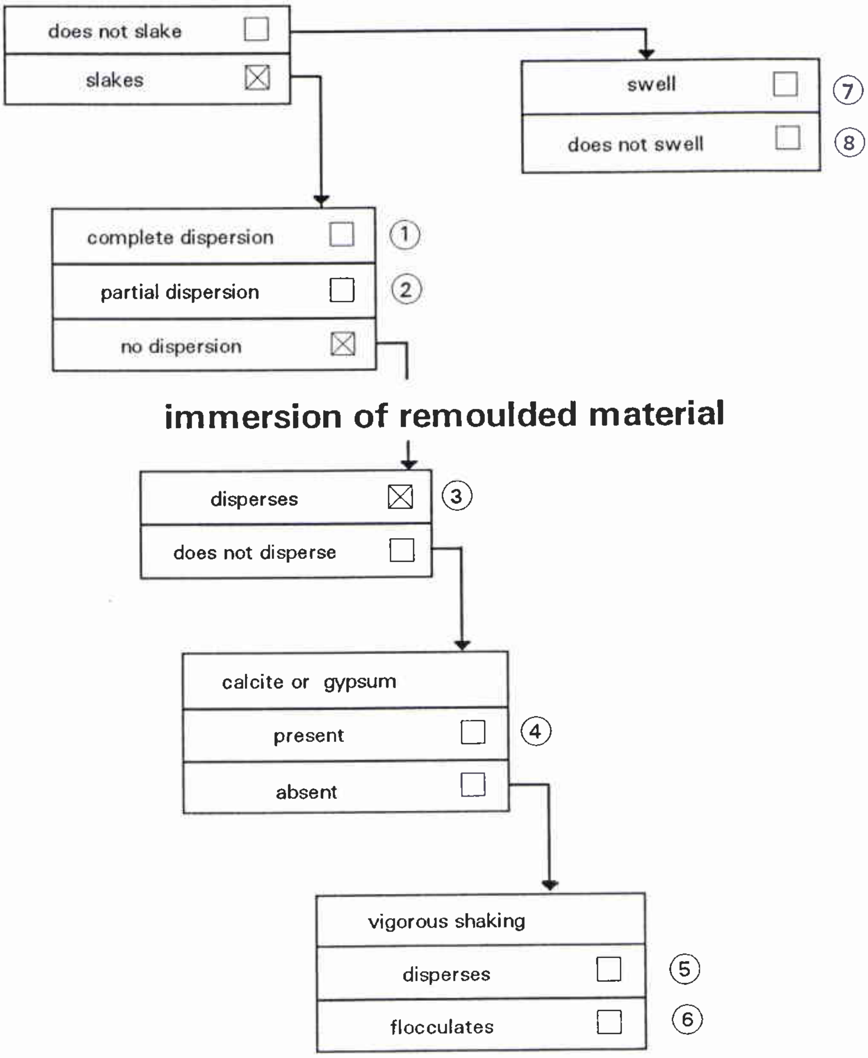
material description

SILTY CLAY, high plasticity, broen

type of water used: *distilled*

water temperature: *20 ° C*

immersion of air dried crumbs



does not slake ☐
slakes ☒

swell ☐ ⑦
does not swell ☐ ⑧

complete dispersion ☐ ①
partial dispersion ☐ ②
no dispersion ☒

immersion of remoulded material

disperses ☒ ③
does not disperse ☐

calcite or gypsum
present ☐ ④
absent ☐

vigorous shaking
disperses ☐ ⑤
flocculates ☐ ⑥

Emerson class number *3*

This laboratory is accredited by the National Association of Testing Authorities, Australia. The test(s) reported herein have been performed in accordance with the terms of accreditation. This documents hall not be reproduced except in full.

Authorised Signature
NATA Accredited Laboratory No. 431
A Catton
ALASTAIR CATTON

Coffey Geosciences Pty Ltd A.C.N. 056 335 516
Geotechnical Resources Environmental Technical Project Management
16 Church Street, Hawthorn, Vic, 3122
Ph: (03) 9853 3396, Fax: (03) 9853 0189
Coffey

determination of emerson class number

client : *INFRASTRUCTURE SOLUTIONS PTY LTD*
principal :
project : *BAIRNSDALE LANDFILL - STAGE 2*
location : *JOHNSTONS ROAD, BAIRNSDALE*

job no : *AW1781/1*
laboratory : *MELBOURNE*
date : *31/08/04*
test report : *AF*

test procedure : *AS1289 3.8.1*
sample identification: *TP6 2.50 - 2.70m*

test data

air dried crumbs

time start of test: *11.12 19/08/04*

time dispersion commences: *11.30 19/08/04*

time dispersion completed: *12:30 19/08/04*

remoulded material

time start of test:

time dispersion commences:

time dispersion completed:

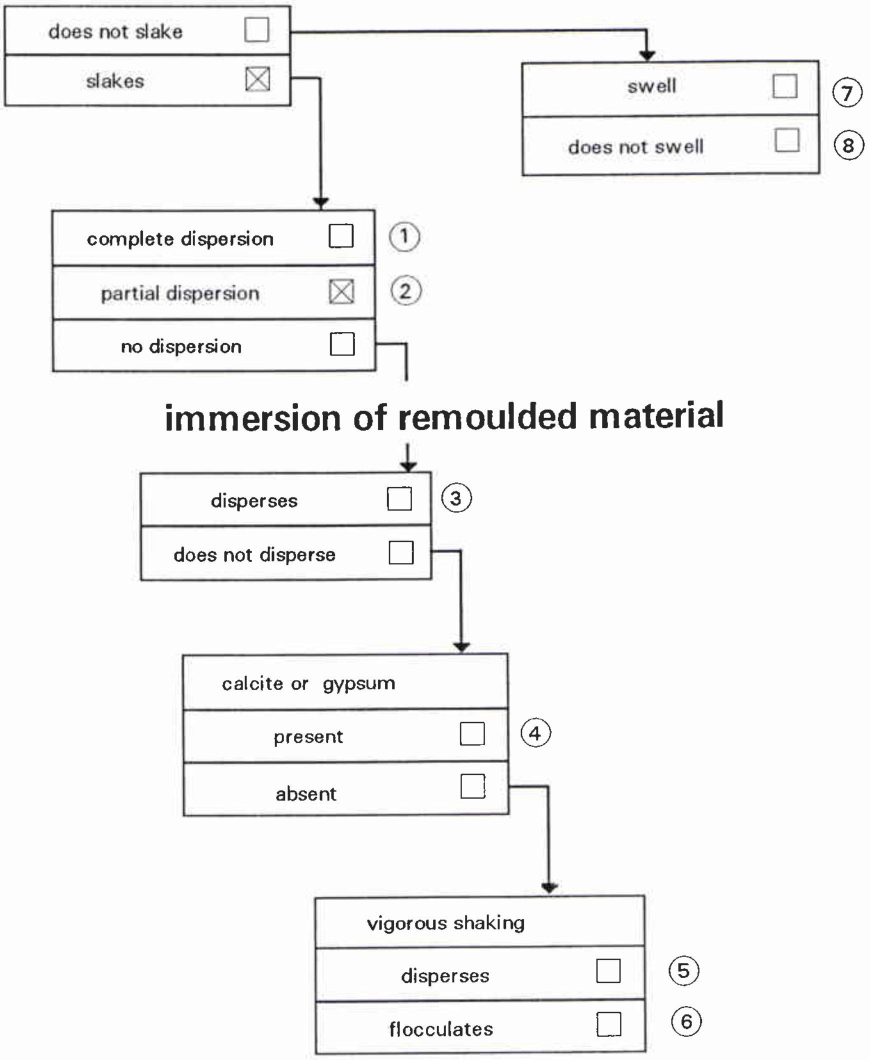
material description

CLAYEY SAND, fine to coarse, orange

type of water used: *distilled*

water temperature: *19° C*

immersion of air dried crumbs



does not slake ☐
slakes ☒

swell ☐ ⑦
does not swell ☐ ⑧

complete dispersion ☐ ①
partial dispersion ☒ ②
no dispersion ☐

immersion of remoulded material

disperses ☐ ③
does not disperse ☐

calcite or gypsum
present ☐ ④
absent ☐

vigorous shaking
disperses ☐ ⑤
flocculates ☐ ⑥

Emerson class number *2*

This laboratory is accredited by the National Association of Testing Authorities, Australia. The test(s) reported herein have been performed in accordance with the terms of accreditation. This documents hall not be reproduced except in full.

Authorised Signature
NATA Accredited Laboratory No. 431

A Catton
ALASTAIR CATTON

Coffey Geosciences Pty Ltd A.C.N. 056 335 516

Geotechnical Resources Environmental Technical Project Management
16 Church Street, Hawthorn, Vic, 3122
Ph: (03) 9853 3396, Fax: (03) 9853 0189

Coffey

determination of emerson class number

client : *INFRASTRUCTURE SOLUTIONS PTY LTD*
principal :
project : *BAIRNSDALE LANDFILL - STAGE 2*
location : *JOHNSTONS ROAD, BAIRNSDALE*

job no : *AW1781/1*
laboratory : *MELBOURNE*
date : *31/08/04*
test report : *AG*

test procedure : *AS1289 3.8.1*
sample identification: *TP9 1.50 - 1.60m*

test data

air dried crumbs

time start of test: *11.21 19/08/04*

time dispersion commences: *11.30 19/08/04*

time dispersion completed: *12:30 19/08/04*

remoulded material

time start of test:

time dispersion commences:

time dispersion completed:

material description

CLAYEY SAND, fine to coarse, orange

type of water used: *distilled*

water temperature: *19°* C

immersion of air dried crumbs

does not slake ☐
slakes ☒

swell ☐ ⑦
does not swell ☐ ⑧

complete dispersion ☐ ①
partial dispersion ☒ ②
no dispersion ☐

immersion of remoulded material

disperses ☐ ③
does not disperse ☐

calcite or gypsum
present ☐ ④
absent ☐

vigorous shaking
disperses ☐ ⑤
flocculates ☐ ⑥

Emerson class number *2*

This laboratory is accredited by the National Association of Testing Authorities, Australia. The test(s) reported herein have been performed in accordance with the terms of accreditation. This documents hall not be reproduced except in full.

NATA

Authorised Signature
NATA Accredited Laboratory No. 431

A Catton
ALASTAIR CATTON

Coffey Geosciences Pty Ltd A.C.N. 056 335 516

Geotechnical Resources Environmental Technical Project Management
16 Church Street, Hawthorn, Vic, 3122
Ph: (03) 9853 3396, Fax: (03) 9853 0189

Coffey

determination of emerson class number

client : *INFRASTRUCTURE SOLUTIONS PTY LTD*
principal :
project : *BAIRNSDALE LANDFILL - STAGE 2*
location : *JOHNSTONS ROAD, BAIRNSDALE*

job no : *AW1781/1*
laboratory : *MELBOURNE*
date : *31/08/04*
test report : *AH*

test procedure : *AS1289 3.8.1*
sample identification: *TP14 0.50 - 0.60m*

test data

air dried crumbs

time start of test: *11.25 19/08/04*

time dispersion commences:

time dispersion completed:

remoulded material

time start of test: *11:50 20/08/04*

time dispersion commences: *12:00 20/08/04*

time dispersion completed: *12:20 20/08/04*

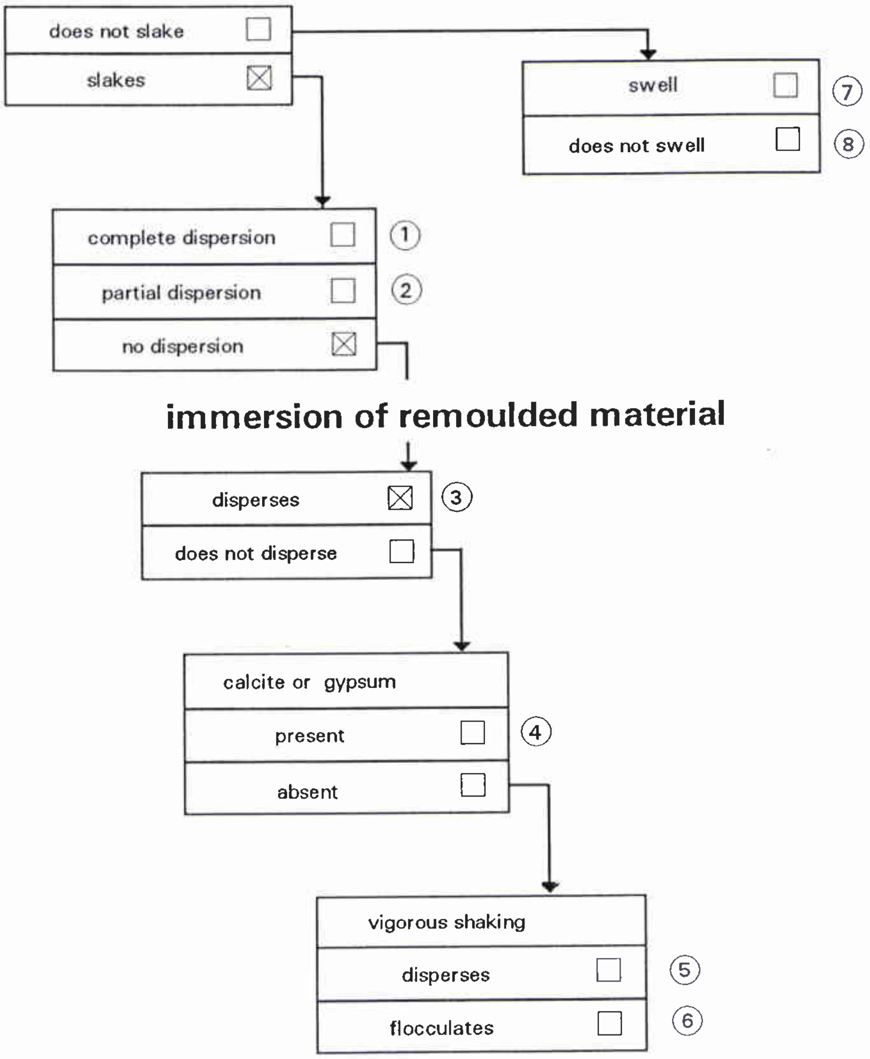
material description

SANDY CLAY, medium plasticity, grey brown

type of water used: *distilled*

water temperature: *19° C*

immersion of air dried crumbs



does not slake ☐
slakes ☒

swell ☐ ⑦
does not swell ☐ ⑧

complete dispersion ☐ ①
partial dispersion ☐ ②
no dispersion ☒

immersion of remoulded material

disperses ☒ ③
does not disperse ☐

calcite or gypsum
present ☐ ④
absent ☐

vigorous shaking
disperses ☐ ⑤
flocculates ☐ ⑥

Emerson class number *3*

This laboratory is accredited by the National Association of Testing Authorities, Australia. The test(s) reported herein have been performed in accordance with the terms of accreditation. This documents hall not be reproduced except in full.

Authorised Signature

NATA Accredited Laboratory No. 431

A Catton

ALASTAIR CATTON

Coffey Geosciences Pty Ltd A.C.N. 056 335 516

Geotechnical Resources Environmental Technical Project Management
16 Church Street, Hawthorn, Vic, 3122
Ph: (03) 9853 3396, Fax: (03) 9853 0189

Coffey

determination of emerson class number

client : *INFRASTRUCTURE SOLUTIONS PTY LTD*
principal :
project : *BAIRNSDALE LANDFILL - STAGE 2*
location : *JOHNSTONS ROAD, BAIRNSDALE*

job no : *AW1781/1*
laboratory : *MELBOURNE*
date : *31/08/04*
test report : *AI*

test procedure : *AS1289 3.8.1*
sample identification: *TP16 2.50 - 2.60m*

test data

air dried crumbs

time start of test: *8:37 23/08/04*

time dispersion commences: *8:47 23/08/04*

time dispersion completed: *10:30 23/08/04*

remoulded material

time start of test:

time dispersion commences:

time dispersion completed:

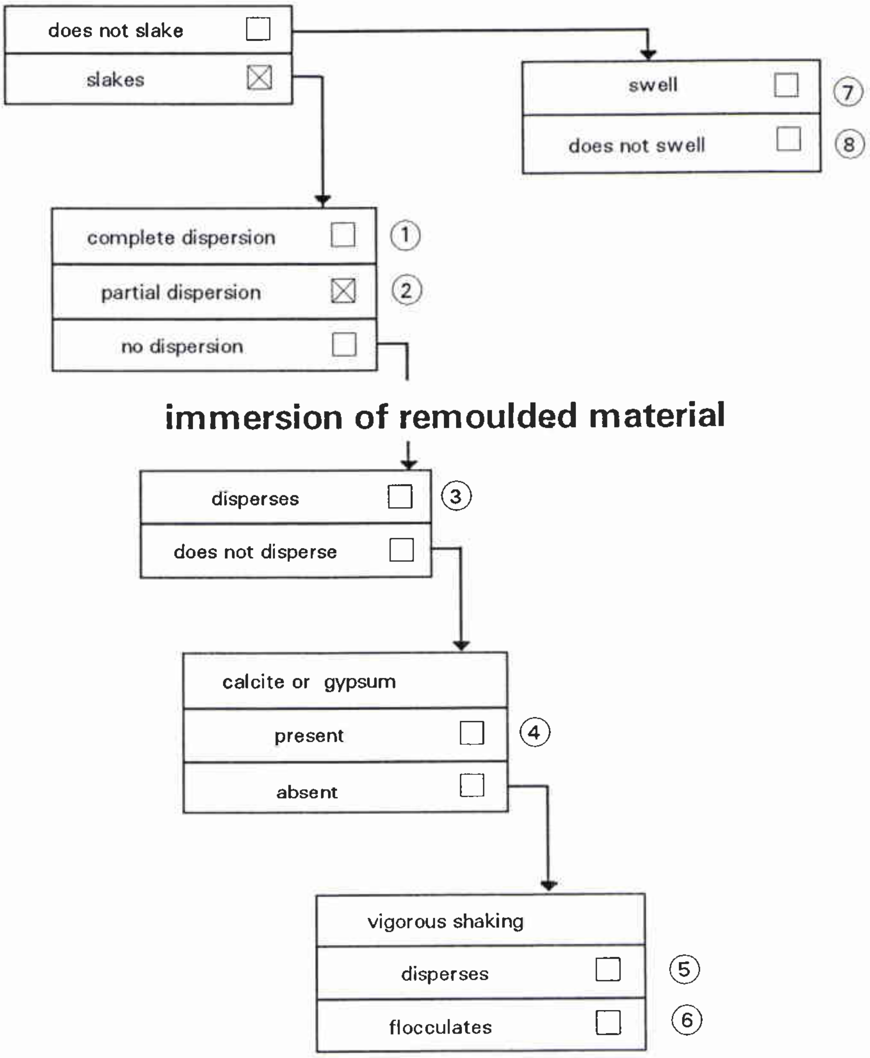
material description

CLAYEY SILT, high plasticity, grey

type of water used: *distilled*

water temperature: *20 ° C*

immersion of air dried crumbs



does not slake ☐
slakes ☒

swell ☐ ⑦
does not swell ☐ ⑧

complete dispersion ☐ ①
partial dispersion ☒ ②
no dispersion ☐

immersion of remoulded material

disperses ☐ ③
does not disperse ☐

calcite or gypsum
present ☐ ④
absent ☐

vigorous shaking
disperses ☐ ⑤
flocculates ☐ ⑥

Emerson class number *2*

This laboratory is accredited by the National Association of Testing Authorities, Australia. The test(s) reported herein have been performed in accordance with the terms of accreditation. This documents hall not be reproduced except in full.

Authorised Signature
NATA Accredited Laboratory
No. 431

A Catton
ALASTAIR CATTON

Coffey Geosciences Pty Ltd A.C.N. 056 335 516

Geotechnical Resources Environmental Technical Project Management
16 Church Street, Hawthorn, Vic, 3122
Ph: (03) 9853 3396, Fax: (03) 9853 0189

Coffey

determination of emerson class number

client : *INFRASTRUCTURE SOLUTIONS PTY LTD*
principal :
project : *BAIRNSDALE LANDFILL - STAGE 2*
location : *JOHNSTONS ROAD, BAIRNSDALE*

job no : *AW1781/1*
laboratory : *MELBOURNE*
date : *31/08/04*
test report : *AJ*

test procedure : *AS1289 3.8.1*
sample identification: *TP17 2.30 - 2.50m*

test data

air dried crumbs

time start of test: *11:12 19/08/04*

time dispersion commences: *11:30 19/08/04*

time dispersion completed: *12:30 19/08/04*

remoulded material

time start of test:

time dispersion commences:

time dispersion completed:

material description

SILTY CLAY, high plasticity, brown

type of water used: *distilled*

water temperature: *19° C*

immersion of air dried crumbs

does not slake ☐
slakes ☒

swell ☐ ⑦
does not swell ☐ ⑧

complete dispersion ☐ ①
partial dispersion ☒ ②
no dispersion ☐

immersion of remoulded material

disperses ☐ ③
does not disperse ☐

calcite or gypsum
present ☐ ④
absent ☐

vigorous shaking
disperses ☐ ⑤
flocculates ☐ ⑥

Emerson class number *2*

Authorised Signature

NATA Accredited Laboratory No. 431

ALASTAIR CATTON

Coffey Geosciences Pty Ltd A.C.N. 056 335 516

Geotechnical **Resources** Environmental **Technical** Project Management
16 Church Street, Hawthorn, Vic, 3122
Ph: (03) 9853 3396, Fax: (03) 9853 0189

Coffey

determination of emerson class number

client : *INFRASTRUCTURE SOLUTIONS PTY LTD*
principal :
project : *BAIRNSDALE LANDFILL - STAGE 2*
location : *JOHNSTONS ROAD, BAIRNSDALE*

job no : *AW1781/1*
laboratory : *MELBOURNE*
date : *31/08/04*
test report : *AK*

test procedure : *AS1289 3.8.1*
sample identification: *TP19* *1.40 - 1.50m*

test data

air dried crumbs

time start of test: *8:37 23/08/04*

time dispersion commences:

time dispersion completed:

remoulded material

time start of test: *9:30 24/08/04*

time dispersion commences:

time dispersion completed:

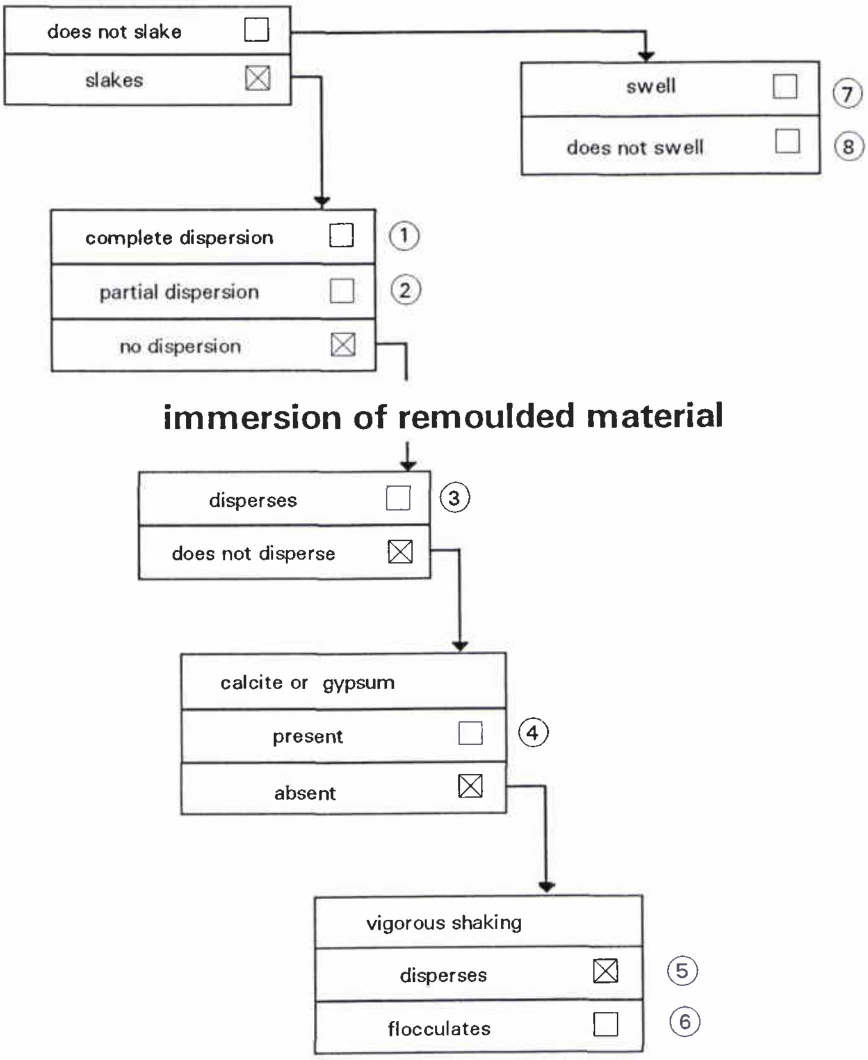
material description

SANDY CLAY, medium plasticity, orange, some fine to medium gravel

type of water used: *distilled*

water temperature: *20 ° C*

immersion of air dried crumbs



does not slake ☐
slakes ☒

swell ☐ ⑦
does not swell ☐ ⑧

complete dispersion ☐ ①
partial dispersion ☐ ②
no dispersion ☒

immersion of remoulded material

disperses ☐ ③
does not disperse ☒

calcite or gypsum
present ☐ ④
absent ☒

vigorous shaking
disperses ☒ ⑤
flocculates ☐ ⑥

Emerson class number *5*

This laboratory is accredited by the National Association of Testing Authorities, Australia. The test(s) reported herein have been performed in accordance with the terms of accreditation. This documents hall not be reproduced except in full.

Authorised Signature

NATA Accredited Laboratory No. 431

A Catton

ALASTAIR CATTON

Coffey Geosciences Pty Ltd A.C.N. 056 335 516
Geotechnical Resources Environmental Technical Project Management
16 Church Street, Hawthorn, Vic, 3122
Ph: (03) 9853 3396, Fax: (03) 9853 0189

determination of emerson class number

client : *INFRASTRUCTURE SOLUTIONS PTY LTD*
principal :
project : *BAIRNSDALE LANDFILL - STAGE 2*
location : *JOHNSTONS ROAD, BAIRNSDALE*

job no : *AW1781/1*
laboratory : *MELBOURNE*
date : *31/08/04*
test report : *AL*

test procedure : *AS1289 3.8.1*
sample identification: *TP19 2.00 - 2.10m*

test data

air dried crumbs

time start of test: *8:37 23/08/04*

time dispersion commences: *8:50 23/08/04*

time dispersion completed: *10:30 23/08/04*

remoulded material

time start of test:

time dispersion commences:

time dispersion completed:

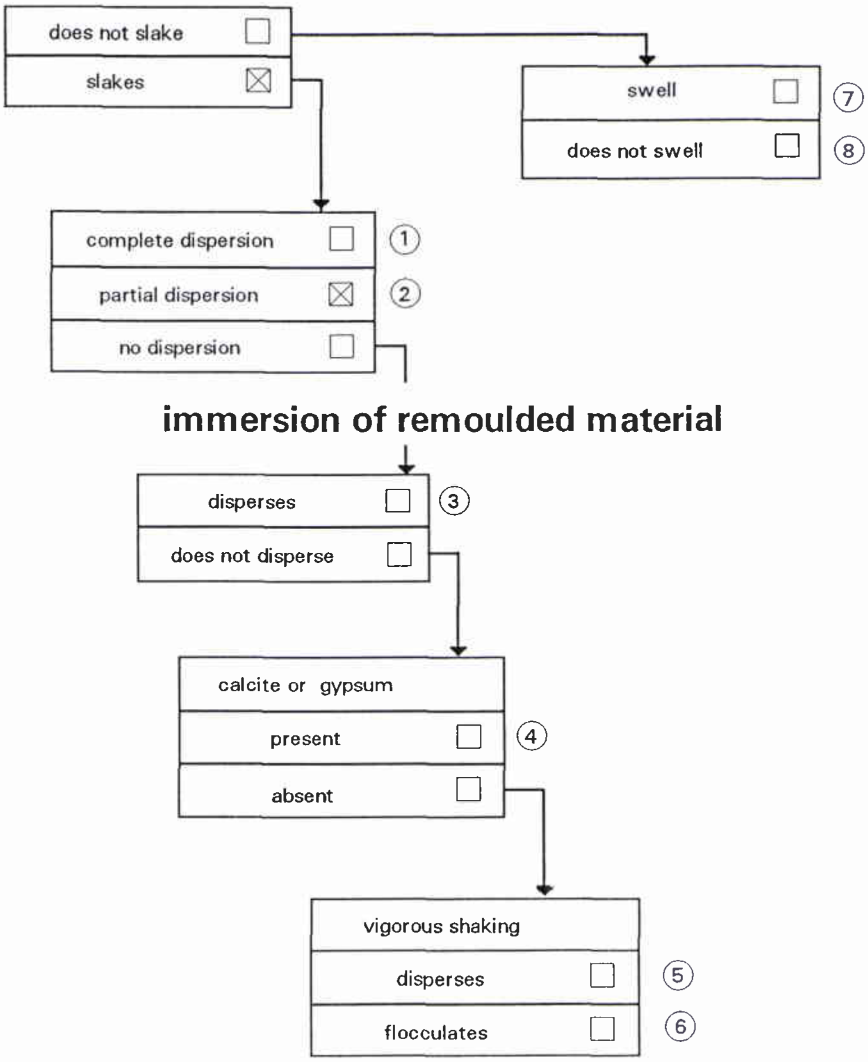
material description

SANDY CLAY, medium plasticity, orange, some fine to medium gravel

type of water used: *distilled*

water temperature: *20 ° C*

immersion of air dried crumbs



does not slake ☐
slakes ☒

swell ☐ ⑦
does not swell ☐ ⑧

complete dispersion ☐ ①
partial dispersion ☒ ②
no dispersion ☐

immersion of remoulded material

disperses ☐ ③
does not disperse ☐

calcite or gypsum
present ☐ ④
absent ☐

vigorous shaking
disperses ☐ ⑤
flocculates ☐ ⑥

Emerson class number *2*

This laboratory is accredited by the National Association of Testing Authorities, Australia. The test(s) reported herein have been performed in accordance with the terms of accreditation. This documents hall not be reproduced except in full.

Authorised Signature
NATA Accredited Laboratory
No. 431
A Catton
ALASTAIR CATTON

APPENDIX H – VISUAL HELP OUTPUT REPORT

Project : Cell 3 Analysis

Johnston's Road Landfill Cell 3

Model : HELP

An US EPA model for predicting landfill hydrologic processes and testing of effectiveness of landfill designs

Author : Project Engineer Rowan Howarth

Client : East Gippsland Shire Council

Location : Bairnsdale

1. Profile. EPA Recommended Profile

Model Settings

[HELP] Case Settings

Parameter	Value	Units
Runoff Method	Model calculated	(-)
Initial Moisture Settings	Model calculated	(-)

[HELP] Surface Water Settings

Parameter	Value	Units
Runoff Area	100	(%%)
Vegetation Class	Good stand of grass	(-)

Profile Structure

Layer	Top (m)	Bottom (m)	Thickness (m)
🟩 **Weekly Cover Material 6**	32.5000	32.2000	0.3000
🟩 **Municipal Waste (312 kg/cub.m) (Layer 6)**	32.2005	30.2005	2.0000
🟩 **Weekly Cover Material 5**	30.2010	29.9010	0.3000
🟩 **Municipal Waste (312 kg/cub.m) (Layer 5)**	29.9015	27.9015	2.0000
🟩 **Weekly Cover Material 4**	27.9020	27.6020	0.3000
🟩 **Municipal Waste (312 kg/cub.m) (Layer 4)**	27.6025	25.6025	2.0000
🟩 **Weekly Cover Material 3**	25.6030	25.3030	0.3000
🟩 **Municipal Waste (312 kg/cub.m) (Layer 3)**	25.3035	23.3035	2.0000
🟩 **Weekly Cover Material 2**	23.3040	23.0040	0.3000
🟩 **Municipal Waste (312 kg/cub.m) (Layer 2)**	23.0045	21.0045	2.0000
🟩 **Weekly Cover Material 1**	21.0045	20.7045	0.3000
🟩 **Municipal Waste (312 kg/cub.m) (Layer 1)**	20.7050	18.7050	2.0000
🟨 **Drainage Aggregate 2**	18.7050	18.4050	0.3000
⬚ **Drainage Net (0.5cm)**	18.4050	18.4000	0.0050
▭ **High Density Polyethylene**	18.4000	18.3990	0.0010
🟨 **Drainage Aggregate 1**	18.3990	17.8990	0.5000
▭ **Butyl Rubber**	17.8990	17.8980	0.0010
▤ **Clay**	17.8980	16.8980	1.0000

1.1. Layer. Weekly Cover Material 6

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units

total porosity	0.457	(vol/vol)
field capacity	0.131	(vol/vol)
wilting point	0.058	(vol/vol)
sat.hydr.conductivity	1E-3	(cm/sec)
subsurface inflow	0	(mm/year)

1.2. Layer. Municipal Waste (312 kg/cub.m) (Layer 6)

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.671	(vol/vol)
field capacity	0.292	(vol/vol)
wilting point	0.077	(vol/vol)
sat.hydr.conductivity	0.001	(cm/sec)
subsurface inflow	0	(mm/year)

1.3. Layer. Weekly Cover Material 5

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.457	(vol/vol)
field capacity	0.131	(vol/vol)
wilting point	0.058	(vol/vol)
sat.hydr.conductivity	1E-3	(cm/sec)
subsurface inflow	0	(mm/year)

1.4. Layer. Municipal Waste (312 kg/cub.m) (Layer 5)

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.671	(vol/vol)
field capacity	0.292	(vol/vol)
wilting point	0.077	(vol/vol)
sat.hydr.conductivity	0.001	(cm/sec)
subsurface inflow	0	(mm/year)

1.5. Layer. Weekly Cover Material 4

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.457	(vol/vol)

field capacity	0.131	(vol/vol)
wilting point	0.058	(vol/vol)
sat.hydr.conductivity	1E-3	(cm/sec)
subsurface inflow	0	(mm/year)

1.6. Layer. Municipal Waste (312 kg/cub.m) (Layer 4)

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.671	(vol/vol)
field capacity	0.292	(vol/vol)
wilting point	0.077	(vol/vol)
sat.hydr.conductivity	0.001	(cm/sec)
subsurface inflow	0	(mm/year)

1.7. Layer. Weekly Cover Material 3

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.457	(vol/vol)
field capacity	0.131	(vol/vol)
wilting point	0.058	(vol/vol)
sat.hydr.conductivity	1E-3	(cm/sec)
subsurface inflow	0	(mm/year)

1.8. Layer. Municipal Waste (312 kg/cub.m) (Layer 3)

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.671	(vol/vol)
field capacity	0.292	(vol/vol)
wilting point	0.077	(vol/vol)
sat.hydr.conductivity	0.001	(cm/sec)
subsurface inflow	0	(mm/year)

1.9. Layer. Weekly Cover Material 2

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.457	(vol/vol)
field capacity	0.131	(vol/vol)

wilting point	0.058	(vol/vol)
sat.hydr.conductivity	1E-3	(cm/sec)
subsurface inflow	0	(mm/year)

1.10. Layer. Municipal Waste (312 kg/cub.m) (Layer 2)

Top Slope Length: 30.0000
Bottom Slope Length: 30.0000
Top Slope: 30.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.6710	(vol/vol)
field capacity	0.2920	(vol/vol)
wilting point	0.0770	(vol/vol)
sat.hydr.conductivity	86.40000000000001	(cm/day)
subsurface inflow	0.0000	(cm/day)

1.11. Layer. Weekly Cover Material 1

Top Slope Length: 30.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.457	(vol/vol)
field capacity	0.131	(vol/vol)
wilting point	0.058	(vol/vol)
sat.hydr.conductivity	1E-3	(cm/sec)
subsurface inflow	0	(mm/year)

1.12. Layer. Municipal Waste (312 kg/cub.m) (Layer 1)

Top Slope Length: 30.0000
Bottom Slope Length: 30.0000
Top Slope: 30.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.6710	(vol/vol)
field capacity	0.2920	(vol/vol)
wilting point	0.0770	(vol/vol)
sat.hydr.conductivity	86.40000000000001	(cm/day)
subsurface inflow	0.0000	(cm/day)

1.13. Layer. Drainage Aggregate 2

Top Slope Length: 30.0000
Bottom Slope Length: 30.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Lateral Drainage Layer Parameters

Parameter	Value	Units
total porosity	0.397	(vol/vol)
field capacity	0.032	(vol/vol)
wilting point	0.013	(vol/vol)

sat.hydr.conductivity	8640	(cm/day)
subsurface inflow	0	(mm/year)

1.14. Layer. Drainage Net (0.5cm)

Top Slope Length: 30.0000
Bottom Slope Length: 30.0000
Top Slope: 5.0000
Bottom Slope : 5.0000

[HELP] Geotextiles and Geonets Parameters

Parameter	Value	Units
total porosity	0.8500	(vol/vol)
field capacity	0.01	(vol/vol)
wilting point	0.005	(vol/vol)
sat.hydr.conductivity	864000.0000000000	(cm/day)
subsurface inflow	0	(cm/day)

1.15. Layer. High Density Polyethylene

Top Slope Length: 30.0000
Bottom Slope Length: 30.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Geomembrane Liner Parameters

Parameter	Value	Units
sat.hydr.conductivity	2E-13	(cm/sec)
pinhole density	2	(#/ha)
installation defects	2	(#/ha)
placement quality	4	(-)
geotextile transmissivity	0	(cm2/sec)

1.16. Layer. Drainage Aggregate 1

Top Slope Length: 30.0000
Bottom Slope Length: 70.0000
Top Slope: 5.0000
Bottom Slope : 4.0000

[HELP] Lateral Drainage Layer Parameters

Parameter	Value	Units
total porosity	0.397	(vol/vol)
field capacity	0.032	(vol/vol)
wilting point	0.013	(vol/vol)
sat.hydr.conductivity	8640	(cm/day)
subsurface inflow	0	(mm/year)

1.17. Layer. Butyl Rubber

Top Slope Length: 70.0000
Bottom Slope Length: 70.0000
Top Slope: 4.0000
Bottom Slope : 4.0000

[HELP] Geomembrane Liner Parameters

Parameter	Value	Units
sat.hydr.conductivity	1.0E-12	(cm/sec)
pinhole density	2	(#/ha)
installation defects	4	(#/ha)
placement quality	4	(-)

geotextile transmissivity	0	(cm2/sec)

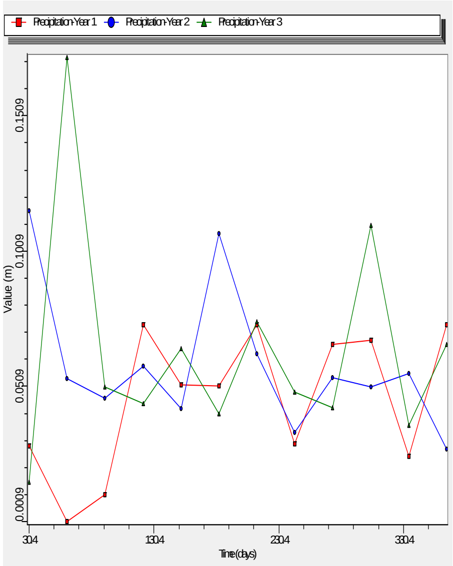
1.18. Layer. Clay

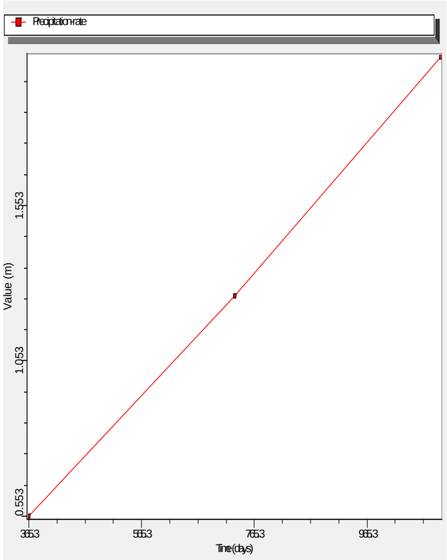
Top Slope Length: 70.0000
Bottom Slope Length: 30.0000
Top Slope: 4.0000
Bottom Slope : 0.0000

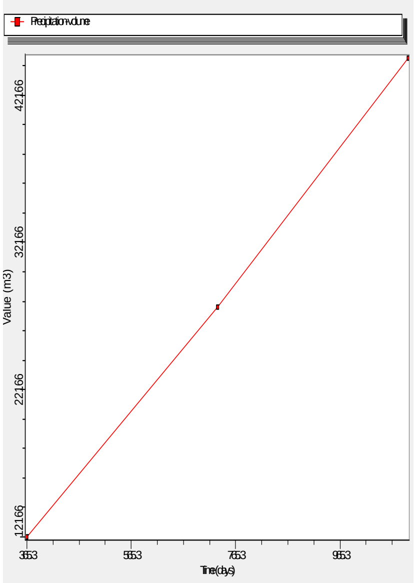
[HELP] Barrier Soil Liner Parameters

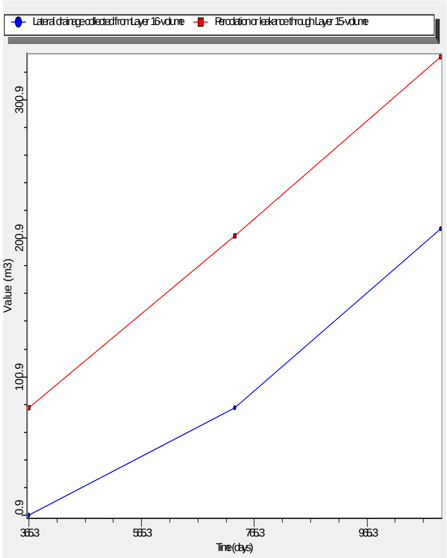
Parameter	Value	Units
total porosity	0.475	(vol/vol)
field capacity	0.378	(vol/vol)
wilting point	0.265	(vol/vol)
sat.hydr.conductivity	0.00095	(cm/day)
subsurface inflow	0	(mm/year)

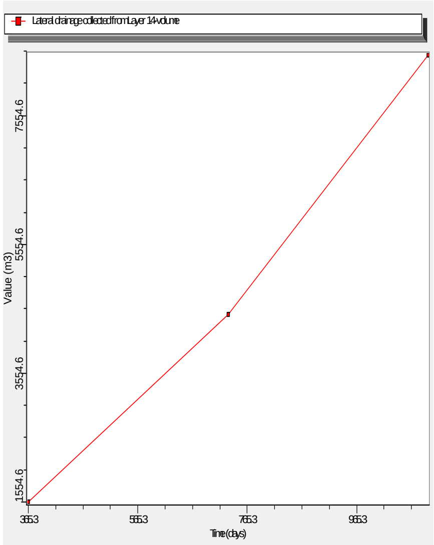
Results:

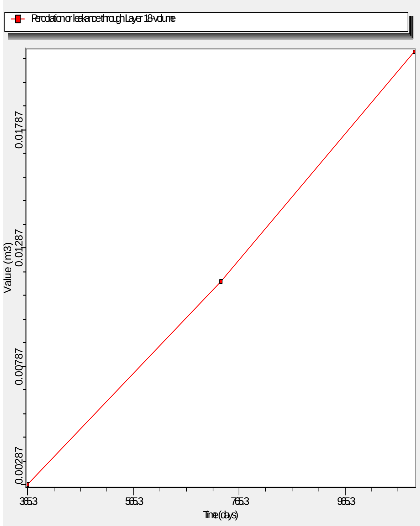



Precipitation-rate
Value (m)
1.553
1.053
0.553
365.3
565.3
765.3
965.3
Time (days)


Precipitation-volume
Value (m3)
42166
32166
22166
12166
365.3
565.3
765.3
965.3
Time (days)


Lateral drainage collected from Layer 16 volume
Percolation or leakance through Layer 15 volume
Value (m3)
0.9
100.9
200.9
300.9
3553
5553
7553
9553
Time (days)


Lateral drainage collected from Layer 14 volume
Value (m3)
1554.6
3554.6
5554.6
7554.6
3553
5553
7553
9553
Time (days)


Percolation or leakance through Layer 18 volume
Value (m3)
0.00287
0.00787
0.01287
0.01787
3553
5553
7553
9553
Time (days)

Annual Totals rate (m)

	Year-1 (m)	Year-2 (m)	Year-3 (m)	Total (m)
Precipitation (m)	5.5300E-01	7.0930E-01	7.6890E-01	2.0312E+00
Runoff (m)	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Evapotranspiration (m)	4.4622E-01	5.8591E-01	5.6170E-01	1.5938E+00
Change in water storage (m)	3.6076E-02	-1.2766E-02	1.8432E-02	4.1742E-02
Water budget balance (m)	-8.3052E-09	-1.0653E-08	-1.1548E-08	-3.0506E-08
Soil water (m)	4.3891E+00	4.3764E+00	4.3948E+00	1.3160E+01
Snow water (m)	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Lateral drainage collected from Layer 14 (m)	7.0664E-02	1.3263E-01	1.8290E-01	3.8619E-01
Percolation or leakance through Layer 15 (m)	3.5775E-03	5.6164E-03	5.8828E-03	1.5077E-02
Lateral drainage collected from Layer 16 (m)	4.1743E-05	3.5318E-03	5.8724E-03	9.4459E-03
Percolation or leakance through Layer 18 (m)	1.3042E-07	3.9028E-07	4.4157E-07	9.6227E-07
Average head on top of Layer 15 (m)	6.7053E-06	1.2658E-05	1.7346E-05	
Average head on top of Layer 17 (m)	1.1628E-06	9.7719E-05	1.6290E-04	

Annual Totals volume (m3)

	Year-1 (m3)	Year-2 (m3)	Year-3 (m3)	Total (m3)
Precipitation (m3)	1.2166E+04	1.5605E+04	1.6916E+04	4.4686E+04
Runoff (m3)	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Evapotranspiration (m3)	9.8168E+03	1.2890E+04	1.2357E+04	3.5064E+04
Change in water storage (m3)	7.9366E+02	-2.8086E+02	4.0551E+02	9.1832E+02
Water budget balance (m3)	-1.8271E-04	-2.3436E-04	-2.5405E-04	-6.7112E-04
Soil water (m3)	9.6561E+04	9.6280E+04	9.6686E+04	2.8953E+05
Snow water (m3)	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Lateral drainage collected from Layer 14 (m3)	1.5546E+03	2.9178E+03	4.0238E+03	8.4962E+03
Percolation or leakance through Layer 15 (m3)	7.8705E+01	1.2356E+02	1.2942E+02	3.3169E+02
Lateral drainage collected from Layer 16 (m3)	9.1834E-01	7.7699E+01	1.2919E+02	2.0781E+02
Percolation or leakance through Layer 18 (m3)	2.8692E-03	8.5862E-03	9.7145E-03	2.1170E-02

Accumulated rate (m)

	Year-1 (m)	Year-2 (m)	Year-3 (m)
Precipitation (m)	5.5300E-01	1.2623E+00	2.0312E+00
Runoff (m)	0.0000E+00	0.0000E+00	0.0000E+00
Evapotranspiration (m)	4.4622E-01	1.0321E+00	1.5938E+00
Lateral drainage collected from Layer 14 (m)	7.0664E-02	2.0329E-01	3.8619E-01
Percolation or leakance through Layer 15 (m)	3.5775E-03	9.1939E-03	1.5077E-02
Lateral drainage collected from Layer 16 (m)	4.1743E-05	3.5735E-03	9.4459E-03
Percolation or leakance through Layer 18 (m)	1.3042E-07	5.2070E-07	9.6227E-07

Accumulated volume (m3)

	Year-1 (m3)	Year-2 (m3)	Year-3 (m3)
Precipitation (m3)	1.2166E+04	2.7771E+04	4.4686E+04
Runoff (m3)	0.0000E+00	0.0000E+00	0.0000E+00
Evapotranspiration (m3)	9.8168E+03	2.2707E+04	3.5064E+04
Lateral drainage collected from Layer 14 (m3)	1.5546E+03	4.4724E+03	8.4962E+03
Percolation or leakance through Layer 15 (m3)	7.8705E+01	2.0227E+02	3.3169E+02
Lateral drainage collected from Layer 16 (m3)	9.1834E-01	7.8617E+01	2.0781E+02
Percolation or leakance through Layer 18 (m3)	2.8692E-03	1.1455E-02	2.1170E-02

Peak daily values

	Rate (m)	Volume (m3)	Day	Year
Precipitation	5.4900E-02	1.2078E+03	45	3
Runoff	3.8645E-03	8.5018E+01	205	3
Lateral drainage collected from Layer 14	5.3747E-05	1.1824E+00	205	3
Percolation or leakance through Layer 15	3.8641E-05	8.5009E-01	234	3
Lateral drainage collected from Layer 16	1.6345E-09	3.5960E-05	234	3
Percolation or leakance through Layer 18	0.0000E+00	3.5494E-02	0	1
Snow water	2.3584E-08	5.5023E-05	0	0

2. Profile. Cell 1 Design

Model Settings

[HELP] Case Settings

Parameter	Value	Units
Runoff Method	Model calculated	(-)
Initial Moisture Settings	Model calculated	(-)

[HELP] Surface Water Settings

Parameter	Value	Units
Runoff Area	100	(%%)
Vegetation Class	Good stand of grass	(-)

Profile Structure

Layer	Top (m)	Bottom (m)	Thickness (m)
🟩 **Weekly Cover Material 6**	32.4935	32.2935	0.2000
🟩 **Municipal Waste (312 kg/cub.m) (Layer 6)**	32.2940	30.2940	2.0000
🟩 **Weekly Cover Material 5**	30.2945	29.9945	0.3000
🟩 **Municipal Waste (312 kg/cub.m) (Layer 5)**	29.9950	27.9950	2.0000
🟩 **Weekly Cover Material 4**	27.9955	27.6955	0.3000
🟩 **Municipal Waste (312 kg/cub.m) (Layer 4)**	27.6960	25.6960	2.0000
🟩 **Weekly Cover Material 3**	25.6965	25.3965	0.3000
🟩 **Municipal Waste (312 kg/cub.m) (Layer 3)**	25.3970	23.3970	2.0000
🟩 **Weekly Cover Material 2**	23.3975	23.0975	0.3000
🟩 **Municipal Waste (312 kg/cub.m) (Layer 2)**	23.0980	21.0980	2.0000
🟩 **Weekly Cover Material 1**	21.0985	20.7985	0.3000
🟩 **Municipal Waste (312 kg/cub.m)**	20.7990	18.7990	2.0000
🟨 **Drainage Aggregate**	18.7995	18.4995	0.3000
▤ **Clay**	18.5000	17.5000	1.0000

2.1. Layer. Weekly Cover Material 6

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.457	(vol/vol)
field capacity	0.131	(vol/vol)
wilting point	0.058	(vol/vol)
sat.hydr.conductivity	1E-3	(cm/sec)
subsurface inflow	0	(mm/year)

2.2. Layer. Municipal Waste (312 kg/cub.m) (Layer 6)

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.671	(vol/vol)
field capacity	0.292	(vol/vol)
wilting point	0.077	(vol/vol)
sat.hydr.conductivity	0.001	(cm/sec)
subsurface inflow	0	(mm/year)

2.3. Layer. Weekly Cover Material 5

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.457	(vol/vol)
field capacity	0.131	(vol/vol)
wilting point	0.058	(vol/vol)
sat.hydr.conductivity	1E-3	(cm/sec)
subsurface inflow	0	(mm/year)

2.4. Layer. Municipal Waste (312 kg/cub.m) (Layer 5)

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.671	(vol/vol)
field capacity	0.292	(vol/vol)
wilting point	0.077	(vol/vol)
sat.hydr.conductivity	0.001	(cm/sec)
subsurface inflow	0	(mm/year)

2.5. Layer. Weekly Cover Material 4

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.457	(vol/vol)
field capacity	0.131	(vol/vol)
wilting point	0.058	(vol/vol)
sat.hydr.conductivity	1E-3	(cm/sec)
subsurface inflow	0	(mm/year)

2.6. Layer. Municipal Waste (312 kg/cub.m) (Layer 4)

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.671	(vol/vol)
field capacity	0.292	(vol/vol)
wilting point	0.077	(vol/vol)
sat.hydr.conductivity	0.001	(cm/sec)
subsurface inflow	0	(mm/year)

2.7. Layer. Weekly Cover Material 3

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.457	(vol/vol)
field capacity	0.131	(vol/vol)
wilting point	0.058	(vol/vol)
sat.hydr.conductivity	1E-3	(cm/sec)
subsurface inflow	0	(mm/year)

2.8. Layer. Municipal Waste (312 kg/cub.m) (Layer 3)

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.671	(vol/vol)
field capacity	0.292	(vol/vol)
wilting point	0.077	(vol/vol)
sat.hydr.conductivity	0.001	(cm/sec)
subsurface inflow	0	(mm/year)

2.9. Layer. Weekly Cover Material 2

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.457	(vol/vol)
field capacity	0.131	(vol/vol)
wilting point	0.058	(vol/vol)
sat.hydr.conductivity	1E-3	(cm/sec)
subsurface inflow	0	(mm/year)

2.10. Layer. Municipal Waste (312 kg/cub.m) (Layer 2)

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.671	(vol/vol)
field capacity	0.292	(vol/vol)
wilting point	0.077	(vol/vol)
sat.hydr.conductivity	0.001	(cm/sec)
subsurface inflow	0	(mm/year)

2.11. Layer. Weekly Cover Material 1

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.457	(vol/vol)
field capacity	0.131	(vol/vol)
wilting point	0.058	(vol/vol)
sat.hydr.conductivity	1E-3	(cm/sec)
subsurface inflow	0	(mm/year)

2.12. Layer. Municipal Waste (312 kg/cub.m)

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.671	(vol/vol)
field capacity	0.292	(vol/vol)
wilting point	0.077	(vol/vol)
sat.hydr.conductivity	0.001	(cm/sec)
subsurface inflow	0	(mm/year)

2.13. Layer. Drainage Aggregate

Top Slope Length: 0.0000
Bottom Slope Length: 70.0000
Top Slope: 0.0000
Bottom Slope : 4.0000

[HELP] Lateral Drainage Layer Parameters

Parameter	Value	Units
total porosity	0.397	(vol/vol)
field capacity	0.032	(vol/vol)
wilting point	0.013	(vol/vol)
sat.hydr.conductivity	8640	(cm/day)
subsurface inflow	0	(mm/year)

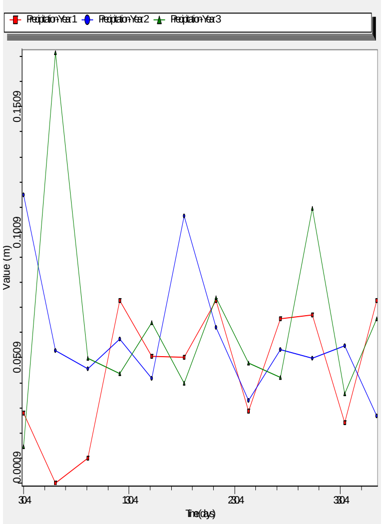
2.14. Layer. Clay

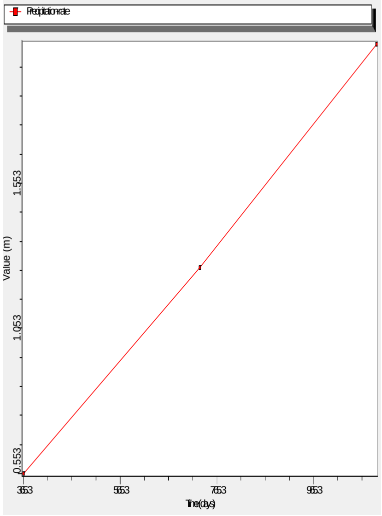
Top Slope Length: 70.0000
Bottom Slope Length: 0.0000
Top Slope: 4.0000
Bottom Slope : 0.0000

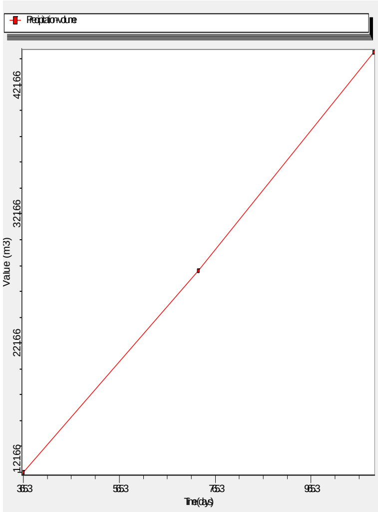
[HELP] Barrier Soil Liner Parameters

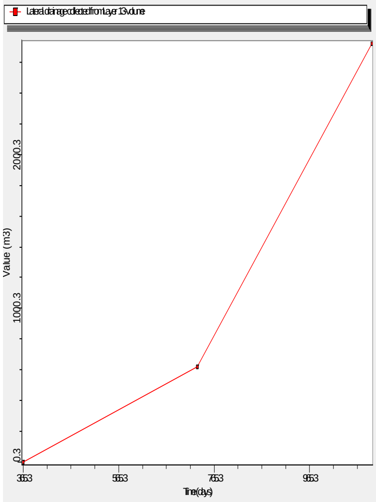
Parameter	Value	Units
total porosity	0.4750	(vol/vol)
field capacity	0.3780	(vol/vol)
wilting point	0.2650	(vol/vol)
sat.hydr.conductivity	0.00095	(cm/day)
subsurface inflow	0.0000	(cm/day)

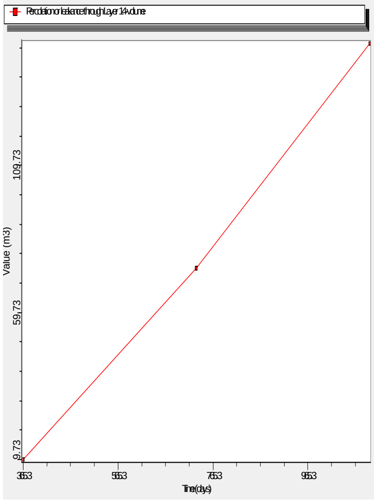
Results:











Annual Totals rate (m)

	Year-1 (m)	Year-2 (m)	Year-3 (m)	Total (m)
Precipitation (m)	5.5300E-01	7.0930E-01	7.6890E-01	2.0312E+00
Runoff (m)	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

Evapotranspiration (m)	5.1917E-01	6.7634E-01	6.5636E-01	1.8519E+00
Change in water storage (m)	3.3375E-02	1.7284E-03	1.3644E-02	4.8748E-02
Water budget balance (m)	-8.3052E-09	-1.0653E-08	-1.1548E-08	-3.0506E-08
Soil water (m)	4.2706E+00	4.2723E+00	4.2860E+00	1.2829E+01
Snow water (m)	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Lateral drainage collected from Layer 13 (m)	1.2668E-05	2.8275E-02	9.5418E-02	1.2371E-01
Percolation or leakance through Layer 14 (m)	4.4246E-04	2.9553E-03	3.4766E-03	6.8744E-03
Average head on top of Layer 14 (m)	4.2474E-07	7.8149E-04	2.6280E-03	
Average head on top of Layer 17 (m)	1.1628E-06	9.7719E-05	1.6290E-04	

Annual Totals volume (m3)

	Year-1 (m3)	Year-2 (m3)	Year-3 (m3)	Total (m3)
Precipitation (m3)	1.2166E+04	1.5605E+04	1.6916E+04	4.4686E+04
Runoff (m3)	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Evapotranspiration (m3)	1.1422E+04	1.4880E+04	1.4440E+04	4.0741E+04
Change in water storage (m3)	7.3426E+02	3.8024E+01	3.0017E+02	1.0724E+03
Water budget balance (m3)	-1.8271E-04	-2.3436E-04	-2.5405E-04	-6.7112E-04
Soil water (m3)	9.3953E+04	9.3991E+04	9.4292E+04	2.8224E+05
Snow water (m3)	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Lateral drainage collected from Layer 13 (m3)	2.7869E-01	6.2205E+02	2.0992E+03	2.7215E+03
Percolation or leakance through Layer 14 (m3)	9.7342E+00	6.5017E+01	7.6486E+01	1.5124E+02

Accumulated rate (m)

	Year-1 (m)	Year-2 (m)	Year-3 (m)
Precipitation (m)	5.5300E-01	1.2623E+00	2.0312E+00
Runoff (m)	0.0000E+00	0.0000E+00	0.0000E+00
Evapotranspiration (m)	5.1917E-01	1.1955E+00	1.8519E+00
Lateral drainage collected from Layer 13 (m)	1.2668E-05	2.8288E-02	1.2371E-01
Percolation or leakance through Layer 14 (m)	4.4246E-04	3.3978E-03	6.8744E-03

Accumulated volume (m3)

	Year-1 (m3)	Year-2 (m3)	Year-3 (m3)
Precipitation (m3)	1.2166E+04	2.7771E+04	4.4686E+04
Runoff (m3)	0.0000E+00	0.0000E+00	0.0000E+00
Evapotranspiration (m3)	1.1422E+04	2.6301E+04	4.0741E+04
Lateral drainage collected from Layer 13 (m3)	2.7869E-01	6.2233E+02	2.7215E+03
Percolation or leakance through Layer 14 (m3)	9.7342E+00	7.4751E+01	1.5124E+02

Peak daily values

	Rate (m)	Volume (m3)	Day	Year
Precipitation	5.4900E-02	1.2078E+03	45	3
Runoff	2.8865E-03	6.3503E+01	197	3
Lateral drainage collected from Layer 13	9.7780E-06	2.1512E-01	197	3
Percolation or leakance through Layer 14	0.0000E+00	7.4751E+01	151	236
Snow water	3.9863E-03	1.2410E+01	0	0

3. Profile. Cell 2 Design

Model Settings

[HELP] Case Settings

Parameter	Value	Units
Runoff Method	Model calculated	(-)
Initial Moisture Settings	Model calculated	(-)

[HELP] Surface Water Settings

Parameter	Value	Units
Runoff Area	100	(%%)
Vegetation Class	Good stand of grass	(-)

Profile Structure

Layer	Top (m)	Bottom (m)	Thickness (m)
🟩 **Weekly Cover Material 6**	32.5000	32.2000	0.3000
🟩 **Municipal Waste (312 kg/cub.m) (Layer 6)**	32.2005	30.2005	2.0000
🟩 **Weekly Cover Material 5**	30.2010	29.9010	0.3000
🟩 **Municipal Waste (312 kg/cub.m) (Layer 5)**	29.9015	27.9015	2.0000
🟩 **Weekly Cover Material 4**	27.9020	27.6020	0.3000
🟩 **Municipal Waste (312 kg/cub.m) (Layer 4)**	27.6025	25.6025	2.0000
🟩 **Weekly Cover Material 3**	25.6030	25.3030	0.3000
🟩 **Municipal Waste (312 kg/cub.m) (Layer 3)**	25.3035	23.3035	2.0000
🟩 **Weekly Cover Material 2**	23.3040	23.0040	0.3000
🟩 **Municipal Waste (312 kg/cub.m) (Layer 2)**	23.0045	21.0045	2.0000
🟩 **Weekly Cover Material 1**	21.0050	20.7050	0.3000
🟩 **Municipal Waste (312 kg/cub.m) (Layer 1)**	20.7055	18.7055	2.0000
🟨 **Drainage Aggregate**	18.7060	18.4060	0.3000
☐ **High Density Polyethylene (HDPE)**	18.4065	18.4055	0.0010
▤ **Clay**	18.4060	17.4060	1.0000

3.1. Layer. Weekly Cover Material 6

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.457	(vol/vol)
field capacity	0.131	(vol/vol)
wilting point	0.058	(vol/vol)
sat.hydr.conductivity	1E-3	(cm/sec)
subsurface inflow	0	(mm/year)

3.2. Layer. Municipal Waste (312 kg/cub.m) (Layer 6)

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.671	(vol/vol)
field capacity	0.292	(vol/vol)
wilting point	0.077	(vol/vol)
sat.hydr.conductivity	0.001	(cm/sec)
subsurface inflow	0	(mm/year)

3.3. Layer. Weekly Cover Material 5

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.457	(vol/vol)
field capacity	0.131	(vol/vol)
wilting point	0.058	(vol/vol)
sat.hydr.conductivity	1E-3	(cm/sec)
subsurface inflow	0	(mm/year)

3.4. Layer. Municipal Waste (312 kg/cub.m) (Layer 5)

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.671	(vol/vol)
field capacity	0.292	(vol/vol)
wilting point	0.077	(vol/vol)
sat.hydr.conductivity	0.001	(cm/sec)
subsurface inflow	0	(mm/year)

3.5. Layer. Weekly Cover Material 4

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.457	(vol/vol)
field capacity	0.131	(vol/vol)
wilting point	0.058	(vol/vol)
sat.hydr.conductivity	1E-3	(cm/sec)
subsurface inflow	0	(mm/year)

3.6. Layer. Municipal Waste (312 kg/cub.m) (Layer 4)

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.671	(vol/vol)
field capacity	0.292	(vol/vol)
wilting point	0.077	(vol/vol)
sat.hydr.conductivity	0.001	(cm/sec)
subsurface inflow	0	(mm/year)

3.7. Layer. Weekly Cover Material 3

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.457	(vol/vol)
field capacity	0.131	(vol/vol)
wilting point	0.058	(vol/vol)
sat.hydr.conductivity	1E-3	(cm/sec)
subsurface inflow	0	(mm/year)

3.8. Layer. Municipal Waste (312 kg/cub.m) (Layer 3)

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.671	(vol/vol)
field capacity	0.292	(vol/vol)
wilting point	0.077	(vol/vol)
sat.hydr.conductivity	0.001	(cm/sec)
subsurface inflow	0	(mm/year)

3.9. Layer. Weekly Cover Material 2

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.457	(vol/vol)
field capacity	0.131	(vol/vol)
wilting point	0.058	(vol/vol)
sat.hydr.conductivity	1E-3	(cm/sec)
subsurface inflow	0	(mm/year)

3.10. Layer. Municipal Waste (312 kg/cub.m) (Layer 2)

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.671	(vol/vol)
field capacity	0.292	(vol/vol)
wilting point	0.077	(vol/vol)
sat.hydr.conductivity	0.001	(cm/sec)
subsurface inflow	0	(mm/year)

3.11. Layer. Weekly Cover Material 1

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.457	(vol/vol)
field capacity	0.131	(vol/vol)
wilting point	0.058	(vol/vol)
sat.hydr.conductivity	1E-3	(cm/sec)
subsurface inflow	0	(mm/year)

3.12. Layer. Municipal Waste (312 kg/cub.m) (Layer 1)

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.671	(vol/vol)
field capacity	0.292	(vol/vol)
wilting point	0.077	(vol/vol)
sat.hydr.conductivity	0.001	(cm/sec)
subsurface inflow	0	(mm/year)

3.13. Layer. Drainage Aggregate

Top Slope Length: 0.0000
Bottom Slope Length: 70.0000
Top Slope: 0.0000
Bottom Slope : 4.0000

[HELP] Lateral Drainage Layer Parameters

Parameter	Value	Units
total porosity	0.397	(vol/vol)
field capacity	0.032	(vol/vol)
wilting point	0.013	(vol/vol)
sat.hydr.conductivity	8640	(cm/day)
subsurface inflow	0	(mm/year)

3.14. Layer. High Density Polyethylene (HDPE)

Top Slope Length: 70.0000
Bottom Slope Length: 70.0000
Top Slope: 4.0000
Bottom Slope : 4.0000

[HELP] Geomembrane Liner Parameters

Parameter	Value	Units
sat.hydr.conductivity	2E-13	(cm/sec)
pinhole density	2	(#/ha)
installation defects	2	(#/ha)
placement quality	3	(-)
geotextile transmissivity	0	(cm2/sec)

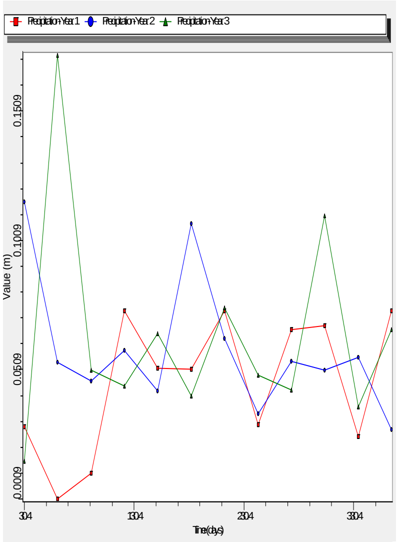
3.15. Layer. Clay

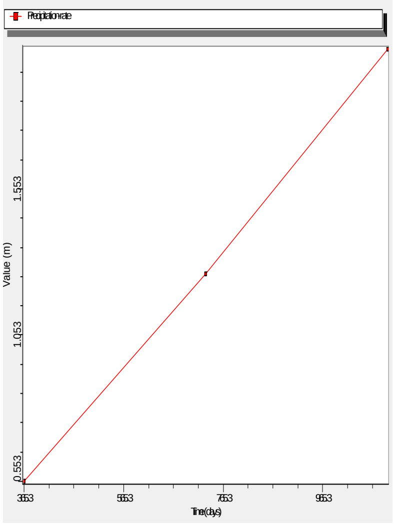
Top Slope Length: 70.0000
Bottom Slope Length: 0.0000
Top Slope: 4.0000
Bottom Slope : 0.0000

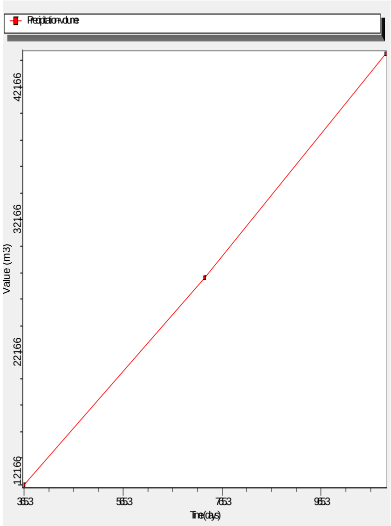
[HELP] Barrier Soil Liner Parameters

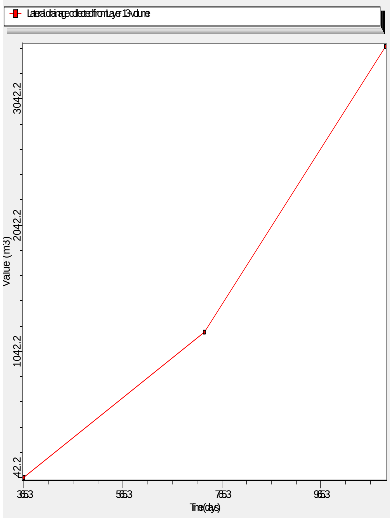
Parameter	Value	Units
total porosity	0.4750	(vol/vol)
field capacity	0.3780	(vol/vol)
wilting point	0.2650	(vol/vol)
sat.hydr.conductivity	0.00095	(cm/day)
subsurface inflow	0.0000	(cm/day)

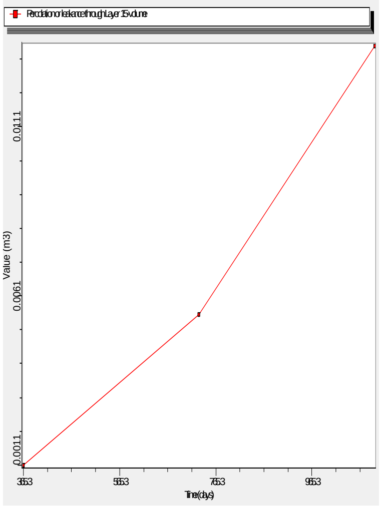
Results:











Annual Totals rate (m)

	Year-1 (m)	**Year-2 (m)**	**Year-3 (m)**	**Total (m)**
Precipitation (m)	5.5300E-01	7.0930E-01	7.6890E-01	2.0312E+00

Runoff (m)	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Evapotranspiration (m)	5.1278E-01	6.6270E-01	6.4910E-01	1.8246E+00
Change in water storage (m)	3.8306E-02	-5.5595E-03	1.6801E-02	4.9547E-02
Water budget balance (m)	-8.3052E-09	-1.0653E-08	-1.1548E-08	-3.0506E-08
Soil water (m)	4.3010E+00	4.2954E+00	4.3122E+00	1.2909E+01
Snow water (m)	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Lateral drainage collected from Layer 13 (m)	1.9188E-03	5.2162E-02	1.0300E-01	1.5708E-01
Percolation or leakance through Layer 15 (m)	4.9800E-08	2.0220E-07	3.6111E-07	6.1311E-07
Average head on top of Layer 14 (m)	5.2466E-05	1.4430E-03	2.8360E-03	
Average head on top of Layer 17 (m)	1.1628E-06	9.7719E-05	1.6290E-04	

Annual Totals volume (m3)

	Year-1 (m3)	**Year-2 (m3)**	**Year-3 (m3)**	**Total (m3)**
Precipitation (m3)	1.2166E+04	1.5605E+04	1.6916E+04	4.4686E+04
Runoff (m3)	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Evapotranspiration (m3)	1.1281E+04	1.4579E+04	1.4280E+04	4.0141E+04
Change in water storage (m3)	8.4273E+02	-1.2231E+02	3.6961E+02	1.0900E+03
Water budget balance (m3)	-1.8271E-04	-2.3436E-04	-2.5405E-04	-6.7112E-04
Soil water (m3)	9.4621E+04	9.4499E+04	9.4869E+04	2.8399E+05
Snow water (m3)	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Lateral drainage collected from Layer 13 (m3)	4.2213E+01	1.1476E+03	2.2660E+03	3.4558E+03
Percolation or leakance through Layer 15 (m3)	1.0956E-03	4.4484E-03	7.9445E-03	1.3489E-02

Accumulated rate (m)

	Year-1 (m)	**Year-2 (m)**	**Year-3 (m)**
Precipitation (m)	5.5300E-01	1.2623E+00	2.0312E+00
Runoff (m)	0.0000E+00	0.0000E+00	0.0000E+00
Evapotranspiration (m)	5.1278E-01	1.1755E+00	1.8246E+00
Lateral drainage collected from Layer 13 (m)	1.9188E-03	5.4081E-02	1.5708E-01
Percolation or leakance through Layer 15 (m)	4.9800E-08	2.5200E-07	6.1311E-07

Accumulated volume (m3)

	Year-1 (m3)	**Year-2 (m3)**	**Year-3 (m3)**
Precipitation (m3)	1.2166E+04	2.7771E+04	4.4686E+04
Runoff (m3)	0.0000E+00	0.0000E+00	0.0000E+00
Evapotranspiration (m3)	1.1281E+04	2.5860E+04	4.0141E+04
Lateral drainage collected from Layer 13 (m3)	4.2213E+01	1.1898E+03	3.4558E+03
Percolation or leakance through Layer 15 (m3)	1.0956E-03	5.5440E-03	1.3489E-02

Peak daily values

	Rate (m)	**Volume (m3)**	**Day**	**Year**
Precipitation	5.4900E-02	1.2078E+03	45	3
Runoff	2.9364E-03	6.4602E+01	200	3
Lateral drainage collected from Layer 13	9.4313E-09	2.0749E-04	200	3
Percolation or leakance through Layer 15	0.0000E+00	5.5440E-03	0	0
Snow water	7.3540E-03	1.3396E+01	0	0

University of Southern Queensland

FACULTY OF ENGINEERING AND SURVEYING

ENG4111/4112 Research Project
PROJECT SPECIFICATION

FOR: **Rowan Alistair HOWARTH**

TOPIC: INVESTIGATION, DESIGN AND DOCUMENTATION OF PROPOSED CELL 3, JOHNSTONS ROAD LANDFILL

SUPERVISORS: Dr Vasantha Aravinthan
Mr. Ron Glasser (Project Officer, EGSC)
Mr. George Black (Principal, Black Geotechnical)

SPONSERSHIP: East Gippsland Shire Council

PROJECT AIM: This project aims to investigate current operational issues and to then develop a design that will address these issues, for the next landfill cell (Cell 3 of 5) at the Johnstons Road Landfill site, Bairnsdale.

PROGRAMME: (Issue C, 19 March 2009)

1. Conduct a Literature review of all relevant guidelines, standards and previous research of Landfill/Liner design.
2. Analyze factors influencing design, existing design issues relating to cell 2, current operational issues and requirements as well as site factors/restrictions.
3. Investigate current site conditions such as hydro-geological conditions including groundwater locations, availability and suitability of clays, feature survey, etc
4. Establish preliminary design requirements regarding site location, required capacity, life span, gas collection, leachate collection and possible treatment etc.
5. Evaluate and model different Liner designs with respect to meeting best practice guidelines and standards, performance and cost.
6. Establish preliminary design, including liner design, leachate collection, gas collection? etc.
7. Submit an academic dissertation on the research and design.

As time permits:

8. Finalize design and establish final drawings and specification

AGREED: ____________________ (student) ____________________ (supervisor)
Date: ___/___/09 Date: ___/___/09

BORROW PIT AREA NOTES:

1. STRIP APPROX. 200mm DEPTH OF TOPSOIL FROM BORROW PIT AREA AS SPECIFIED IN GEOTECHNICAL REPORT AND STOCKPILE.
2. THE BORROW PIT SHALL NOT ALLOW EGRESS OF STORMWATER.
3. BATTER SLOPES SHALL BE LEFT AT A SLOPE NO GREATER THAN 1.5:1 (1.5 HORIZ. TO 1 VERT.) AT COMPLETION OF WORKS.
4. STORMWATER ACCUMULATING IN THE BORROW PIT SHALL BE PUMPED TO THE SEDIMENTATION DAM ONCE WATER QUALITY MEETS EPA GUIDELINES.
5. PLACE 100mm THICK LAYER OF TOPSOIL FROM STOCKPILE OVER BATTER SLOPES AND SEED AND FERTILISE WITH A MIXTURE SUITABLE FOR DRYLAND GRAZING AS RECOMMENDED BY SUPPLIER WHEN CELL CONSTRUCTION IS COMPLETED.

TEST PIT NOTE:

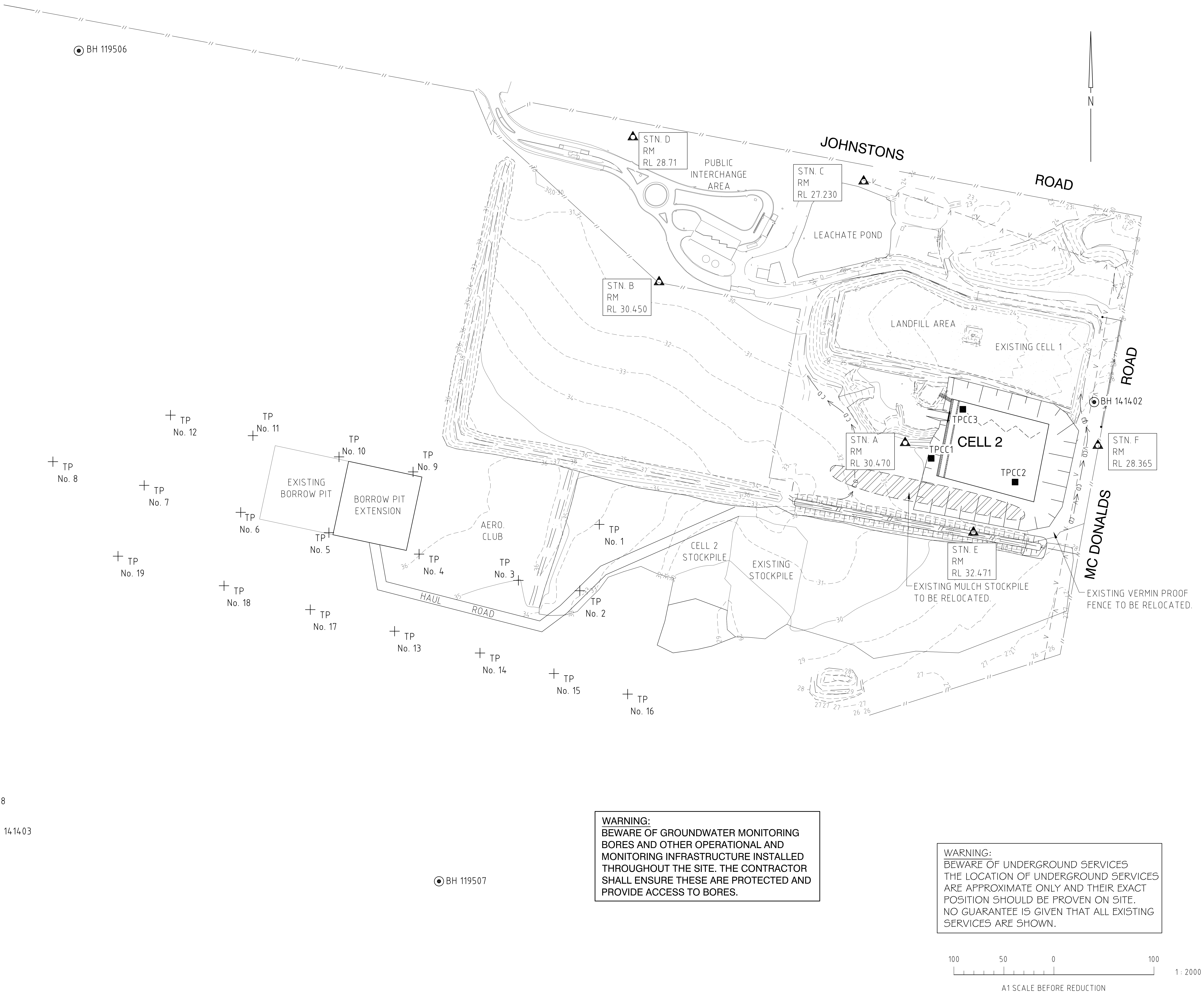
1. T.P. REFERS TO GEOTECHNICAL TEST PITS. DETAILS OF THE SOILS LOGGED FROM THESE TEST PITS INCLUDING CLAY PERMEABILITY TEST RESULTS ARE CONTAINED IN THE GEOTECHNICAL REPORT BY COFFEY GEOSCIENCES PTY. LTD. REFER TO SPECIFICATION.
2. FOR EXCAVATION LOGS FOR TPCC1 TO TPCC3 REFER TO APPENDIX 1 OF THE SPECIFICATION.

STATION CO-ORDINATE SET OUT TABLE

POINT No.	DESCRIPTION	EASTING	NORTHING	RL.
STN. A	RM	555345.903	5806818.140	30.470
STN. B	RM	555099.978	5806978.876	30.450
STN. C	RM	555304.438	5807079.584	27.230
STN. D	RM	555073.796	5807123.698	28.71
STN. E	RM	555414.129	5806728.663	32.471
STN. F	RM	555538.499	5806815.397	28.365

LEGEND:

+ TP No. 12	GEOTECHNICAL TEST PITS
■ TPCC2	EXCAVATION LOGS
⦿ BH 119507	GROUNDWATER MONITORING BORE (PROTECTION REQUIRED)



WARNING:
BEWARE OF GROUNDWATER MONITORING BORES AND OTHER OPERATIONAL AND MONITORING INFRASTRUCTURE INSTALLED THROUGHOUT THE SITE. THE CONTRACTOR SHALL ENSURE THESE ARE PROTECTED AND PROVIDE ACCESS TO BORES.

WARNING:
BEWARE OF UNDERGROUND SERVICES
THE LOCATION OF UNDERGROUND SERVICES ARE APPROXIMATE ONLY AND THEIR EXACT POSITION SHOULD BE PROVEN ON SITE.
NO GUARANTEE IS GIVEN THAT ALL EXISTING SERVICES ARE SHOWN.

Rv.	APPR.	DATE	REVISIONS
C	A.C.C.	14.08.2007	DESIGN AUDIT AMENDMENT
B	A.C.C.	07.06.2007	SIZE OF LANDFILL AMENDED
A	A.C.C.	01.03.2007	ORIGINAL ISSUE

EAST GIPPSLAND
SHIRE COUNCIL

Crossco Consulting Pty Ltd
ABN: 88 135 548 110
154 Macleod St
P.O. Box 858
Bairnsdale Vic 3875
Tel:(03) 51526298
Fax (03) 51527222
Email: consult@crossco.net.au

CROSSCO
ENGINEERING & ENVIRONMENTAL CONSULTANTS

Quality System
Quality Endorsed Company
ISO 9001
LIC. 2178
DLIQ

DESIGNED:	A.G.	A1	DATUM: A.H.D.
DRAWN:	L.W.S.		
CHECKED:	A.C.C.		
APPROVED:	A.C.C.	SURVEY REF:	-
SCALE:	1 : 2000	PLAN No:	-

XREF ATTACHED: R:\00001388 Bairnsdale Landfill Cell 2\ACAD\Xref\1388-Title Block.dwg
CAD FILE NAME: R:\00001388 Bairnsdale Landfill Cell 2\ACAD\Drgs\1388-1001.dwg

EAST GIPPSLAND SHIRE COUNCIL

BAIRNSDALE REGIONAL LANDFILL
CELL 2
EXISTING CONDITIONS AND CLAY
LINER BORROW PIT AREA DETAILS

DATE: MARCH 2007
SHEET 2 OF 12
DRAWING No: 1388/1001
Rv. C

EPA
VICTORIA

LICENCE

issued under Section 20 of the Environment Protection Act 1970

This licence allows the licence holder to deposit waste to land at the premises subject to the attached conditions.

LICENCE HOLDER:	EAST GIPPSLAND SHIRE COUNCIL
REGISTERED ADDRESS:	273 MAIN STREET BAIRNSDALE VIC 3875
PREMISES ADDRESS:	JOHNSTON ROAD BAIRNSDALE SOUTH
LICENCE NUMBER:	LS52327
DATE OF ISSUE:	15 JULY 2003

MICHAEL ROBERT TONTA

ENVIRONMENT PROTECTION AUTHORITY

Plant Activities

This licence applies to a premises where municipal waste is deposited to land.

Licence Objectives

The licence holder shall adopt the following objectives for the protection of the environment:

- meet environmental quality requirements for all segments of the environment. This includes meeting the general provisions of the *Environment Protection Act (1970)*, State environment protection policies, and Industrial waste management policies. In particular,
  - *State environment protection policy (Waters of Victoria);*
  - *State environment protection policy (Groundwaters of Victoria);*
  - *State environment protection policy (Air Quality Management);*
  - *State environment protection policy (Siting and Management of Landfills receiving Municipal Wastes)*
- operate in accordance with good environmental practice at all times, including the provisions of EPA Publication No 788 *Siting, Design, Operation and Rehabilitation of Landfills*; and
- take opportunities to minimise waste and continuously improve environmental performance.

Licence Structure

The licence consists of the following parts.

1. *Waste Management*
   - specifies which wastes may be deposited and the general requirements under which this may occur.
2. *Environment Improvement Plan and Operational Controls*
   - may require an Environment Improvement Plan to be produced and regularly reviewed; and
   - may include operating requirements for good waste management to ensure protection of the environment under both normal and upset conditions.
3. *Monitoring and Reporting*
   - specifies the monitoring requirements and the arrangements for submission of reports to EPA.
4. *Plan of Premises*
   - plan of the premises covered by this licence.

DEFINITIONS

For the purposes of this licence the following interpretations apply:

"EPA" means the Environment Protection Authority

"Municipal waste" includes putrescible wastes and solid inert wastes from manufacturing, commercial, processing and services industries and waste generated within residential dwellings, but does not include liquid wastes, night-soil or grease trap wastes.

1. WASTE MANAGEMENT

Waste Discharge Components

1.1. Only the following wastes may be deposited at the premises:

a) municipal waste, both putrescible and solid inert fractions / only solid inert fractions; and

b) pneumatic automotive tyres shredded into pieces less than 250 millimetres in all dimensions.

Waste Discharge Location

1.2. Waste may only be deposited in that area described as the tipping area on the Plan of Premises.

1.3. Wastes, including litter, must not be:

a) deposited or allowed to accumulate in waters or leachate dams;

b) discharged beyond the boundaries of the premises; or

c) burned.

1.4. Leachate, or any water containing leachate, must not be discharged to the environment beyond the boundary of the premises.

1.5. Seepage of waste to groundwater at the premises must not cause any groundwater quality objective, as specified in State environment protection policy (*Groundwaters of Victoria*), to be exceeded.

Odours

1.6. Odours offensive to the senses of human beings must not be discharged beyond the boundaries of the premises.

Future Landfill Cells and Areas

1.7. At least 3 months prior to the commencement of construction of a new landfill cell, the licence holder must submit to EPA for approval, plans and specifications for the design and construction of the cell liner and leachate[4] collection system.

1.8. Prior to the commencement of construction of any landfill cell, the licence holder must engage an environmental auditor appointed under the Environment Protection Act 1970 to prepare an environmental audit report.

1.9. The environmental audit report referred to in Condition 1.8 must confirm that the cell has been constructed in accordance with the Authority approved plans and specifications as required by Condition 1.7 and be submitted to the Authority.

1.10. In preparing the environmental audit report referred to in Condition 1.8 above, the environmental auditor must:

a. review the approved plans and specifications including the Construction Quality Assurance Plan;

b. review all reports, measurements and other data provided in the context of the Construction Quality Assurance Plan;

c. review all other records and/ or management systems relevant to the construction of the landfill cell;

---

[4] "Leachate" means water that has become contaminated by being in contact with landfill wastes

d. collect and review all other data or information which the relevant environmental auditor considers relevant;

e. undertake one or more inspections of the site; and

f. assess the risk of any possible harm or detriment to the groundwater environment caused by the manner in which the cell has been constructed.

Financial Assurance

1.11. By 1 September 2003 the licence holder must submit a financial assurance in accordance with section 67B of the Environment Protection Act to EPA and the financial assurance proposal accepted by the Authority.

2. ENVIRONMENT IMPROVEMENT PLAN AND OPERATIONAL CONTROLS

Environment Improvement Plan

2.1. By 1 October 2003 the licence holder must submit a revised Environment Improvement Plan (EIP) to EPA for approval.

2.2. The licence holder must operate the landfill in accordance with the latest version of the Environment Improvement Plan approved by EPA.

Tipping and Cover

2.3. The tipping area must be supervised at all times when the landfill is open for the reception of wastes.

2.4. All wastes must be deposited and compacted in layers not exceeding a vertical height of two metres.

2.5. Putrescible wastes must be immediately covered by earth or other EPA approved material after deposition.

2.6. At the end of each day's operation all waste must be covered by a layer of earth or other EPA approved material.

2.7. By the end of each week, all wastes must be covered by a layer of earth or other EPA approved material not less than 300 millimetres in thickness.

2.8. Adequate cover material for at least one month's operation must be readily available on the premises.

Leachate and Stormwater Management

2.9. All surface drainage must be diverted from those portions of the premises which are or have been used for waste deposit.

2.10. Leachate must be extracted from the landfill such that the depth of leachate above the lowest point of the drainage layer does not exceed 300 millimetres.

2.11. Leachate or water must not be permitted to pond on the surface of the landfill.

2.12. All leachate and contaminated stormwater run-off must be collected and directed to the leachate treatment and disposal pond system.

2.13. Leachate and contaminated stormwater must only be discharged from the leachate pond system in accordance with the following:

- a) to irrigation in accordance with the conditions of this licence; or
- b) by tanker to an approved sewerage authority works in accordance with the conditions of this licence; or
- c) for emergency use on the premises to suppress a fire on the premises.

Irrigation of Leachate within the Premises

2.14. Leachate may only be irrigated over that portion of the premises identified as a leachate irrigation area as shown on the attached plan of premises.

2.15. Irrigation must only take place between the hours of 8:00 am and 5:00 pm, except with the approval of EPA.

2.16. Irrigation must not commence or continue during weather conditions which may reasonably be expected to cause spray drift or run-off beyond the boundaries of the premises.

2.17. Irrigation must not cause run-off, ponding or seepage to surface downslope.

2.18. The supply of wastewater to the emitters must be manually controlled by an operator who must remain on the premises during the whole of the irrigation cycle.

2.19. The licence holder must inform EPA of all modifications or additions to the irrigation system, associated works or equipment.

Disposal of Leachate from the Premises

2.20. Liquid waste in the leachate treatment and disposal system must be tankered to an approved disposal site whenever the level in pond reaches a level where the freeboard is reduced below 500 mm and irrigation is not permitted by this licence.

2.21. No discharge of leachate to a sewer shall occur unless approval to discharge to a sewerage system has been obtained from the appropriate authority.

2.22. All leachate transported from the premises must be in accordance with the Environment Protection (Prescribed Waste) Regulations 1998.

Abutting Roads

2.23. The licence holder must ensure that vehicles exiting the premises do not deposit waste, sand, soil, clay or stones on the abutting roads.

2.24. The licence holder must ensure that all vehicles use the wheel cleaning facility when vehicles are likely to take mud off-site.

Site Screening

2.25. A screen of suitable trees and shrubs must be maintained around the northern, western and southern perimeters of the Stage 1 tipping areas, as shown on the plan of premises.

2.26. Tree screening plantations must be maintained and extended as necessary during the life of the landfill by the replacement or infill planting such that the screening remains effective.

Fires

2.27. A water supply and a means of distribution must be readily available to enable the extinguishment of a fire at any part of the premises.

2.28. In the event of a fire breaking out, the licence holder must take immediate action to extinguish the fire.

Signs and Fences

2.29. Signs must be prominently displayed at the premises indicating:

a) EPA waste discharge licence number;

b) the hours of opening of the premises;

c) the types of wastes which may be deposited;

- d) that fires must not be lit on the premises;
- e) the types of wastes which may be recycled;
- f) where wastes may be deposited; and
- g) emergency contact phone numbers.

2.30. All fences and gates surrounding the premises must be:

- a) at least 1.8 metres in height;
- b) maintained to prevent uncontrolled access by livestock or people; and
- c) kept clean and litter-free.

Landfill Gas Management

2.31. Landfill gas must be managed in accordance with the latest version of the landfill gas management plan for the premises approved by EPA.

722?

Progressive Premises Rehabilitation

2.32. The landfill must be progressively rehabilitated in accordance with the latest version of the premises rehabilitation plan for the premises approved by EPA.

Environment Management Review Committee

2.33. The licence holder must establish and facilitate the continued operation of an Environment Management Review Committee to review the development and management of the landfill, the implementation of the EIP and report to EPA.

2.34. The Environment Management Review Committee shall be chaired by a representative of the licence holder, and invite representative(s) of stakeholders with an interest in the management and operation of the facility.

2.35. The objectives and function of the Environment Management Review Committee must be:

- a) to receive reports on the progress and development of the landfill;
- b) to review the development and operation of the landfill;
- c) to identify and address local concerns;
- d) to act as a forum for the exchange of information between the operator and the community on issues relating to refuse collection and disposal;
- e) to coordinate information to the public on litter, recycling and waste management issues;
- f) to review the groundwater monitoring data; and
- g) to report to EPA.

3. MONITORING AND REPORTING

Groundwater Monitoring Program

3.1. The licence holder must maintain five groundwater monitoring bores ('the bores') at the locations shown on the attached plan of premises.

3.2. The bores must be reasonably accessible at all times to any Authorised Officer of EPA or any Authorised Officer under the Water Act 1989.

3.3. Standing water level in the bores must be measured and recorded on each occasion that samples are obtained in accordance with condition number 3.4. This measurement must be:

- a) carried out prior to any disturbance by sampling;
- b) measured relative to ground level; and
- c) referenced to Australian Height Datum.

3.4. Samples of water must be taken from the bores at least once every 6 months, and analysed or tested for:

- a) electrical conductivity
- b) pH
- c) redox potential
- d) total dissolved solids
- e) total kjeldahl nitrogen
- f) ammonia nitrogen
- g) nitrate nitrogen
- h) bicarbonate (as bicarbonate)
- i) chloride
- j) sulfate
- k) sodium
- l) potassium
- m) calcium
- n) magnesium
- o) total iron
- p) manganese
- q) total organic carbon
- r) chemical oxygen demand

3.5. The licence holder must forward to the Project Manager - Groundwater, Department of Natural Resources and Environment, Groundwater Database, PO Box 500, East Melbourne 3002 a copy of all groundwater analyses, measurements and observations within 28 days of the completion of analyses for each sampling occasion referred to in condition 3.4.

Leachate Monitoring Program

3.6. Standing leachate levels in the leachate collection sumps must be measured and reported on every occasion that samples are obtained in accordance with condition 3.7 such that it is:

- a) carried out prior to any disturbance by sampling;
- b) measured relative to ground level;
- c) referenced to Australian Height Datum; and
- d) reported as metres above the lowest point of the top of the landfill liner.

3.7. The licence holder must take a sample from the leachate collection sump on at least one occasion in every period of 6 months and have the sample analysed or tested for:

- a) electrical conductivity
- b) pH
- c) redox potential
- d) total dissolved solids
- e) ammonia nitrogen
- f) bicarbonate (as bicarbonate)
- g) chloride
- h) sulfate
- i) sodium
- j) potassium
- k) calcium
- l) magnesium
- m) total iron
- n) manganese
- o) total organic carbon
- p) volatile fatty acids (C_{2-6})

Sampling and Analysis Procedure

3.8. The licence holder must ensure that all samples required by conditions 3.4 and 3.7 are:

- a) collected, preserved and analysed as specified in the most recent edition of EPA Publication number 441, *"A Guide to the Sampling and Analysis of Waters, Wastewater, Soils and Wastes"*, or by other methods approved by EPA;
- b) sampled, in the case of groundwater, consistent with the most recent edition of EPA Publication number 669, "*Groundwater Sampling Guidelines*" or other methods approved by EPA;
- c) submitted to an analytical laboratory accredited by the National Association of Testing Authorities (NATA) to undertake the analyses specified in this licence unless prior agreement to do otherwise has been obtained from EPA; and
- d) the results of the analysis are submitted to EPA in a NATA endorsed test report unless prior agreement to do otherwise has been obtained from EPA.

Greenhouse Gas Action Plan

3.9. By 30 November 2003, the licence holder must submit a Greenhouse Gas Action Plan to EPA for written approval in accordance with EPA Protocol for Environmental Management (PEM), *Greenhouse Gas Emissions and Energy Efficiency in Industry*.

824

National Pollutant Inventory

3.10. By the 30 September each year, the licence holder must submit a National Pollutant Inventory report using the NPI Emission Estimation Technique Manual, *Municipal Solid Inert Landfills*, for the licence holder's previous year's NPI Reporting Period to EPA.

Premises Rehabilitation Plan

3.11. On or before 1 October 2003, the licence holder must submit a revised premises rehabilitation plan to EPA for approval.

3.12. The premises rehabilitation plan required by condition 3.11 must include consideration of, and designs for, the following provisions where applicable:

a) proposed timetable for the progressive rehabilitation of the current and previous tipping areas;

b) anticipated timetable for the closure and rehabilitation of the premises;

c) after-use options, including the preferred option;

d) final contour plan of the premises at the completion of waste filling;

e) final contour plan after capping and rehabilitation of the premises (allowing for settlement);

f) capping design and specifications for cap installation;

g) surface water drainage system;

h) landfill gas management system;

i) leachate collection and disposal after landfill closure;

j) provision for irrigation measures to promote vegetation on the final surface;

k) proposed cap protection measures and settlement monitoring program; and

l) anticipated period of and provisions for after-care of the premises.

Complaints

3.13. The licence holder must keep a written record of all complaints received concerning the environmental impact of the premises which includes:

a) name and address of complainant;

b) date and time of complaint;

c) location from which complaint arose;

d) general description of the nature of the complaint;

e) approximate wind direction and temperature at the time of the complaint;

f) the likely source of the cause of the complaint; and

g) action taken by licence holder.

Annual Reporting

3.14. By 1 October each year the licence holder must submit a report to EPA on the operations at the premises during the previous financial year which includes:

a) the results of the groundwater monitoring program required by conditions 3.1 to 3.4 with monitoring bores identified by their Groundwater Database Number;

b) assessment by an appropriately qualified and experienced hydrogeologist of the results of the groundwater monitoring including trends in quality and potential impacts on beneficial uses of groundwater and a review of the basis for forward leachate behaviour and groundwater impact;

c) certification by an appropriately qualified and experienced hydrogeologist that groundwater quality objectives as specified in State environment protection policy (Groundwaters of Victoria) are not being exceeded;

d) leachate management report including:

i) volume extracted from the landfill;

ii) results of leachate monitoring program required by conditions 3.6 to 3.7;

iii) program/method for preventing odours; and

iv) method and volume of leachate disposed;

e) summary of number, nature and action taken in regard to any environmental complaints;

f) a contour plan of the premises as at the end of the previous financial year;

g) the remaining air space at the landfill and projected landfill life;

h) a review of the progressive premises rehabilitation plan and any proposed changes; and

i) a review of performance against the measures specified in the Environment Improvement Plan and identify any proposed changes to the plan.

Groundwater Audit Report

3.15. By no later than 1 October each year, the licence holder must submit to the Authority an environmental audit report prepared by an environmental auditor appointed under the *Environment Protection Act* 1970 in relation to the risk of any possible harm or detriment to groundwaters caused by the activities of the licence holder on the premises as determined by:

a) the review of any relevant data including but not limited to the leachate management records and the results of any sampling and analysis from relevant groundwater monitoring bores and leachate sumps;

b) an inspection of any relevant activity on the site as the auditor sees fit; and

c) the taking of any sample, measurement, reading or test as the auditor sees fit;

that are relevant to the impact of the landfill's operations on the quality of local groundwater.

3.16. Specifically, the environmental audit report referred to in Condition 3.15 shall confirm:

a) that groundwater quality objectives as specified in State environment protection policy (Groundwaters of Victoria):

(i) are being met at the premises; or

(ii) are not being met at the premises and recommend measures, including an implementation timetable, necessary to ensure groundwater quality objectives will be met; or

b) that the status of groundwater quality objectives at the premises can not be determined and recommend measures necessary, including an implementation timetable, to ensure that the status of the groundwater quality will be able to be determined.

Landfill Levy

3.17. The licence holder must submit a landfill levy statement and accompanying payment quarterly as follows:

a) July-September quarter – paid on or before 31 December;

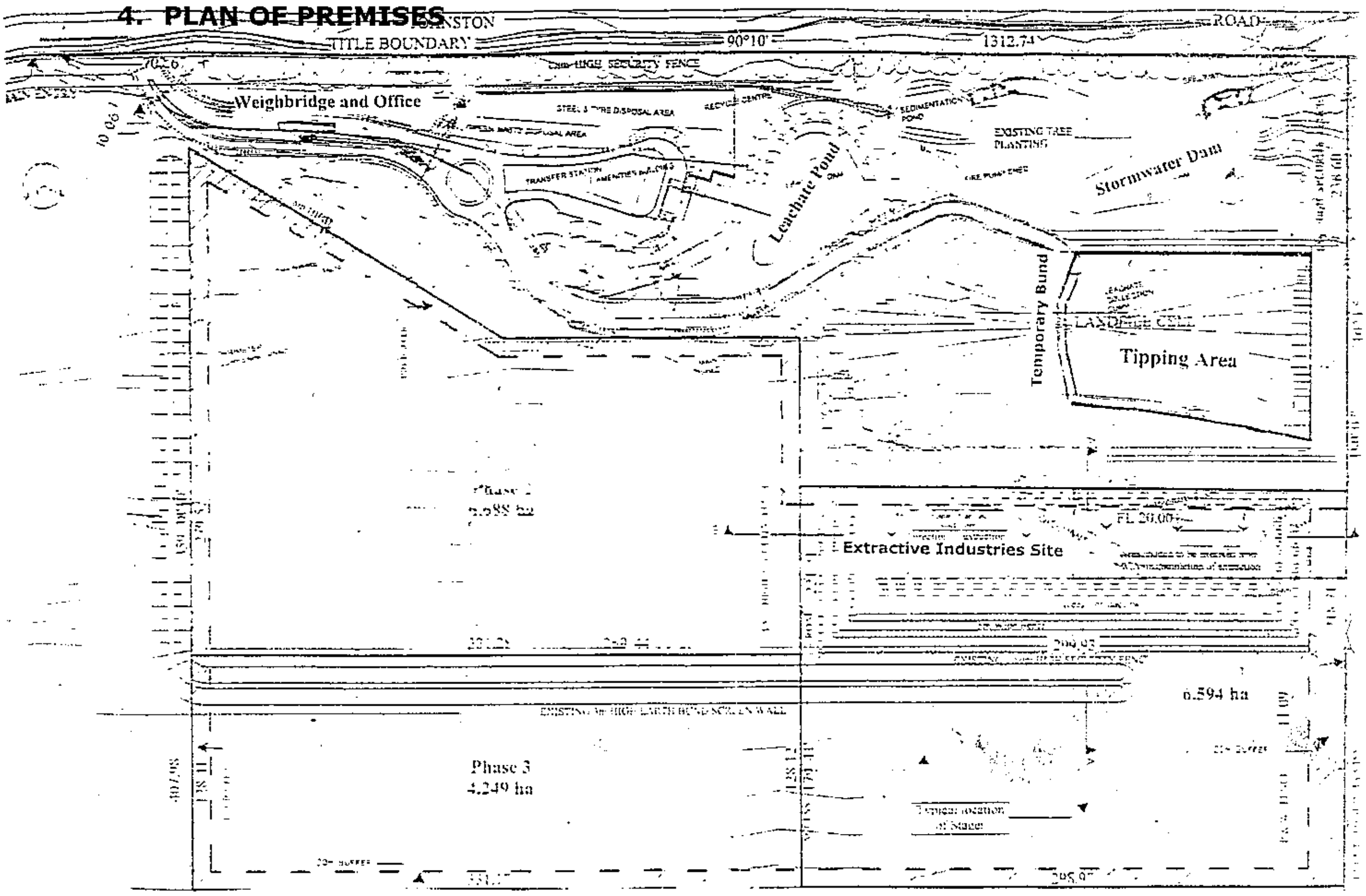
b) October-December quarter – paid on or before 31 March;

c) January-March quarter – paid on or before 30 June; and

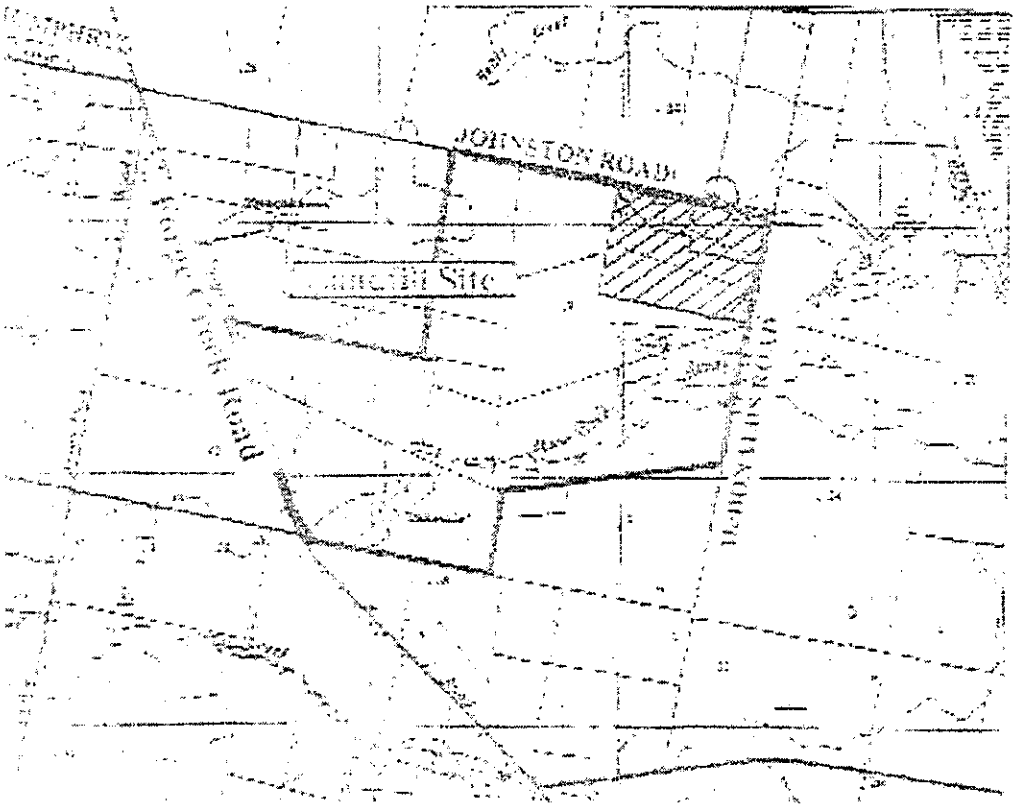
d) April-June quarter – paid on or before 30 September to reconcile previous quarterly payments with the amount of levy payable in respect of waste deposited during that financial year.

3.18. The statement referred to in condition 3.17 must be supported by accurate records detailing the quantity of municipal waste received and cover material used during each quarter.

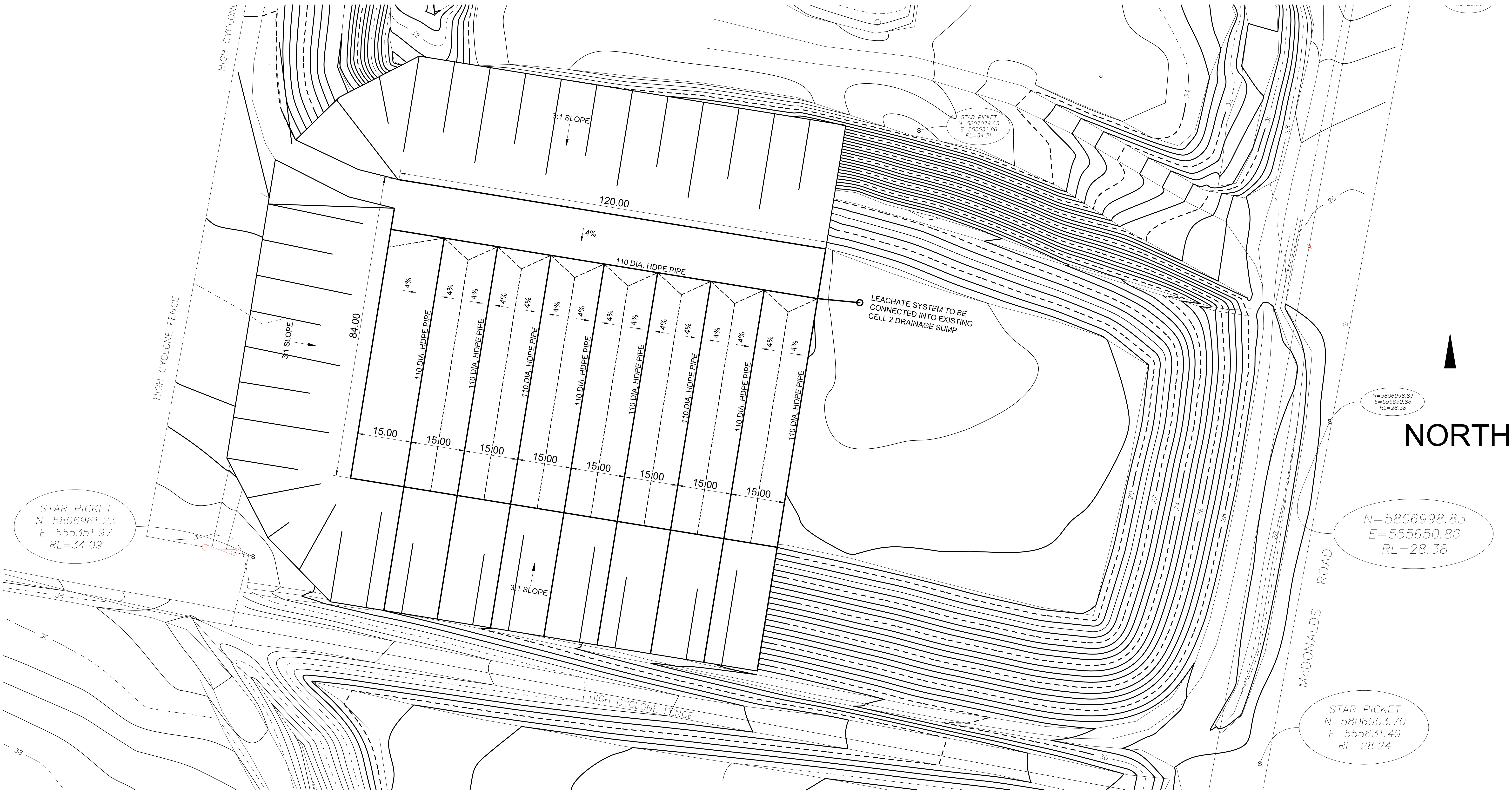
4. PLAN OF PREMISES



Plan of Premises



Locality Plan


HIGH CYCLONE
HIGH CYCLONE FENCE
3:1 SLOPE
120.00
4%
110 DIA. HDPE PIPE
84.00
3:1 SLOPE
LEACHATE SYSTEM TO BE CONNECTED INTO EXISTING CELL 2 DRAINAGE SUMP
15.00
15.00
15.00
15.00
15.00
15.00
15.00
15.00
3:1 SLOPE
HIGH CYCLONE FENCE
STAR PICKET N=5807079.63 E=555536.86 RL=34.31
STAR PICKET N=5806961.23 E=555351.97 RL=34.09
N=5806998.83 E=555650.86 RL=28.38
N=5806998.83 E=555650.86 RL=28.38
STAR PICKET N=5806903.70 E=555631.49 RL=28.24
McDONALDS ROAD
NORTH
32
34
32
30
28
28
20
22
24
26
28
28
30
34
36
36
38

EAST GIPPSLAND
SHIRE COUNCIL

SPECIFICATIONS

CONTRACT NO. XXX/XXX

CONSTRUCTION OF CELL 3
BAIRNSDALE REGIONAL LANDFILL
JOHNSONS ROAD, BAIRNSDALE

Closing Date: XXXXXXXXXXXXXXXXXXXXXX

Our Vision, Our Values

OUR VISION

The East Gippsland Shire will provide strong and inclusive leadership and, through a shared commitment with our diverse communities, nurture our healthy lifestyle and environment, supporting a sustainable economy

OUR VALUES

- Transparency and accountability
- Decision making framework that considers financial, environmental and social consequences
- Community engagement
- Professionalism and commitment
- Teamwork
- Innovation and excellence
- Responsible financial management

Contents

Contents 1
SECTION 3 - SPECIFICATION 4
1 General 4
1.1 Drawings 4
1.2 General 4
1.3 Scope of Work 4
1.4 Contract Times 4
1.5 Adverse Weather Conditions 5
1.6 Contractor's Establishment 5
1.7 Time and Performance Schedule 6
1.8 Site Conditions 6
1.9 Covering Letter 6
1.10 Definitions 6
1.11 Standard Specification 6
1.12 Trade-Named Items 7
1.13 Co-Operation With Other Contractors 7
1.14 Fires 7
1.15 Measurement Of Quantities 7
1.16 Testing Of Works 8
1.17 Provision Sum 8
1.18 Provisional Quantities 8
1.19 Instructions 8
1.20 Variations On Contract 9
1.21 Hours Of Work 9
1.22 Safety Of Contractor Personnel 9
1.23 First Aid 10
1.24 Safety Of The Public And Protection Of Works 10
1.25 Injury To Persons 10
1.26 Liability Of Contractor For Actions, Suits, Claims, Etc 10
1.27 Temporary Storage And Amenities 10
1.28 Datum Marks 10
1.29 Setting Out The Works 11
1.30 Use of Public Roads 12
1.31 Structures to Drainage Works 12
1.32 Existing Services, Structures And Property Of The Principal 12
1.33 Removal of Existing Structures 12
1.34 Trenches To Be Timbered 12
1.35 Explosives 13

1.36 Maintenance – During Construction 13
1.37 Clearing Up On Completion 13
1.38 Maintenance - After Completion 14
1.39 "As Constructed" Drawings 14
1.40 Practical Completion Of Works 14
1.41 Defects Liability Period 15
1.42 Final Acceptance Of Works 15
1.43 Environmental Controls 15
1.44 Dust Suppression 15
1.45 Control Of Soil Erosion 15
1.46 Surface Drainage During Site Operations 16
1.47 Industrial Matters 16
1.48 Co-Ordination Meetings 16
2 Earthworks 18
2.1 Scope 18
2.2 Nature of the Ground 18
2.3 Testing 18
2.4 Safety of Earthworks 19
2.5 Clearing, Grubbing and Topsoil Stripping 19
2.6 Landfill Site Earthworks 19
2.7 Compaction Plant 20
2.8 Borrow Area and Management of Materials 21
2.9 Other Site Earthworks 27
2.10 Topsoiling and Grassing 27
3 HDPE Liner Supply & Installation 29
3.1 General 29
3.2 Trimming & Compaction 29
3.3 Anchor Trench 29
3.4 Area To Be Lined 29
3.5 Experience 30
3.6 Material Specifications 30
3.7 Factory Quality Control 30
3.8 Subgrade Preparation 31
3.9 Liner Installation 31
3.10 Field Seams 32
3.11 Field Seam Testing 32
3.12 Quality Assurance Certificates and Records 32
3.13 Protection of Works 33
3.14 Warranty 33
4 CONCRETE 34
4.1 General 34

4.2 Standards 34
4.3 Materials 34
4.4 Storage of Materials 34
4.5 Mixture 35
4.6 Pre-Mixed Concrete 35
4.7 Mixed On-Site Concrete 35
4.8 Cement Mortar 35
4.9 Additives 35
4.10 Consistency 35
4.11 Concrete Strength 36
4.12 Standard Tests For Material and Concrete 36
4.13 Formwork 36
4.14 Reinforcement 36
4.15 Inspection prior to placement of concrete 36
4.16 Placing of Concrete 36
4.17 Compaction of Concrete 37
4.18 Curing 37
4.19 Defective Concrete 37

5 Leachate Pipes and Fittings 38

5.1 Scope 38
5.2 Materials 38
5.3 Handling and Delivery of Pipes and Fittings 39
5.4 Construction 39

6 Quality System 41

6.1 General 41
6.2 Construction Quality Assurance Plan 41
6.3 Environmental Management Plan (Construction) 41
6.4 Environmental Audit 43
6.5 Occupational Health and Safety 43
6.6 Construction Program 43

SECTION 4 – GEOTECHNICAL REPORT .... Error! Bookmark not defined.

SECTION 3 - SPECIFICATION

1 General

1.1 Drawings

The following drawings shall be used in conjunction with this Specification and will form part of the Contract Documents.

Drawing No.	Title

INSERT DRAWING NUMBERS AND TITLES

1.2 General

The works of this Contract shall be carried out in accordance with this Specification, the accompanying drawings and General Conditions of Contract AS2124-1992. An extract of Annexure A of AS2124-1992 is attached.

1.3 Scope of Work

The works under this Contract comprise the supply of all labour, materials and equipment necessary for construction and testing of all works associated with the development of Cell 3 of the Landfill located at the Bairnsdale Regional Waste Management Facility, Johnston's Road, Forge Creek.

The works will include, but are not limited to:

- Preliminary works including relocation of vermin proof fence and mulch stockpile and stripping of topsoil.
- Bulk earthworks to create the Cell 3 void to the design sub-grade line and levels
- Screening and stockpiling material from the bulk earthworks to obtain sufficient material for placement of a drainage filter over the clay liner.
- Development of a clay borrow pit and placement of a compacted clay liner, including haul road and erosion control.
- Installation of a 2mm thick HDPE liner and geo-textile to the base and sides of Cell 3.
- Placement of leachate collection pipes, and drainage filter blanket on top of the liner, and connection into the drainage sump located within Cell 2.
- Other miscellaneous works.

The whole of the works will be carried out in strict accordance with and to the true intent and purpose of the accompanying drawings and specifications and under the supervision of the Superintendent.

1.4 Contract Times

a) Time for Commencement

The works under this contract shall commence within fourteen (14) days from the date of notification of acceptance of tender.

b) Time for Completion of Contract

The whole of the works shall be completed within Thirty (30) weeks from the date of Notification of Acceptance of Tender, inclusive of all public and industry holidays. This time also includes a provision time of six (6) working days for time lost during or as a consequence of adverse weather conditions.

The Principal shall be entitled to deduct or set off as and by way of liquidated damages, the sums noted in Annexure A of the General Conditions of Contract for any delay in the completion of works beyond the stated time of completion.

1.5 Adverse Weather Conditions

Time lost due to adverse weather conditions is defined for the purpose of this contract as time lost due to wet weather or excessively hot or dusty conditions and to the effects of these adverse conditions, eg. wet site conditions following rain.

The Contractor's site representative shall notify the Superintendent immediately of any time lost due to adverse weather conditions and shall confirm such notification in writing within 7 days. This confirmation shall provide details of the nature and extent of delays and the construction activities affected. The Superintendent, if satisfied that the Contractor has taken reasonable steps to minimise the period of delay, will certify within 7 days an appropriate period of time lost. The Superintendent will only certify time lost during customary working hours as defined in the General Conditions of Contract. The maximum period of time, which will be certified on any working day, will be eight hours.

Only delays affecting critical activities included in the approved construction program shall be considered as time lost due to adverse weather conditions.

If, subject to the above, the total period of time certified exceeds the total allowance for the Contract the Superintendent will, in accordance with General Conditions of Contract, grant an extension of time for completion on the basis of one (1) working day for each eight (8) hours of certified time in excess. No extension of time will be granted until the total excess period equals eight (8) hours or a multiple thereof. Periods of less than eight (8) hours duration shall accrue to form part of a subsequent extension of one working day when the total excess equals the next successive multiple of eight (8) hours.

No payment of any kind will be made for the granting of extension of time due to adverse weather conditions.

1.6 Contractor's Establishment

The Contractor shall erect his site establishment adjacent to the area of the Works at a location approved by the Superintendent.

Upon receipt of notice to remove his site establishment at the completion of the Contract, the Contractor shall immediately remove all sheds, temporary fencing, buildings, equipment, surplus materials, etc., and restore the area used to its original condition to the satisfaction of the Superintendent.

The Contractor shall at his own expense provide any necessary temporary access facilities to this site establishment and remove these at the completion of the works of the Contract, restoring the site to its original condition and to the satisfaction of the Superintendent.

1.7 Time and Performance Schedule

Within seven (7) days of the Date of Letter of Acceptance of Contract, the Contractor shall prepare and submit to the Superintendent a construction program for the orderly completion of the works.

During the initial preparation of the construction program the Contractor shall confer with the Superintendent to ensure that agreement is reached regarding layout and conventions.

At fortnightly intervals during the construction period the Contractor shall lodge with the Superintendent two (2) copies of the time and progress schedule showing the percentage of progress made in each section of the work.

1.8 Site Conditions

The Contractor must satisfy himself as to the different sub-surface, ground and groundwater conditions likely to be encountered during construction and shall be deemed to have made full allowance for contingencies arising there from in the tendered price.

A Geotechnical report by Coffey Geosciences is attached to this specification as information only.

It shall be the responsibility of the Tenderer to ascertain the ground conditions to the full extent of the proposed excavation.

The associated tender amount shall remain firm irrespective of the type of material or excavation conditions actually encountered during construction.

1.9 Covering Letter

If the Tenderer deems it necessary to submit qualifying conditions or exceptions with his Tender, then all these qualifying conditions and exceptions shall be contained in a single covering letter, giving where possible the sums of money which would be required in lieu of these qualifying conditions and exceptions.

1.10 Definitions

References to "the Engineer" herein shall refer to the Superintendent except where it is intended to refer to the Municipal Engineer. The Municipal Engineer is the Manager, Projects of the East Gippsland Shire Council. The Municipality is the East Gippsland Shire Council or its Authorised Representative.

Where the word 'approved' is used in this Specification, it shall mean approved by the Superintendent.

1.11 Standard Specification

All materials, equipment and fittings supplied under this Contract shall be new and in accordance with the requirements of the relevant Australian Standard Specifications where such exist or, in their absence, with the relevant British Standard Specifications or American Society for Testing and Materials (ASTM) Specifications.

If any requirements of this Specification conflict with the Standard requirements, then the specified requirements shall apply.

Wherever a Standard Specification or Code is specified herein, it shall mean the latest edition and/or amendment of that Specification or Code at the date of calling of tenders for this Contract.

1.12 Trade-Named Items

Trade names, brands and catalogue numbers specified herein are intended as an indication of the quality, appearance, type, finish, and/or method of construction which will meet the approval of the Superintendent.

Any alternative offered by the Contractor must be equivalent to that specified and to the approval of the Superintendent.

An alternative item to a specified item will be approved by the Superintendent provided the alternative item can be shown to:

a. be at least equal in quality, durability, appearance, strength and design to the specified item; and

b. perform at least equally the specific function imposed by the general design; and

c. conform substantially even with deviations to the detailed requirements for the item in the Specification; and

d. have at least an equal operational performance record.

1.13 Co-Operation With Other Contractors

During the progress of this Contract, work may be undertaken by others in the vicinity of the works. Access to the existing landfill cell must be maintained at all times between 8am to 5pm daily for waste contractors.

It is expected that the Contractor will liaise with others concerning access, construction schedules, etc. and should at all times co-operate with other personnel in the execution of their work.

The Contractor shall avoid interference with the work being carried out by others in the vicinity of the site and shall co-operate in order to prevent any delays to the progress of the project. Should the Contractor damage any adjacent work being carried out by others, he shall at his own expense make good such damage as directed by the Superintendent.

1.14 Fires

No fires shall be lit for any purpose in connection with this Contract unless authorised in writing by the Superintendent and not forbidden by any current Government Regulations. The Contractor shall give occupiers of adjoining properties and other contractors forty-eight (48) hours' notice of his intention to burn.

The Contractor shall be responsible for all damage to fences, grass cultivation, buildings or other property occasioned by fires lit for any purpose in connection with this Contract.

1.15 Measurement Of Quantities

All quantities are to be measured in accordance with the AS1181-1971 "Measurement of Civil Engineering Quantities".

a) Volume

Each quantity relating to volume shall be defined as being the volume, which it occupies or will occupy in the present proposed location. All volumes stated in the schedule refer to solid volumes; no allowance is made for bulking or compaction.

b) Area

Each quantity relating to area shall be defined as being the plan area for the item being measured except for:

i) Surface treatment of concrete or masonry surfaces other than those directly associated with excavation or earthworks, and

ii) Any other items which the Superintendent considers reasonable.

All of which shall have their areas measured in the plane of the item being considered.

Payment for all earthworks items shall be made based on as constructed survey results received from the contractor's licensed surveyor. Measurement of quantities shall be undertaken utilising the Superintendent's mathematical and computing tools.

1.16 Testing Of Works

All materials, equipment, installation and workmanship included in the works of this Contract, if so requested by the Superintendent, shall be tested and inspected to provide compliance with the Contract requirements.

Tests and inspections, unless otherwise specified or accepted, shall be in accordance with the relevant standards of the Australian Standards Association or those of the British Standard Institution or American Society for Testing and Materials.

At all times when tests are in progress, the Contractor shall have at least one qualified and approved representative present. In the case of tests on works of Sub-Contractors a qualified and approved representative of the Sub-Contractor shall also be present for the duration of the tests.

Testing of all earthworks shall be undertaken by the Contractor in accordance with Section 2.3 of this specification

In the event that any tests fail and additional retesting is required, then the cost of this additional retesting shall be borne by the Contractor.

1.17 Provision Sum

The provision sum specified in this clause shall be added by the Contractor and included in a schedule and in his Tender amount. The whole, part or no part of any provision sum may be expended, as the Superintendent may, at his discretion deem advisable. The Contractor will be paid only for work actually ordered in writing and carried out and the Contractor will have no claim in respect of any provision sum except as to the portion of it actually expended under written order by the Superintendent.

1.18 Provisional Quantities

Any provisional quantities specified in this clause shall be added by the Contractor and included in a schedule and in his Tender amount.

More than or the whole, part or no part of any provisional quantity may be ordered as the Superintendent may, at his discretion, deem advisable. The Contractor will have no claim in respect of any provisional quantity, except as to the amount actually authorised under a written order by the Superintendent.

1.19 Instructions

The Contractor shall at all times give immediate effect to the Superintendent's instructions, whether written or verbal. The Superintendent shall be in sole control of the Contract. He shall define the order or work or the program of construction which the Contractor shall strictly observe.

In reply to the Superintendent's absence, the Contractor shall fulfil the instructions of the Superintendent's nominated representative.

At his discretion and at no additional cost to the Principal the Superintendent can order one portion of the Contract to be proceeded with before another part is completed. The Superintendent has power to amend the designed layout and Contract Drawings, as he may deem necessary on the site. The order of the work can be amended by the Superintendent if he deems it will quicken the completion of the Contract or is necessary in the interest of completing the other contracts.

1.20 Variations On Contract

No extra work shall be done by the Contractor and no section of the works omitted, without a written direction from the Superintendent being first obtained. Such direction shall be on the Superintendent's Variation Order form. The Contractor shall check the quantities shown on such orders and shall ensure that they are correct before commencing any extras ordered. Payment shall not be made for any extras performed in excess of those ordered.

1.21 Hours Of Work

The hours of work shall be restricted to 7:00am to 6:00pm, Monday to Saturday inclusive. Should the Contractor wish to perform any work, including plant maintenance, outside these hours he shall first obtain the permission of the Superintendent to do so.

The Superintendent reserves the right to restrict the Contractor's use of public roads during hours of peak traffic flows. Such restrictions will not be unnecessarily imposed.

The time for Practical Completion is inclusive of all industry Rostered Days off and Public Holidays. Should the Contractor wish to work on these days, he shall first obtain the permission of the Superintendent.

When construction works are carried out on industry Rostered Days Off and Public Holidays, it may be necessary, at the Superintendents discretion, for the Contractor to pay to Council or the Superintendent the cost of supervision at the current rates which can be obtained from the Superintendent.

In this regard the Contractor will-be required to give 48 hours notice of this intention to work so that the necessary arrangement of staff may be carried out.

No payment of any kind will be made for overtime rates or site allowances.

1.22 Safety Of Contractor Personnel

It is the Contractors responsibility to be informed of the provisions of the Occupational Health and Safety Act 2004. The duties and all other obligations that the Act placed on an employer shall be properly discharged by the Contractor.

The Contractor shall take all necessary precautions to ensure the safety of personnel employed on the works site and shall bear sole responsibility for giving effect to such precautions and for any damage or injury to personnel. Contractor personnel employed in excavations or required to work within the operating radius of a crane, backhoe or excavator shall be equipped with safety helmets.

The Contractor shall be required to provide the Superintendent with a detailed Occupational Health and Safety Plan prepared by a registered Occupational Hygienist which addresses the provisions of the Occupational Health and Safety Act 2004. In particular, the Contractor shall be required to provide details of procedures which comply Section 21 of the Act: Duties of Employers, and evidence of compliance with these procedures. The Superintendent will conduct random checks to confirm compliance with the Health and Safety Plan.

The Contractor shall ensure that all employees on site wear approved safety footwear and high visibility clothing at all times.

The Contractor shall take all precautions considered necessary by the Superintendent, to prevent the entry of unauthorised persons into the construction areas.

1.23 First Aid

The Contractor shall provide, equip and maintain an adequate first aid treatment centre on the site and shall have an experienced first aider available at all times when work is in progress.

1.24 Safety Of The Public And Protection Of Works

The Contractor shall, to the satisfaction of the Superintendent, erect and maintain all necessary warning signs, barricades and lights and take all necessary precaution for the safety of the public and protection of the works.

All works adjacent to access roads shall be cordoned off and appropriately lit to the satisfaction of the Superintendent.

1.25 Injury To Persons

The Contractor shall be solely liable for and shall indemnify the Principal in reply to respect of and shall insure against any liability, loss, claim or proceedings whatsoever arising under any statute (other than as provided in the previous clause dealing with Worksafe) or at Common Law in respect of personal injury to or death of any person whomsoever arising out of or in the course of or caused by the execution of the works.

1.26 Liability Of Contractor For Actions, Suits, Claims, Etc.

The Contractor shall be liable for and shall indemnify the Principal against all liability, loss, actions, suits, claims and demands whatsoever directly or indirectly arising out of or in respect of any accident to or damage suffered by any person in consequence of any works carried out under this contract or upon the site of such works whether or not such accident or damage were caused by the negligence of the Contractor or of any of his servants, agents, sub-contractors, or of any other person whatsoever including the Principal, its officers, servants or agents.

The Contractor shall take out and maintain insurance policies in accordance with the Conditions of Contract (and Annexures).

1.27 Temporary Storage And Amenities

The Principal will make a suitable area available for the Contractor to provide temporary building and storage. The Contractor shall not occupy an area outside the limits set down by the Superintendent. In addition to facilities required for his own use, the Contractor is not required to provide facilities for use by the Superintendent.

The Contractor shall provide all statutory and necessary amenities and sanitary facilities for personnel and other persons lawfully upon the site and remove on completion of the Works.

The Contractor at his own expense shall provide for any temporary electrical power supply, telephone and other necessary requirements.

1.28 Datum Marks

The Contractor shall carefully preserve all datum marks at all times. Should any become disturbed by the Contractor's operations, these must be immediately replaced by a Licensed Surveyor approved by the Superintendent and at the Contractor's expense.

1.29 Setting Out The Works

The Contractor shall set out the works and be responsible for the accuracy of such setting out as provided in the General Conditions of Contract, at his expense.

The Contractor shall provide a suitably qualified and experienced licensed surveyor to set out and check the work during construction and to supply an accurate record of the locations and levels of all works as constructed.

The Contractor shall arrange for the licensed surveyor to survey the site and verify the accuracy of the existing survey details.

Should the Contractor discover any error or discrepancy in the lines of levels, or the plans, or the site, he shall immediately notify the Superintendent before proceeding with the work.

The cost of re-pegging or additional survey as a result of discrepancies or error made by the Contractor shall also be paid for by the Contractor.

A series of temporary benchmarks shall be pegged by the Principal's surveyor prior to the commencement of works. Any re-pegging for any reasons whatsoever that is required by the Contractor during the period of the Contract shall be undertaken by the Principal's surveyor or by a licensed surveyor approved in writing by the Superintendent and the costs so incurred by these works shall be wholly met by the Contractor.

The costs associated with any title survey re-establishment, which was brought about by the Contractor's negligence or failure to take adequate precautions, shall be met by the Contractor.

The Contractor shall also supply and maintain on the works approved straight edges, levels, templates, ranging rods, survey tapes and other equipment and instruments to enable Contractor personnel to set out the work accurately and those instruments and templates in particular shall be used throughout as the work proceeds.

The Contractor shall see that the work is accurately done in all respects by the use of such templates and other instruments and shall correct any errors or inaccuracies before other work is done.

The Contractor shall, when required by the Superintendent or his representative, either personally or by his representative test the accuracy of the work and if necessary, retest the same when any adjustments have been made.

The Contractor shall take adequate precautions to protect all survey pegs and marks and shall not disturb any such without prior consent of the Superintendent.

The benchmarks to be used for the setting out of levels shall be as indicated on the drawings.

The work of additional setting out shall be kept at least two days ahead of the work done or being done.

The Contractor shall arrange at his cost for a licensed surveyor to undertaken a level survey prior to:

i) Commencement of work in cell and borrow area;

ii) Completion of subgrade before placement of the clay liner; and

iii) Immediately after the liner is completed and borrow area.

iv) The surveyor will provide a contour plan for each condition to the Superintendent in both hardcopy and digital form.

1.30 Use of Public Roads

Access to the site shall be via Johnston’s Road. The Contractor shall be responsible for cleaning up to the satisfaction of the Superintendent any material spilled by him or his subcontractors on the works, on access and public roads. All costs associated with the above requirements shall be deemed to be included in the contract rates and the work shall be carried out immediately such spillage occurs.

The Contractor shall be responsible for the maintenance of all access / haul roads for the duration of the Contract. The cost of this above work shall be deemed to be included in the Contract Sum.

1.31 Structures to Drainage Works

Structures on or to drainage works shall be installed as the construction of the drain proceeds and completed immediately and erosion protection devices installed to prevent soil and silt entering existing drainage systems.

1.32 Existing Services, Structures And Property Of The Principal

The Contractor shall make himself fully conversant with all existing services, structures and property of the Principal within and adjacent to the site of the works and shall be responsible for the continuous maintenance of these services during the currency of the Contract.

The locations of the various underground and overhead structures and services or other property shown on the plans and dimensions of such are believed to be correct by reference to the various authorities, but cannot be guaranteed to be exactly so. These have been plotted for the information of the Contractor and information so given is not to be construed as being complete and accurate. The Contractor shall check with the Principal's staff and other statutory authorities to ascertain the exact location of all existing services and assets.

In the event of damage by the Contractor or any Sub-Contractor to any services, structures or property of the Principal, the Contractor shall effect immediate repair of same, which shall be carried out at no cost to the Principal.

1.33 Removal of Existing Structures

Except where relocation and extension of fencing is specified in these works , perimeter fences are to be maintained in their present condition for the duration of the Contract.

Any fence requiring removal to allow construction to progress shall only be removed with the Superintendents permission and such fences shall be replaced with fences of equal quality and condition as that which existed.

The Contractor is responsible for damage to all fences within the scope of works over the duration of the Contract.

1.34 Trenches To Be Timbered

Whenever and wherever it is necessary that the sides of any trench or other excavation be held up by timbering or means to ensure the safety of the public of adjoining ground or property, the Contractor shall, as the work proceeds, carry out such shoring up and timbering and other works required for the purpose indicated as part of this contract and without any special or extra payment for the same and shall maintain such timbering, shoring up or other works in a safe and secure condition until they can be removed without the safety of the public or the stability of the adjoining ground or property being prejudiced by such removal.

The Contractor shall keep sufficient timber on the job to meet any emergency.

Where ordered by the Superintendent, the Contractor shall leave timbering in position. Such timbering shall be cut off 0.60 metres below the surface. The timber (including that cut off) shall be paid for at the market price fixed by the Superintendent, less 10%.

1.35 Explosives

The Contractor shall not use any explosives in the execution of the works except where, when and under such conditions as shall be previously approved by the Superintendent. The Contractor shall provide himself with the necessary licence from the appropriate authority and shall conform to all Government regulations and instructions, relating to the transport, storage, handling and use of explosives.

The Contractor shall be liable for any accident, damage or injury to any person or thing resulting from the use of explosives.

The Contractor shall notify the Superintendent and other relevant authorities in writing of his intention to use explosives at least 48 hours prior to commencement of any works involving explosives.

1.36 Maintenance – During Construction

The Contractor and Sub-Contractors shall keep the site of the works clean and tidy at all times and pay continuous attention to the removal of litter and waste materials.

Under no circumstances will the Contractor or Sub-Contractors dispose of any material or goods, construction debris, rubbish or like material on or about the site.

During the progress of the work until the date of certification by the Superintendent that the work is complete, the Contractor shall maintain the works for the time being, in a careful and workmanlike manner so that the excavations, fills, formations, sub-grades, sub-base and base always present a smooth, even surface.

All subsidence and failures shall be filled, made good and compacted as hereinafter specified by the Contractor at his own expense.

All drains shall be kept clear at all times so that no obstruction or impediment is presented to the flow of water.

The road pavement and site formations shall be maintained in such a condition that it is well drained at all times. No ruts, waves or soft spots shall be allowed to remain and the Contractor shall keep the formations trimmed to the required level and grade by constant use of an approved grader.

1.37 Clearing Up On Completion

The Contractor shall ensure that all works of the contract, including works of all sub-contractors, be absolutely complete immediately prior to the date of expiry of the contract time.

The Contractor shall remove all debris from the site and any material he may have stored conveniently adjacent to the site, and leave the area tidy to the satisfaction of the Superintendent i.e.

- Removal and disposal of all dead trees. Grading up of site to ensure it is free draining.
- Removal and disposal of all rubbish, e.g. building materials, dead wood, rocks, foundations etc.
- Topsoiling and grassing of all disturbed areas.

1.38 Maintenance - After Completion

As each section of the work as determined by Superintendent is accepted and taken over, it shall be efficiently maintained by the Contractor for a period as nominated in Annexure A from the date of certification by the Superintendent that the work or section of the work is complete.

All ruts and subsidences shall be filled and all drains shall be cleaned out on completion. All pavement failures *shall* be reinstated and road surfaces shall be true to alignment, level and left in a perfect condition.

1.39 "As Constructed" Drawings

Prior to the issuing of the Certificate of Practical Completion the Contractor shall furnish to the Superintendent "as constructed" details of the works as executed.

This requirement applies also to Sub-Contractors. Such amendments as are necessary to depict in detail the as-built condition shall be carefully and accurately prepared by competent draft persons. Where an as-built condition requires a drawing to be amended all related drawings influenced by this amendment shall be similarly amended.

Upon completion of all amendments three (3) copies of each drawing prepared pursuant to the requirements of this Contract, each clearly marked adjacent to the title block "Work-as-Executed Drawing" and a digital copy shall be delivered to the Superintendent prior to the issue of the Certificate of Practical Completion.

The Contractor shall also provide survey plans prepared by a Licensed Surveyor, showing "As Constructed" levels for the landfill and leachate pond;

- prepared foundation (pre and post) for bulk earthworks volumes,
- clay base and side liner
- filter material won from on site

This information shall be provided in AutoCAD, 12D or similar format (on disk) together with an accompanying hard copy, prior to filling with the next layer of material.

The cost of preparing and printing the above work-as-executed drawings, notwithstanding that some amendments may have been required as the result of instructions issued by the Superintendent, shall be deemed to be included in the Contract Sum.

1.40 Practical Completion Of Works

When the Contractor has carried out all the work, including testing and submission of "as built" drawings and, in the Contractor's opinion, the works are practically completed, he shall so advise the Superintendent in writing and, within a reasonable time but not exceeding 14 days of receipt of such advice, the Superintendent shall:

(a) If satisfied that the works are practically complete, issue to the Contractor a Certificate of Practical Completion in accordance with the General Conditions of Contract; or

(b) If not reasonably satisfied that the works are practically completed, give to the Contractor written notice that the Certificate of Practical Completion will not be issued until the Contractor has completed such further works and/or attained satisfactory performance results as are necessary for practical completion of the works.

The Contractor shall within 14 days of such notice issued under (b) above proceed with such further works as necessary to achieve practical completion of the works, and shall advise the Superintendent when he has completed such works and, within seven (7) days of such advice, the Superintendent shall:

i) if satisfied that the works are practically completed, issue the Certificate of Practical Completion; or

ii) if not satisfied that the works are practically completed, issue to the Contractor a further notice or notices. The Contractor shall then comply with the notice and advice the Superintendent when he has so complied until the Superintendent is satisfied that a Certificate of Practical Completion may be issued.

1.41 Defects Liability Period

The Defects Liability Period shall be for the period stated in the Annexure A of the General Conditions of Contract.

1.42 Final Acceptance Of Works

At the end of the Defects Liability Period and provided all defects notified to the Contractor by the Superintendent have been satisfactorily completed, the Contractor shall notify the Superintendent in writing of the completion of the work.

The Superintendent will promptly, by inspection, satisfy himself as to the actual completion of the work in accordance with the terms of the Contract and shall, if in agreement, issue a Final Certificate in accordance with the General Conditions of Contract.

The Final Certificate will not be issued until the Superintendent is satisfied that the performance of the works is in conformity with all requirements of this Specification and with all performance guarantees tendered by the Contractor.

The Contractor may during the Defects Liability Period be called upon to further amend the Works-as-Executed drawings should it be found necessary for the Superintendent to order modifications to the work.

1.43 Environmental Controls

It is the Contractors responsibility to be informed of the provisions of the Environment Protection Act 1970 and any associated regulations and policies, and to carry out all works under the contract in accordance with the requirements of the Act and any associated regulations and policies.

The Contractor shall submit with his tender a proposed Environmental Management Plan, refer to Section 6.3 for specific requirements of this plan.

1.44 Dust Suppression

The Contractor shall take all necessary measures to keep airborne dust to a minimum by watering.

The Superintendent may direct the suspension of work at any time where that work in the Superintendent's opinion creates a dust hazard or nuisance to the public, personnel working on the site or property such as crops, stock and houses in the vicinity of the work. Where the Superintendent has directed a suspension of work and considers that the Contractor could not have been expected to have adequately controlled the dust, the Superintendent may consider an extension of time due to adverse weather conditions. No claim for increased costs due to such suspension will be considered.

1.45 Control Of Soil Erosion

The Contractor shall take all measures necessary to control soil erosion and to minimise the siltation of watercourses and water storages and ensure no offsite impact. Areas that may need soil erosion control protection include but not limited to; the access track from the borrow pit, stormwater drain discharge points to existing drainage and surface systems. Such measures shall be deemed to have been included in the lump sum and scheduled rates.

When directed by the Superintendent, temporary control works shall be removed and the area reinstated to the satisfaction of the Superintendent.

1.46 Surface Drainage During Site Operations

It is the Contractor's responsibility to undertake and maintain all works necessary, and as approved by the Superintendent, to ensure the area of works remains free from stormwater and runoff from other areas do not enter the site.

1.47 Industrial Matters

The Contractor shall keep the Superintendent informed concerning any industrial matter, which could affect the progress of the work under the Contract.

The Contractor shall inform the Superintendent immediately if bans are applied to the work under the Contract or if work under the Contract ceases due to industrial action, and shall also inform the Superintendent of measures being taken to resolve such action.

The Contractor shall make no claim against the Principal for increased labour costs, or for additional costs, loss or damage arising from increased labour costs, incurred by or as a result of:

(a) any variation to any Award of the Australian Conciliation and Arbitration Commission or to any Award of the State Industrial Relations Commission, whether by consent or by formal arbitration;

(b) any agreement, award, settlement, fee or like payment made by the Contractor or any organisation or any person acting on behalf of the Contractor with any union or any other body or any person;

(c) any industrial action through which occurs a strike, work stoppage, work ban or work limitation of any kind;

(d) any site allowance claim lodged by unions in respect of the works.

Provided that any industrial action causing lost time does not arise from factors within the control of the Contractor, the Contractor may be granted an extension of time for completion pursuant to the General Conditions of Contract, however will receive no payment of any kind for such extension.

1.48 Co-Ordination Meetings

At intervals not exceeding two weeks, the Contractor and the Superintendent shall together review the progress of the work under the Contract in comparison with the construction program. Where required by the Superintendent, such review will be conducted as a site meeting between representatives of the Principal and the Contractor held weekly or at intervals decided by the Superintendent. Site meetings will be chaired by the Superintendent and minutes will be prepared by the Superintendent and distributed to the Principal and the Contractor not later than two days prior to the next site meeting.

The Superintendent may at any time require the Contractor to submit in writing within 14 days:

(a) an explanation of delays in execution of the work under the Contract in comparison with the construction program;

(b) an amended construction program.

Where no current construction program has been supplied and the Superintendent at any time considers that the rate of progress is insufficient to ensure completion of the whole or any separable part of the Works by the relevant Date of Practical Completion, the Superintendent may direct the Contractor to submit within 14 days written details of the intended procedure for the execution of the remainder of the work under the Contract.

2 Earthworks

2.1 Scope

The Contractor shall provide all labour, materials and equipment necessary to clear, excavate, fill, backfill, compact and trim to grade for all earthworks included in this Contract.

2.2 Nature of the Ground

The Contractor must satisfy himself as to the different subsurface, ground and groundwater conditions likely to be encountered during construction and shall be deemed to have made full allowance for contingencies arising there form in this tendered price.

The Geotechnical report contains factual data conducted at the site and should be read in conjunction with this Specification.

The document is entitled:

- Geotechnical Assessment Report, Bairnsdale Landfill Stage 2, 25 September 2004. Author: Coffey Geoscience Pty. Ltd.

The Geotechnical report appended to this Specification provides details on clay depths at the nominated borrow area and clay permeability of the various clay layers. In addition to the geotechnical report. Two (3) test pit logs have been provided down to a depth of 4 metres in the existing excavation, and from the undisturbed ground. The location of the Coffey Geoscience test pits and these additional test pits are shown in the drawings.

2.3 Testing

Geotechnical testing required by this Specification shall be to AS1289 test methods, as set out in Table 1.

Table 1 List of Tests

Abbreviation	Description	Australian Standard
LL	Liquid Limit	1289.3.1.1/1289.3.1.2
PL	Plastic Limit	1289.3.2.1
PI	Plasticity Index	1289.3.3.1
% fines	Percent by weight passing 75um sieve	1289.3.6.1
K	Permeability - Constant head method - Falling head method	1289.6.7.1 1289.6.7.2
	Standard Compaction	1289.5.1.1
	Dry Density Ratio	1289.5.4.1
	Hilf Density Ration	1289.5.7.1
	Field Wet Density – Sand Replacement Method	1289.5.3.1
	Field Wet Density – Nuclear Density Gauge Method	1289.5.8.1

Sampling and in-situ density testing of fill material shall be performed by a NATA Accredited Testing Authority appointed (and managed) by the Contractor. Density tests will be carried out not later than 24 hours after compaction has been completed.

Test results shall be made available to the Superintendent in writing not later than 24 hours after the completion of the test.

The Contractor shall be responsible for giving notice to the Superintendent that areas are ready for testing, and he shall allow free and safe access for persons carrying out tests.

No additional filling or compaction shall be carried out in an area that has been tested before the Contractor is advised by the Superintendent that the test results in this area are satisfactory.

The Contractor shall allow for delays resulting from the taking of tests and shall accept the interpretation of the results by the Superintendent and the resulting directions.

In the event of failed or unsatisfactory results from the tests performed by the Geotechnical Subconsultant then all subsequent re-working and re-testing shall be at the Contractor's expense.

2.4 Safety of Earthworks

The Contractor shall be solely responsible for the security of all excavations and earthworks. The Contractor shall comply with the provisions of the Mines (Trenches) Regulations and shall submit to the Victorian Workcover Authority, a completed copy of the form "Notice of Intention to Commence Operation in Trenches, Shafts, Tunnels or other Excavations" should any proposed trench depth exceed 1.50 metres.

All excavations shall be carried out in such a manner that the surrounding materials receive the minimum amount of disturbance. Any damage or disturbance caused to materials, whether or not within the area of operations, will be made good by the Contractor at his own expense, in accordance with the Superintendent’s instructions.

Excavations shall be timbered or supported as necessary so as to ensure minimum disturbance to the surrounding ground and to ensure the safety of personnel, adjacent structures and the Works. The sides of excavations may be battered if approved or directed.

If, in the opinion of the Superintendent, the Contractor's method of support of an excavation is inadequate then the Contractor shall alter or increase the support at his own expense as directed. Any direction so given will in no way relieve the Contractor of his responsibilities under the Contract.

2.5 Clearing, Grubbing and Topsoil Stripping

Prior to the commencement of any earthworks, the limit of such earthworks shall be cleared of all vegetation, refuse and obstructions, and stripped of all topsoil to a nominal depth of 200 mm. Hard waste materials such as rock shall be disposed of on-site as directed by the Superintendent.

All vegetation such as trees, shrubs or grasses shall be cleared and grubbed and removed from site.

The Superintendent may direct that any designated tree or shrub shall be retained.

2.6 Landfill Site Earthworks

2.6.1 Preamble

The Contractor should note that the base and side liner of the landfill must be constructed so as to ensure that the permeability achieved is not greater than 1 x 10^{-9} metres per second and a minimum clay liner thickness of 1.0m shall be maintained throughout the cell.

To ensure that the technical requirements for the base and side liner of the landfill are satisfied the Contractor is to seek the specialist advice of a Geotechnical Subconsultant to monitor the placement of the clay base and side liner. The subconsultant's role will comprise density and compaction testing of each progressively placed clay layer to ensure the specified standards are met. Also ensuring that the mixing of clay from the borrow pit retains a permeability not greater than 1×10^{-9}m/s. Any clay placed in the liner that does not meet the permeability test standard shall be removed and replaced with suitable clay at the contractors cost. The overall responsibilities in the supervision of the works covered by this Specification are however, retained by the Contractor.

2.6.2 Testing and Certification

All testing of earthworks shall be undertaken in accordance with the specification and included in the applicable rates for each item of work.

The Contractor shall obtain the specialist advice of an independent Geotechnical Subconsultant to monitor all earthworks. The Contractor shall submit with his tender, details of the proposed Geotechnical Subconsultant together with a proposed Construction Quality Assurance Plan. This plan shall include details of the nature and frequency of proposed testing.

The Construction Quality Assurance Plan shall conform to the requirements described herein with regard to compliance testing, inspection and reporting procedures.

The Contractor shall nominate in the Quality Plan a suitably qualified and experienced Geotechnical Subconsultant who shall be responsible for the independent certification of each part of the works as appropriate, as part of the quality assurance program.

The Geotechnical Subconsultant inspections shall include, but are not limited to, the following stages of the Works:-

i) completion of stripping for foundation preparation, but prior to or during compaction,

ii) completion of side wall trimming before placement of liner,

iii) construction of the base and side wall liner.

Once the Construction Quality Assurance Plan has been reviewed and approved by the Superintendent, the Contractor shall carry out all earthworks strictly in accordance with the Plan, unless otherwise directed by the Superintendent in writing.

At the completion of works, the Contractor shall provide the Superintendent with three (3) copies of a report from the Geotechnical Subconsultant certifying that earthworks have been constructed to the standard nominated in this specification. All test results must be appended to the report which clearly identified the location of the test performed. The subconsultant shall undertake sufficient testing throughout construction to enable such certification to be made. This report should form part of the Construction Quality Assurance Report required under section 6.2.

The Contract Price shall include allowances for possible time delays while samples are being collected and tested. No additional payment will be made or extension of time granted for any completed work requiring removal and/or repair as deemed by the results of any tests.

At the direction of the Superintendent, independent testing may be undertaken by the Principal's Geotechnical Subconsultant. The Contractor shall provide at his expense, all labour, materials and equipment necessary to prepare areas and assist testing. Such testing shall be at the expense of the Principal, and shall not exclude the Contractor from his testing responsibilities under the Contract.

2.7 Compaction Plant

The Contractor shall be entirely responsible for providing plant of adequate type, capacity and availability to carry out the works in accordance with the Specification.

2.8 Borrow Area and Management of Materials

2.8.1 Borrow Area

The area designated as the source of materials for the construction of the liner, known as the Borrow Area, is shown in the Drawings. The area boundaries are indicative only, and represent the region indicated by the site investigation as likely to contain material conforming to the liner specification.

Clay materials suitable for use in the liner directly underlie the topsoil to an average depth of 2.7 m below the stripped surface. Below this, material particle sizes become predominantly sand and gravel-sized, and are generally not suitable for use. This depth is indicative only, and details are provided in the test pit logs of the geotechnical report. Confirmation of the actual depth of suitable material in a particular area is the responsibility of the Contractor.

The Contractor shall make maximum use of all material to be obtained from the designated borrow area and any other suitable material clay from the cell excavation, so as to produce a sufficient quantity of material necessary for the completion of the Works.

2.8.1.1 Borrow Material

Borrow material for use as a liner in the base and side walls of the landfill shall be low permeability, essentially fine grained material and shall conform to the soil classification outlined in the geotechnical report and as specified.

2.8.1.2 Borrow Pit Configuration

Borrow pit configurations shall comply with the drawings.

The Contractor shall be responsible for providing suitable access to the borrow pits. The location of access roads should be maintained on existing, or proposed access track alignments, or otherwise within the limits of existing clearing unless otherwise approved by the Superintendent

2.8.1.3 Clearing, Grubbing and Topsoil Stripping

The Contractor shall clear and grub all vegetation, and strip all topsoil to a nominal depth of 200 mm the designated borrow area. Vegetation shall be disposed of as directed by the Superintendent. Topsoil shall be stockpiled in area(s) designated by the Superintendent.

2.8.1.4 Borrow of Construction Materials

The Contractor shall excavate, and blend if necessary, material within the borrow pits to achieve uniform material for liner construction complying with the requirements of this Specification.

The Contractor shall, at whatever location, depth and by whatever method, perform all mixing and other conditioning processes, including the addition or removal of water as necessary, to produce the required materials.

If required, moisture shall be introduced into the material at the borrow area. Watering in the borrow area shall be carried out sufficiently far in advance of excavation operations to ensure uniformity of moisture content. This time shall be at least 24 hours.

If at the borrow location there is excessive moisture, the Contractor shall make selective excavation to secure materials of suitable moisture content and shall excavate drainage channels, rip, work or aerate the material, or perform such other work as may be necessary to reduce the moisture content of the material.

2.8.1.5 Unsuitable Material

For the purposes of this Contract, the Superintendent shall have power to classify material (other than topsoil or overburden) which is excavated or taken from stockpile as unsuitable for incorporation in any particular part of the works. Such material may consist of silty deposits or excessively sandy soils and shall be designated "unsuitable material", transported to designated spoil areas; taken for use in another particular part of the works, or stockpiled for later use, as the Superintendent may direct.

2.8.1.6 Management of Materials

While the Contractor is responsible for proper management of all materials so as to enable all the required works under the Contract to be constructed within the time required, he shall recognise that particular problems of this kind will inevitably present themselves. The constraints of space, time and the order in which materials will be excavated coupled with the requirement for moisture conditioning, may require multiple handling of materials and the use of temporary stockpiles. The Contractor shall allow for the time and work requirements to meet these needs in his construction program. Materials shall be stockpiled only in areas designated by the Superintendent.

2.8.2 Dewatering

The landfill base and borrow areas shall be kept free from water and the Contractor shall make all necessary arrangements to dispose of any water which enters the excavations. Any flow or seepage of water into excavations shall be properly diverted, pumped, drained or otherwise disposed of to the satisfaction of the Superintendent, in accordance with the EMP.

The Contractor shall, at all times, take adequate precautions and provide suitable equipment to keep all excavations dewatered and dry. Should water be allowed to accumulate on the works during construction, as a consequence of which work previously accepted as suitable are rendered unsuitable, then the Superintendent shall direct the Contractor to remove and replace at his own expense any works which have become so affected.

2.8.3 Preparation of Base liner and Side Liner Foundation

2.8.3.1 General

The base and side liner foundation shall be excavated to the profiles and levels as indicated on the Drawings and as directed on-site by the Superintendent. Where the foundation is considered by the Superintendent to be soft, wet or unstable, this material should be excavated.

2.8.3.2 Areas to be Lined

Cell areas to be lined include existing undisturbed regions as well as those areas which have been disturbed during previous quarrying and landfill activities.

Surface preparation shall involve the clearing and grubbing of all vegetation, and stripping of all topsoil to a nominal depth stated in the geotechnical report. The area shall be excavated to the profile and levels shown on the drawings. Areas undergoing preparation for final subgrade level shall be inspected by the Superintendent, who may instigate remedial works on any soft or loose areas revealed during the works.

2.8.3.3 Removal of Unsuitable Material

All unsuitable material including soft clay soil and any other foreign matter shall be removed from the base and side wall areas to the satisfaction of the Superintendent and the levels and gradings shown on the Drawings. Removal of this material shall be performed under the supervision of the Superintendent to ensure that the base and/or side walls are not damaged.

The remedial treatment used may vary depending upon conditions encountered and may consist of hard rockfill, geotextiles, geogrids and drainage geotextiles.

Payment for remedial works shall be in accordance with rates quoted in the Schedule of Prices or where no rate is given, as agreed with the Superintendent.

All removed unsuitable material shall be disposed of at the disposal area as directed by the Superintendent.

2.8.3.4 Excavation and Filling

Prior to placement of the clay liner, the existing surface shall be regraded to the grades and elevations in accordance with the formation surface levels shown on the drawings.

Where fill is placed to raise the existing surface to the formation level, such material shall be placed in layers not exceeding 250 mm loose layer thickness. Layers of soil fill shall be compacted to achieve a minimum dry density ratio of 98% Standard at optimum moisture content ± 2% in accordance with AS1289.5.1.1 and 5.4.1. A greater loose layer thickness may only be placed if it can be demonstrated that uniform compaction can be achieved over the total layer thickness.

Should the Contractor excavate to depths greater than required, the excess excavation shall be backfilled at the Contractor's expense to the correct lines and levels with approved material and compacted to the satisfaction of the Superintendent.

Material removed during the preparation of the base and side walls shall be used to form the perimeter bunds or stockpiled at a location approved by the Superintendent, for possible subsequent reuse, or disposed of within the site in a carefully controlled manner approved, and as directed, by the Superintendent should excessive deleterious material be present.

2.8.3.5 Subgrade Preparation

The subgrade material exposed after excavation (or filling) to the design subgrade level shall be scarified to a depth of approximately 150mm and moisture conditioned to within ±2% of Standard Optimum Moisture Content, and then re-compacted to a minimum dry density of 98% Standard in accordance with AS1289 5.1.1, 5.4.1 or 5.7.1. Compaction testing of the subgrade is not required unless requested by the Superintendent.

Following compaction of the subgrade and prior to the placement of the clay liner, the Contractor shall prepare the subgrade surface such that it is smooth and hard in preparation for proof rolling. The proof roll shall be conducted in the presence of the Superintendent with a 10 tonne equivalent smooth wheeled roller or loaded truck with an intensity of contact pressure on the rear wheels of not less than 6 tonne per metre, without visible deformation.

Any soft or weak areas encountered during proof rolling that do not respond to further compaction shall be removed and replaced with suitable site material in layers not exceeding 250mm thickness (loose), and compacted and re-tested to the above criteria.

Following rolling, the Superintendent shall inspect and approve the prepared surface prior to the clay liner being placed. The Superintendent shall satisfy himself that no deflection of the subgrade is visible during proof rolling, and may direct further rolling of the formation surface to be undertaken at the expense of the Contractor.

The Contractor shall arrange for a detailed feature survey of the prepared surface to be undertaken by an independent licensed surveyor following the completion of proof rolling and prior to the placement of the clay liner.

2.8.4 Construction of Base and Side Liner

2.8.4.1 Liner Compaction Requirements

The required compaction for lining material shall be a Dry Density Ratio of not less than 98% of the standard maximum dry density (AS1289.5.4.1) or a Hilf Density Ratio of not less than 98% (Standard Compaction) (AS1289.5.7.1). The moisture variation (w_0-w_f) shall be maintained in the range ± 2% of optimum moisture content. The clay must achieve a permeability of 1 x 10^{-9} m/s or better. Clay material is to be tested for permeability in accordance with (AS1289.6.7.1 & 2).

2.8.4.2 Preparation of Trial Liners

The contractor must win at least 40 cu.m of clay won from the cell excavation and from at least 6-8 different locations in the borrow pit area. The trial liners must be representative of the full depth of clay determined in the borrow pit area. The clays must be mixed, moisture conditioned, spread in 200mm thick layers and compacted until a 1.0m thick liner depth is achieved.

The Geotechnical Subconsultant is required to ensure sufficient representative clay has been sourced for the trials and undertake appropriate moisture, density and permeability samples and tests in accordance with the Specification and Australian Standards. The Geotechnical Subconsultant is required to certify all results and submit a report to the Superintendent for approval. The Contractor shall not commence placement of the clay liner until such approval in writing has been obtained from the Superintendent. Between two and four trial liners are recommended so that a number of clay mixture and compaction level options can be analysed, providing the Contractor with more flexibility during the construction of the compacted clay liner. Provision for four (4) permeability tests on the trial liners has been included in the Bill of Quantities.

When the mixture(s) of clay identified as passing the permeability requirement have been established and approved by the Superintendent, the Contractor and Geotechnical Subconsultant shall ensure that all clay being used to construct the liner is at least of equivalent quality.

2.8.4.3 Placement

i) The clay lining material to form the base and side wall liners shall be constructed to the lines, levels, grades and cross-sections as shown on the Drawings.

ii) Before placing lining material, the surface of the previously compacted layer shall be scarified to a depth of at least 50 mm. If the surface has dried out and/or cracked, it shall be ripped or disc-ploughed to at least 50 mm below the depth of drying or cracking, then watered and mixed, lining material shall not be placed on a surface on which free water has ponded.

iii) The lining material shall be placed in near horizontal layers which are longitudinally and transversely continuous. The layers shall be of uniform loose thickness not greater than 250 mm. Rolling shall be conducted in at least two different directions for the base liner, and in a direction parallel to the longitudinal axis of the side wall liner. The liner shall be placed to the cross falls and levels specified on the Drawings.

iv) At the completion of each day's work, or if adverse weather conditions are imminent and the Contractor intends to suspend operations, the surface shall be graded to a self shedding profile and sealed with a smooth drum roller or equivalent.

v) If the required density and moisture is not achieved the compacted material shall be reworked in accordance with the standard to meet the density and moisture content requirements. If the density and moisture content requirements again cannot be achieved, the failed lift shall be removed at the Superintendent's direction for either moisture conditioning in a borrow area before reuse or stockpiled if still considered unsuitable.

vi) The Superintendent may order trafficked sections to be ripped and recompacted if he deems that the quality of these sections has deteriorated due to construction traffic.

vii) The Contractor shall arrange with their Geotechnical Subconsultant to take clay liner samples for permeability testing. Results are to be forwarded to the Superintendent. Areas of the clay liner that fail to meet 1×10^{-9} m/s permeability have to be reworked or removed and suitable clay placed as specified and retested at the Contractors expense.

2.8.4.4 Moisture Conditioning

The Contractor's attention is drawn to the fact that meeting the specified moisture condition of this Specification is equally as important a compaction requirement as the specified Density Ratio.

Tests at the time of the site investigation (September 2004) showed that the in-situ moisture contents of liner borrow materials were generally between ± 2% of optimum moisture content. Water addition or drying out that may be required in excess of this shall be carried out in the borrow area or at a temporary stockpile. After such moisture content adjustment in the borrow area or at a temporary stockpile, the lining material shall be stockpiled and allowed to cure for 24 hours prior to placement.

The compacted surface of each layer of the liner should be kept moist by frequent watering until subsequent layers or the HDPE Liner is placed.

2.8.4.5 Filter Blanket

The entire exposed surface area of the clay liner base and sides is to be lined with a 2mm thick HDPE liner covered by a geotextile fabric (refer section 3). The base of the cell shall be protected by the placement of a minimum thickness of 300mm filter blanket, being a aggregate free of organic material, sticks, roots, sharp objects or debris of any kind. Particle size of the aggregate screened from the excavated material shall be between 20mm and 75mm with a fines content of less than 1%.

Previous screening of material from the site has indicated that between 20 to 25% of material screened would meet the required aggregate size. A second screening of the filter blanket stockpile is normally required to ensure the 1% or less of fines is achieved.

2.8.4.6 Protection Cover

The entire exposed surface area of the HDPE and geotextile side wall liner and top of batter shall be protected by the placement of a minimum thickness of 300mm road gravel (by-product of screening filter blanket material) as protective cover (measured normal to the exposed surface) as specified in the construction drawings.

2.8.5 Placement of Leachate Collection System

The Contractor shall, at all times, take adequate precautions during the laying of the leachate pipe to prevent damage to the base. A minimum of 50mm of bedding material will be placed on the geotextile–covered HDPE Liner directly beneath the HDPE collection pipe. Further bedding material will be place around and above the pipe to ensure that a minimum of 100mm surrounds the top and sides of the pipe. The sides shall be haunched with care to ensure crushing of the pipe is avoided. The pipe may need to be sandbagged to prevent it from moving during placement of filter medium. If, in the opinion of the Superintendent, the compacted clay liner or HDPE liner has been damaged during excavation, remedial work shall be carried out to the satisfaction of the Superintendent by the Contractor at his own expense.

The Superintendent shall inspect all installed leachate collection pipes prior to placement of the filter medium.

2.8.6 Temporary Earthen Banks

The Contractor shall construct temporary earthen banks to the lines, levels and grades shown on the Drawings and shall construct associated stormwater drains.

Spoil from the excavation of the temporary stormwater drains which, in the opinion of the Superintendent, is unsuitable for the construction of the bank shall be disposed of on site as directed.

Prior to the placement of fill material, the surface of the liner base on which the bank is to be constructed, shall be thoroughly scarified. The fill material shall be placed in uniform 250mm loose thickness layers and compacted in successive layers to the requirements specified in 2.8.4.1

2.8.7 Acceptance Testing

The Contractor shall test for compliance with the requirements of Clause 2.8.4.1 herein strictly in accordance with the approved Construction Quality Assurance Plan.

Notwithstanding the above, the following criteria for acceptance shall be taken as minimum requirements:

i) Base and Side Wall liner compaction/moisture content testing frequency:

- The minimum overall frequency for testing shall be one test per 1,000m^3,
- Two tests per 250mm thick (loose) layer (if the compacted volume of a layer is less than 2,000m^3

ii) Each test location shall be selected by the contractors geotechnical sub-consultant. Should a test fail to meet the specified density or moisture content then remedial action shall be carried out *as* described in Table 2. The Superintendent may select a test location at his discretion.

iii) Should the Superintendent consider the depth of non conforming material to be greater than can be effectively compacted from the surface, material shall be removed to a depth at which compaction is satisfactory and replaced and compacted in layers.

Table 2 – Remedial Action for Compacted Fill

Category	Density Ratio Result	Moisture Result	Remedial Action
A	Fail by less than 1%	Pass	RE-roll (no. of passes to be specified by the Superintendent – max. 3)
B	Fail by 1% or more	Pass, but not more than 1% wet of OMC	Rip, re-water, re-roll and re-test
D	Fail by 1% or more	Pass by 1% or more wet of OMC	Rip, re-roll and re-test
E	Pass	Fail, but no more than 2% dry of OMC	Rip, water re-roll and re-test
F	Fail	Fail: more than 2% dry or more than 3% wet of OMC	Remove fill, replace and re-test

In addition to the compaction testing described above, routine compliance testing with regard to the criteria specified shall be conducted on samples taken for compaction testing, in accordance with the approved Construction Quality Assurance Plan, but not less than the following:

Testing frequency - 1 group of compliance testing per 5,000m^3 (minimum number for Cell 2 shall be 4).

Required tests (other than compaction test)
- % fines (Grading Analysis)
- Plasticity Index (PI)
- Permeability (k)

Permeability compliance testing shall be carried out on samples prepared at a Dry Density Ratio and Moisture Content equivalent to that which was obtained from the compaction test for that sample.

Notwithstanding the compliance testing described above, the Superintendent reserves the right to reject incoming material based upon a field assessment of sand content (% fines) or silt content (PI).

The Superintendent may authorise the nominated Testing Authority to perform % fines and/or PI testing on selected samples. When such testing is being carried out the requirements of Section 2.3 and Clause 2.6.2 shall be followed.

2.9 Other Site Earthworks

Material for the construction of general filling layers shall be sourced, as far as practical, from on site, or other area on site as directed by the Superintendent. The material shall be clean well graded material, unless notified otherwise by the Superintendent in writing. The materials used shall be free of stones larger than 20mm, rock, cobbles, boulders, roots, sticks or any sharp objects or debris of any kind.

Any material which fails to comply with these requirements, or is otherwise considered unsuitable by the Superintendent, shall be reused elsewhere on site or disposed of on site as directed by the Superintendent at the Contractor's expense.

2.10 Topsoiling and Grassing

2.10.1 Scope

This section covers the requirements for topsoiling and grassing, including the control of weeds and erosion and promotion of grass cover.

The Contractor shall topsoil and grass all disturbed areas within the limit of works. Topsoil stripped as part of the works shall be stockpiled and reused as part of these works in the first instance. The written approval of the Superintendent is required prior to the importation of topsoil. Imported topsoil will only be considered if there is a deficiency of available topsoil from within the site.

The Contractor shall provide all labour, materials and equipment necessary to undertake the works detailed in this section.

2.10.2 Topsoiling

2.10.2.1 Materials

All topsoil shall be free from perennial weeds and their roots, stone or rubble, clods of subsoil and other extraneous material.

2.10.2.2 Ground Preparation

Prior to the placement of topsoil, the surface for topsoiling shall be lightly cultivated across the slope to achieve a coarse surface texture which will assist in retaining topsoil on sloping ground.

2.10.2.3 Spreading of Topsoil

Topsoil shall be spread:
Where petrol, oil, lime or other harmful materials have been spilt on the subgrade or topsoil, the affected material shall be excavated and removed from site.

Finished surface levels of topsoiled areas shall be graded evenly toward drainage structures, and shall be finished flush with paved surfaces and kerbs. Following spreading and grading, the surface of topsoiled areas shall be tine harrowed across the slope.

Grassing Scope

All topsoiled areas, drainage channels and open drains shall be grassed. This includes:

- Final preparation of seed bed as required.
- Sowing by broadcasting
- Protection and maintenance.

2.10.2.4 Seed Bed Preparation

Ensure areas to be seed have been brought to a suitable tilth before sowing and is free of major weed infestations.

Soil shall not be worked under unfavourable moisture conditions that may not allow proper cultivation or that may damage the soil structure. Final cultivation shall be by tine harrow across the slope of the land, ie. along the contours.

2.10.2.5 Seed Mix

All grass seed shall be a prepared mix of:

- Valda Hard Fescue
- MX86 Sheeps Fescue
- Delaware Dwarf Fine Rye Grass

Sow Valda and MX86 as a 50/50 mix at 50kg per hectare and Delaware Rye at 70kg per hectare, (total rate 120kg per hectare).

2.10.2.6 Sowing and Subsequent Treatment

Sow only on a calm day and do not sow when seed bed is in a muddy condition. Seeding shall be carried out only at times of the year when a good result can be reasonably expected, ie. The months of April, May, September and October.

For sowing outside these times as may be required for surface stabilisation seed shall be sown by machine in two equal sowing in a transverse direction.

Protect newly-grassed areas against traffic or stock access.

Re-seed all areas where grass fails to germinate within one month of the original seeding.

3 HDPE Liner Supply & Installation

3.1 General

The area to be lined is the internal surface of Cell 3. The cell base shall be lined with 2mm thick smooth HDPE and the permanent cell walls shall be lined with 2mm thick textured HDPE. After installation the liner will be completely covered with a non-woven needle punched geotextile (Bidim A24 or approved equivalent). A 300mm thick drainage aggregate will be placed on the base of the cell, and a 300mm thick protective gravel cover layer will be placed on the sides.

The contractor shall examine drawings provided and submit with the tender details of any design amendments required to suit the HDPE membrane lining. In particular, details affecting the surface finish under the liner, slope transitions and anchoring should be considered.

3.2 Trimming & Compaction

The Contractor shall trim the floor and embankments of the cell to the lines and levels indicated on the drawings and compact with a smooth flat drum roller to provide a smooth dense finish.

Embankment tops are to be trimmed prior to construction of anchor trench to ensure minimum fall of 1:30 towards the outside batter slope.

3.3 Anchor Trench

The Contractor is to excavate the anchor trench on the outside embankments and temporary bund to the lines and levels indicated on the drawings.

Following the installation of the HDPE membrane liner the anchor trench shall backfill and compacted with approved material.

The backfill material shall be placed in layers not exceeding 200mm loose depth. Each layer shall be compacted by means of mechanical compactor to achieve 90% Standard Dry Density.

3.4 Area To Be Lined

The area to be lined consists of the base and sides of the cell. The true areas of the lined areas are represented in the Bill of Quantities, meaning that the contractor does not need to allow additional area for the 1 in 3 slope on the walls or the peaks and troughs of the floor.

The schedule does NOT make allowance for the following:

- Joints, overlaps and expansion or contraction of material;
- Edge treatment required beyond the 2.1m wide strip specified for anchor trenches on top of the embankments.

Contractors are to make their own assessment of the quantity of liner required, based on the drawings attached to this Specification.

3.5 Experience

The Contractor shall provide with their tender, evidence of their (or their subcontractor's) ability and experience to supply and install HDPE membrane lining. A minimum of five years continuous experience in the manufacture and installation of HDPE membrane lining is required.

A list of similar past projects including relevant details of each installation and a Client contact is to be provided.

3.6 Material Specifications

The liner shall be a premium grade High Density Polyethylene and shall be manufactured of new, first quality products designed and manufactured specifically for the purpose of liquid containment in hydraulic structures and landfills.

The liner shall have nominal thickness of 2mm minimum.

The liner shall be free of surface striations or roughness (apart from those inherent in the textured liner), holes, blisters, undispersed raw materials, bubbles or any sign of contamination by foreign matter.

The lining materials shall be provided in rolls of a minimum width of 6.0 metres and each roll shall be labelled identifying the following data:

- Name of Manufacturer
- Product Identification;
- Material thickness;
- Roll Length, Width and Weight;
- Year of Production and manufacturer's roll number.

There shall be no factory seams.

Contractors may offer an equivalent to the 2mm HDPE liner for assessment by the Principal. Details of the alternative offer including any supporting technical literature is to be included in the tender.

3.7 Factory Quality Control

3.7.1 Raw Material

Prior to the production of the liner, the liner manufacturer shall test the raw material batches to certify the raw material suppliers test results and entity of the singular resin.

The liner manufacturer shall provide certification and all test results for raw materials prior to the delivery of materials to site.

3.7.2 Manufactured Material

The manufacturing process must provide for the continuous monitoring of thickness and sheet quality.

Details of testing methods shall be provided with each roll delivered to the site and shall include the following information and test results:

- Thickness (ASTM D 1593)
- Tensile Properties (ASTM D 638)
- Tensile Strength at Yield and Break
- Elongation at Yield and Break
- Tear Resistance (ASTM D 1004, Die C)
- Puncture Resistance (FTMS 101C 2031/FTMS 101C 2065)
- Carbon Black Content (ASTM D 1603)
- Density (ASTM 1505)
- Melt Index (ASTM D 1238)
- Brittleness (ASTM D 746)

The Superintendent and the Contractor shall jointly inspect any material rejected on site by the Superintendent. If required, the material shall be tested at the Contractors expense. If the material fails to meet the Specification, the Contractor at his cost shall replace it.

3.8 Subgrade Preparation

The surfaces to be lined shall be smooth and free of all rocks, stones, sticks, roots, sharp objects, or debris of any kind. The surface should provide a firm, unyielding foundation for the membrane with no sudden, sharp or abrupt change or break in grade. No standing water or excessive moisture shall be allowed. The Contractor shall certify in writing the surface on which the membrane is to be installed is acceptable before commencing works. The Contractor's Quality Assurance Program shall allow for submission of the certification to the Superintendent prior to laying the liner. The Superintendent shall also inspect the entire subgrade surface area of the cell prior to commencement of liner placement.

3.9 Liner Installation

The liner shall be placed in a manner, which minimises handling and wrinkling of the liner. Due allowance shall be made for shrinkage and thermal expansion and contraction of the liners. The membrane panel layout is the responsibility of the Contractor.

The liner shall be terminated with anchor trenches as shown in the drawings. The anchor trench shall be continuous around the perimeter of the cell. Once the membrane liners are in place the anchor trench shall be backfilled and suitably compacted to prevent slippage of the liner. The contractor is to make allowance for any temporary ballasting required to hold the liner in place in the anchor trench prior to backfilling the anchor trench.

The full cost of this joint or edge treatment including excavation and backfilling of the anchor trenches shall be deemed to be included in the Contract Sum.

The Contractor shall allow for any works required to hold the installed liners in position against the action of wind prior to placement of the leachate collection system, filter blanket aggregate and protective gravel cover.

The Contractor shall ensure that no vehicles or mobile equipment is permitted on the liner until the full depth (300mm) of protective cover or filter blanket has been placed.

The Contractor shall be responsible for making allowance considered necessary to accommodate variations in temperature and weather conditions.

3.10 Field Seams

Seams are to be orientated down the slope, not across it. The layout of the liner will be such to minimise the number and length of seams.

All welds require a minimum of 100mm overlap.

Two types of welds shall be used, Hot Wedge Welding and Extrusion Welding.

Extrusion Welding shall be kept to a minimum and should only be used in 'non stressed' locations.

Extreme care shall be taken by the installer in the preparation of the areas to be welded. The area to be welded shall be cleaned and prepared according to the procedures laid down by the material manufacturer.

The welding equipment used shall be capable of continuously monitoring and controlling the temperatures in the zone of contact when the machine is actually fusing the lining material so as to ensure changes in environmental conditions will not affect the integrity of the weld.

The Contractor shall submit his weld procedure as part of the Quality Assurance/Quality Control Program before any welding is commenced.

3.11 Field Seam Testing

On site physical non destruction testing shall be conducted on ail welds by air pressure testing and/o vacuum box. The testing methods shall be included in the Quality Control program submission.

Any area showing a defect shall be marked and repaired in accordance with HDPE repair procedures at the Contractor's expense.

Prior to the beginning of each weld period, trial welds, shall be made on fragment pieces of membrane. Destructive seam tests will be carried out on these samples. Additional destructive seam tests will be performed at random selected locations during installation. These tests are conducted to confirm and evaluate seam strength and continuity during the field seaming.

In the event of failure, all prior welds shall be tested back to the last test which passed. All repairs necessary to make good the seams to the Principal's satisfaction, including additional testing shall be carried out by the Contractor at his own expense.

3.12 Quality Assurance Certificates and Records

The Contractor shall provide the Superintendent with the following listed Test certificates and records prior, during and at the completion of the works as each report and record is required:

- Certification & Test Results of Raw Materials from Raw Material Supplier
- Certification & Test Results of Raw Materials from Membrane Manufacturer
- Roll Test Date Reports, for Each Roll of Material
- HDPE Welding Granulate Test Reports
- Daily Installation Reports for each welder and technician:
  - ➢ Trial Test Weld Record
  - ➢ Wedge Weld Records

  - ➢Surface Extrusion Weld Records
  - ➢Weld Peel & Tensile Test Records
  - ➢Wedge Air Tunnel Pressure Test Records
  - ➢Vacuum Box Test Records
  - ➢Repair Records
- Completed As Built Drawing, including roll numbers, panel layout, seam locations and repair locations.

3.13 Protection of Works

As soon as possible after installation of the liner, the Contractor shall provide protection of the liner by placement of the specified geotextile (Bidim A24 or equivalent) protective cover material and drainage aggregate. If a crusher run filter blanket material is used, the geotextile grade shall be increase to Bidum A34 or equivalent to provide greater protection to the HDPE liner.

Extreme care must be taken at all times to avoid damage to the liner.

No equipment is permitted to operate on the unprotected liner. Personnel walking on the liner should be kept to a minimum, and footwear must be checked prior to accessing the liner to ensure rocks or other sharp objects are not embedded in the sole.

Formwork for the sump slab shall be pre-fabricated in a location external to the lined cell and assembled at the location site. The formwork may only be held in place with screened filter blanket material placed around its perimeter. Under no circumstance should the formwork be staked to the ground. Bar chairs used in the slab construction shall be of a flat based plastic type so as to not damage the HDPE liner.

3.14 Warranty

The Contractor shall provide a written 10 year warranty for the liner material. The warranty shall include all labour and materials required to effect any repair under warranty.

4 CONCRETE

4.1 General

This section specifies concrete for use in the Leachate Collection Sump.

4.2 Standards

The latest editions of the following Australian Standard shall form part of this specification:-

AS 3600	Concrete structures.
AS 3972	Portland and blended cements
AS 2758.1	Aggregates and rock for engineering purposes - Concrete aggregates
AS 1012	Methods of testing concrete.
AS 1379	Specification and supply of concrete
AS 1303	Steel reinforcing wire for concrete
AS 1302	Steel Reinforcing bars for concrete
AS 1304	Welded wire reinforcing fabric for concrete

4.3 Materials

(a) Portland Cement

Portland Cement shall comply with the requirements of Australian Standard AS 3972.

(b) Fine Aggregate

Fine aggregate for concrete shall be sand or fine gravel from an approved source to be thoroughly clean and free from clay, loam or organic impurity and shall comply with the Australian Standard AS 2758.

(c) Course Aggregate

Course aggregate for concrete shall be gravel or screenings from an approved source and shall comply with the Australian Standard AS 2758.

(d) Water

All water shall be free of matter harmful to concrete and its reinforcing.

(e) Reinforcing

Steel reinforcement shall comply with the respective Australian Standards AS 1302, AS 1303 and AS 1304.

4.4 Storage of Materials

Any material that has deteriorated or has been damaged shall not be used for construction purposes. Cement and aggregates shall be stored separately in a manner such as will prevent deterioration and the inclusion of foreign materials.

4.5 Mixture

The concrete shall consist of a mixture of cement, fine aggregate,

course aggregate and water, mixed in such proportions necessary to produce concrete complying with the requirements of this Specification.

The proportion of fine aggregate to course aggregate will depend on the grading of the materials, but the amount of fine aggregate shall always be the minimum which, when combined with cement, will produce only sufficient mortar to fill the voids in the course aggregate and leave a slight excess for finishing.

The proportions of the mix will be determined by the Superintendent and shall be strictly adhered to by the Contractor.

4.6 Pre-Mixed Concrete

All concrete used on the Contract Works shall be premixed concrete, from sources approved by the Superintendent, mixed at a central mixing plant, delivered and placed in strict accordance with Australian Standards AS 1379.

It is the responsibility of the Contractor, not the concrete supplier, to ensure that requirements of this Specification are met. The concrete must be delivered to the site of the works and placed in its final position before initial set takes place and the addition of water or other retempering of the concrete before placing will not be permitted.

4.7 Mixed On-Site Concrete

Mixed on-site concrete shall not be used except when specifically approved by the Superintendent where small quantities of concrete are required. When required and approved, mixed on-site concrete shall be hand or machine mixed as specified by the Superintendent, to produce concrete complying with the requirements of this Specification.

4.8 Cement Mortar

All cement mortar shall consist of:-

One (1) part cement

One and one quarter (1 and 1/4) parts sand

One and one quarter (1 and 1/4) parts screened bluestone dust.

The materials shall be thoroughly mixed with a proper quantity of water, by a method and to a consistency approved by the Superintendent.

4.9 Additives

Additives shall not be permitted.

4.10 Consistency

The concrete to be placed in the work shall be of such consistency that it can be readily placed and compacted in the forms without causing segregation of the materials or excess free water to collect on the surface.

The consistency of the concrete shall be determined by a slump test in accordance with Australian Standard AS 1012.

The maximum slump allowable for concrete used in the works shall be 75mm.

4.11 Concrete Strength

Concrete shall develop minimum compression strength at seven (7) days of 14 Megapascals and at 28 days of 40 Megapascals.

4.12 Standard Tests For Material and Concrete

The materials and concrete will be tested as and when directed by the Superintendent in accordance with Australian Standard AS 1012.

Test cylinders shall be prepared by the Contractor when directed by the Superintendent and shall be numbered and marked with dates. The Contractor shall keep a register of such test cylinders, which shall also show the dimensions and changes of the various concrete works executed on every day and in particular those executed on the day on which the samples were taken.

The Contractor shall be responsible for having the samples tested at an approved Laboratory.

Three cylinders will be prepared and disposed of as follows:-

No.1 Tested for 7 days strength, 14 megapascals.

No.2 Tested for 28 days strength, 40 megapascals.

In the event of No.2 not reaching the required standard, No.3 will be tested. The result of this test will be binding and final on the Contractor and the Superintendent. The Contractor is to take immediate steps to remove and reconstruct any work condemned by reason of this section of the Specification.

4.13 Formwork

Formwork and framing for concrete shall be in accordance with the provision of Australian Standard AS 3600.

The forms shall be to the shape, lines and dimensions required by the Contract Drawings.

Forms shall be properly supported and braced to maintain position during and after the placing of concrete and shall not be stripped until the concrete has hardened and obtained sufficient strength to support its own weight and any construction loads, without injury to the concrete.

In no case shall the forms be removed before 12 hours after placing of the concrete.

4.14 Reinforcement

Where detailed, reinforcement shall be accurately fixed in accordance with the accompanying drawings and the provisions of Australian Standard AS 3600.

Reinforcement shall be thoroughly cleaned of all loose scale, rust and other detrimental coatings and shall be accurately placed, secured and maintained in position until incorporated in the concrete.

4.15 Inspection prior to placement of concrete

No concrete shall be placed before the formwork reinforcement and bedding, in place, have been inspected by the Superintendent.

4.16 Placing of Concrete

After mixing, concrete shall be conveyed to the place of final deposit, without delay, and placed into its final position as rapidly as possible by methods which prevent the loss or segregation of materials.

Dropping concrete a greater height than one (1) metre, depositing large quantities at any point and moving or working it along the forms will not be permitted. A plastic surface shall be maintained until the completion of the unit.

Concrete placing shall be carried on continuously up to the construction points as shown on the drawings, or as directed by the Superintendent.

Wherever the work of placing concrete is delayed until the concrete shall have taken its initial set, the point of stopping shall be deemed a construction joint. The location of construction joints shall be planned in advance and shall be made only when approved by the Superintendent. The placing of concrete shall be carried on continuously from joint to joint. These joints shall be perpendicular to the principal lines of stress and in general, shall be located at points of minimum shear.

Before placing new concrete on or against concrete which has set, the form shall be re-tightened and the surface of the set concrete shall be roughened as required by the Superintendent, thoroughly cleaned of foreign matter, laitance and loose or porous material, and saturated with water. The surface shall be then covered with a thin coat of stiff, neat cement to ensure bond and concreting shall then proceed immediately.

Precautions shall be taken in placing concrete when air temperatures are above 30^{o}C and below 5^{o}C. No concrete is to be placed under water unless methods used are approved by the Superintendent.

4.17 Compaction of Concrete

The concrete shall be thoroughly compacted to the satisfaction of the Superintendent, whilst it is being placed in the works. Compaction shall be by means of continuous tamping, spading and vibration with approved vibrators.

Care shall be taken to fill every part of the forms, to force the concrete under and around the reinforcement without displacing it, to work back coarse aggregate from the face and to remove all air bubbles and voids.

4.18 Curing

Concrete and rendering shall be cured so as to prevent excessive loss of moisture from the surface for at least seven (7) days continuously, following the time of placing.

In hot weather the Superintendent may direct the curing period to extend up to fourteen (14) days.

Curing shall be accomplished by one or more of the following methods:-

(a) Covering with Hessian, plastic sheeting or similar material maintained in a wet condition.

(b) Covering with at least 25mm thickness of sand or earth maintained in a damp condition.

(c) Coating with approved curing compound.

(d) New surfaces shall be effectively protected from rain until hard set has occurred.

4.19 Defective Concrete

The Contractor shall be fully responsible for employing effective methods of mixing, placing, protecting and curing concrete; and for the adequacy of falsework and forms. Approval of any such work or methods by the Superintendent will be tentative only and shall not relieve the Contractor of this responsibility. Concrete which is not placed and completed in accordance with this Specification or which is, in the opinion of the Superintendent, defective, shall be removed within the limits assigned by the Superintendent and replaced to his satisfaction.

5 Leachate Pipes and Fittings

5.1 Scope

The Contractor shall provide all materials, labour and equipment necessary to supply, install and test all pipes, fittings and valves, and all associated structural work as shown on the Drawings and as specified herein, and as required to make the work complete and operable.

5.2 Materials

5.2.1 General

The Contractor shall give the Superintendent sufficient notice to enable him to inspect any material or article that is delivered on the site of the works and all materials and articles shall be stacked in such a manner as will facilitate inspection. Materials and articles will be inspected before their use in the works of the Contract, but may be ultimately rejected if defects of any kind referred to or implied in this Specification be found before the completion of the Contract.

Samples and materials and/or articles supplied, which fail to meet the requirements of this Specification, whether definitely stated or implied, shall together with all materials and/or articles represented by such samples, be subject to rejection, and if rejected shall be replaced by the contractor at his own cost by materials and/or articles fully in accordance with such requirements of this Specification. The Contractor shall have no claim for extra payment or extension of time in respect of any such replacements.

The Superintendent may, at his discretion, require the Contractor to submit samples of any materials or articles to any test which he may prescribe for the purpose of determining whether or not they are in accordance with the requirements of this Specification. The cost of providing such samples shall be borne by the Contractor if the material is found to be unsatisfactory.

5.2.2 Leachate Pipes and Fittings

The leachate collection pipe shall be slotted 110mm nominal diameter (as specified in the drawings) Vinidex PE80B polyethylene pipe (class PN16) and fittings, or equivalent approved by the Superintendent in writing, manufactured in accordance with AS 4310.

Slots are to be 4mm x 100mm in length, with three slots staggered around the circumference of the pipe. Slots are at 300mm centres along the length of the pipe.

A filter sock is not to be fitted over the pipe.

Pipe work is to be connected to the sump within Cell 2 as per the construction drawings. Pipe ends shall protrude 50mm into the sump. Pipe penetrations shall be neatly constructed and rendered.

The Contractor shall not damage the flexible membrane liner. Any damage caused to the liner system must be repaired immediately to the satisfaction of the Superintendent.

Connections at pipe intersection shall be achieved using a single piece HDPE, Fabricated Tee constructed with an appropriate offset so as to maintain a constant pipe invert level across the transition. Alternate connection methods may only be used with the approval of the Superintendent.

5.2.3 Drainage Aggregate

Drainage aggregate for the area immediately surrounding leachate collection pipes trenches shall be 14 mm size rock of uniform grade.

Drainage aggregate for the filter blanket shall meet the requirements of clause 2.8.4.5.

Representative samples of drainage aggregate shall be provided to the Superintendent for approval, prior to material being brought to site.

5.3 Handling and Delivery of Pipes and Fittings

5.3.1 Transport and Unloading

Pipes shall be transported by an approved method which shall safeguard their condition.

Prior to commencement of deliveries, the proposed method of unloading at the site shall be in accordance with manufacturers specifications and approval by the Superintendent and no alteration of the approved method will be permitted without the further approval of the Superintendent.

When delivered all pipes are to be secured from rolling and be spaced so that free access can be obtained around them. Particular care shall be taken to avoid damage due to incorrect use of slings and pipe handling.

5.3.2 Acceptance After Delivery

Pipes and fittings will be subjected to inspection at the point of delivery and items which fail to meet the requirements of this Specification, independent of physical tests, will be rejected. Any item that is damaged beyond repair shall be removed immediately by the contractor and replaced by him at his expense.

After pipes and fittings have been delivered, unloaded, stacked and finally inspected, a Certificate of Acceptance shall be issued by the Superintendent for all items accepted, and forwarded to the Contractor. However, if the Superintendent is not satisfied that items have been delivered in accordance with this Specification, written notification of the reasons for non-acceptance will be given to the Contractor, who shall carry out forthwith such further works as are necessary for acceptance by the Superintendent.

The Superintendent may permit the repair of minor damage to the items at the delivery site if he is satisfied that the damage is superficial; otherwise the Contractor shall return the item to the factory for replacement.

Notwithstanding prior acceptance, any item which cannot be jointed properly will be rejected and shall be replaced by the Contractor at his expense.

5.4 Construction

5.4.1 General

For the purpose of this Section the term pipework shall be deemed to include all appurtenances built into or fixed on to the pipelines.

It shall be the Contractor's responsibility to ensure proper fit of all pipework. Dimensions and levels shown on the Drawings are to be retained unless such dimensions or levels result in a misfit or interference of the pipework with other pipework, structures or objects, or the dimensions given are not compatible with equipment items to be installed under this Contract, in which case the Contractor shall advise the Superintendent of changes he wishes to make to ensure proper fit and seek the Superintendent's approval to such changes. Approval to so modify such dimensions or pipework arrangements shall not constitute a Contract variation and such modifications shall be deemed to be part of the work of this Contract.

5.4.2 Leachate Collection Pipes

Before laying pipe, all dirt shall and foreign matter, etc. shall be removed from inside the pipe.

Unless otherwise approved by the Superintendent, laying shall commence at the low points of the pipeline and proceed upgrade. All pipelines shall be laid to the lines, levels and grades shown on the Drawings. Pipes must be seated on the geofabric and ballasted (commonly with sandbags) to prevent movement when aggregate is applied.

Angular changes in pipe alignment such as those required to enter the leachate sump, and transition from the base to the wall of the cell shall be achieve using the allowable bending radius of the pipe. The minimum allowable radius of a bend in HDPE pipe is 33 times the outside diameter of the pipe.

5.4.2.1 Jointing of Leachate Collection Pipes

All jointing of HDPE pipes shall be achieved by butt welding. Flanged, Victaulic, and compression fitting shall not be used without the written authority of the Superintendent. All procedures specified by the manufacturer must be followed; in particular:

- The pipe ends must be trimmed square to allow uniform pressure build up. The jointing ends must be free from dirt, grease and contamination to prevent foreign material being trapped inside the weld section.
- The heating time must not be reduced from that specified by the manufacturer and in windy or wet conditions the welding machine must be protected to prevent uneven heating or cooling around the pipe surface.
- The heating plate temperatures must not be changed from the recommended levels to ensure adequate heating and to prevent oxidation of the jointing surfaces.
- The temperature of the welding plate must be checked during the heating cycle.
- The trimmed and heated ends must be held for the appropriate time, depending on the pipe diameter and class.
- The zone must be kept under compression for the nominated period to prevent stresses being built into the joint and reducing the strength of the weld.
- The weld zone must be allowed to cool under ambient conditions and cooling by water spray should not be attempted.
- Weld beads may be left in place providing they are smooth and do not place significant pressure on the HDPE liner beneath.

The Contractor shall provide evidence in the appropriate schedule, of the experience of the pipe welding subcontractor.

Jointing may take place on the HDPE liner, providing adequate steps are taken to ensure that no damage occurs to the HDPE Liner. In the event of such damage the Contractor shall undertake repairs to the satisfaction of the Superintendent at no cost to the Principal.

After laying, jointing and inspection of the pipework, drainage stone shall be placed around the pipework as indicated on the Drawings. Approved 14 mm nominal sized drainage aggregate shall be mounded over the pipework to the cross-sections shown on the Drawings.

5.4.3 Excavation of Open Drains

The open drains shall be excavated to the lines, levels, grades and cross-sections as shown on the Drawings.

Should the Contractor excavate to depths greater than required, the excess excavation shall be backfilled at the Contractor's expense to the correct levels with approved material and compacted and tested to the satisfaction of the Superintendent.

Excavated material shall be stockpiled for possible subsequent use and placed on site as directed by the Superintendent.

6 Quality System

6.1 General

The Contractor shall for all works, plan, develop, document and implement a Quality System based on the principles and practices specified in the AS/NZS ISO 9000 series.

The Quality System shall include development and implementation of:

- Landfill Construction Quality Assurance Plan
- Environmental Management Plan (Construction Management Plan)
- Occupational Health & Safety Plan
- Construction Program

6.2 Construction Quality Assurance Plan

The Contractor/shall submit with his tender details of a proposed Construction Quality Assurance Plan (CQAP) for the landfill works. This plan shall include details of the nature and frequency of proposed testing.

The Construction Quality Assurance Plan shall conform to the geotechnical testing requirements described in Section 5 with consideration to EPA Best Practice Environmental Management (Landfills) Publication No. 788.

Once the Construction Quality Assurance Plan has been reviewed and approved by the Superintendent, the Contractor shall carry out all earthworks strictly in accordance with the Plan, unless otherwise directed by the Superintendent in writing.

The Contractor shall be deemed to have made full allowances for compliance with the approved CQAP and any contingencies arising there from in his tendered price.

The CQAP shall include preparation of a Construction Quality Assurance Report at the completion of works to the satisfaction of the Superintendent. This report will provide documentary evidence and certification that the works have been constructed in accordance with the drawings, specifications and CQAP. The report will include at least the following:

- Survey data/plans confirming compacted clay liner thickness
- Survey data/plans confirming correct pipe and liner grades and levels
- Results of the trial clay liners (including compaction and permeability test results)
- Compacted clay liner density, moisture content and permeability test results and evidence of frequency and locations of tests
- Test results and quality assurance certification of the HDPE liner manufacture and installation

6.3 Environmental Management Plan (Construction)

During construction, control of drainage flows along drainage lines, erosion and sediment transportation must be controlled by the Contractor to acceptable levels.

For this reason the Contractor shall submit with his tender a proposed Environmental Management Plan (EMP) which details how all the works under the Contract are to be carried out in accordance with the requirements of the Environment Protection Act 1970 and associated regulations and policies. The Plan (EMP) shall be applied throughout the project, commencing prior to the start of construction and being maintained until the end of the maintenance period.

The EMP shall be prepared by the Contractor and submitted to the Superintendent for approval within 7 days of the notification of acceptance of tender. The Contractor shall not be given possession of the site to commence works until the Superintendent has approved the EMP.

Once the EMP has been reviewed and approved by the Superintendent, the Contractor shall carry out all works strictly in accordance with the Plan, unless otherwise directed by the Superintendent in writing.

The Contractor shall be deemed to have made full allowances for compliance with the approved EMP and any contingencies arising there from in his tendered price.

The EMP should also be prepared in accordance with the Environment Protection Authority Publications "Construction Techniques for Sediment Pollution Control" (publication 275), "Environmental Guidelines for Major Construction Sites" (publication 480), and “Siting, Design, Operation and Rehabilitation of Landfills” (publication 788) copies of which are available for viewing at the Council offices or from the Victorian EPA website www.epa.vic.gov.au.

Items to be addressed in the EMP include, but are not limited to, the following:

- Establishing a practical sequence for construction of drains to divert drainage flows around the works or take other measures as appropriate to convey drainage flows during the period of works. Existing drainage sumps and pumping capacity installed for the current landfill operation may only be used by the contractor with permission of the landfill operator.
- Turbidity testing of water in dams adjoining the construction site, daily from the date when construction commences on site. In accordance with Table 6 of EPA publication 788, the following stormwater turbidity limits shall apply. Stormwater exceeding these limits must be retained on site for either reuse or treatment prior to discharge

	Maximum NTU	Median NTU
Dry weather	50	25
Stormwater flows	100	50

- Minimising effects of runoff from upstream surfaces by locating stockpiles on flat areas, away from flowpaths and constructing perimeter diversion banks around the site boundary and stockpiles to intercept upstream flows and direct them to stable drainage routes.
- Maintaining stability of stockpiles by limiting stockpile height and side slopes.
- Trapping sediment at source by constructing silt fencing around lower edge of stockpiles or by installing other alternative types of sediment traps.
- Establishing a practical construction sequence which traps sediment and prevents it from entering drainage lines.
- Reducing lengths of exposed slopes into non-erosive segments by constructing berms at regular intervals.
- Trapping of sediment on site at strategic locations along drainage lines by installation of sediment controls such as silt fences and traps.
- Protection of soil surface from rain and runoff by early establishment of vegetation, eg.: hydroseeding.

- Reducing dust from haul roads by watering or gravelling.
- Conveyance of concentrated flows down slopes without causing erosion by installing appropriate energy dissipaters and constructing a stabilised/lined base for drainage lines.
- Minimising area of works and disturbance of soil.
- Limiting construction equipment movement by fencing off critical areas.

The Contractor's adherence to the EMP shall be monitored throughout the course of the contract. If appropriate, the approved EMP shall be amended by agreement between the Superintendent and Contractor in order to better meet the objectives of the EMP.

At his discretion, the Superintendent may instruct the Contractor, at no additional cost to the Principal, to install additional control measures in areas where sediment control is not being satisfactorily achieved. Long term treatment of these areas will then be subject to amendment of the EMP as detailed above.

The EMP shall remain in force until the issue of the Final Certificate.

6.4 Environmental Audit

As required under the conditions of the EPA Waste Discharge Licence for the landfill, the Principal shall engage the services of an Environmental Auditor to prepare an Environmental Audit Report. The Superintendent shall provide the Environmental Auditor with a copy of the CQAP, the EMP and any other data, records or details of management systems relevant to the construction of the landfill. The Contractor shall co-operate with the provision of such items if requested. The Environmental Auditor is also required to undertake one or more inspections of the site during construction.

6.5 Occupational Health and Safety

The Contractor shall submit for consideration by the Superintendent an Occupational Health and Safety Plan covering the management of occupational health and safety in accordance with the Occupational Health and Safety Act 2000. Refer to Clause **Error! Reference source not found.** for further details of the Contractors responsibility regarding Occupational Health and Safety and the OH&S Plan.

The Plan shall provide for the prompt notification to the Superintendent of any accident or injury occurring at the site.

The Contractor and the Contractor's agents shall, so far as is practicable, provide and maintain for employees and agents of the Principal and the Superintendent who, in the course of their work for the Principal, enter the site, an environment that is safe and without risks to health.

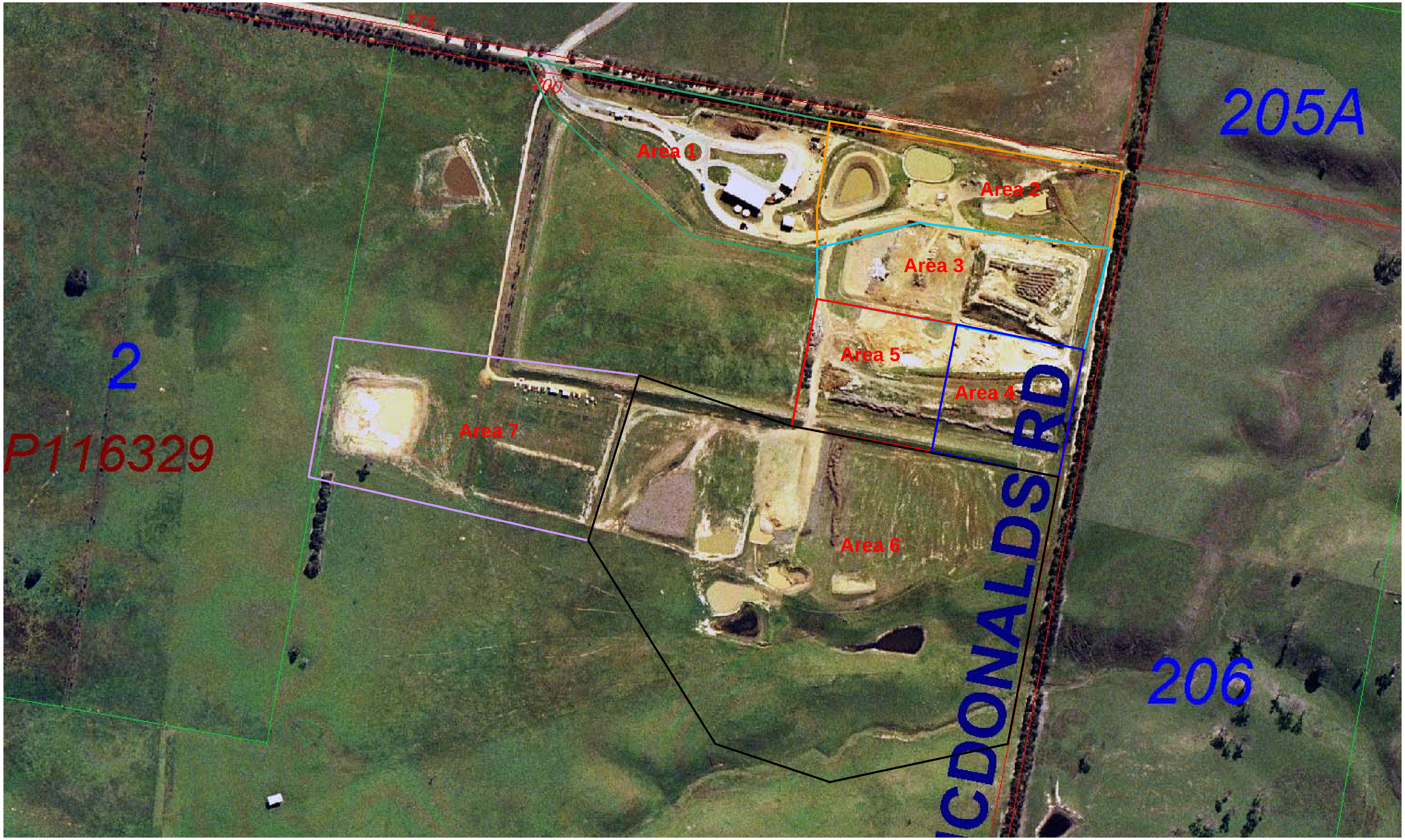
6.6 Construction Program

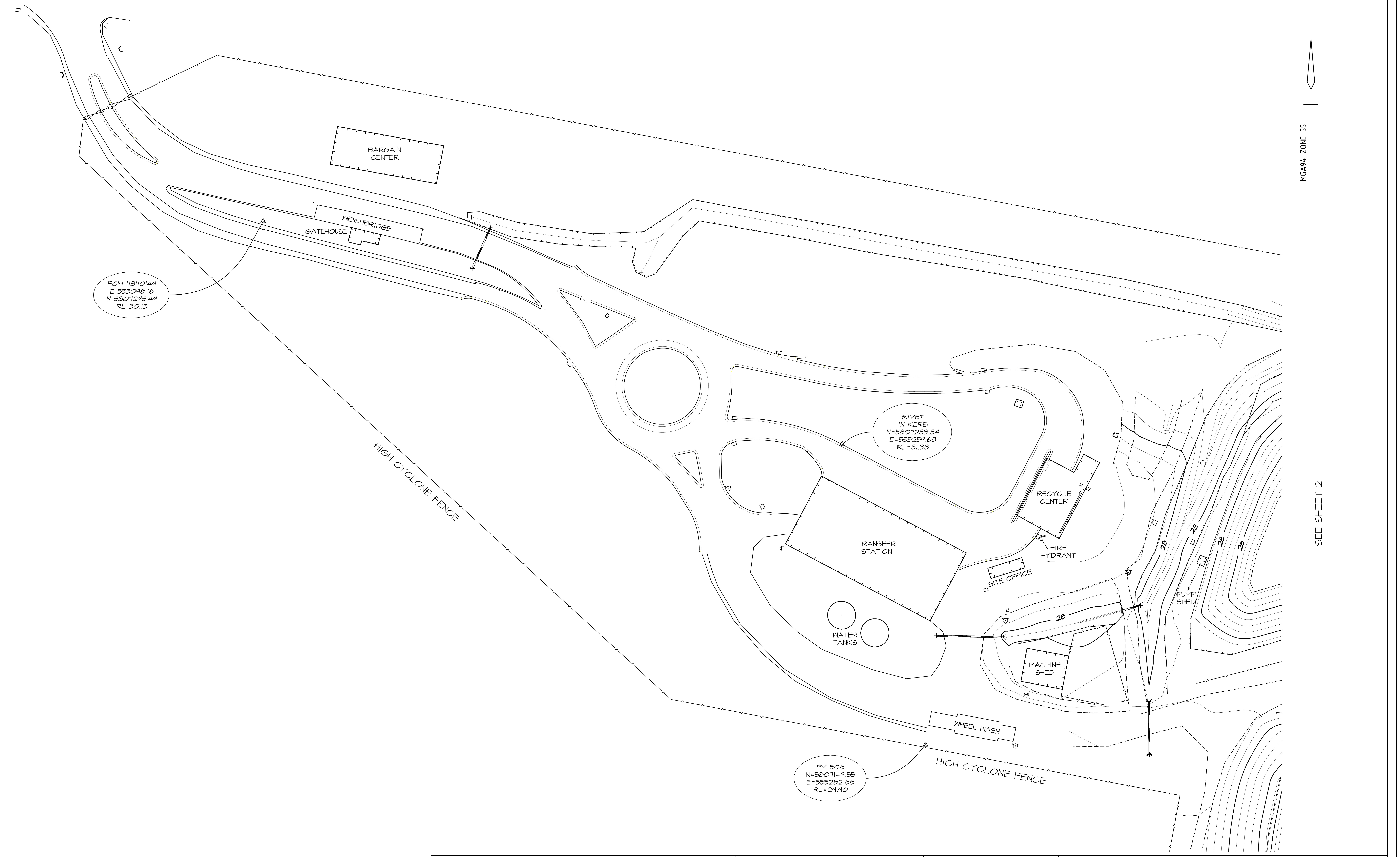
Within fourteen (14) days of the Date of Letter of Acceptance of Contract, the Contractor shall prepare and submit to the Superintendent a construction program for the orderly completion of the works.

During the initial preparation of the construction program the Contractor shall confer with the Superintendent to ensure that agreement is reached regarding layout and conventions.

The diagrams submitted shall be revised and resubmitted as required, until the Contractor's programmed sequence of operations, construction procedures and use of labour, materials and equipment is, in the opinion of the Superintendent, such as to ensure satisfactory progress for completion of the works within the times specified and in accordance with the requirements of the Contract. All revisions required under this sub-clause shall be completed within four (4) calendar weeks of the Date of Letter of Acceptance of Contract.

The program shall be subject to review and acceptance by the Superintendent.


175
200
205A
Area 1
Area 2
Area 3
Area 5
Area 4
Area 7
Area 6
2
P116329
CDONALDS RD
206



NOTATIONS

CO-ORDINATE DATUM IS MGA94
HEIGHT DATUM IS AHD

CONTOUR INTERVAL IS 0.5m

DATE OF SURVEY : JULY 2009

Crowther&Sadler Pty.Ltd.
LICENSED SURVEYORS & TOWN PLANNERS
152 MACLEOD STREET, BAIRNSDALE, VIC., 3875
TELEPHONE (03) 5152 5011

SURVEYORS REF.	SCALE
13679	1 : 500

N:\DATA 2009\13601-13700\13679 E.G Shire\13679 merged data.pro

Legend of Features

- Ⓔ Electricity Pit
- ⋈ Stop Valve
- 🅃 Telecom Pit
- ⊠ Electricity Pole
- Ⓢ Sewerage Manhole
- △ Water Meter
- ▣ Fire Plug
- △ Tap
- ⊙ Fire Hydrant

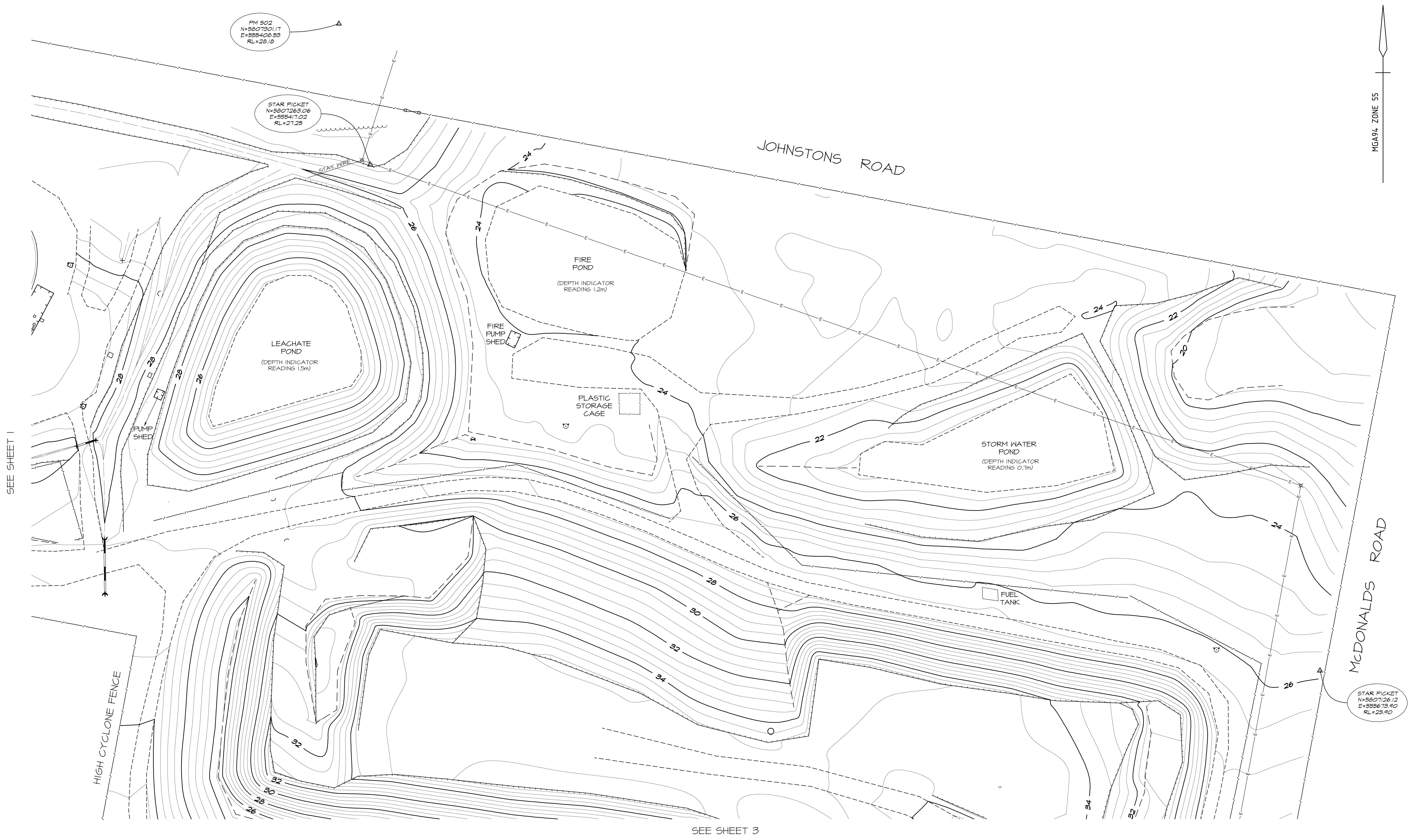
PLAN OF FEATURES

PARISH OF BAIRNSDALE
CROWN ALLOTMENTS H, 88 & 258

JOHNSTONS ROAD LANDFILL, BAIRNSDALE
AREA 1 : GATEHOUSE/TRANSFER STATION

EAST GIPPSLAND SHIRE COUNCIL

SHEET 1 OF 7



NOTATIONS

CO-ORDINATE DATUM IS MGA94
HEIGHT DATUM IS AHD

CONTOUR INTERVAL IS 0.5m

DATE OF SURVEY : JULY 2009

Crowther&Sadler Pty. Ltd.
LICENSED SURVEYORS & TOWN PLANNERS
152 MACLEOD STREET, BAIRNSDALE, VIC., 3875
TELEPHONE (03) 5152 5011

SURVEYORS REF.	SCALE
13679	1 : 500

N:\DATA 2009\13601-13700\13679 E.G Shire\13679 merged data.pro

Legend of Features

- Ⓔ Electricity Pit
- ⋈ Stop Valve
- 🅃 Telecom Pit
- ¤ Electricity Pole
- Ⓢ Sewerage Manhole
- △ Water Meter
- ▣ Fire Plug
- △ Tap
- ⊙ Fire Hydrant

PLAN OF FEATURES

PARISH OF BAIRNSDALE
CROWN ALLOTMENTS H, 88 & 258

JOHNSTONS ROAD LANDFILL, BAIRNSDALE
AREA 2 : LEACHATE POND & STORMWATER DAM

EAST GIPPSLAND SHIRE COUNCIL

SHEET 2 OF 7

SEE SHEET 2

SEE SHEET 4

NOTATIONS

CO-ORDINATE DATUM IS MGA94
HEIGHT DATUM IS AHD

CONTOUR INTERVAL IS 0.5m

DATE OF SURVEY : JULY 2009

Crowther&Sadler Pty. Ltd.
LICENSED SURVEYORS & TOWN PLANNERS
152 MACLEOD STREET, BAIRNSDALE, VIC., 3875
TELEPHONE (03) 5152 5011

SURVEYORS REF.	SCALE
13679	1 : 500

N:\DATA 2009\13601-13700\13679 E.G Shire\13679 merged data.pro

Legend of Features

- Ⓔ Electricity Pit
- ⋈ Stop Valve
- 🅃 Telecom Pit
- ⌧ Electricity Pole
- Ⓢ Sewerage Manhole
- △ Water Meter
- ▣ Fire Plug
- △ Tap
- ○ Fire Hydrant

PLAN OF FEATURES

PARISH OF BAIRNSDALE
CROWN ALLOTMENTS H, 88 & 258

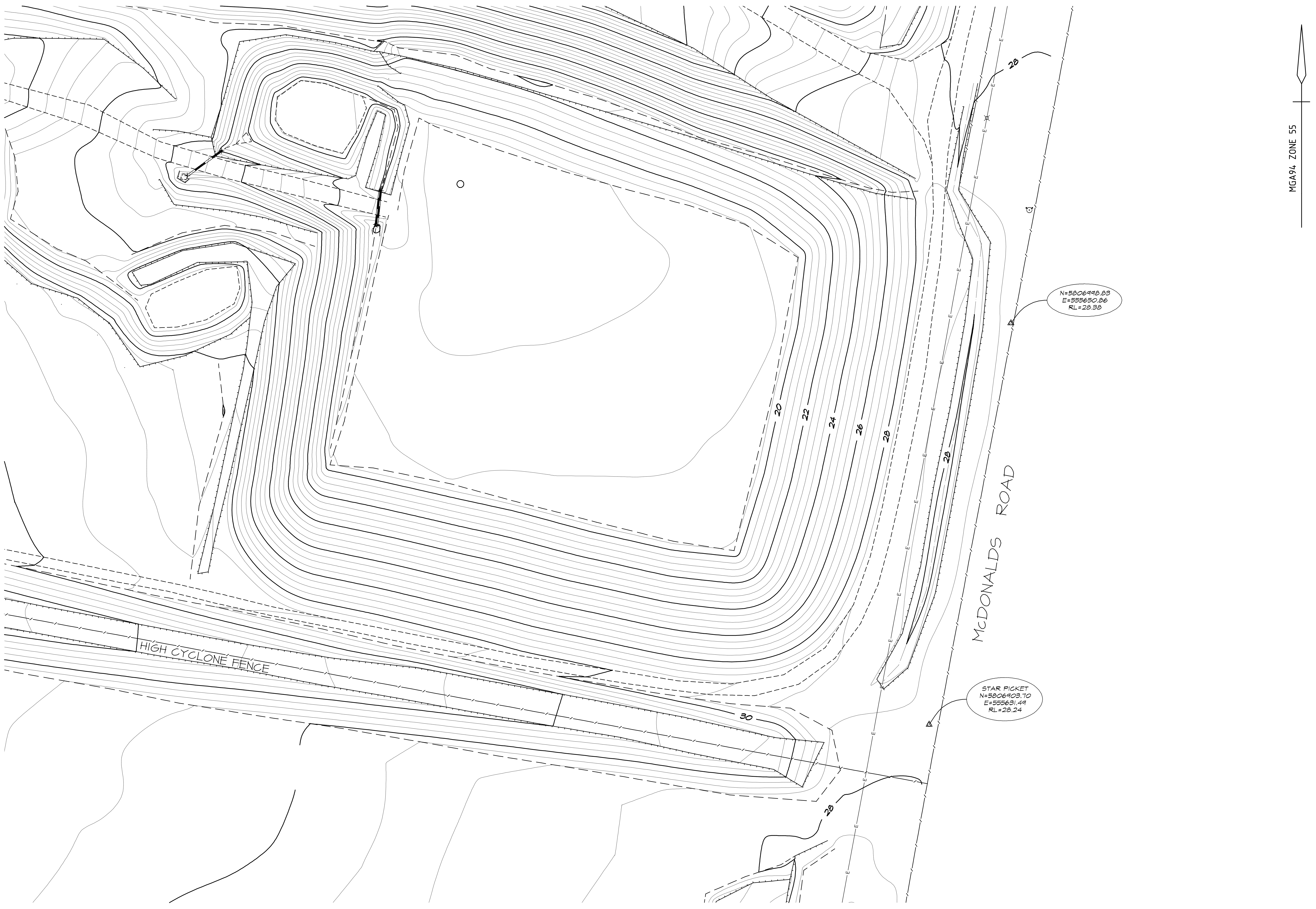
JOHNSTONS ROAD LANDFILL, BAIRNSDALE
AREA 3 : CELL 1

EAST GIPPSLAND SHIRE COUNCIL

SHEET 3 OF 7

SEE SHEET 3

SEE SHEET 5



SEE SHEET 6

NOTATIONS

CO-ORDINATE DATUM IS MGA94
HEIGHT DATUM IS AHD

CONTOUR INTERVAL IS 0.5m

DATE OF SURVEY : JULY 2009

Crowther&Sadler Pty.Ltd.
LICENSED SURVEYORS & TOWN PLANNERS
152 MACLEOD STREET, BAIRNSDALE, VIC., 3875
TELEPHONE (03) 5152 5011

SURVEYORS REF.	SCALE
13679	1 : 500

N:\DATA 2009\13601-13700\13679 E.G Shire\13679 merged data.pro

Legend of Features

- Ⓔ Electricity Pit
- ⋈ Stop Valve
- 🅃 Telecom Pit
- ⌧ Electricity Pole
- Ⓢ Sewerage Manhole
- △ Water Meter
- ■ Fire Plug
- △ Tap
- ⊙ Fire Hydrant

PLAN OF FEATURES

PARISH OF BAIRNSDALE
CROWN ALLOTMENTS H, 88 & 258

JOHNSTONS ROAD LANDFILL, BAIRNSDALE
AREA 4 : CELL 2

EAST GIPPSLAND SHIRE COUNCIL

SHEET 4 OF 7

NOTATIONS

CO-ORDINATE DATUM IS MGA94
HEIGHT DATUM IS AHD

CONTOUR INTERVAL IS 0.5m

DATE OF SURVEY : JULY 2009

Crowther&Sadler Pty.Ltd.
LICENSED SURVEYORS & TOWN PLANNERS
152 MACLEOD STREET, BAIRNSDALE, VIC., 3875
TELEPHONE (03) 5152 5011

SURVEYORS REF.	SCALE
13679	1 : 500

N:\DATA 2009\13601-13700\13679 E.G Shire\13679 merged data.pro

Legend of Features

- Ⓔ Electricity Pit
- ⋈ Stop Valve
- 🅃 Telecom Pit
- ¤ Electricity Pole
- Ⓢ Sewerage Manhole
- △ Water Meter
- ■ Fire Plug
- △ Tap
- ⊙ Fire Hydrant

PLAN OF FEATURES

PARISH OF BAIRNSDALE
CROWN ALLOTMENTS H, 88 & 258

JOHNSTONS ROAD LANDFILL, BAIRNSDALE
AREA 5 : FUTURE CELL 3

EAST GIPPSLAND SHIRE COUNCIL

SHEET 5 OF 7

PLAN OF FEATURES

PARISH OF BAIRNSDALE
CROWN ALLOTMENTS H, 88 & 258

JOHNSTONS ROAD LANDFILL, BAIRNSDALE
AREA 6 : SPOIL AREA / STOCKPILE

EAST GIPPSLAND SHIRE COUNCIL

SHEET 6 OF 7

NOTATIONS

CO-ORDINATE DATUM IS MGA94
HEIGHT DATUM IS AHD

CONTOUR INTERVAL IS 0.5m

DATE OF SURVEY : JULY 2009

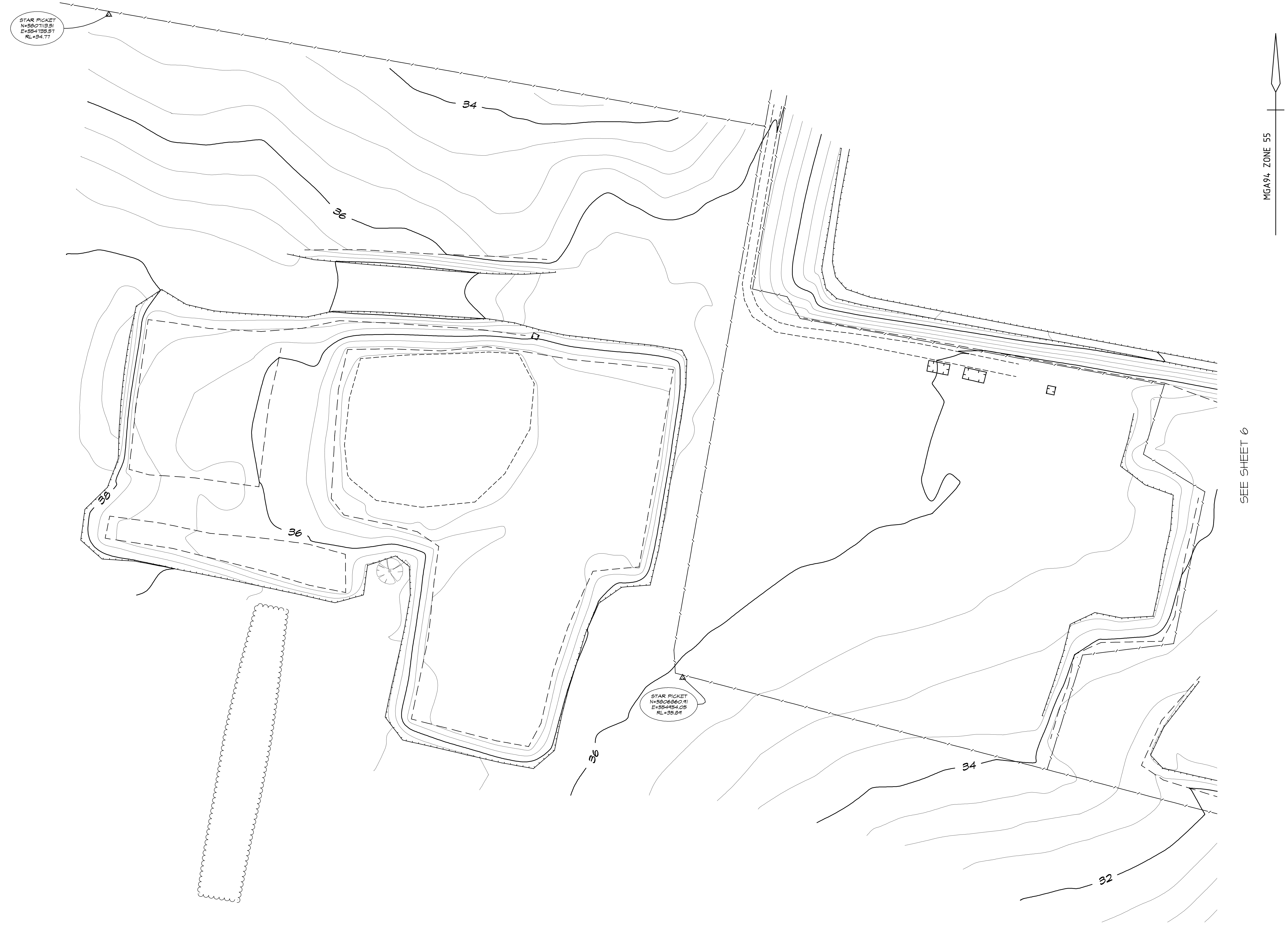
Legend of Features

- Ⓔ Electricity Pit
- ⋈ Stop Valve
- 🅃 Telecom Pit
- ¤ Electricity Pole
- Ⓢ Sewerage Manhole
- △ Water Meter
- ■ Fire Plug
- △ Tap
- ☉ Fire Hydrant

Crowther&Sadler Pty. Ltd.
LICENSED SURVEYORS & TOWN PLANNERS
152 MACLEOD STREET, BAIRNSDALE, VIC., 3875
TELEPHONE (03) 5152 5011

SURVEYORS REF.	SCALE
13679	1 : 1000

N:\DATA 2009\13601-13700\13679 E.G Shire\13679 merged data.pro



NOTATIONS

CO-ORDINATE DATUM IS MGA94
HEIGHT DATUM IS AHD

CONTOUR INTERVAL IS 0.5m

DATE OF SURVEY : JULY 2009

Crowther&Sadler Pty.Ltd.
LICENSED SURVEYORS & TOWN PLANNERS
152 MACLEOD STREET, BAIRNSDALE, VIC., 3875
TELEPHONE (03) 5152 5011

SURVEYORS REF.	SCALE
13679	1 : 800

N:\DATA 2009\13601-13700\13679 E.G Shire\13679 merged data.pro

Legend of Features
- Ⓔ Electricity Pit
- ⋈ Stop Valve
- 🅃 Telecom Pit
- ⌧ Electricity Pole
- Ⓢ Sewerage Manhole
- ⚠ Water Meter
- ▣ Fire Plug
- △ Tap
- ⊙ Fire Hydrant

PLAN OF FEATURES

PARISH OF BAIRNSDALE
CROWN ALLOTMENTS H, 88 & 258

JOHNSTONS ROAD LANDFILL, BAIRNSDALE
AREA 7 : BORROW PIT AREA

EAST GIPPSLAND SHIRE COUNCIL

SHEET7 OF 7

INFRASTRUCTURE SOLUTIONS PTY LTD

GEOTECHNICAL ASSESSMENT REPORT
BAIRNSDALE LANDFILL - STAGE 2
BAIRNSDALE VIC

AW1781.1AC

25th September 2004

AW1781.1ABC AE
25th September 2004

Infrastructure Solutions Pty Ltd
1 Orchard Court
SHEPPARTON VIC 3632

Attention: Mr Trevor Woodcock

Dear Sir,

RE: GEOTECHNICAL ASSESSMENT REPORT
BAIRNSDALE LANDFILL - STAGE 2
BAIRNSDALE VIC

We have pleasure in submitting our geotechnical assessment report for the sourcing of clay material to construct an engineered clay liner at the above site. Three copies of the report are provided for your information.

We trust this report meets your current requirements for the design of the above project. Please contact the undersigned, or Mr. Bojan Knezevic at this office on (02) 6023 3799 for any queries regarding this report or further assistance.

For and on behalf of
COFFEY GEOSCIENCES PTY LTD

TONY EDWARDS - PRINCIPAL

Distribution:

3 copies	Infrastructure Solutions Pty Ltd
1 copy	Coffey Geosciences Pty Ltd Library
Original	Held by Coffey Geosciences Pty Ltd

1/314 Kiewa Street
Albury NSW 2640 Australia
PO Box 803 Albury
NSW 2640 Australia
Telephone +61 2 **6023 3799**
Facsimile +61 2 6023 3644
Email albury@coffey.com.au

Coffey Geosciences Pty Ltd ACN 056 335 516

TABLE OF CONTENTS

1. INTRODUCTION I

2. FIELDWORK I

3. LABORATORY TESTING I

4. SITE CONDITIONS II
4.1 Regional Geology ii
4.2 Subsurface Conditions ii
4.3 Groundwater ii

5. GEOTECHNICAL ASSESSMENT III
5.1 Investigation Finding. iii
  5.1.1 Soil Permeability iii
  5.1.2 Soil Dispersion iii
  5.1.3 Liner Materials iii
5.2 Earthworks iii
  5.2.1 Excavation Conditions iii
  5.2.2 Fill Placement iii

6. APPLICABILITY IV

IMPORTANT INFORMATION ABOUT YOUR COFFEY REPORT

Table 2. Extraction Zones for Clay Liner Materials

Figure

1 Field Investigation Plan

Appendix

A Results of Field Investigation

B Results of Laboratory Tests

1. INTRODUCTION

This report presents a geotechnical assessment for the source of clay material to construct an engineered clay liner at the Bairnsdale Landfill – Stage 2, Bairnsdale VIC. Coffey Geosciences Pty Ltd (Coffey) carried out the geotechnical assessment that was commissioned by Mr Trevor Woodcock of Infrastructure Solutions Pty Ltd in accordance with our proposal (AW1781/1-PAA, dated 07 June 2004).

The objectives of the assessment were to determine the suitable soil from the available soil sourcing area, for use as a clay liner at the proposed landfill extension.

The scope of the work carried out to meet the above objectives included:

- Fieldwork involving the excavation and logging of 20 test pits;
- Assessment of subsurface conditions, including groundwater conditions;
- Laboratory testing including five Falling Head Permeability and eleven Emerson Crumb tests;
- Recommendations for suitable earthworks, and
- Preparation of this geotechnical report.

2. FIELDWORK

The fieldwork was carried out on 26 August 2004 and comprised excavation of twenty test pits to depths ranging from 1.8 to 3.5m below the ground level.

A geotechnician from Coffey observed the excavation of the test pits and logged the encountered subsurface soils and conditions within the test pits. Disturbed and bulk soil samples were collected from the test pits and returned to our laboratory for further assessment and testing.

Engineering excavation logs, together with explanation sheets outlining the terms and symbols used in their preparation, are presented in Appendix A.

3. LABORATORY TESTING

The following geotechnical laboratory tests were undertaken to assist in assessing the engineering properties of the soils at the site:

- 4 No. Falling Head Permeability Tests using distilled water;
- 1 No. Falling Head Permeability Test using saline solution;
- 10 No. Emerson Crumb Tests using distilled water, and
- 1 No. Emerson Crumb Test using saline solution.

The laboratory testing was performed in Coffey's NATA accredited laboratories in Melbourne and Sydney. The results of the tests are included in Appendix B of this report.

4. SITE CONDITIONS

4.1 Regional Geology

The published map 'Geological Survey of Victoria, Baimsdale sheet, 1:250,000" indicates that the near surface geology of the site as:

- Quaternary aged Paludal lagoon deposits comprising silts and clays;
- Quaternary Fluvial deposits comprising gravels, sands and silts, and
- Tertiary deposits of Seaspray and Sale groups.

The results of our fieldwork indicate the presence of alluvial soils generally below a thin layer of topsoil at the site.

4.2 Subsurface Conditions

The subsurface conditions encountered within the test pits at the site during our fieldwork are summarised in Table 1.

TABLE 1: SUMMARY OF SUBSURFACE CONDITIONS

Interpreted Unit	Depth to Top of Unit (m)	Unit Thickness (m)	Description of Materials
Topsoil	0.0	0.2	SANDY SILT: low plasticity, fine to medium grained sand, dark grey, pale brown, brown. Not observed in test pit TP20.
Alluvium	0.2	Not Penetrated (>3.5m)	SANDY CLAY, CLAYEY SAND, SAND, SILTY CLAY, GRAVELLY SAND: low, medium and high plasticity, fine to medium grained sand, fine to course grained gravel, orange, pale grey, red mottles, grey; very stiff or dense to very dense. COBBLES IN SAND MATRIX in test pits TP2, TP14, TP15 and TP20 at depths of 2.5m, 1.6m, 0.8m and 0.7m, respectively.
Weathered Rock	1.7	Not Penetrated	MUDSTONE: slightly weathered, light grey. Observed in test pit TP3 only.

4.3 Groundwater

Standing groundwater was observed within the test pit TP15 only at depth of 2.2m below existing ground level at the time of our investigation. Fluctuations in groundwater level and seepage could occur due to rainfall, change in temperature and other factors.

5. GEOTECHNICAL ASSESSMENT

5.1 Investigation Finding.

5.1.1 Soil Permeability

Four Falling Head Permeability tests were carried out on remoulded soil samples collected from the test pits and resulted in permeability rates of between 3.0×10^{-9}m/sec and 8.8×10^{-11}m/sec using distilled water.

One additional Falling Head Permeability test was carried out on a remoulded Silty Clay sample of high plasticity, using 2% saline solution instead of distilled water in order to observe the effects that a saline, landfill leachate may have on the permeability of the soil. The results of the test using the saline solution indicated little or no apparent impact on the permeability of the sample, which recorded a permeability of 1.9×10^{-10}m/sec.

The laboratory soil samples used in all permeability tests were remoulded to a dry density ratio of approximately 95% Standard within a moisture ratio of ±2% of Standard Optimum Moisture Content (SOMC) and test results are presented in Appendix B of this report.

5.1.2 Soil Dispersion

A total of eleven Emerson Crumb tests were carried out in our laboratory in order to assess the dispersion characteristics of the soils. Ten of the tests were performed using potable water and one duplicate test using saline solution of 2%.

On the basis of the Emerson Crumb testing it was apparent that most of the Clayey soils are mildly dispersive when subject to potable water however the duplicate sample tested with saline solution was only slightly dispersive. Given the leachate from municipal landfills is commonly of a saline nature we assess the dispersion of the clays will not be significant in the application as a liner.

5.1.3 Liner Materials

On the basis of the field observations and the results of the laboratory tests we recommend the materials encountered in the test pits and as shown in Table 2 following the text of this report as being suitable for use as a liner for the landfill if adequately compacted and moisture conditioned. We have included in the chart some mixing of materials in adjoining layers that on the basis of the laboratory testing are expected to meet the specified criteria provided they are adequately mixed. Because of the variable nature of the soils across the site we recommend that the potential liner materials should be excavated and mixed under direction of a geotechnical practitioner, then stockpiled, sampled and tested for permeability compliance prior to placement.

5.2 Earthworks

5.2.1 Excavation Conditions

Excavation of the alluvial soils should be achievable using conventional earthmoving equipment such as excavators and scrappers. Minor water inflows are likely to be encountered if excavation is extended in to the more granular materials such as where encountered in TP15 particularly following extended rainfall periods.

5.2.2 Fill Placement

The new Clay liner material should be placed and compacted to an engineering specification in general accordance with recommendations outlined in AS3798-1996, 'Guidelines for Commercial and Residential

Developments'.

The following procedure is recommended as a guide for site preparation and the placement of controlled fill.

- The soils exposed after excavation to the design base level should be scarified to a depth of about 150mm, moisture conditioned to within ±2% of Standard Optimum Moisture Content (SOMC) and then re-compacted to a minimum dry density of 98% Standard in accordance with AS1289 5.1.1, 5.4.1 or 5.7.1.
- Any soft or weak areas identified during the compaction process that do not respond to further compaction should be removed and replaced with suitable site materials in layers not exceeding 250mm thickness and should be compacted to the above criteria.
- Subsequent layers of general fill or the Clay liner material fill should be placed in uniform 250mm loose thickness layers, moisture conditioned and compacted to the above criteria. The final layer of the Clay liner should be maintained in a moist condition until covered with a protective layer to prevent drying and cracking

Earthworks should be carried out during dry weather conditions, if possible. Provision should be made for effective diversion of surface water from outside the site. The surface runoff from the site should be treated to remove excess sediments before discharge.

6. APPLICABILITY

Recommendations and opinions contained in this report are based on the interpretation of subsurface conditions from the investigation test pits and information from published geological maps. The nature and continuity of the subsoil away from the test locations are inferred, but it must be appreciated that actual conditions could vary from the assumed geotechnical model. If conditions other than those described are encountered, Coffey should be engaged to assess whether the recommendations should be revised.

The attached "Important Information about Your Coffey Report" provides additional information in the uses and limitations of this report.

For and on Behalf of

COFFEY GEOSCIENCES PTY LTD

Tony Edwards - Principal

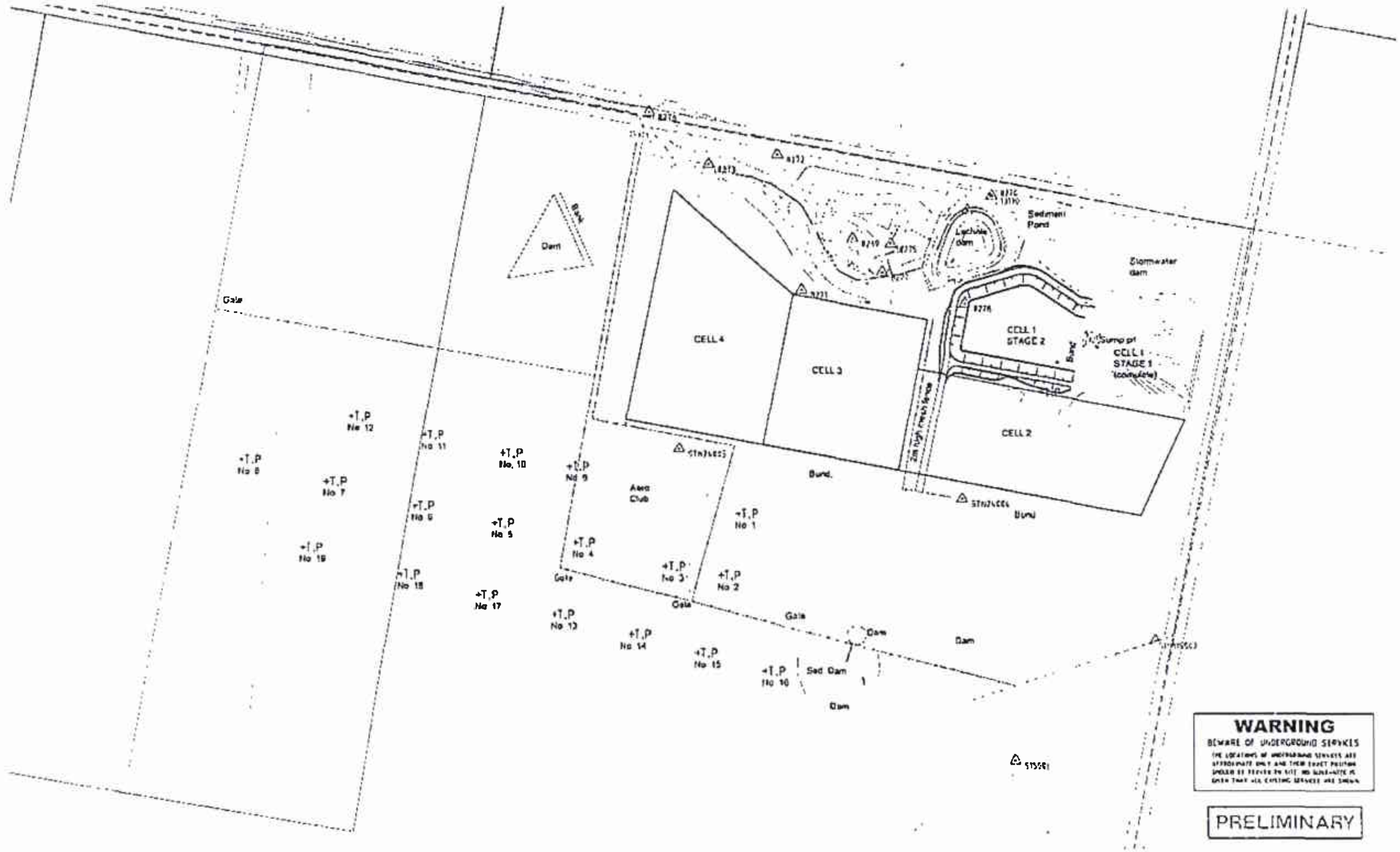
Table 2. Extraction Zones for Clay Liner Materials

Test Pit No.	Depth (m)	Material	Comments
1	0.2 – 1.0	Sandy Clay, medium plasticity.	-
2	0.2 – 0.8	Silty Clay, medium plasticity.	-
3	0.2 – 1.7	Silty Clay, high plasticity and Sandy Clay, medium plasticity.	Mixed layers
4	0.4 – 3.0	Silty Clay, medium & high plasticity	Mixed layers
5	0.2 – 3.0	Silty Clay & Sandy Clay, medium & high plasticity.	Mixed layers
6	0.2 – 3.0	Silty Clay & Sandy Clay, medium & high plasticity.	Mixed layers
7	0.2 – 2.2	Silty Clay, high plasticity	-
8	0.2 – 3.0	Silty Clay & Sandy Clay, medium & high plasticity	Mixed layers
9	0.2 – 2.1	Silty Clay, medium & high plasticity	Mixed layers
10	0.2 – 1.5	Silty Clay, medium & high plasticity	Mixed layers
11	0.2 – 3.4	Silty clay, medium & high plasticity	Mixed layers
12	0.2 – 3.0	Silty Clay, medium & high plasticity	Mixed layers
13	0.2 – 3.0	Silty Clay, medium & high plasticity	Mixed layers
16	0.2 – 2.5	Silty Clay, medium plasticity.	-
17	0.2 – 3.1	Silty Clay, medium & high plasticity	Mixed layers
18	0.2 – 1.7	Silty Clay, medium & high plasticity	Mixed layers
19	0.2 – 1.6	Silty Clay, medium & high plasticity	Mixed layers

Materials from TP's, 14, 15 & 20 not assessed as suitable for liner use.

Refer to figure 1 for test pit locations.

Coffey



Notes:

LEGEND

✚ T.P Denotes approximate location of Test Pit.

Coffey Geosciences Pty Ltd ACN 056 335 516

Geotechnical | **Resources** | Environmental | **Technical** | Project Management

Drawn	RK
Approved	
Date	18.10.2004
Scale	N.T.S

INFRASTRUCTURE SOLUTIONS PTY LTD
BAIRNSDALE LANDFILL, STAGE 2,
BAIRNSDALE VIC
FIELD INVESTIGATION PLAN

Figure No:
1

Job No.
AW1781/1-AB

Information

Important information about your **Coffey** Report

As a client of Coffey you should know that site subsurface conditions cause more construction problems than any other factor. These notes have been prepared by Coffey to help you interpret and understand the limitations of your report.

Your report is based on project specific criteria

Your report has been developed on the basis of your unique project specific requirements as understood by Coffey and applies only to the site investigated. Project criteria typically include the general nature of the project; its size and configuration; the location of any structures on the site; other site improvements; the presence of underground utilities; and the additional risk imposed by scope-of-service limitations imposed by the client. Your report should not be used if there are any changes to the project without first asking Coffey to assess how factors that changed subsequent to the date of the report affect the report's recommendations. Coffey cannot accept responsibility for problems that may occur due to changed factors if they are not consulted.

Subsurface conditions can change

Subsurface conditions are created by natural processes and the activity of man. For example, water levels can vary with time, fill may be placed on a site and pollutants may migrate with time. Because a report is based on conditions which existed at the time of the subsurface exploration, decisions should not be based on a report whose adequacy may have been affected by time. Consult Coffey to be advised how time may have impacted on the project.

Interpretation of factual data

Site assessment identifies actual subsurface conditions only at those points where samples are taken and when they are taken. Data derived from literature and external data source review, sampling and subsequent laboratory testing are interpreted by geologists, engineers or scientists to provide an opinion about overall site conditions, their likely impact on the proposed development and recommended actions. Actual conditions may differ from those inferred to exist, because no professional, no matter how qualified, can reveal what is hidden by earth, rock and time. The actual interface between materials may be far more gradual or abrupt than assumed based on the facts obtained. Nothing can be done to change the actual site conditions which exist, but steps can be taken to reduce the impact of unexpected conditions. For this reason, owners should retain the services of Coffey through the development stage, to identify variances, conduct additional tests if required, and recommend solutions to problems encountered on site.

Your report will only give preliminary recommendations

Your report is based on the assumption that the site conditions as revealed through selective point sampling are indicative of actual conditions throughout an area. This assumption cannot be substantiated until project implementation has commenced and therefore your report recommendations can only be regarded as preliminary. Only Coffey, who prepared the report, is fully familiar with the background information needed to assess whether or not the report's recommendations are valid and whether or not changes should be considered as the project develops. If another party undertakes the implementation of the recommendations of this report there is a risk that the report will be misinterpreted and Coffey cannot be held responsible for such misinterpretation.

Your report is prepared for specific purposes and persons

To avoid misuse of the information contained in your report it is recommended that you confer with Coffey before passing your report on to another party who may not be familiar with the background and the purpose of the report. Your report should not be applied to any project other than that originally specified at the time the report was issued.

Interpretation by other design professionals

Costly problems can occur when other design professionals develop their plans based on misinterpretations of a report. To help avoid misinterpretations, retain Coffey to work with other project design professionals who are affected by the report. Have Coffey explain the report implications to design professionals affected by them and then review plans and specifications produced to see how they have incorporated the report findings.

Data should not be separated from the report*

The report as a whole presents the findings of the site assessment and the report should not be copied in part or altered in any way.

Logs, figures, drawings etc. are customarily included in our reports and are developed by scientists, engineers or geologists based on their interpretation of field logs (assembled by field personnel) and laboratory evaluation of field samples. These logs etc. should not under any circumstances be redrawn for inclusion in other documents or separated from the report in any way.

Geoenvironmental concerns are not at issue

Your report is not likely to relate any findings, conclusions, or recommendations about the potential for hazardous materials existing at the site unless specifically required to do so by the client. Specialist equipment, techniques, and personnel are used to perform a geoenvironmental assessment. Contamination can create major health, safety and environmental risks. If you have no information about the potential for your site to be contaminated or create an environmental hazard, you are advised to contact Coffey for information relating to geoenvironmental issues.

Rely on Coffey for additional assistance

Coffey is familiar with a variety of techniques and approaches that can be used to help reduce risks for all parties to a project, from design to construction. It is common that not all approaches will be necessarily dealt with in your site assessment report due to concepts proposed at that time. As the project progresses through design toward construction, speak with Coffey to develop alternative approaches to problems that may be of genuine benefit both in time and cost.

Responsibility

Reporting relies on interpretation of factual information based on judgement and opinion and has a level of uncertainty attached to it, which is far less exact than the design disciplines. This has often resulted in claims being lodged against consultants, which are unfounded. To help prevent this problem, a number of clauses have been developed for use in contracts, reports and other documents. Responsibility clauses do not transfer appropriate liabilities from Coffey to other parties but are included to identify where Coffey's responsibilities begin and end. Their use is intended to help all parties involved to recognise their individual responsibilities. Read all documents from Coffey closely and do not hesitate to ask any questions you may have.

** For further information on this aspect reference should be made to "Guidelines for the Provision of Geotechnical Information in Construction Contracts" published by the Institution of Engineers Australia, National Headquarters, Canberra, 1987.*

APPENDIX A

Results of Field Investigation

Explanation Sheets

Engineering Logs

Soil Description

Explanation Sheet (1 of 2)

DEFINITION:

In engineering terms soil includes every type of uncemented or partially cemented inorganic or organic material found in the ground. In practice, if the material can be remoulded or disintegrated by hand in its field condition or in water it is described as a soil.

Other materials are described using rock description terms.

CLASSIFICATION SYMBOL & SOIL NAME

Soils are described in accordance with the Unified Soil Classification (UCS) as shown in the table on Sheet 2.

PARTICLE SIZE DESCRIPTIVE TERMS

NAME	SUBDIVISION	SIZE
Boulders		>200 mm
Cobbles		63 mm to 200 mm
Gravel	coarse	20 mm to 63 mm
	medium	6 mm to 20 mm
	fine	2.36 mm to 6 mm
Sand	coarse	600 µm to 2.36 mm
	medium	200 µm to 600µm
	fine	75 µm to 200 µm

MOISTURE CONDITION

Dry	Looks and feels dry. Cohesive and cemented soils are hard, friable or powdery. Uncemented granular soils run freely through hands.
Moist	Soil feels cool and darkened in colour. Cohesive soils can be moulded. Granular soils tend to cohere.
Wet	As for moist but with free water forming on hands when handled.

CONSISTENCY OF COHESIVE SOILS

TERM	UNDRAINED STRENGTH s_u (kPa)	FIELD GUIDE
Very Soft	<12	A finger can be pushed well into the soil with little effort.
Soft	12 - 25	A finger can be pushed into the soil to about 25mm depth.
Firm	25 - 50	The soil can be indented about 5mm with the thumb, but not penetrated.
Stiff	50 - 100	The surface of the soil can be indented with the thumb, but not penetrated.
Very Stiff	100 - 200	The surface of the soil can be marked, but not indented with thumb pressure.
Hard	>200	The surface of the soil can be marked only with the thumbnail.
Friable	-	Crumbles or powders when scraped by thumbnail.

DENSITY OF GRANULAR SOILS

TERM	DENSITY INDEX (%)
Very loose	Less than 15
Loose	15 - 35
Medium Dense	35 - 65
Dense	65 — 85
Very Dense	Greater than 85

MINOR COMPONENTS

TERM	ASSESSMENT GUIDE	PROPORTION OF MINOR COMPONENT IN:
Trace of	Presence just detectable by feel or eye, but soil properties little or no different to general properties of primary component.	Coarse grained soils: < 5% Fine grained soils: <15%
With some	Presence easily detected by feel or eye, soil properties little different to general properties of primary component.	Coarse grained soils: 5 - 12% Fine grained soils: 15 - 30%

SOIL STRUCTURE

ZONING		CEMENTING	
Layers	Continuous across exposure or sample.	Weakly cemented	Easily broken up by hand in air or water.
Lenses	Discontinuous layers of lenticular shape.	Moderately cemented	Effort is required to break up the soil by hand in air or water.
Pockets	Irregular inclusions of different material.		

GEOLOGICAL ORIGIN

WEATHERED IN PLACE SOILS

Extremely weathered material	Structure and fabric of parent rock visible.
Residual soil	Structure and fabric of parent rock not visible.

TRANSPORTED SOILS

Aeolian soil	Deposited by wind.
Alluvial soil	Deposited by streams and rivers.
Colluvial soil	Deposited on slopes (transported downslope by gravity).
Fill	Man made deposit. Fill may be significantly more variable between tested locations than naturally occurring soils.
Lacustrine soil	Deposited by lakes.
Marine soil	Deposited in ocean basins, bays, beaches and estuaries.

Explanation Sheet (2 of 2) – Soil Description

SOIL CLASSIFICATION INCLUDING IDENTIFICATION AND DESCRIPTION

FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 60 mm and basing fractions on estimated mass)							USC	PRIMARY NAME
COARSE GRAINED SOILS More than 50% of material less than 63 mm is larger than 0.075 mm	(A 0.075 mm particle is about the smallest particle visible to the naked eye)	GRAVELS More than half of coarse fraction is larger than 2.0 mm	CLEAN GRAVELS (Little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes			GW	GRAVEL
				Predominantly one size or a range of sizes with more intermediate sizes missing			GP	GRAVEL
			GRAVELS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below)			GM	SILTY GRAVEL
				Plastic fines (for identification procedures see CL below)			GC	CLAYEY GRAVEL
		SANDS More than half of coarse fraction is smaller than 2.0 mm	CLEAN SANDS (Little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate sizes missing			SW	SAND
				Predominantly one size or a range of sizes with some intermediate sizes missing			SP	SAND
			SANDS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below)			SM	SILTY SAND
				Plastic fines (for identification procedures see CL below)			SC	CLAYEY SAND
FINE GRAINED SOILS More than 50% of material less than 63 mm is smaller than 0.075 mm				IDENTIFICATION PROCEDURES ON FRACTIONS <0.2 mm				
				DRY STRENGTH	DILATANCY	TOUGHNESS		
		SILTS & CLAYS Liquid limit less than 50		None to Low	Quick to slow	None	ML	SILT
				Medium to High	None	Medium	CL	CLAY
				Low to medium	Slow to very slow	Low	OL	ORGANIC SILT
		SILTS & CLAYS Liquid limit greater than 50		Low to medium	Slow to very slow	Low to medium	MH	SILT
				High	None	High	CH	CLAY
				Medium to high	None	Low to medium	OH	ORGANIC CLAY
HIGHLY ORGANIC SOILS				Readily identified by colour, odour, spongy feel and frequently by fibrous texture.			Pt	PEAT

- Low plasticity - Liquid Limit W_L less than 35%. • Medium plasticity - W_L between 35% and 50%.

COMMON DEFECTS IN SOIL

TERM	DEFINITION	DIAGRAM
PARTING	A surface or crack across which the soil has little or no tensile strength. Parallel or sub parallel to layering (eg bedding). May be open or closed.	
JOINT	A surface or crack across which the soil has little or no tensile strength but which is not parallel or sub parallel to layering. May be open or closed. The term 'fissure' may be used for irregular joints <0.2m in length.	
SHEARED ZONE	Zone in clayey soil with roughly parallel near planar, curved or undulating boundaries containing closely spaced, smooth or slickensided, curved intersecting joints which divide the mass into lenticular or wedge shaped blocks.	
SHEARED SURFACE	A near planar curved or undulating, smooth, polished or slickensided surface in clayey soil. The polished or slickensided surface indicates that movement (in many cases very little) has occurred along the defect.	

TERM	DEFINITION	DIAGRAM
SOFTENED ZONE	A zone in clayey soil, usually adjacent to a defect in which the soil has a higher moisture content than elsewhere.	
TUBE	Tubular cavity. May occur singly or as one of a large number of separate or inter-connected tubes. Walls often coated with clay or strengthened by denser packing of grains. May contain organic matter.	
TUBE CAST	Roughly cylindrical elongated body of soil different from the soil mass in which it occurs. In some cases the soil which makes up the tube cast is cemented.	
INFILLED SEAM	Sheet or wall like body of soil substance or mass with roughly planar to irregular near parallel boundaries which cuts through a soil mass. Formed by infilling of open joints.	

Coffey Geosciences Pty Ltd ACN 056 335 516

Engineering log - Excavation

Excavation No. *TP01*
Sheet 1 of 1
Office Job No.: *AW1781/1*

Client: *Infrastructure Solutions Pty Ltd*
Principal:
Project: *Bairnsdale Landfill - Stage 2*
Test pit location: *Refer to Figure 1*

Date started: *12.8.2004*
Date completed: *12.8.2004*
Logged by: *MFT*
Checked by:

equipment type and model: Backhoe
Pit Orientation:
Easting: m
R.L. Surface: Not Measured
excavation dimensions: 5m long 0.8m wide
Northing: m
datum:

excavation information							material substance							
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
BH		N						ML	**SANDY SILT:** low plasticity, dark grey, fine to medium grained sand	D	F		Topsoil
						0.5		CL	**SANDY CLAY:** medium plasticity, orange to pale grey, fine to medium grained sand	M	VSt		Alluvial
				Bs								×	
			None Observed			1.0		SC	**CLAYEY SAND:** fine to medium grained, orange, low plasticity clay		D		
						1.5			with red staining				
						2.0							
						2.5		SP	**SAND:** fine to medium grained, orange				
						3.0			Test pit TP01 terminated at 3m				
						3.5							
						4.0							

Sketch

method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator

support

S shoring N nil

penetration

1 2 3 4
no resistance ranging to refusal

water

▼ water level on date shown
► water inflow
◄ water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Coffey Geosciences Pty Ltd ACN 056 335 516

Engineering log - Excavation

Excavation No.	*TP02*
Sheet	1 of 1
Office Job No.:	*AW1781/1*
Client:	*Infrastructure Solutions Pty Ltd*
Principal:	
Project:	*Bairnsdale Landfill - Stage 2*
Test pit location:	*Refer to Figure 1*
Date started:	*12.8.2004*
Date completed:	*12.8.2004*
Logged by:	*MFT*
Checked by:	

equipment type and model:	Backhoe	Pit Orientation:		Easting: m	R.L. Surface: Not Measured
excavation dimensions:	5m long 0.8m wide			Northing: m	datum:

excavation information / **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
BH		N	None Observed				ML	**SANDY SILT:** low plasticity, brown to pale grey, fine to medium grained sand	M	F		Topsoil
							CL	**SILTY CLAY:** medium plasticity, orange		VSt	600	Alluvial
				D								
						0.5						
							SP	**SAND:** fine to medium grained, orange with red mottles		D		
						1.0						
								becoming orange to pale grey in colour				
						1.5						
						2.0						
								with some cobbles up to 200mm in diameter		VD		
						2.5						
								COBBLES IN A SAND MATRIXupto 200mm in diameter, rounded, fine to coarse grained orange sand, with some fine to coarse grained gravel				
						3.0		Test pit TP02 terminated at 3m				
						3.5						
						4.0						

Sketch

TESTPIT AW1781.1.GPJ COFFEY.GDT 15.09.04

method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator

support

S shoring N nil

penetration

1 2 3 4 no resistance ranging to refusal

water

▼ water level on date shown

► water inflow

◄ water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Form GEO 5.2 Issue 3 Rev.2

Coffey Geosciences Pty Ltd ACN 056 335 516

Engineering log - Excavation

Excavation No. *TP03*

Sheet 1 of 1

Office Job No.: *AW1781/1*

Client: *Infrastructure Solutions Pty Ltd*

Principal:

Project: *Bairnsdale Landfill - Stage 2*

Test pit location: *Refer to Figure 1*

Date started: *12.8.2004*

Date completed: *12.8.2004*

Logged by: *MFT*

Checked by:

equipment type and model: Backhoe

excavation dimensions: 5m long 0.8m wide

Pit Orientation:

Easting: m

Northing: m

R.L. Surface: Not Measured

datum:

excavation information							material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
BH		N	None Observed					SM	**SILTY SAND:** fine to medium grained, grey	D	MD		Topsoil
						0.5		CH	**SILTY CLAY:** high plasticity, orange to pale grey	M	VSt	x	Alluvial
				Bs		1.0							
						1.5		CL	**SANDY CLAY:** medium plasticity, orange to pale grey with red mottles, fine grained sand			x	
				D					**MUDSTONE:** low strength, slightly weathered, light grey				
						2.0			Refusal Test pit TP03 terminated at 1.8m				
						2.5							
						3.0							
						3.5							
						4.0							

Sketch

method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator

support

S shoring N nil

penetration

1 2 3 4 no resistance ranging to refusal

water

water level on date shown

water inflow

water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Coffey Geosciences Pty Ltd ACN 056 335 516

Engineering log - Excavation

Excavation No.	*TP04*
Sheet	1 of 1
Office Job No.:	*AW1781/1*
Client:	*Infrastructure Solutions Pty Ltd*
Principal:	
Project:	*Bairnsdale Landfill - Stage 2*
Test pit location:	*Refer to Figure 1*
Date started:	*12.8.2004*
Date completed:	*12.8.2004*
Logged by:	*MFT*
Checked by:	

equipment type and model:	Backhoe	Pit Orientation:		Easting:	m	R.L. Surface:	Not Measured
excavation dimensions:	5m long 0.8m wide			Northing:	m	datum:	

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	structure and additional observations
BH		N	None Observed				ML	**SANDY SILT:** low plasticity, brown, fine to medium grained sand	M	F	Topsoil
							CL	**SANDY CLAY:** low plasticity, brown, fine to medium grained sand		VSt	Alluvial
						0.5	CH	**SILTY CLAY:** high plasticity, orange with black mottles			
						1.0					
						1.5					
							CL	**SILTY CLAY:** medium plasticity, orange to pale brown			
						2.0					
				D							
						2.5					
				Bs							
						3.0		Test pit TP04 terminated at 3m			
						3.5					
						4.0					

Sketch

method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator

support

S	shoring	N	nil

penetration

1 2 3 4

no resistance ranging to refusal

water

▼ water level on date shown

► water inflow

◄ water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Coffey Geosciences Pty Ltd ACN 056 335 516

Engineering log - Excavation

Excavation No. ***TP05***
Sheet 1 of 1
Office Job No.: ***AW1781/1***

Client: ***Infrastructure Solutions Pty Ltd***
Principal:
Project: ***Bairnsdale Landfill - Stage 2***
Test pit location: ***Refer to Figure 1***

Date started: ***12.8.2004***
Date completed: ***12.8.2004***
Logged by: ***MFT***
Checked by:

equipment type and model:	Backhoe	Pit Orientation:	Easting: m	R.L. Surface:	Not Measured
excavation dimensions:	5m long 0.8m wide		Northing: m	datum:	

excavation information						material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
BH		N	None Observed					ML	**SANDY SILT:** low plasticity, brown, fine to medium grained sand	M	D		Topsoil
						0.5	▨	CH	**SILTY CLAY:** high plasticity, orange		VSt	x 600x	Alluvial
						1.0 1.5	▨	CL	**SANDY CLAY:** medium plasticity, orange to pale grey, fine grained sand				
						2.0 2.5 3.0	▨	CL	**SILTY CLAY:** medium plasticity, orange to pale grey with red mottles				
						3.5 4.0			Test pit TP05 terminated at 3m				

Sketch

TESTPIT AW1781.1.GPJ COFFEY.GDT 15.09.04

method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator

support

S shoring N nil

penetration

1 2 3 4 no resistance ranging to refusal

water

- water level on date shown
- water inflow
- water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Form GEO 5.2 Issue 3 Rev.2

Coffey Geosciences Pty Ltd ACN 056 335 516

Engineering log - Excavation

		Excavation No.	*TP06*
		Sheet	1 of 1
		Office Job No.:	*AW1781/1*
Client:	*Infrastructure Solutions Pty Ltd*	Date started:	*12.8.2004*
Principal:		Date completed:	*12.8.2004*
Project:	*Bairnsdale Landfill - Stage 2*	Logged by:	*MFT*
Test pit location:	*Refer to Figure 1*	Checked by:	

equipment type and model:	Backhoe	Pit Orientation:	Easting: m	R.L. Surface:	Not Measured
excavation dimensions:	5m long 0.8m wide		Northing: m	datum:	

excavation information							material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
BH		N	None Observed					ML	**SANDY SILT:** low plasticity, brown, fine to medium grained sand	M	D		Topsoil
								CH	**SILTY CLAY:** high plasticity, orange		VSt	x	Alluvial
				Bs		0.5							
						1.0							
									becoming orange to pale grey in colour, with red mottles				
						1.5		CL	**SANDY CLAY:** medium plasticity, orange to pale grey with red mottles, fine grained sand				
						2.0						x	
				Bs		2.5							
						3.0			Test pit TP06 terminated at 3m				
						3.5							
						4.0							

Sketch

method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator

support

S shoring N nil

penetration

1 2 3 4 no resistance ranging to refusal

water

water level on date shown

water inflow

water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Coffey Geosciences Pty Ltd ACN 056 335 516

Engineering log - Excavation

Excavation No. *TP07*
Sheet 1 of 1
Office Job No.: *AW1781/1*

Client: *Infrastructure Solutions Pty Ltd*
Principal:
Project: *Bairnsdale Landfill - Stage 2*
Test pit location: *Refer to Figure 1*

Date started: *12.8.2004*
Date completed: *12.8.2004*
Logged by: *MFT*
Checked by:

Coffey

equipment type and model:	Backhoe	Pit Orientation:		Easting:	m	R.L. Surface:	Not Measured
excavation dimensions:	5m long 0.8m wide			Northing:	m	datum:	

excavation information							**material substance**						
method	penetration 1 2 3	support	water	**notes** samples, tests, etc	RL	depth metres	graphic log	classification symbol	**material** soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro- meter kPa 100 200 300 400	**structure and additional observations**
BH		N	None Observed					ML	**SANDY SILT:** low plasticity, grey, fine to medium grained sand	M	F		Topsoil
						0.5 1.0 1.5 2.0		CH	**SILTY CLAY:** high plasticity, orange, with some fine to medium grained SAND becoming orange to pale grey with red mottles in colour with some cobbles up to 200mm in diameter		VSt	x	Alluvial
						2.5		SP	**GRAVELLY SAND:** fine to medium grained, orange, fine to coarse grained gravel, with some cobbles up to 200mm in diameter		VD		
						3.0 3.5 4.0			Test pit TP07 terminated at 2.7m				

Sketch

TESTPIT AW1781.1.GPJ COFFEY.GDT 15.09.04

Form GEO 5.2 Issue 3 Rev.2

method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator

support

S shoring N nil

penetration

1 2 3 4 no resistance ranging to refusal

water

water level on date shown

water inflow

water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Coffey Geosciences Pty Ltd ACN 056 335 516

Engineering log - Excavation

		Excavation No.	*TP08*
		Sheet	1 of 1
		Office Job No.:	*AW1781/1*
Client:	*Infrastructure Solutions Pty Ltd*	Date started:	*12.8.2004*
Principal:		Date completed:	*12.8.2004*
Project:	*Bairnsdale Landfill - Stage 2*	Logged by:	*MFT*
Test pit location:	*Refer to Figure 1*	Checked by:	

equipment type and model:	Backhoe	Pit Orientation:		Easting:	m	R.L. Surface:	Not Measured
excavation dimensions:	5m long 0.8m wide			Northing:	m	datum:	

excavation information							material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
BH		N	None Observed					ML	**SANDY SILT:** low plasticity, brown, fine to medium grained sand	M	F		Topsoil
						0.5 1.0 1.5	▨	CH	**SILTY CLAY:** high plasticity, orange to pale grey, with red mottles		VSt	x	Alluvial
						2.0	▨	CL	**SANDY CLAY:** medium plasticity, orange tp pale grey, fine grained sand				
						2.5 3.0	▨	CL	**SILTY CLAY:** medium plasticity, orange to pale grey			600x	
						3.5 4.0			Test pit TP08 terminated at 3m				

Sketch

method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator

support

S shoring N nil

penetration

1 2 3 4

no resistance ranging to refusal

water

water level on date shown

water inflow

water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Coffey Geosciences Pty Ltd ACN 056 335 516

Engineering log - Excavation

Excavation No.	*TP09*
Sheet	1 of 1
Office Job No.:	*AW1781/1*
Client:	*Infrastructure Solutions Pty Ltd*
Principal:	
Project:	*Bairnsdale Landfill - Stage 2*
Test pit location:	*Refer to Figure 1*
Date started:	*13.8.2004*
Date completed:	*13.8.2004*
Logged by:	*MFT*
Checked by:	BR

equipment type and model:	Backhoe	Pit Orientation:		Easting: m	R.L. Surface: Not Measured
excavation dimensions:	5m long 0.8m wide			Northing: m	datum:

excavation information							material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
BH		N	None Observed					ML	**SANDY SILT:** low plasticity, brown, fine to medium grained sand	M	F		Topsoil
						0.5		CH	**SILTY CLAY:** high plasticity, brownish orange		VSt	×	Alluvial
						1.0							
								CL	**SILTY CLAY:**medium plasticity, orange to pale grey				
				Bs		1.5		CL	**SANDY CLAY:** medium plasticity, orange to pale brown, fine grained sand				
						2.0		SC	**CLAYEY SAND:**fine to medium grained, orange		VD		
						2.5							
						3.0			Test pit TP09 terminated at 3m				
						3.5							
						4.0							

Sketch

TESTPIT AW1781.1.GPJ COFFEY.GDT 15.09.04

method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator

support

S shoring N nil

penetration

1 2 3 4 no resistance ranging to refusal

water

water level on date shown

water inflow

water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Form GEO 5.2 Issue 3 Rev.2

Coffey Geosciences Pty Ltd ACN 056 335 516

Engineering log - Excavation

Excavation No. *TP10*
Sheet 1 of 1
Office Job No.: *AW1781/1*

Client: *Infrastructure Solutions Pty Ltd*
Principal:
Project: *Bairnsdale Landfill - Stage 2*
Test pit location: *Refer to Figure 1*

Date started: *13.8.2004*
Date completed: *13.8.2004*
Logged by: *MFT*
Checked by:

Coffey

equipment type and model:	Backhoe	Pit Orientation:	Easting: m	R.L. Surface:	Not Measured
excavation dimensions:	5m long 0.8m wide		Northing: m	datum:	

excavation information							material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
BH		N	None Observed					ML	**SANDY SILT:** low plasticity, brown, fine to medium grained sand	M	F		Topsoil
						0.5 1.0		CH	**SILTY CLAY:** high plasticity, brownish orange		VSt	x	Alluvial
						1.5		CL	**SILTY CLAY:**medium plasticity, orange to pale brown				
						2.0 2.5 3.0		SC	**CLAYEY SAND:** fine to medium grained, orange		VD		
						3.5 4.0			Test pit TP10 terminated at 3m				

Sketch

method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator

support
S shoring N nil

penetration
1 2 3 4
no resistance ranging to refusal

water
▼ water level on date shown
► water inflow
◄ water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description
based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Coffey Geosciences Pty Ltd ACN 056 335 516

Coffey

Engineering log - Excavation

Excavation No.	*TP11*
Sheet	1 of 1
Office Job No.:	*AW1781/1*
Client:	*Infrastructure Solutions Pty Ltd*
Principal:	
Project:	*Bairnsdale Landfill - Stage 2*
Test pit location:	*Refer to Figure 1*
Date started:	*13.8.2004*
Date completed:	*13.8.2004*
Logged by:	*MFT*
Checked by:	

equipment type and model:	Backhoe	Pit Orientation:	Easting: m	R.L. Surface:	Not Measured
excavation dimensions:	5m long 0.8m wide		Northing: m	datum:	

excavation information							material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
BH		N	None Observed					ML	**SANDY SILT:** low plasticity, brown, fine to medium grained sand	M	F		Topsoil
								CH	**SILTY CLAY:** high plasticity, orange		VSt	600	Alluvial
						0.5							
								CL	**SILTY CLAY:** medium plasticity, orange to pale grey with red mottles			×	
						1.0							
						1.5							
						2.0							
						2.5			becoming orange to pale grey with with black mottles in colour				
						3.0							
						3.5			Test pit TP11 terminated at 3.4m				
						4.0							

Sketch

method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator

support

S shoring N nil

penetration

1 2 3 4 no resistance ranging to refusal

water

▼	water level on date shown
▶	water inflow
◀	water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Coffey Geosciences Pty Ltd ACN 056 335 516

Engineering log - Excavation

Excavation No.	*TP12*
Sheet	1 of 1
Office Job No.:	*AW1781/1*
Client:	*Infrastructure Solutions Pty Ltd*
Principal:	
Project:	*Bairnsdale Landfill - Stage 2*
Test pit location:	*Refer to Figure 1*
Date started:	*13.8.2004*
Date completed:	*13.8.2004*
Logged by:	*MFT*
Checked by:	

equipment type and model: Backhoe
Pit Orientation:
Easting: m
R.L. Surface: Not Measured
excavation dimensions: 5m long 0.8m wide
Northing: m
datum:

excavation information							material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
BH		N	None Observed					ML	**SANDY SILT:** low plasticity, brown, fine to medium grained sand	M	F		Topsoil
							▨	CH	**SILTY CLAY:** high plasticity, orange, with some fine grained sand		VSt	×	Alluvial
						0.5	▨						
						1.0	▨					×	
							▨	CL	**SILTY CLAY:** medium plasticity, orange to pale grey with red mottles				
						1.5	▨						
				Bs			▨						
						2.0	▨						
						2.5	▨						
						3.0	▨						
									Test pit TP12 terminated at 3m				
						3.5							
						4.0							

Sketch

TESTPIT AW1781.1.GPJ COFFEY.GDT 15.09.04

method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator

support

S shoring N nil

penetration

1 2 3 4 no resistance ranging to refusal

water

▼ water level on date shown

►— water inflow

—◄ water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Form GEO 5.2 Issue 3 Rev.2

Coffey Geosciences Pty Ltd ACN 056 335 516

Engineering log - Excavation

Client:	*Infrastructure Solutions Pty Ltd*	Excavation No.	*TP13*
Principal:		Sheet	1 of 1
Project:	*Bairnsdale Landfill - Stage 2*	Office Job No.:	*AW1781/1*
Test pit location:	*Refer to Figure 1*	Date started:	*13.8.2004*
		Date completed:	*13.8.2004*
		Logged by:	*MFT*
		Checked by:	

equipment type and model:	Backhoe	Pit Orientation:	Easting: m	R.L. Surface:	Not Measured
excavation dimensions:	5m long 0.8m wide		Northing: m	datum:	

excavation information / **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	**material** soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	**structure and additional observations**
BH		N	None Observed					ML	**SANDY SILT:** low plasticity, brown, fine to medium grained sand	M	F		Topsoil
							▨	CH	**SILTY CLAY:** high plasticity, orange		VSt	x (300)	Alluvial
						0.5	▨						
						1.0	▨						
							▨		becoming orange to pale grey with red mottles in colour				
						1.5	▨	CL	**SILTY CLAY:** medium plasticity, orange to pale grey with red mottles				
						2.0	▨						
						2.5	▨						
						3.0			Test pit TP13 terminated at 3m				
						3.5							
						4.0							

Sketch

TESTPIT AW1781.1.GPJ COFFEY.GDT 15.09.04

Form GEO 5.2 Issue 3 Rev.2

method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator

support

S shoring N nil

penetration

1 2 3 4 no resistance ranging to refusal

water

- water level on date shown
- water inflow
- water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Coffey Geosciences Pty Ltd ACN 056 335 516

Engineering log - Excavation

Excavation No. **TP14**
Sheet 1 of 1
Office Job No.: **AW1781/1**

Client:	*Infrastructure Solutions Pty Ltd*	Date started:	*13.8.2004*
Principal:		Date completed:	*13.8.2004*
Project:	*Bairnsdale Landfill - Stage 2*	Logged by:	*MFT*
Test pit location:	*Refer to Figure 1*	Checked by:	

equipment type and model:	Backhoe	Pit Orientation:		Easting:	m	R.L. Surface:	Not Measured
excavation dimensions:	5m long 0.8m wide			Northing:	m	datum:	

excavation information							material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
BH		N	None Observed			0.0		ML	**SANDY SILT:** low plasticity, brown, fine to medium grained sand	M	F		Topsoil
								CL	**SANDY CLAY:** medium plasticity, orange to pale grey, fine grained sand		VSt	x	Alluvial
				Bs		0.5							
						1.0		SC	**CLAYEY SAND:** fine to medium grained, orange		VD		
						1.5							
									COBBLES IN A SAND MATRIXupto 200mm in diameter, rounded, fine to coarse grained orange sand, with some fine to coarse grained gravel				
						2.0							
						2.5							
						3.0			Test pit TP14 terminated at 3m				
						3.5							
						4.0							

Sketch

TESTPIT AW1781.1.GPJ COFFEY.GDT 15.09.04

method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator

support

S shoring N nil

penetration

1 2 3 4

no resistance ranging to refusal

water

water level on date shown

water inflow

water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Form GEO 5.2 Issue 3 Rev.2

Coffey Geosciences Pty Ltd ACN 056 335 516

Engineering log - Excavation

Excavation No. *TP15*

Sheet 1 of 1

Office Job No.: *AW1781/1*

Client: *Infrastructure Solutions Pty Ltd*

Principal:

Project: *Bairnsdale Landfill - Stage 2*

Test pit location: *Refer to Figure 1*

Date started: *13.8.2004*

Date completed: *13.8.2004*

Logged by: *MFT*

Checked by:

equipment type and model: Backhoe | Pit Orientation: | Easting: m | R.L. Surface: Not Measured

excavation dimensions: 5m long 0.8m wide | Northing: m | datum:

excavation information							material substance							
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
BH		N						ML	**SANDY SILT:** low plasticity, brown, fine to medium grained sand	M	F		Topsoil
						0.5		SM	**SILTY SAND:** fine to medium grained, brownish orange		VD		Alluvial
						1.0			**COBBLES IN A SAND MATRIX**upto 200mm in diameter, rounded, fine to coarse grained orange sand, with some fine to coarse grained gravel				
			Observed Water Level			1.5			becoming orange to pale grey in colour				
			▼			2.0			becoming medium to coarse grained sand	W			
						2.5							
						3.0		SC	**CLAYEY SAND:** medium to coarse grained, pale grey, with some cobbles up to 100mm in diameter				
									Test pit TP15 terminated at 3m				
						3.5							
						4.0							

Sketch

method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator

support

S shoring N nil

penetration

1 2 3 4 no resistance ranging to refusal

water

▼ water level on date shown

▶ water inflow

◀ water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Coffey Geosciences Pty Ltd ACN 056 335 516

Coffey

Engineering log - Excavation

Excavation No. *TP16*

Sheet 1 of 1

Office Job No.: *AW1781/1*

Client: *Infrastructure Solutions Pty Ltd*

Principal:

Project: *Bairnsdale Landfill - Stage 2*

Test pit location: *Refer to Figure 1*

Date started: *13.8.2004*

Date completed: *13.8.2004*

Logged by: *MFT*

Checked by: BVZ

equipment type and model:	Backhoe	Pit Orientation:		Easting:	m	R.L. Surface:	Not Measured
excavation dimensions:	5m long 0.8m wide			Northing:	m	datum:	

excavation information							material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
BH		N	None Observed				▥	ML	**SANDY SILT:** low plasticity, brown, fine to medium grained sand	M	F		Topsoil
							▨	CL	**SILTY CLAY:** medium plasticity, orange to pale grey		VSt	*	Alluvial
						0.5	▨						
						1.0	▨					600*	
						1.5	▨						
						2.0	▨						
						2.5	▨					600*	
				Bs & D			▥	ML	**SILT:** low plasticity, pale grey				
							░	SP	**SAND:** fine to medium grained, orange		VD		
						3.0			Test pit TP16 terminated at 3m				
						3.5							
						4.0							

Sketch

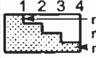
method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator

support

S shoring N nil

penetration



water

▼ water level on date shown

▶ water inflow

◀ water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Coffey Geosciences Pty Ltd ACN 056 335 516

Engineering log - Excavation

Excavation No.	*TP17*
Sheet	1 of 1
Office Job No.:	*AW1781/1*
Client:	*Infrastructure Solutions Pty Ltd*
Principal:	
Project:	*Bairnsdale Landfill - Stage 2*
Test pit location:	*Refer to Figure 1*
Date started:	*13.8.2004*
Date completed:	*13.8.2004*
Logged by:	*MFT*
Checked by:	BUL

equipment type and model:	Backhoe	Pit Orientation:		Easting:	m	R.L. Surface:	Not Measured
excavation dimensions:	5m long 0.8m wide			Northing:	m	datum:	

excavation information							material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	**material** soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	**structure and additional observations**
BH		N	None Observed					ML	**SANDY SILT:** low plasticity, brown, fine to medium grained sand	M	F		Topsoil
						0.5 1.0 1.5	▨	CH	**SILTY CLAY:** high plasticity, orange becoming orange to pale grey with red mottles in colour		VSt	× × ×	Alluvial
				Bs		2.0 2.5 3.0	▨	CL	**SILTY CLAY:** medium plasticity, orange to pale grey with red mottles becoming orange to pale grey with black mottles in colour				
						3.5 4.0			Test pit TP17 terminated at 3.1m				

Sketch

TESTPIT AW1781.1.GPJ COFFEY.GDT 15.09.04

method	
N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator

support

S shoring N nil

penetration

1 2 3 4

no resistance ranging to refusal

water

water level on date shown

water inflow

water outflow

notes, samples, tests	
U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture	
D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index	
VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Coffey Geosciences Pty Ltd ACN 056 335 516

Engineering log - Excavation

Excavation No.	*TP18*
Sheet	1 of 1
Office Job No.:	*AW1781/1*
Client:	*Infrastructure Solutions Pty Ltd*
Date started:	*13.8.2004*
Principal:	
Date completed:	*13.8.2004*
Project:	*Bairnsdale Landfill - Stage 2*
Logged by:	*MFT*
Test pit location:	*Refer to Figure 1*
Checked by:	

equipment type and model:	Backhoe	Pit Orientation:	
Easting:	m	R.L. Surface:	Not Measured
excavation dimensions:	5m long 0.8m wide	Northing:	m
datum:			

excavation information / **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
BH		N	None Observed					ML	**SANDY SILT:** low plasticity, brown, fine to medium grained sand	M	F		Topsoil
						0.5 1.0		CH	**SILTY CLAY:** high plasticity, orange with red mottles		VSt	x	Alluvial
						1.5		CL	**SILTY CLAY:** medium plasticity, orange to pale grey with red mottles, with some fine to medium grained sand and cobbles up to 200mm in diameter				
						2.0		SC	**CLAYEY SAND:** fine to coarse grained, orange to pale grey with some cobbles up to 200mm in diameter		VD		
						2.5 3.0 3.5 4.0			Refusal Test pit TP18 terminated at 2.4m				

Sketch

method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator

support

S shoring N nil

penetration

1 2 3 4 no resistance ranging to refusal

water

▼ water level on date shown

► water inflow

◄ water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Coffey Geosciences Pty Ltd ACN 056 335 516

Engineering log - Excavation

Excavation No. *TP19*
Sheet 1 of 1
Office Job No.: *AW1781/1*

Client: *Infrastructure Solutions Pty Ltd*
Principal:
Project: *Bairnsdale Landfill - Stage 2*
Test pit location: *Refer to Figure 1*

Date started: *13.8.2004*
Date completed: *13.8.2004*
Logged by: *MFT*
Checked by:

equipment type and model: Backhoe
Pit Orientation:
Easting: m
R.L. Surface: Not Measured
excavation dimensions: 5m long 0.8m wide
Northing: m
datum:

excavation information							material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
BH		N	None Observed					ML	**SANDY SILT:** low plasticity, brown, fine to medium grained sand	M	F		Topsoil
						0.5 1.0		CH	**SILTY CLAY:** high plasticity, orange, trace cobbles up to 100mm in diameter		VSt	×	Alluvial
				Bs		1.5		CL	**SILTY CLAY:** medium plasticity, orange to pale grey with red mottles and trace cobbles up to 100mm in diameter				
				Bs		2.0		CL	**SANDY CLAY:** medium plasticity, orange to pale grey with red mottles, fine grained sand, with some cobbles up to 200mm in diameter				
						2.5 3.0		SC	**CLAYEY SAND:** fine to medium grained, orange to pale grey		VD		
						3.5 4.0			Test pit TP19 terminated at 3m				

Sketch

method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator

support
S shoring N nil

penetration
1 2 3 4
no resistance ranging to refusal

water
▼ water level on date shown
► water inflow
◄ water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description
based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Coffey Geosciences Pty Ltd ACN 056 335 516

Engineering log - Excavation

Excavation No.	*TP20*
Sheet	1 of 1
Office Job No.:	*AW1781/1*
Date started:	*13.8.2004*
Date completed:	*13.8.2004*
Logged by:	*MFT*
Checked by:	

Client:	*Infrastructure Solutions Pty Ltd*
Principal:	
Project:	*Bairnsdale Landfill - Stage 2*
Test pit location:	*Refer to Figure 1*

equipment type and model:	Backhoe	Pit Orientation:		Easting:	m	R.L. Surface:	Not Measured
excavation dimensions:	5m long 0.8m wide			Northing:	m	datum:	

excavation information							material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
BH		N	None Observed						**COBBLES IN A SAND MATRIX**upto 200mm in diameter, rounded, medium to coarse grained orange sand	D	VD		Alluvial
						0.5							
						1.0							
						1.5							
						2.0			becoming orange to pale grey in colour				
						2.5							
						3.0							
						3.5			Test pit TP20 terminated at 3.5m				
						4.0							

Sketch

method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator

support

S shoring N nil

penetration

1 2 3 4

no resistance ranging to refusal

water

water level on date shown

water inflow

water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

APPENDIX B

Results of Laboratory Tests

Coffey Geosciences Pty Ltd A.C.N.0 56 335 516

Geotechnical | **Resources** | Environmental | **Technical** | Project Management

Unit 8, 12 Mars Road, Lane Cove West,NSW,2066
Ph:(02) 9911 1000 Fax (02) 9911 1001

Coffey

test results

client : *INFRASTRUCTURE SOLUTIONS PTY LTD*

job no : *AW1781/1*

principal :

laboratory : *SYDNEY*

project : *BAIRNSDALE LANDFILL - STAGE 2*

report date : *17 September, 2004*

location : *JOHNSTONS ROAD, BAIRNSDALE*

test report : -

test procedure : *AS 1289.6.7.2*
AS 1289.2.1.1

test date : *07/09/04 to 17/09/04*

Sample Identification	REMOULDED DRY DENSITY t/m^3	REMOULDED MOISTURE CONTENT %	REMOULDED FALLING HEAD PERMEABILITY cm/sec	REMOULDED FALLING HEAD PERMEABILITY m/sec
TP 6 0.5 - 0.8m	*1.46*	*26.6*	1.9×10^{-8}	1.9×10^{-10}

Notes:- 1.Specimen remoulded to 95% of Standard Maximum Dry Density and at Standard Optimum Moisture Content.

2.Tested with 2% saline solution.

3.Sample and Compaction Data received from CG-(Albury) on the 31/08/04.

4. 0% Percenatge of material retained on 19mm sieve.

5.5 0 kPa pressure was applied to the sample.

remarks : *Samples suplied by CG (Albury) on the 31/08/04*

NATA

NATA Accredited Laboratory
No.4 31

Date : *September 17, 2004*

Authorised Signature:

James Russell
Laboratory Manager

Form Number L1.0R1 Version 5.2

Coffey Geosciences Pty Ltd A.C.N. 056 335 516

Geotechnical Resources Environmental Technical Project Management

16 Church Street, Hawthorn, Vic, 3122
Ph: (03) 9853 3396, Fax: (03) 9853 0189

Coffey

test results

client : *INFRASTRUCTURE SOLUTIONS PTY LTD*
principal :
project : *BAIRNSDALE LANDFILL - STAGE 2*
location : *JOHNSTONS ROAD, BAIRNSDALE*

job no : *AW1781/1*
laboratory : *MELBOURNE*
date : *31/08/04*
test report : *AA*

test procedure : *AS1289 5.1.1 2.1.1*

test date : *17 - 26/08/2004*

		MAXIMUM DRY DENSITY t/m3	OPTIMUM MOISTURE CONTENT %	FIELD MOISTURE CONTENT %
TP3	*0.80 - 1.00m*	*1.61*	*23.5*	*25.3*
TP4	*2.60 - 2.80m*	*1.80*	*15.5*	*15.1*
TP6	*0.50 - 0.80m*	*1.54*	*26.0*	*27.0*
TP6	*2.50 - 2.70m*	*1.94*	*11.0*	*9.5*
TP9	*1.50 - 1.60m*	*1.85*	*14.0*	*12.6*
TP14	*0.50 - 0.60m*	*1.96*	*11.5*	*12.2*
TP16	*2.50 - 2.60m*	*1.71*	*18.5*	*20.1*
TP17	*2.30 - 2.50m*	*1.81*	*15.5*	*14.8*
TP19	*1.40 - 1.50m*	*1.73*	*18.0*	*19.2*
TP19	*2.00 - 2.10m*	*1.97*	*10.5*	*10.7*

remarks :

NATA

This laboratory is accredited by the National Association of Testing Authorities, Australia. The test(s) reported herein have been performed in accordance with the terms of accreditation. This document shall not be reproduced except in full.

Authorised Signature

NATA Accredited Laboratory
No. 431

A Catton

ALASTAIR CATTON

Coffey Geosciences Pty Ltd A.C.N. 056 335 516

Geotechnical Resources Environmental Technical Project Management
16 Church Street, Hawthorn, Vic, 3122
Ph: (03) 9853 3396, Fax: (03) 9853 0189

Coffey

test results

client : *INFRASTRUCTURE SOLUTIONS PTY LTD*
principal :
project : *BAIRNSDALE LANDFILL - STAGE 2*
location : *JOHNSTONS ROAD, BAIRNSDALE*

job no : *AW1781/1*
laboratory : *MELBOURNE*
date : *31/08/04*
test report : *AB*

test procedure : *AS1289 6.7.2 (Falling Head Permeability)*
AS1289 5.1.1 2.1.1

test date : *19 - 27/08/2004*

		TP3 0.80 - 1.00m	TP4 2.60 - 2.80m	TP9 1.50 - 1.60m	TP17 2.30 - 2.50m
Maximum Dry Density	*t/m^3*	1.61	1.80	1.85	1.81
Optimum Moisture Content	%	23.5	15.5	14.0	15.5
Field Moisture Content	%	25.3	15.1	12.6	14.8
Moisture Variation		+ 1.8	- 0.4	- 1.4	- 0.7
Target Density Ratio		95	95	95	95
Actual Density Ratio		95.0	95.0	94.6	95.0
Moisture Ratio of sample		100.4	100.0	102.1	100.0
PERMEABILITY	*m/s*	5.2 E -10	3.0 E -9	1.2 E -9	8.8 E -11
Water Type		*potable*	*potable*	*potable*	*potable*
Sample Description		*SANDY CLAY* *medium plasticty* *orange*	*CLAYEY SILT* *medium plasticity* *orange*	*CLAYEY SAND* *fine to coarse* *orange*	*SILTY CLAY* *high plasticity* *brown*

remarks :

Authorised Signature
NATA Accredited Laboratory
No. 431

ALASTAIR CATTON

Coffey Geosciences Pty Ltd A.C.N. 056 335 516

Geotechnical Resources Environmental Technical Project Management
16 Church Street, Hawthorn, Vic, 3122
Ph: (03) 9853 3396, Fax: (03) 9853 0189

Coffey

determination of emerson class number

client : *INFRASTRUCTURE SOLUTIONS PTY LTD*
principal :
project : *BAIRNSDALE LANDFILL - STAGE 2*
location : *JOHNSTONS ROAD, BAIRNSDALE*

job no : *AW1781/1*
laboratory : *MELBOURNE*
date : *31/08/04*
test report : *AC*

test procedure : *AS12893 .8.1*
sample identification: *TP3 0.80 - 1.00m*

test data

air dried crumbs

time start of test: *11.12 19/08/04*

time dispersion commences: *15:15 19/08/04*

time dispersion completed: *16:30 19/08/04*

remoulded material

time start of test:

time dispersion commences:

time dispersion completed:

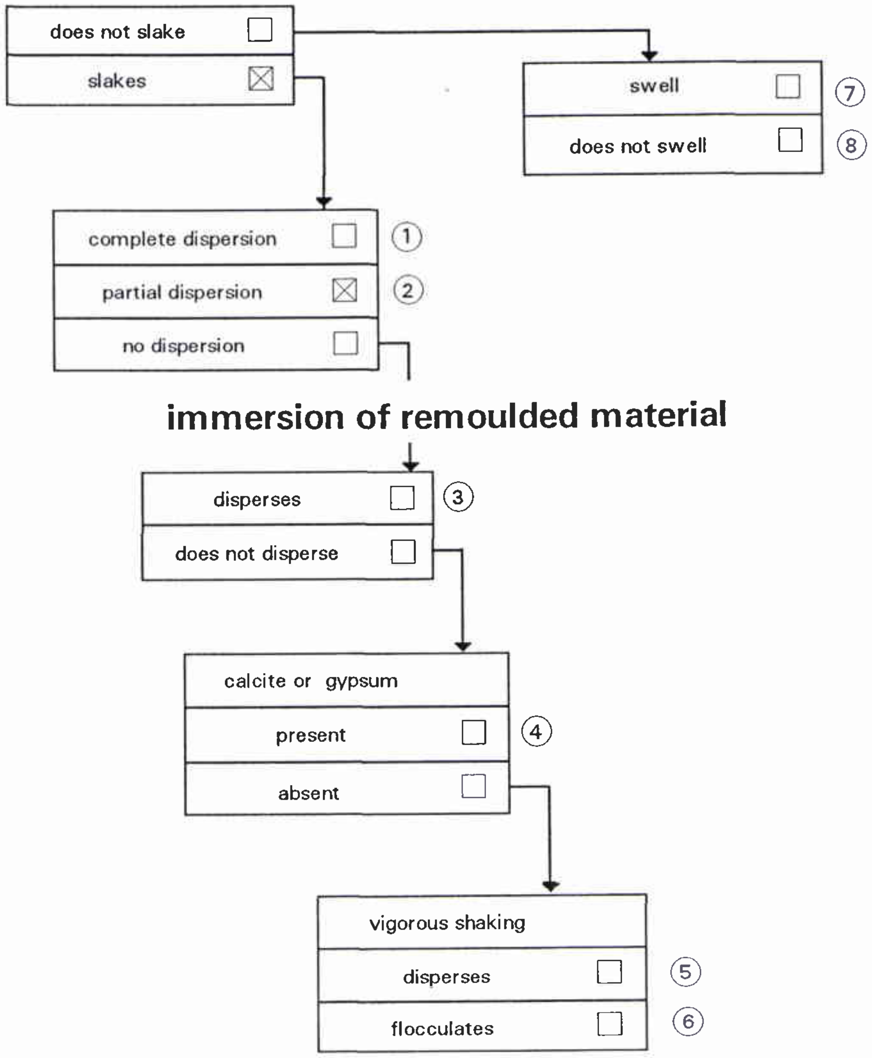
material description

SANDY CLAY, medium plasticity, orange

type of water used: *distilled*

water temperature: *19° C*

immersion of air dried crumbs



does not slake ☐
slakes ☒

swell ☐ ⑦
does not swell ☐ ⑧

complete dispersion ☐ ①
partial dispersion ☒ ②
no dispersion ☐

immersion of remoulded material

disperses ☐ ③
does not disperse ☐

calcite or gypsum
present ☐ ④
absent ☐

vigorous shaking
disperses ☐ ⑤
flocculates ☐ ⑥

Emerson class number *2*

This laboratory is accredited by the National Association of Testing Authorities, Australia. The test(s) reported herein have been performed in accordance with the terms of accreditation. This documents hall not be reproduced except in full.

Authorised Signature

NATA Accredited Laboratory No. 431

A Catton

ALASTAIR CATTON

Form Number L4.8R1 Version 4.0

Coffey Geosciences Pty Ltd A.C.N. 056 335 516

Geotechnical Resources Environmental Technical Project Management
16 Church Street, Hawthorn, Vic, 3122
Ph: (03) 9853 3396, Fax: (03) 9853 0189

determination of emerson class number

client : *INFRASTRUCTURE SOLUTIONS PTY LTD*
principal :
project : *BAIRNSDALE LANDFILL - STAGE 2*
location : *JOHNSTONS ROAD, BAIRNSDALE*

job no : *AW1781/1*
laboratory : *MELBOURNE*
date : *31/08/04*
test report : *AD*

test procedure : *AS12893 .8.1*
sample identification: *TP4 2.60 - 2.80m*

test data

air dried crumbs

time start of test:	*11.12 19/08/04*
time dispersion commences:	*11.30 19/08/04*
time dispersion completed:	*12:30 19/08/04*

remoulded material

time start of test:
time dispersion commences:
time dispersion completed:

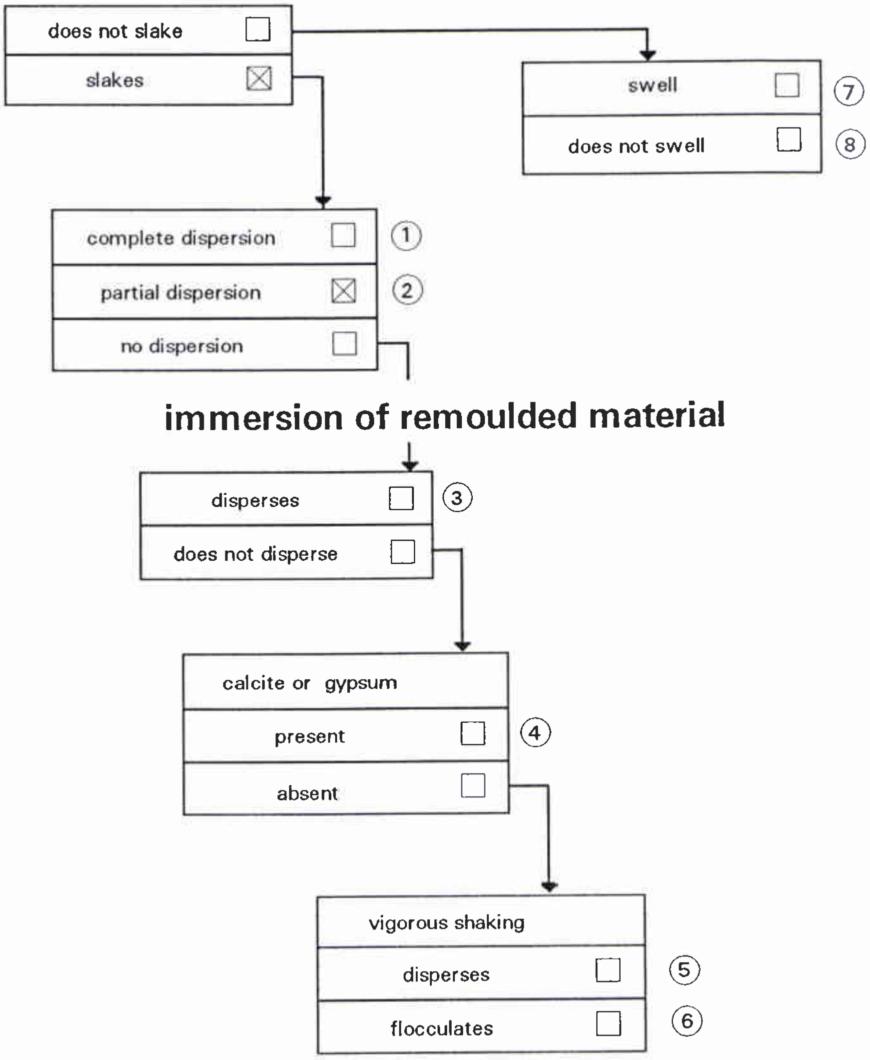
material description

CLAYEY SILT, medium plasticty, orange

type of water used: *distilled*

water temperature: *19° C*

immersion of air dried crumbs



does not slake ☐
slakes ☒
swell ☐ ⑦
does not swell ☐ ⑧
complete dispersion ☐ ①
partial dispersion ☒ ②
no dispersion ☐

immersion of remoulded material

disperses ☐ ③
does not disperse ☐
calcite or gypsum
present ☐ ④
absent ☐
vigorous shaking
disperses ☐ ⑤
flocculates ☐ ⑥

Emerson class number *2*

This laboratory is accredited by the National Association of Testing Authorities, Australia. The test(s) reported herein have been performed in accordance with the terms of accreditation. This documents hall not be reproduced except in full.

Authorised Signature
NATA Accredited Laboratory No. 431

A Catton
ALASTAIR CATTON

Coffey Geosciences Pty Ltd A.C.N. 056 335 516

Geotechnical **Resources** Environmental **Technical** Project Management
16 Church Street, Hawthorn, Vic, 3122
Ph: (03) 9853 3396, Fax: (03) 9853 0189

determination of emerson class number

client : *INFRASTRUCTURE SOLUTIONS PTY LTD*
principal :
project : *BAIRNSDALE LANDFILL - STAGE 2*
location : *JOHNSTONS ROAD, BAIRNSDALE*

job no : *AW1781/1*
laboratory : *MELBOURNE*
date : *1/09/04*
test report : *AM*

test procedure : *AS1289 3.8.1*
sample identification: *TP 4 2.60 - 2.80m*

test data

air dried crumbs

time start of test: *11:25 31/08/04*

time dispersion commences:

time dispersion completed:

remoulded material

time start of test: *8:25 1/09/04*

time dispersion commences:

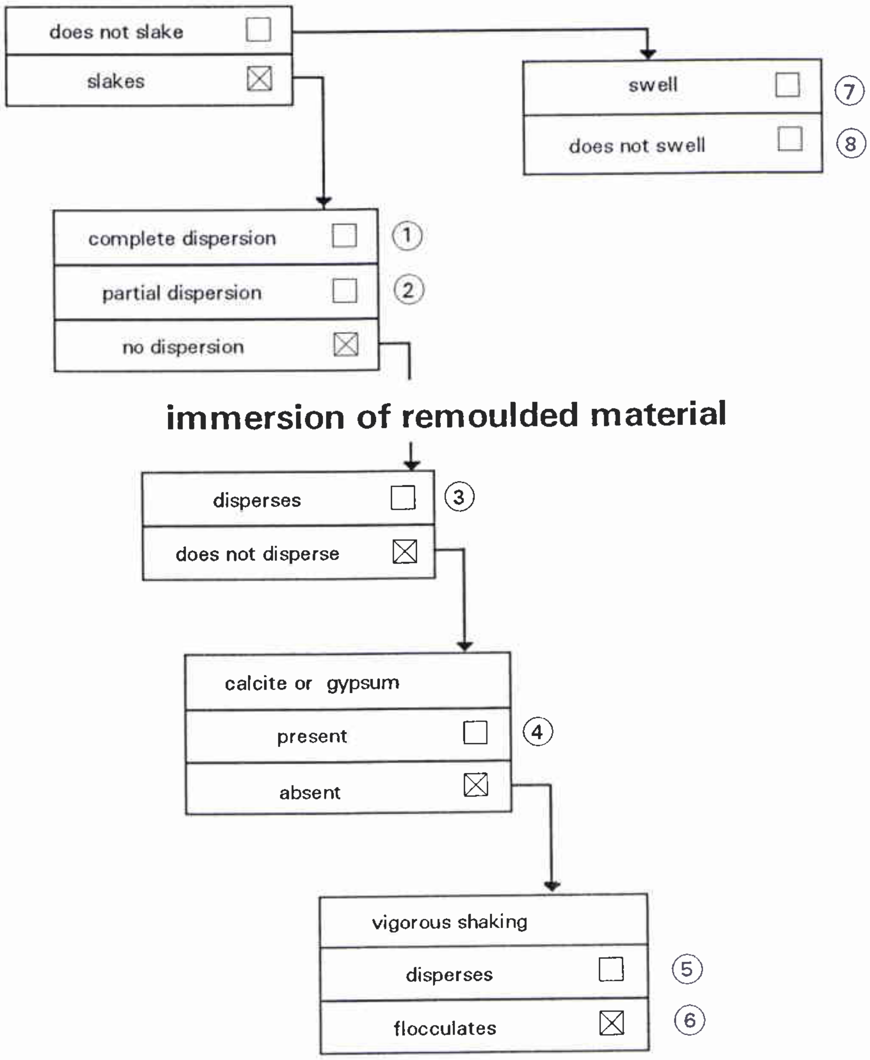
time dispersion completed:

material description

CLAYEY SILT, medium plasticty, orange

type of water used: *1 % saline*

water temperature: *20 ° C*



immersion of air dried crumbs

does not slake ☐
slakes ☒

swell ☐ ⑦
does not swell ☐ ⑧

complete dispersion ☐ ①
partial dispersion ☐ ②
no dispersion ☒

immersion of remoulded material

disperses ☐ ③
does not disperse ☒

calcite or gypsum
present ☐ ④
absent ☒

vigorous shaking
disperses ☐ ⑤
flocculates ☒ ⑥

Emerson class number *6*

Authorised Signature

NATA Accredited Laboratory
No. 431

A Catton
ALASTAIR CATTON

Coffey Geosciences Pty Ltd A.C.N. 056 335 516

Geotechnical Resources Environmental Technical Project Management
16 Church Street, Hawthorn, Vic, 3122
Ph: (03) 9853 3396, Fax: (03) 9853 0189

Coffey

determination of emerson class number

client : *INFRASTRUCTURE SOLUTIONS PTY LTD*
principal :
project : *BAIRNSDALE LANDFILL - STAGE 2*
location : *JOHNSTONS ROAD, BAIRNSDALE*

job no : *AW1781/1*
laboratory : *MELBOURNE*
date : *1/09/04*
test report : *AE*

test procedure : *AS1289 3.8.1*
sample identification: *TP6 0.50 - 0.80m*

test data

air dried crumbs

time start of test: *8:55 31/08/04*

time dispersion commences:

time dispersion completed:

remoulded material

time start of test: *8:25 1/09/04*

time dispersion commences: *11:30 1/09/04*

time dispersion completed: *13:00 1/09/04*

material description

SILTY CLAY, high plasticity, broen

type of water used: *distilled*

water temperature: *20 ° C*

immersion of air dried crumbs

does not slake ☐
slakes ☒

swell ☐ ⑦
does not swell ☐ ⑧

complete dispersion ☐ ①
partial dispersion ☐ ②
no dispersion ☒

immersion of remoulded material

disperses ☒ ③
does not disperse ☐

calcite or gypsum
present ☐ ④
absent ☐

vigorous shaking
disperses ☐ ⑤
flocculates ☐ ⑥

Emerson class number *3*

This laboratory is accredited by the National Association of Testing Authorities, Australia. The test(s) reported herein have been performed in accordance with the terms of accreditation. This documents hall not be reproduced except in full.

NATA

Authorised Signature

NATA Accredited Laboratory No. 431

ALASTAIR CATTON

Form Number L4.8Rt Version 4.0

Coffey Geosciences Pty Ltd A.C.N. 056 335 516

Geotechnical Resources Environmental Technical Project Management
16 Church Street, Hawthorn, Vic, 3122
Ph: (03) 9853 3396, Fax: (03) 9853 0189

Coffey

determination of emerson class number

client : *INFRASTRUCTURE SOLUTIONS PTY LTD*
principal :
project : *BAIRNSDALE LANDFILL - STAGE 2*
location : *JOHNSTONS ROAD, BAIRNSDALE*

job no : *AW1781/1*
laboratory : *MELBOURNE*
date : *31/08/04*
test report : *AF*

test procedure : *AS1289 3.8.1*
sample identification: *TP6 2.50 - 2.70m*

test data

air dried crumbs

time start of test: *11.12 19/08/04*

time dispersion commences: *11.30 19/08/04*

time dispersion completed: *12:30 19/08/04*

remoulded material

time start of test:

time dispersion commences:

time dispersion completed:

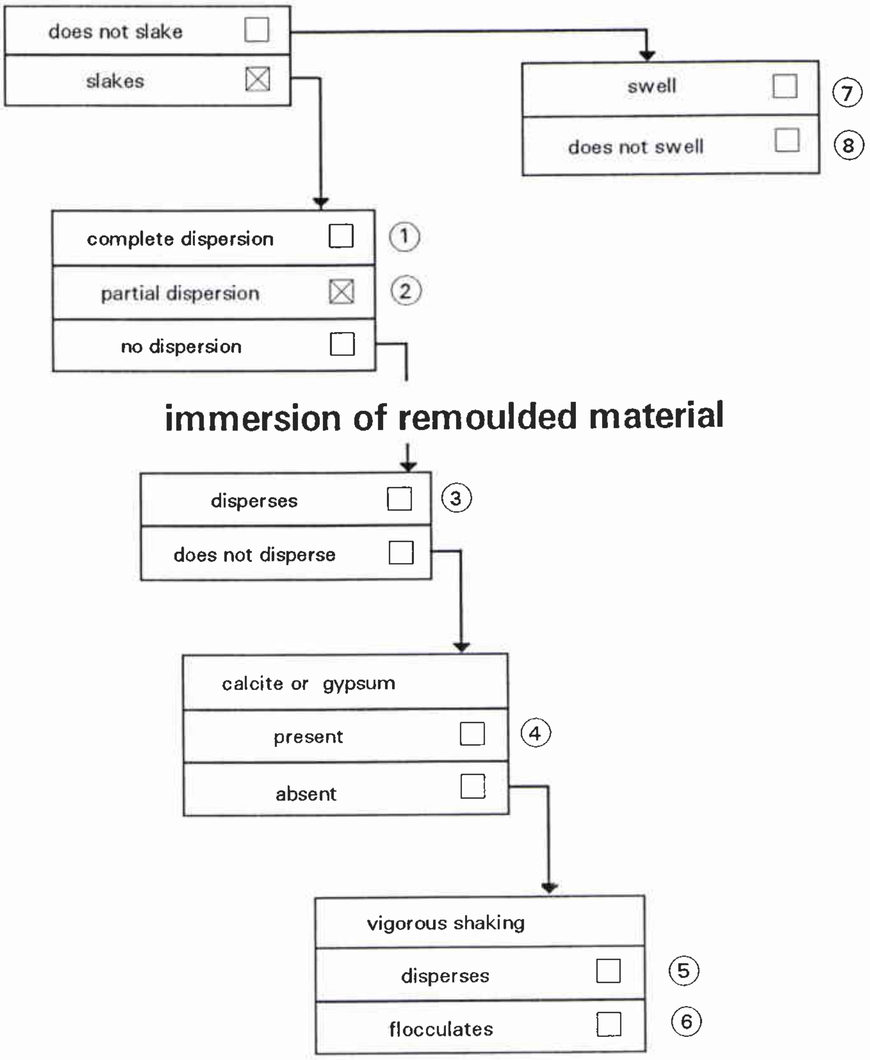
material description

CLAYEY SAND, fine to coarse, orange

type of water used: *distilled*

water temperature: *19° C*

immersion of air dried crumbs



does not slake ☐
slakes ☒

swell ☐ ⑦
does not swell ☐ ⑧

complete dispersion ☐ ①
partial dispersion ☒ ②
no dispersion ☐

immersion of remoulded material

disperses ☐ ③
does not disperse ☐

calcite or gypsum
present ☐ ④
absent ☐

vigorous shaking
disperses ☐ ⑤
flocculates ☐ ⑥

Emerson class number *2*

Authorised Signature
NATA Accredited Laboratory
No. 431

A Catton
ALASTAIR CATTON

Form Number L4.8R1 Version 4.0

Coffey Geosciences Pty Ltd A.C.N. 056 335 516

Geotechnical Resources Environmental Technical Project Management
16 Church Street, Hawthorn, Vic, 3122
Ph: (03) 9853 3396, Fax: (03) 9853 0189

Coffey

determination of emerson class number

client : *INFRASTRUCTURE SOLUTIONS PTY LTD*
principal :
project : *BAIRNSDALE LANDFILL - STAGE 2*
location : *JOHNSTONS ROAD, BAIRNSDALE*

job no : *AW1781/1*
laboratory : *MELBOURNE*
date : *31/08/04*
test report : *AG*

test procedure : *AS1289 3.8.1*
sample identification: *TP9 1.50 - 1.60m*

test data

air dried crumbs

time start of test:	*11.21* *19/08/04*
time dispersion commences:	*11.30* *19/08/04*
time dispersion completed:	*12:30* *19/08/04*

remoulded material

time start of test:

time dispersion commences:

time dispersion completed:

material description

CLAYEY SAND, fine to coarse, orange

type of water used: *distilled*

water temperature: *19° C*

immersion of air dried crumbs

does not slake ☐
slakes ☒

swell ☐ ⑦
does not swell ☐ ⑧

complete dispersion ☐ ①
partial dispersion ☒ ②
no dispersion ☐

immersion of remoulded material

disperses ☐ ③
does not disperse ☐

calcite or gypsum
present ☐ ④
absent ☐

vigorous shaking
disperses ☐ ⑤
flocculates ☐ ⑥

Emerson class number *2*

Form Number L4.8R1 Version 4.0

NATA

This laboratory is accredited by the National Association of Testing Authorities, Australia. The test(s) reported herein have been performed in accordance with the terms of accreditation. This documents hall not be reproduced except in full.

Authorised Signature

NATA Accredited Laboratory No. 431

A Catton
ALASTAIR CATTON

Coffey Geosciences Pty Ltd A.C.N. 056 335 516

Geotechnical **Resources** Environmental **Technical** Project Management

16 Church Street, Hawthorn, Vic, 3122

Ph: (03) 9853 3396, Fax: (03) 9853 0189

Coffey

determination of emerson class number

client : *INFRASTRUCTURE SOLUTIONS PTY LTD*

principal :

project : *BAIRNSDALE LANDFILL - STAGE 2*

location : *JOHNSTONS ROAD, BAIRNSDALE*

job no : *AW1781/1*

laboratory : *MELBOURNE*

date : *31/08/04*

test report : *AH*

test procedure : *AS1289 3.8.1*

sample identification: *TP14 0.50 - 0.60m*

test data

air dried crumbs

time start of test: *11.25 19/08/04*

time dispersion commences:

time dispersion completed:

remoulded material

time start of test: *11:50 20/08/04*

time dispersion commences: *12:00 20/08/04*

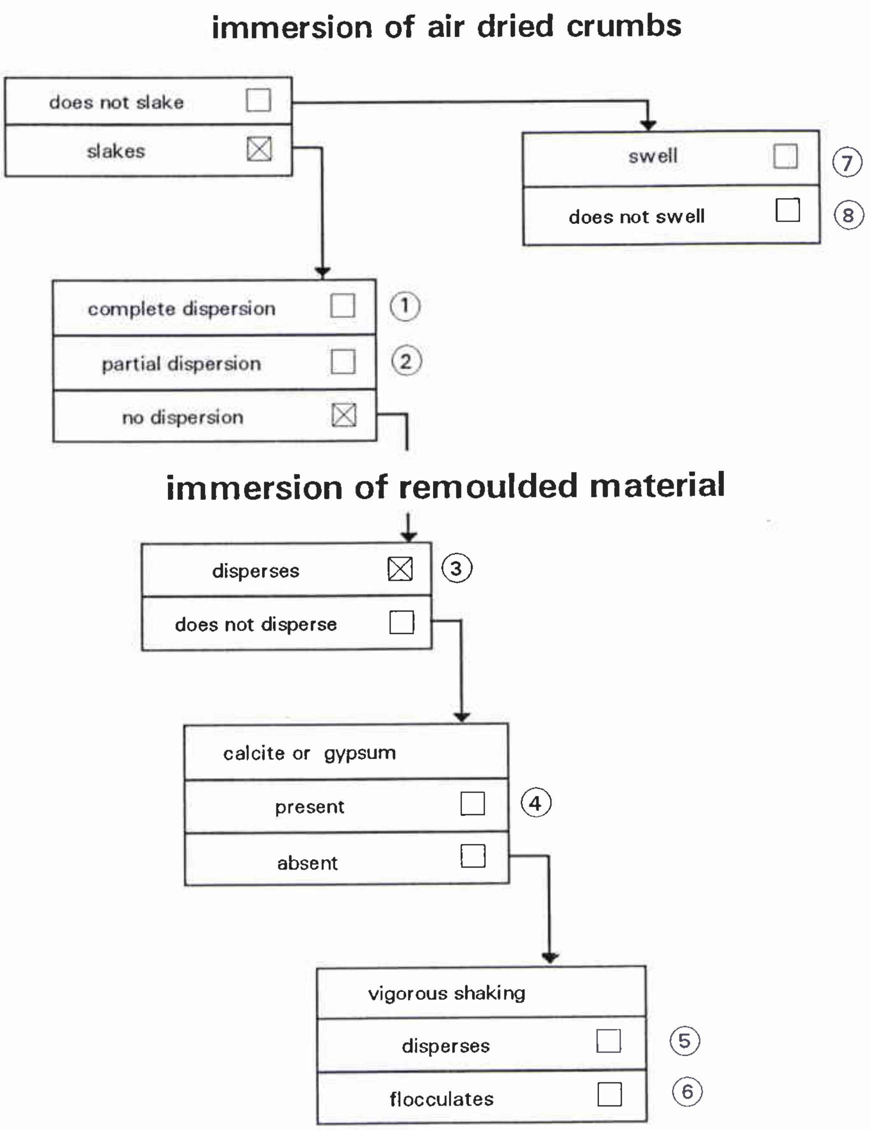
time dispersion completed: *12:20 20/08/04*

material description

SANDY CLAY, medium plasticity, grey brown

type of water used: *distilled*

water temperature: *19° C*



immersion of air dried crumbs

does not slake ☐

slakes ☒

swell ☐ ⑦

does not swell ☐ ⑧

complete dispersion ☐ ①

partial dispersion ☐ ②

no dispersion ☒

immersion of remoulded material

disperses ☒ ③

does not disperse ☐

calcite or gypsum

present ☐ ④

absent ☐

vigorous shaking

disperses ☐ ⑤

flocculates ☐ ⑥

Emerson class number	*3*

This laboratory is accredited by the National Association of Testing Authorities, Australia. The test(s) reported herein have been performed in accordance with the terms of accreditation. This documents hall not be reproduced except in full.

Authorised Signature

NATA Accredited Laboratory No. 431

A Catton

ALASTAIR CATTON

Coffey Geosciences Pty Ltd A.C.N. 056 335 516

Geotechnical Resources Environmental Technical Project Management
16 Church Street, Hawthorn, Vic, 3122
Ph: (03) 9853 3396, Fax: (03) 9853 0189

Coffey

determination of emerson class number

client : *INFRASTRUCTURE SOLUTIONS PTY LTD*
principal :
project : *BAIRNSDALE LANDFILL - STAGE 2*
location : *JOHNSTONS ROAD, BAIRNSDALE*

job no : *AW1781/1*
laboratory : *MELBOURNE*
date : *31/08/04*
test report : *AI*

test procedure : *AS1289 3.8.1*
sample identification: *TP16 2.50 - 2.60m*

test data

air dried crumbs

time start of test: *8:37 23/08/04*

time dispersion commences: *8:47 23/08/04*

time dispersion completed: *10:30 23/08/04*

remoulded material

time start of test:

time dispersion commences:

time dispersion completed:

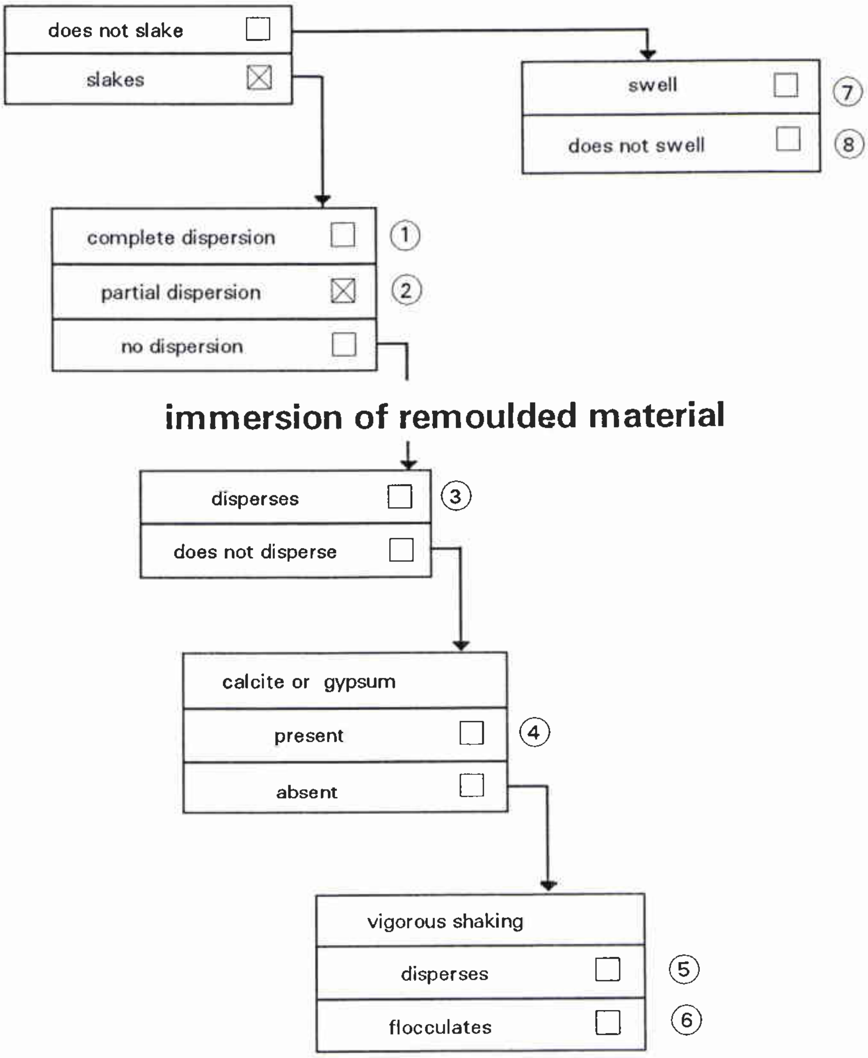
material description

CLAYEY SILT, high plasticity, grey

type of water used: *distilled*

water temperature: *20 ° C*

immersion of air dried crumbs



does not slake ☐
slakes ☒

swell ☐ ⑦
does not swell ☐ ⑧

complete dispersion ☐ ①
partial dispersion ☒ ②
no dispersion ☐

immersion of remoulded material

disperses ☐ ③
does not disperse ☐

calcite or gypsum
present ☐ ④
absent ☐

vigorous shaking
disperses ☐ ⑤
flocculates ☐ ⑥

Emerson class number *2*

Authorised Signature

NATA Accredited Laboratory
No. 431

A Catton

ALASTAIR CATTON

Coffey Geosciences Pty Ltd A.C.N. 056 335 516

Geotechnical Resources Environmental Technical Project Management
16 Church Street, Hawthorn, Vic, 3122
Ph: (03) 9853 3396, Fax: (03) 9853 0189

Coffey

determination of emerson class number

client : *INFRASTRUCTURE SOLUTIONS PTY LTD*
principal :
project : *BAIRNSDALE LANDFILL - STAGE 2*
location : *JOHNSTONS ROAD, BAIRNSDALE*

job no : *AW1781/1*
laboratory : *MELBOURNE*
date : *31/08/04*
test report : *AJ*

test procedure : *AS1289 3.8.1*
sample identification: *TP17 2.30 - 2.50m*

test data

air dried crumbs

time start of test: *11:12 19/08/04*

time dispersion commences: *11:30 19/08/04*

time dispersion completed: *12:30 19/08/04*

remoulded material

time start of test:

time dispersion commences:

time dispersion completed:

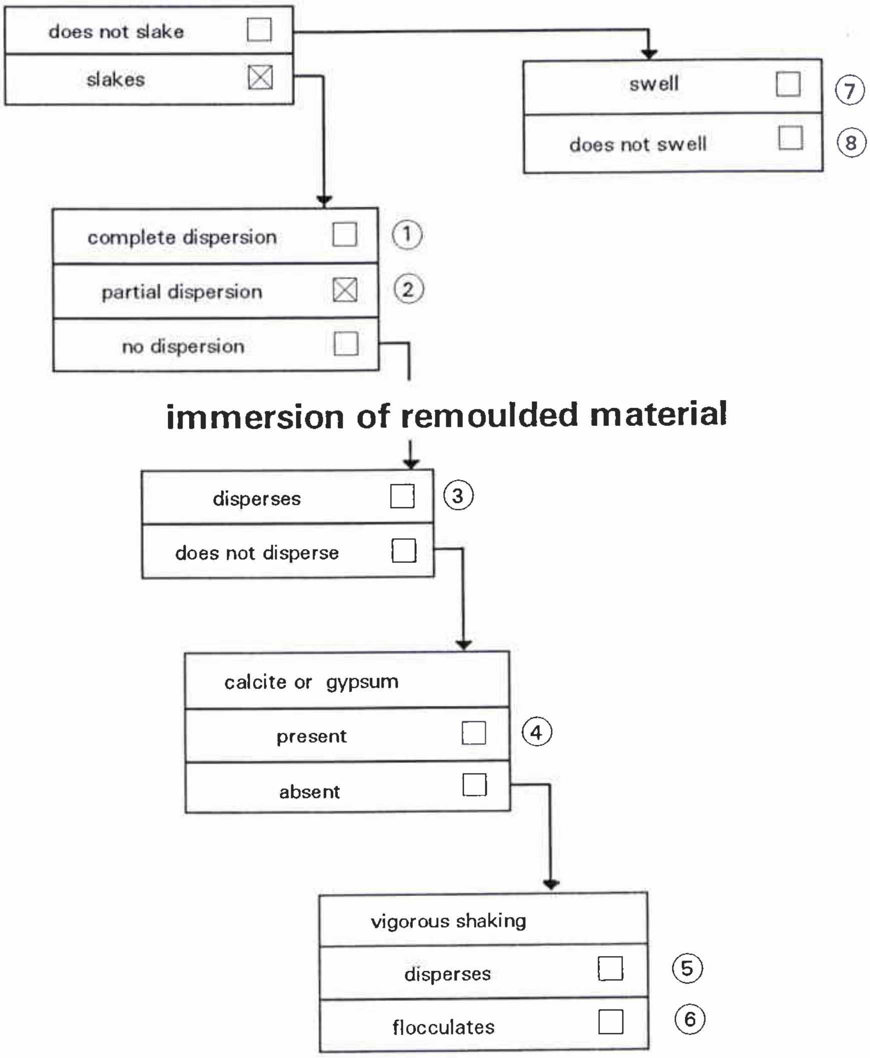
material description

SILTY CLAY, high plasticity, brown

type of water used: *distilled*

water temperature: *19° C*

immersion of air dried crumbs



does not slake ☐
slakes ☒

swell ☐ ⑦
does not swell ☐ ⑧

complete dispersion ☐ ①
partial dispersion ☒ ②
no dispersion ☐

immersion of remoulded material

disperses ☐ ③
does not disperse ☐

calcite or gypsum
present ☐ ④
absent ☐

vigorous shaking
disperses ☐ ⑤
flocculates ☐ ⑥

Emerson class number *2*

This laboratory is accredited by the National Association of Testing Authorities, Australia. The test(s) reported herein have been performed in accordance with the terms of accreditation. This documents hall not be reproduced except in full.

Authorised Signature

NATA Accredited Laboratory
No. 431

ALASTAIR CATTON

Coffey Geosciences Pty Ltd A.C.N. 056 335 516

Geotechnical **Resources** Environmental **Technical** Project Management
16 Church Street, Hawthorn, Vic, 3122
Ph: (03) 9853 3396, Fax: (03) 9853 0189

Coffey

Form Number L4.8R1 Version 4.0

determination of emerson class number

client : *INFRASTRUCTURE SOLUTIONS PTY LTD*
principal :
project : *BAIRNSDALE LANDFILL - STAGE 2*
location : *JOHNSTONS ROAD, BAIRNSDALE*

job no : *AW1781/1*
laboratory : *MELBOURNE*
date : *31/08/04*
test report : *AK*

test procedure : *AS1289 3.8.1*
sample identification: *TP19* *1.40 - 1.50m*

test data

air dried crumbs

time start of test: *8:37 23/08/04*

time dispersion commences:

time dispersion completed:

remoulded material

time start of test: *9:30 24/08/04*

time dispersion commences:

time dispersion completed:

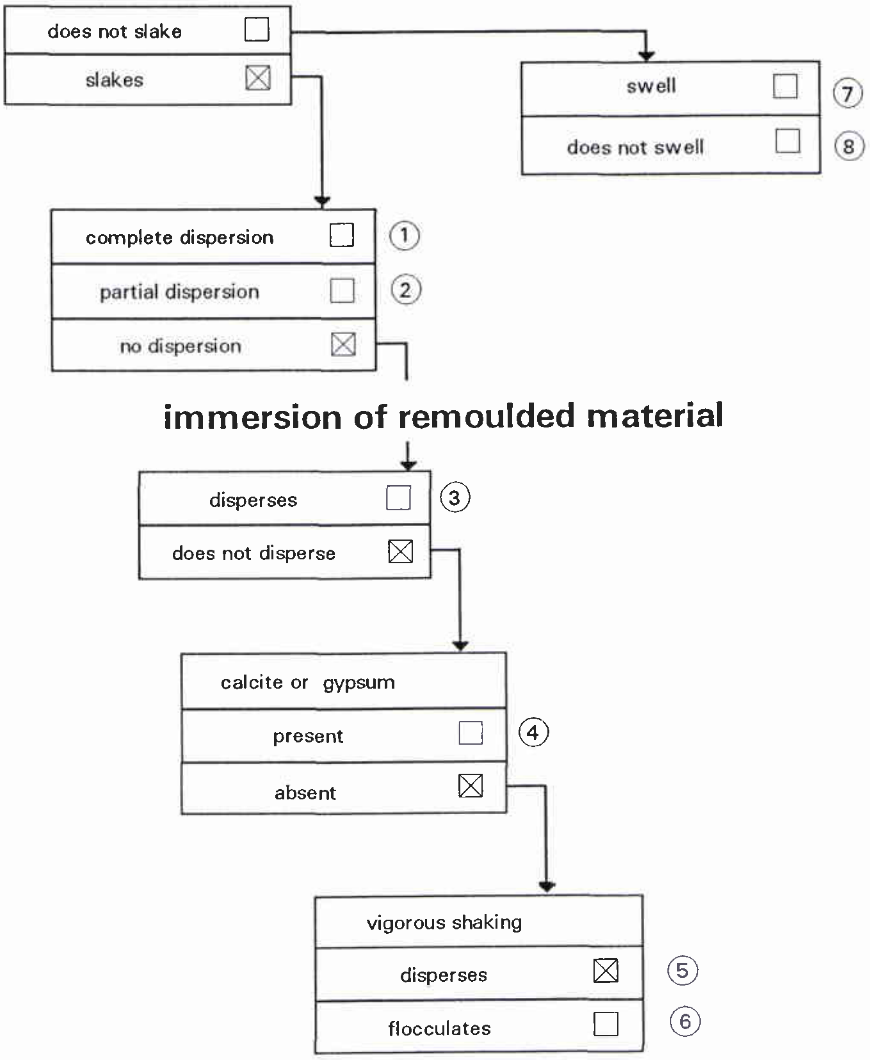
material description

SANDY CLAY, medium plasticity, orange, some fine to medium gravel

type of water used: *distilled*

water temperature: *20 ° C*

immersion of air dried crumbs



does not slake ☐
slakes ☒

swell ☐ ⑦
does not swell ☐ ⑧

complete dispersion ☐ ①
partial dispersion ☐ ②
no dispersion ☒

immersion of remoulded material

disperses ☐ ③
does not disperse ☒

calcite or gypsum
present ☐ ④
absent ☒

vigorous shaking
disperses ☒ ⑤
flocculates ☐ ⑥

Emerson class number *5*

NATA

This laboratory is accredited by the National Association of Testing Authorities, Australia. The test(s) reported herein have been performed in accordance with the terms of accreditation. This documents hall not be reproduced except in full.

Authorised Signature

NATA Accredited Laboratory
No. 431

A Catton

ALASTAIR CATTON

Coffey Geosciences Pty Ltd A.C.N. 056 335 516

Geotechnical Resources Environmental Technical Project Management
16 Church Street, Hawthorn, Vic, 3122
Ph: (03) 9853 3396, Fax: (03) 9853 0189

determination of emerson class number

client : *INFRASTRUCTURE SOLUTIONS PTY LTD*
principal :
project : *BAIRNSDALE LANDFILL - STAGE 2*
location : *JOHNSTONS ROAD, BAIRNSDALE*

job no : *AW1781/1*
laboratory : *MELBOURNE*
date : *31/08/04*
test report : *AL*

test procedure : *AS1289 3.8.1*
sample identification: *TP19* *2.00 - 2.10m*

test data

air dried crumbs

time start of test: *8:37 23/08/04*

time dispersion commences: *8:50 23/08/04*

time dispersion completed: *10:30 23/08/04*

remoulded material

time start of test:

time dispersion commences:

time dispersion completed:

material description

SANDY CLAY, medium plasticity, orange, some fine to medium gravel

type of water used: *distilled*

water temperature: *20 ° C*

immersion of air dried crumbs

does not slake ☐
slakes ☒

swell ☐ ⑦
does not swell ☐ ⑧

complete dispersion ☐ ①
partial dispersion ☒ ②
no dispersion ☐

immersion of remoulded material

disperses ☐ ③
does not disperse ☐

calcite or gypsum
present ☐ ④
absent ☐

vigorous shaking
disperses ☐ ⑤
flocculates ☐ ⑥

Emerson class number *2*

This laboratory is accredited by the National Association of Testing Authorities, Australia. The test(s) reported herein have been performed in accordance with the terms of accreditation. This documents hall not be reproduced except in full.

Authorised Signature
NATA Accredited Laboratory
No. 431

A Catton
ALASTAIR CATTON

Form Number L4.8R1 Version 4.0

Project : Cell 3 Analysis

Johnston's Road Landfill Cell 3

Model : HELP

An US EPA model for predicting landfill hydrologic processes and testing of effectiveness of landfill designs

Author : Project Engineer Rowan Howarth

Client : East Gippsland Shire Council

Location : Bairnsdale

1. Profile. EPA Recommended Profile

Model Settings

[HELP] Case Settings

Parameter	Value	Units
Runoff Method	Model calculated	(-)
Initial Moisture Settings	Model calculated	(-)

[HELP] Surface Water Settings

Parameter	Value	Units
Runoff Area	100	(%%)
Vegetation Class	Good stand of grass	(-)

Profile Structure

Layer	Top (m)	Bottom (m)	Thickness (m)
🟩 **Weekly Cover Material 6**	32.5000	32.2000	0.3000
🟩 **Municipal Waste (312 kg/cub.m) (Layer 6)**	32.2005	30.2005	2.0000
🟩 **Weekly Cover Material 5**	30.2010	29.9010	0.3000
🟩 **Municipal Waste (312 kg/cub.m) (Layer 5)**	29.9015	27.9015	2.0000
🟩 **Weekly Cover Material 4**	27.9020	27.6020	0.3000
🟩 **Municipal Waste (312 kg/cub.m) (Layer 4)**	27.6025	25.6025	2.0000
🟩 **Weekly Cover Material 3**	25.6030	25.3030	0.3000
🟩 **Municipal Waste (312 kg/cub.m) (Layer 3)**	25.3035	23.3035	2.0000
🟩 **Weekly Cover Material 2**	23.3040	23.0040	0.3000
🟩 **Municipal Waste (312 kg/cub.m) (Layer 2)**	23.0045	21.0045	2.0000
🟩 **Weekly Cover Material 1**	21.0045	20.7045	0.3000
🟩 **Municipal Waste (312 kg/cub.m) (Layer 1)**	20.7050	18.7050	2.0000
🟨 **Drainage Aggregate 2**	18.7050	18.4050	0.3000
⬚ **Drainage Net (0.5cm)**	18.4050	18.4000	0.0050
▭ **High Density Polyethylene**	18.4000	18.3990	0.0010
🟨 **Drainage Aggregate 1**	18.3990	17.8990	0.5000
▭ **Butyl Rubber**	17.8990	17.8980	0.0010
▤ **Clay**	17.8980	16.8980	1.0000

1.1. Layer. Weekly Cover Material 6

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units

total porosity	0.457	(vol/vol)
field capacity	0.131	(vol/vol)
wilting point	0.058	(vol/vol)
sat.hydr.conductivity	1E-3	(cm/sec)
subsurface inflow	0	(mm/year)

1.2. Layer. Municipal Waste (312 kg/cub.m) (Layer 6)

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.671	(vol/vol)
field capacity	0.292	(vol/vol)
wilting point	0.077	(vol/vol)
sat.hydr.conductivity	0.001	(cm/sec)
subsurface inflow	0	(mm/year)

1.3. Layer. Weekly Cover Material 5

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.457	(vol/vol)
field capacity	0.131	(vol/vol)
wilting point	0.058	(vol/vol)
sat.hydr.conductivity	1E-3	(cm/sec)
subsurface inflow	0	(mm/year)

1.4. Layer. Municipal Waste (312 kg/cub.m) (Layer 5)

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.671	(vol/vol)
field capacity	0.292	(vol/vol)
wilting point	0.077	(vol/vol)
sat.hydr.conductivity	0.001	(cm/sec)
subsurface inflow	0	(mm/year)

1.5. Layer. Weekly Cover Material 4

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.457	(vol/vol)

field capacity	0.131	(vol/vol)
wilting point	0.058	(vol/vol)
sat.hydr.conductivity	1E-3	(cm/sec)
subsurface inflow	0	(mm/year)

1.6. Layer. Municipal Waste (312 kg/cub.m) (Layer 4)

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.671	(vol/vol)
field capacity	0.292	(vol/vol)
wilting point	0.077	(vol/vol)
sat.hydr.conductivity	0.001	(cm/sec)
subsurface inflow	0	(mm/year)

1.7. Layer. Weekly Cover Material 3

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.457	(vol/vol)
field capacity	0.131	(vol/vol)
wilting point	0.058	(vol/vol)
sat.hydr.conductivity	1E-3	(cm/sec)
subsurface inflow	0	(mm/year)

1.8. Layer. Municipal Waste (312 kg/cub.m) (Layer 3)

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.671	(vol/vol)
field capacity	0.292	(vol/vol)
wilting point	0.077	(vol/vol)
sat.hydr.conductivity	0.001	(cm/sec)
subsurface inflow	0	(mm/year)

1.9. Layer. Weekly Cover Material 2

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.457	(vol/vol)
field capacity	0.131	(vol/vol)

wilting point	0.058	(vol/vol)
sat.hydr.conductivity	1E-3	(cm/sec)
subsurface inflow	0	(mm/year)

1.10. Layer. Municipal Waste (312 kg/cub.m) (Layer 2)

Top Slope Length: 30.0000
Bottom Slope Length: 30.0000
Top Slope: 30.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.6710	(vol/vol)
field capacity	0.2920	(vol/vol)
wilting point	0.0770	(vol/vol)
sat.hydr.conductivity	86.40000000000001	(cm/day)
subsurface inflow	0.0000	(cm/day)

1.11. Layer. Weekly Cover Material 1

Top Slope Length: 30.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.457	(vol/vol)
field capacity	0.131	(vol/vol)
wilting point	0.058	(vol/vol)
sat.hydr.conductivity	1E-3	(cm/sec)
subsurface inflow	0	(mm/year)

1.12. Layer. Municipal Waste (312 kg/cub.m) (Layer 1)

Top Slope Length: 30.0000
Bottom Slope Length: 30.0000
Top Slope: 30.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.6710	(vol/vol)
field capacity	0.2920	(vol/vol)
wilting point	0.0770	(vol/vol)
sat.hydr.conductivity	86.40000000000001	(cm/day)
subsurface inflow	0.0000	(cm/day)

1.13. Layer. Drainage Aggregate 2

Top Slope Length: 30.0000
Bottom Slope Length: 30.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Lateral Drainage Layer Parameters

Parameter	Value	Units
total porosity	0.397	(vol/vol)
field capacity	0.032	(vol/vol)
wilting point	0.013	(vol/vol)

sat.hydr.conductivity	8640	(cm/day)
subsurface inflow	0	(mm/year)

1.14. Layer. Drainage Net (0.5cm)

Top Slope Length: 30.0000
Bottom Slope Length: 30.0000
Top Slope: 5.0000
Bottom Slope : 5.0000

[HELP] Geotextiles and Geonets Parameters

Parameter	Value	Units
total porosity	0.8500	(vol/vol)
field capacity	0.01	(vol/vol)
wilting point	0.005	(vol/vol)
sat.hydr.conductivity	864000.0000000000	(cm/day)
subsurface inflow	0	(cm/day)

1.15. Layer. High Density Polyethylene

Top Slope Length: 30.0000
Bottom Slope Length: 30.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Geomembrane Liner Parameters

Parameter	Value	Units
sat.hydr.conductivity	2E-13	(cm/sec)
pinhole density	2	(#/ha)
installation defects	2	(#/ha)
placement quality	4	(-)
geotextile transmissivity	0	(cm2/sec)

1.16. Layer. Drainage Aggregate 1

Top Slope Length: 30.0000
Bottom Slope Length: 70.0000
Top Slope: 5.0000
Bottom Slope : 4.0000

[HELP] Lateral Drainage Layer Parameters

Parameter	Value	Units
total porosity	0.397	(vol/vol)
field capacity	0.032	(vol/vol)
wilting point	0.013	(vol/vol)
sat.hydr.conductivity	8640	(cm/day)
subsurface inflow	0	(mm/year)

1.17. Layer. Butyl Rubber

Top Slope Length: 70.0000
Bottom Slope Length: 70.0000
Top Slope: 4.0000
Bottom Slope : 4.0000

[HELP] Geomembrane Liner Parameters

Parameter	Value	Units
sat.hydr.conductivity	1.0E-12	(cm/sec)
pinhole density	2	(#/ha)
installation defects	4	(#/ha)
placement quality	4	(-)

geotextile transmissivity	0	(cm2/sec)

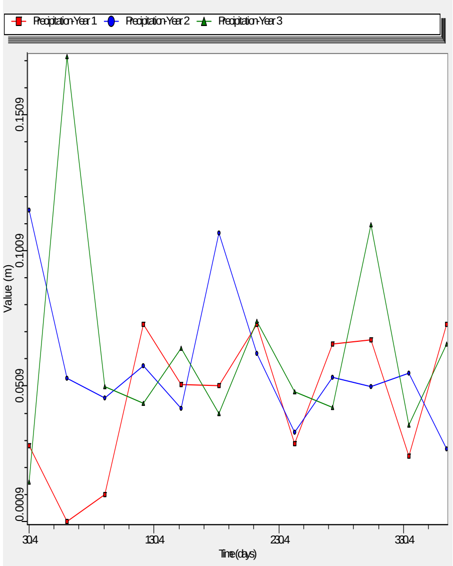
1.18. Layer. Clay

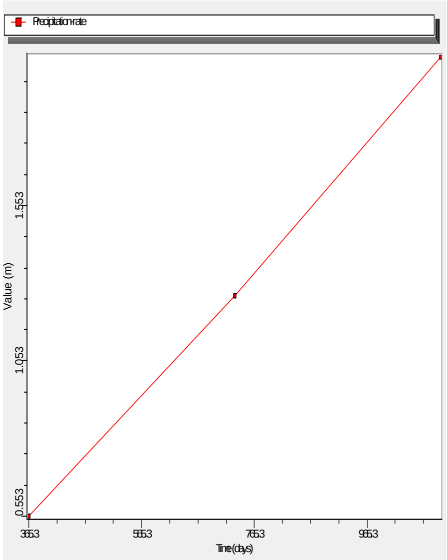
Top Slope Length: 70.0000
Bottom Slope Length: 30.0000
Top Slope: 4.0000
Bottom Slope : 0.0000

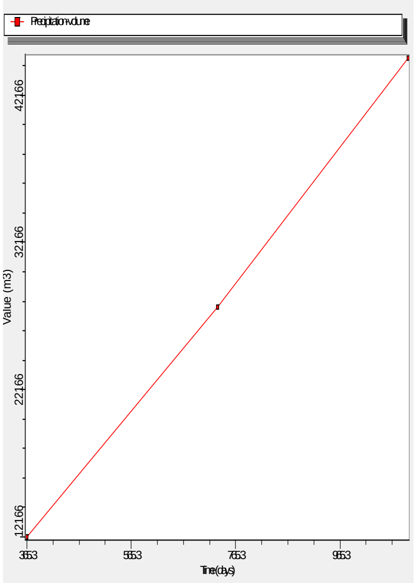
[HELP] Barrier Soil Liner Parameters

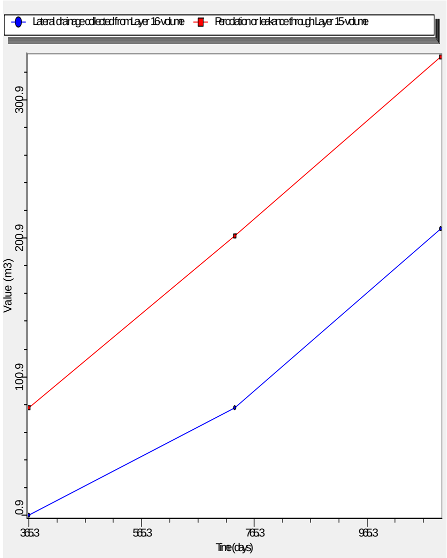
Parameter	Value	Units
total porosity	0.475	(vol/vol)
field capacity	0.378	(vol/vol)
wilting point	0.265	(vol/vol)
sat.hydr.conductivity	0.00095	(cm/day)
subsurface inflow	0	(mm/year)

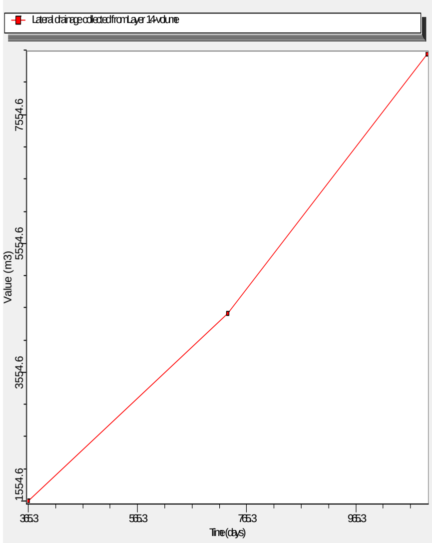
Results:

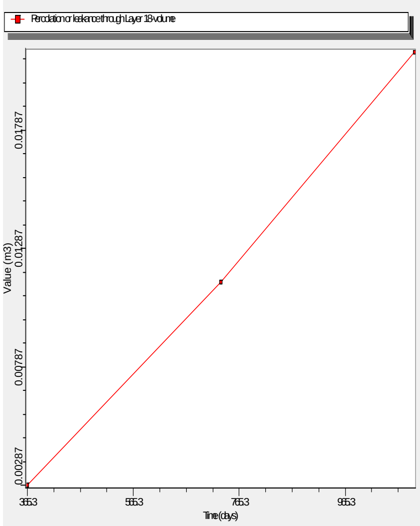



Precipitation-rate
Value (m)
0.553
1.053
1.553
365.3
565.3
765.3
965.3
Time (days)


Precipitation-volume
Value (m3)
12166
22166
32166
42166
365.3
565.3
765.3
965.3
Time (days)


Lateral drainage collected from Layer 16-volume
Percolation or leakance through Layer 15-volume
Value (m3)
300.9
200.9
100.9
0.9
3653
5653
7653
9653
Time (days)


Lateral drainage collected from Layer 14-volume
Value (m3)
7554.6
5554.6
3554.6
1554.6
3653
5653
7653
9653
Time (days)


Percolation or leakance through Layer 18-volume
Value (m3)
0.01787
0.01287
0.00787
0.00287
3653
5653
7653
9653
Time (days)

Annual Totals rate (m)

	Year-1 (m)	**Year-2 (m)**	**Year-3 (m)**	**Total (m)**
Precipitation (m)	5.5300E-01	7.0930E-01	7.6890E-01	2.0312E+00
Runoff (m)	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Evapotranspiration (m)	4.4622E-01	5.8591E-01	5.6170E-01	1.5938E+00
Change in water storage (m)	3.6076E-02	-1.2766E-02	1.8432E-02	4.1742E-02
Water budget balance (m)	-8.3052E-09	-1.0653E-08	-1.1548E-08	-3.0506E-08
Soil water (m)	4.3891E+00	4.3764E+00	4.3948E+00	1.3160E+01
Snow water (m)	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Lateral drainage collected from Layer 14 (m)	7.0664E-02	1.3263E-01	1.8290E-01	3.8619E-01
Percolation or leakance through Layer 15 (m)	3.5775E-03	5.6164E-03	5.8828E-03	1.5077E-02
Lateral drainage collected from Layer 16 (m)	4.1743E-05	3.5318E-03	5.8724E-03	9.4459E-03
Percolation or leakance through Layer 18 (m)	1.3042E-07	3.9028E-07	4.4157E-07	9.6227E-07
Average head on top of Layer 15 (m)	6.7053E-06	1.2658E-05	1.7346E-05	
Average head on top of Layer 17 (m)	1.1628E-06	9.7719E-05	1.6290E-04	

Annual Totals volume (m3)

	Year-1 (m3)	**Year-2 (m3)**	**Year-3 (m3)**	**Total (m3)**
Precipitation (m3)	1.2166E+04	1.5605E+04	1.6916E+04	4.4686E+04
Runoff (m3)	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Evapotranspiration (m3)	9.8168E+03	1.2890E+04	1.2357E+04	3.5064E+04
Change in water storage (m3)	7.9366E+02	-2.8086E+02	4.0551E+02	9.1832E+02
Water budget balance (m3)	-1.8271E-04	-2.3436E-04	-2.5405E-04	-6.7112E-04
Soil water (m3)	9.6561E+04	9.6280E+04	9.6686E+04	2.8953E+05
Snow water (m3)	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Lateral drainage collected from Layer 14 (m3)	1.5546E+03	2.9178E+03	4.0238E+03	8.4962E+03
Percolation or leakance through Layer 15 (m3)	7.8705E+01	1.2356E+02	1.2942E+02	3.3169E+02
Lateral drainage collected from Layer 16 (m3)	9.1834E-01	7.7699E+01	1.2919E+02	2.0781E+02
Percolation or leakance through Layer 18 (m3)	2.8692E-03	8.5862E-03	9.7145E-03	2.1170E-02

Accumulated rate (m)

	Year-1 (m)	**Year-2 (m)**	**Year-3 (m)**
Precipitation (m)	5.5300E-01	1.2623E+00	2.0312E+00
Runoff (m)	0.0000E+00	0.0000E+00	0.0000E+00
Evapotranspiration (m)	4.4622E-01	1.0321E+00	1.5938E+00
Lateral drainage collected from Layer 14 (m)	7.0664E-02	2.0329E-01	3.8619E-01
Percolation or leakance through Layer 15 (m)	3.5775E-03	9.1939E-03	1.5077E-02
Lateral drainage collected from Layer 16 (m)	4.1743E-05	3.5735E-03	9.4459E-03
Percolation or leakance through Layer 18 (m)	1.3042E-07	5.2070E-07	9.6227E-07

Accumulated volume (m3)

	Year-1 (m3)	**Year-2 (m3)**	**Year-3 (m3)**
Precipitation (m3)	1.2166E+04	2.7771E+04	4.4686E+04
Runoff (m3)	0.0000E+00	0.0000E+00	0.0000E+00
Evapotranspiration (m3)	9.8168E+03	2.2707E+04	3.5064E+04
Lateral drainage collected from Layer 14 (m3)	1.5546E+03	4.4724E+03	8.4962E+03
Percolation or leakance through Layer 15 (m3)	7.8705E+01	2.0227E+02	3.3169E+02
Lateral drainage collected from Layer 16 (m3)	9.1834E-01	7.8617E+01	2.0781E+02
Percolation or leakance through Layer 18 (m3)	2.8692E-03	1.1455E-02	2.1170E-02

Peak daily values

	Rate (m)	**Volume (m3)**	**Day**	**Year**
Precipitation	5.4900E-02	1.2078E+03	45	3
Runoff	3.8645E-03	8.5018E+01	205	3
Lateral drainage collected from Layer 14	5.3747E-05	1.1824E+00	205	3
Percolation or leakance through Layer 15	3.8641E-05	8.5009E-01	234	3
Lateral drainage collected from Layer 16	1.6345E-09	3.5960E-05	234	3
Percolation or leakance through Layer 18	0.0000E+00	3.5494E-02	0	1
Snow water	2.3584E-08	5.5023E-05	0	0

2. Profile. Cell 1 Design

Model Settings

[HELP] Case Settings

Parameter	Value	Units
Runoff Method	Model calculated	(-)
Initial Moisture Settings	Model calculated	(-)

[HELP] Surface Water Settings

Parameter	Value	Units
Runoff Area	100	(%%)
Vegetation Class	Good stand of grass	(-)

Profile Structure

Layer	Top (m)	Bottom (m)	Thickness (m)
🟩 **Weekly Cover Material 6**	32.4935	32.2935	0.2000
🟩 **Municipal Waste (312 kg/cub.m) (Layer 6)**	32.2940	30.2940	2.0000
🟩 **Weekly Cover Material 5**	30.2945	29.9945	0.3000
🟩 **Municipal Waste (312 kg/cub.m) (Layer 5)**	29.9950	27.9950	2.0000
🟩 **Weekly Cover Material 4**	27.9955	27.6955	0.3000
🟩 **Municipal Waste (312 kg/cub.m) (Layer 4)**	27.6960	25.6960	2.0000
🟩 **Weekly Cover Material 3**	25.6965	25.3965	0.3000
🟩 **Municipal Waste (312 kg/cub.m) (Layer 3)**	25.3970	23.3970	2.0000
🟩 **Weekly Cover Material 2**	23.3975	23.0975	0.3000
🟩 **Municipal Waste (312 kg/cub.m) (Layer 2)**	23.0980	21.0980	2.0000
🟩 **Weekly Cover Material 1**	21.0985	20.7985	0.3000
🟩 **Municipal Waste (312 kg/cub.m)**	20.7990	18.7990	2.0000
🟨 **Drainage Aggregate**	18.7995	18.4995	0.3000
▤ **Clay**	18.5000	17.5000	1.0000

2.1. Layer. Weekly Cover Material 6

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.457	(vol/vol)
field capacity	0.131	(vol/vol)
wilting point	0.058	(vol/vol)
sat.hydr.conductivity	1E-3	(cm/sec)
subsurface inflow	0	(mm/year)

2.2. Layer. Municipal Waste (312 kg/cub.m) (Layer 6)

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.671	(vol/vol)
field capacity	0.292	(vol/vol)
wilting point	0.077	(vol/vol)
sat.hydr.conductivity	0.001	(cm/sec)
subsurface inflow	0	(mm/year)

2.3. Layer. Weekly Cover Material 5

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.457	(vol/vol)
field capacity	0.131	(vol/vol)
wilting point	0.058	(vol/vol)
sat.hydr.conductivity	1E-3	(cm/sec)
subsurface inflow	0	(mm/year)

2.4. Layer. Municipal Waste (312 kg/cub.m) (Layer 5)

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.671	(vol/vol)
field capacity	0.292	(vol/vol)
wilting point	0.077	(vol/vol)
sat.hydr.conductivity	0.001	(cm/sec)
subsurface inflow	0	(mm/year)

2.5. Layer. Weekly Cover Material 4

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.457	(vol/vol)
field capacity	0.131	(vol/vol)
wilting point	0.058	(vol/vol)
sat.hydr.conductivity	1E-3	(cm/sec)
subsurface inflow	0	(mm/year)

2.6. Layer. Municipal Waste (312 kg/cub.m) (Layer 4)

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.671	(vol/vol)
field capacity	0.292	(vol/vol)
wilting point	0.077	(vol/vol)
sat.hydr.conductivity	0.001	(cm/sec)
subsurface inflow	0	(mm/year)

2.7. Layer. Weekly Cover Material 3

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.457	(vol/vol)
field capacity	0.131	(vol/vol)
wilting point	0.058	(vol/vol)
sat.hydr.conductivity	1E-3	(cm/sec)
subsurface inflow	0	(mm/year)

2.8. Layer. Municipal Waste (312 kg/cub.m) (Layer 3)

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.671	(vol/vol)
field capacity	0.292	(vol/vol)
wilting point	0.077	(vol/vol)
sat.hydr.conductivity	0.001	(cm/sec)
subsurface inflow	0	(mm/year)

2.9. Layer. Weekly Cover Material 2

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.457	(vol/vol)
field capacity	0.131	(vol/vol)
wilting point	0.058	(vol/vol)
sat.hydr.conductivity	1E-3	(cm/sec)
subsurface inflow	0	(mm/year)

2.10. Layer. Municipal Waste (312 kg/cub.m) (Layer 2)

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.671	(vol/vol)
field capacity	0.292	(vol/vol)
wilting point	0.077	(vol/vol)
sat.hydr.conductivity	0.001	(cm/sec)
subsurface inflow	0	(mm/year)

2.11. Layer. Weekly Cover Material 1

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.457	(vol/vol)
field capacity	0.131	(vol/vol)
wilting point	0.058	(vol/vol)
sat.hydr.conductivity	1E-3	(cm/sec)
subsurface inflow	0	(mm/year)

2.12. Layer. Municipal Waste (312 kg/cub.m)

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.671	(vol/vol)
field capacity	0.292	(vol/vol)
wilting point	0.077	(vol/vol)
sat.hydr.conductivity	0.001	(cm/sec)
subsurface inflow	0	(mm/year)

2.13. Layer. Drainage Aggregate

Top Slope Length: 0.0000
Bottom Slope Length: 70.0000
Top Slope: 0.0000
Bottom Slope : 4.0000

[HELP] Lateral Drainage Layer Parameters

Parameter	Value	Units
total porosity	0.397	(vol/vol)
field capacity	0.032	(vol/vol)
wilting point	0.013	(vol/vol)
sat.hydr.conductivity	8640	(cm/day)
subsurface inflow	0	(mm/year)

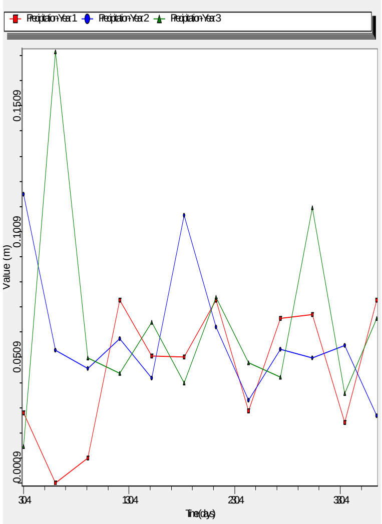
2.14. Layer. Clay

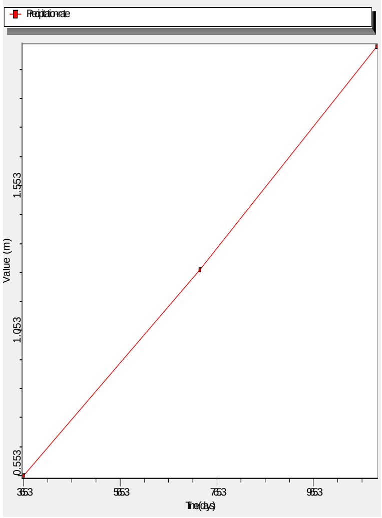
Top Slope Length: 70.0000
Bottom Slope Length: 0.0000
Top Slope: 4.0000
Bottom Slope : 0.0000

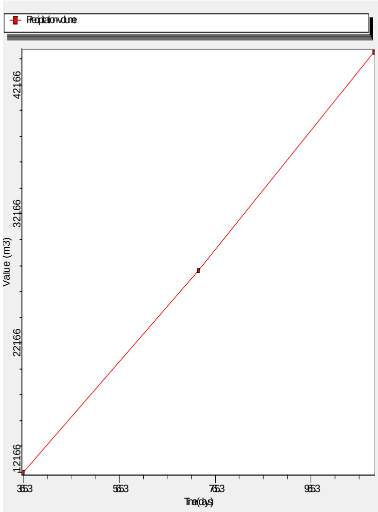
[HELP] Barrier Soil Liner Parameters

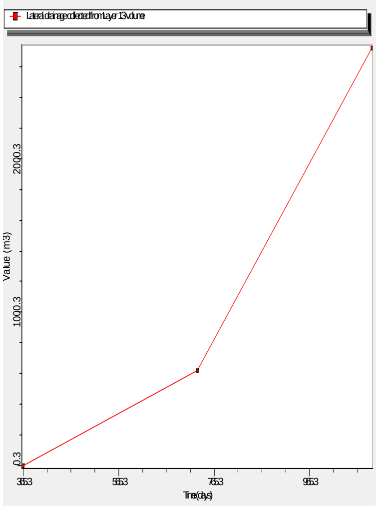
Parameter	Value	Units
total porosity	0.4750	(vol/vol)
field capacity	0.3780	(vol/vol)
wilting point	0.2650	(vol/vol)
sat.hydr.conductivity	0.00095	(cm/day)
subsurface inflow	0.0000	(cm/day)

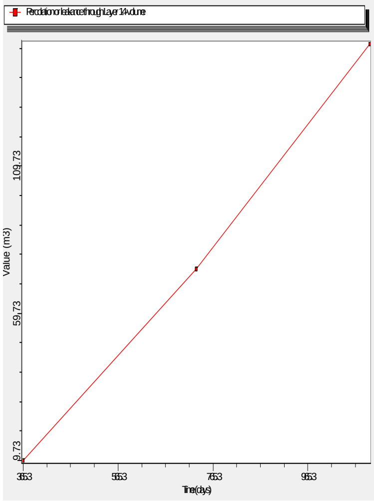
Results:











Annual Totals rate (m)

	Year-1 (m)	Year-2 (m)	Year-3 (m)	Total (m)
Precipitation (m)	5.5300E-01	7.0930E-01	7.6890E-01	2.0312E+00
Runoff (m)	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

Evapotranspiration (m)	5.1917E-01	6.7634E-01	6.5636E-01	1.8519E+00
Change in water storage (m)	3.3375E-02	1.7284E-03	1.3644E-02	4.8748E-02
Water budget balance (m)	-8.3052E-09	-1.0653E-08	-1.1548E-08	-3.0506E-08
Soil water (m)	4.2706E+00	4.2723E+00	4.2860E+00	1.2829E+01
Snow water (m)	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Lateral drainage collected from Layer 13 (m)	1.2668E-05	2.8275E-02	9.5418E-02	1.2371E-01
Percolation or leakance through Layer 14 (m)	4.4246E-04	2.9553E-03	3.4766E-03	6.8744E-03
Average head on top of Layer 14 (m)	4.2474E-07	7.8149E-04	2.6280E-03	
Average head on top of Layer 17 (m)	1.1628E-06	9.7719E-05	1.6290E-04	

Annual Totals volume (m3)

	Year-1 (m3)	Year-2 (m3)	Year-3 (m3)	Total (m3)
Precipitation (m3)	1.2166E+04	1.5605E+04	1.6916E+04	4.4686E+04
Runoff (m3)	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Evapotranspiration (m3)	1.1422E+04	1.4880E+04	1.4440E+04	4.0741E+04
Change in water storage (m3)	7.3426E+02	3.8024E+01	3.0017E+02	1.0724E+03
Water budget balance (m3)	-1.8271E-04	-2.3436E-04	-2.5405E-04	-6.7112E-04
Soil water (m3)	9.3953E+04	9.3991E+04	9.4292E+04	2.8224E+05
Snow water (m3)	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Lateral drainage collected from Layer 13 (m3)	2.7869E-01	6.2205E+02	2.0992E+03	2.7215E+03
Percolation or leakance through Layer 14 (m3)	9.7342E+00	6.5017E+01	7.6486E+01	1.5124E+02

Accumulated rate (m)

	Year-1 (m)	Year-2 (m)	Year-3 (m)
Precipitation (m)	5.5300E-01	1.2623E+00	2.0312E+00
Runoff (m)	0.0000E+00	0.0000E+00	0.0000E+00
Evapotranspiration (m)	5.1917E-01	1.1955E+00	1.8519E+00
Lateral drainage collected from Layer 13 (m)	1.2668E-05	2.8288E-02	1.2371E-01
Percolation or leakance through Layer 14 (m)	4.4246E-04	3.3978E-03	6.8744E-03

Accumulated volume (m3)

	Year-1 (m3)	Year-2 (m3)	Year-3 (m3)
Precipitation (m3)	1.2166E+04	2.7771E+04	4.4686E+04
Runoff (m3)	0.0000E+00	0.0000E+00	0.0000E+00
Evapotranspiration (m3)	1.1422E+04	2.6301E+04	4.0741E+04
Lateral drainage collected from Layer 13 (m3)	2.7869E-01	6.2233E+02	2.7215E+03
Percolation or leakance through Layer 14 (m3)	9.7342E+00	7.4751E+01	1.5124E+02

Peak daily values

	Rate (m)	Volume (m3)	Day	Year
Precipitation	5.4900E-02	1.2078E+03	45	3
Runoff	2.8865E-03	6.3503E+01	197	3
Lateral drainage collected from Layer 13	9.7780E-06	2.1512E-01	197	3
Percolation or leakance through Layer 14	0.0000E+00	7.4751E+01	151	236
Snow water	3.9863E-03	1.2410E+01	0	0

3. Profile. Cell 2 Design

Model Settings

[HELP] Case Settings

Parameter	Value	Units
Runoff Method	Model calculated	(-)
Initial Moisture Settings	Model calculated	(-)

[HELP] Surface Water Settings

Parameter	Value	Units
Runoff Area	100	(%%)
Vegetation Class	Good stand of grass	(-)

Profile Structure

Layer	Top (m)	Bottom (m)	Thickness (m)
🟩 **Weekly Cover Material 6**	32.5000	32.2000	0.3000
🟩 **Municipal Waste (312 kg/cub.m) (Layer 6)**	32.2005	30.2005	2.0000
🟩 **Weekly Cover Material 5**	30.2010	29.9010	0.3000
🟩 **Municipal Waste (312 kg/cub.m) (Layer 5)**	29.9015	27.9015	2.0000
🟩 **Weekly Cover Material 4**	27.9020	27.6020	0.3000
🟩 **Municipal Waste (312 kg/cub.m) (Layer 4)**	27.6025	25.6025	2.0000
🟩 **Weekly Cover Material 3**	25.6030	25.3030	0.3000
🟩 **Municipal Waste (312 kg/cub.m) (Layer 3)**	25.3035	23.3035	2.0000
🟩 **Weekly Cover Material 2**	23.3040	23.0040	0.3000
🟩 **Municipal Waste (312 kg/cub.m) (Layer 2)**	23.0045	21.0045	2.0000
🟩 **Weekly Cover Material 1**	21.0050	20.7050	0.3000
🟩 **Municipal Waste (312 kg/cub.m) (Layer 1)**	20.7055	18.7055	2.0000
🟨 **Drainage Aggregate**	18.7060	18.4060	0.3000
▭ **High Density Polyethylene (HDPE)**	18.4065	18.4055	0.0010
▤ **Clay**	18.4060	17.4060	1.0000

3.1. Layer. Weekly Cover Material 6

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.457	(vol/vol)
field capacity	0.131	(vol/vol)
wilting point	0.058	(vol/vol)
sat.hydr.conductivity	1E-3	(cm/sec)
subsurface inflow	0	(mm/year)

3.2. Layer. Municipal Waste (312 kg/cub.m) (Layer 6)

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.671	(vol/vol)
field capacity	0.292	(vol/vol)
wilting point	0.077	(vol/vol)
sat.hydr.conductivity	0.001	(cm/sec)
subsurface inflow	0	(mm/year)

3.3. Layer. Weekly Cover Material 5

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.457	(vol/vol)
field capacity	0.131	(vol/vol)
wilting point	0.058	(vol/vol)
sat.hydr.conductivity	1E-3	(cm/sec)
subsurface inflow	0	(mm/year)

3.4. Layer. Municipal Waste (312 kg/cub.m) (Layer 5)

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.671	(vol/vol)
field capacity	0.292	(vol/vol)
wilting point	0.077	(vol/vol)
sat.hydr.conductivity	0.001	(cm/sec)
subsurface inflow	0	(mm/year)

3.5. Layer. Weekly Cover Material 4

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.457	(vol/vol)
field capacity	0.131	(vol/vol)
wilting point	0.058	(vol/vol)
sat.hydr.conductivity	1E-3	(cm/sec)
subsurface inflow	0	(mm/year)

3.6. Layer. Municipal Waste (312 kg/cub.m) (Layer 4)

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.671	(vol/vol)
field capacity	0.292	(vol/vol)
wilting point	0.077	(vol/vol)
sat.hydr.conductivity	0.001	(cm/sec)
subsurface inflow	0	(mm/year)

3.7. Layer. Weekly Cover Material 3

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.457	(vol/vol)
field capacity	0.131	(vol/vol)
wilting point	0.058	(vol/vol)
sat.hydr.conductivity	1E-3	(cm/sec)
subsurface inflow	0	(mm/year)

3.8. Layer. Municipal Waste (312 kg/cub.m) (Layer 3)

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.671	(vol/vol)
field capacity	0.292	(vol/vol)
wilting point	0.077	(vol/vol)
sat.hydr.conductivity	0.001	(cm/sec)
subsurface inflow	0	(mm/year)

3.9. Layer. Weekly Cover Material 2

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.457	(vol/vol)
field capacity	0.131	(vol/vol)
wilting point	0.058	(vol/vol)
sat.hydr.conductivity	1E-3	(cm/sec)
subsurface inflow	0	(mm/year)

3.10. Layer. Municipal Waste (312 kg/cub.m) (Layer 2)

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.671	(vol/vol)
field capacity	0.292	(vol/vol)
wilting point	0.077	(vol/vol)
sat.hydr.conductivity	0.001	(cm/sec)
subsurface inflow	0	(mm/year)

3.11. Layer. Weekly Cover Material 1

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.457	(vol/vol)
field capacity	0.131	(vol/vol)
wilting point	0.058	(vol/vol)
sat.hydr.conductivity	1E-3	(cm/sec)
subsurface inflow	0	(mm/year)

3.12. Layer. Municipal Waste (312 kg/cub.m) (Layer 1)

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.671	(vol/vol)
field capacity	0.292	(vol/vol)
wilting point	0.077	(vol/vol)
sat.hydr.conductivity	0.001	(cm/sec)
subsurface inflow	0	(mm/year)

3.13. Layer. Drainage Aggregate

Top Slope Length: 0.0000
Bottom Slope Length: 70.0000
Top Slope: 0.0000
Bottom Slope : 4.0000

[HELP] Lateral Drainage Layer Parameters

Parameter	Value	Units
total porosity	0.397	(vol/vol)
field capacity	0.032	(vol/vol)
wilting point	0.013	(vol/vol)
sat.hydr.conductivity	8640	(cm/day)
subsurface inflow	0	(mm/year)

3.14. Layer. High Density Polyethylene (HDPE)

Top Slope Length: 70.0000
Bottom Slope Length: 70.0000
Top Slope: 4.0000
Bottom Slope : 4.0000

[HELP] Geomembrane Liner Parameters

Parameter	Value	Units
sat.hydr.conductivity	2E-13	(cm/sec)
pinhole density	2	(#/ha)
installation defects	2	(#/ha)
placement quality	3	(-)
geotextile transmissivity	0	(cm2/sec)

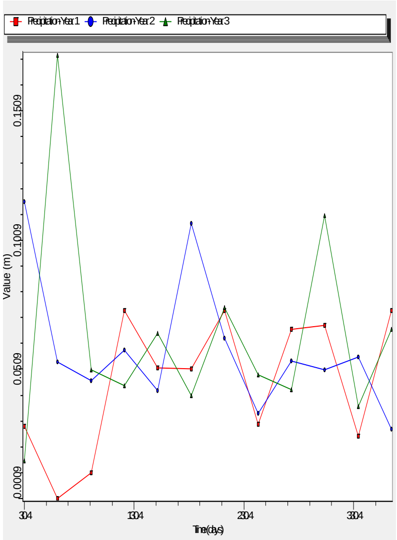
3.15. Layer. Clay

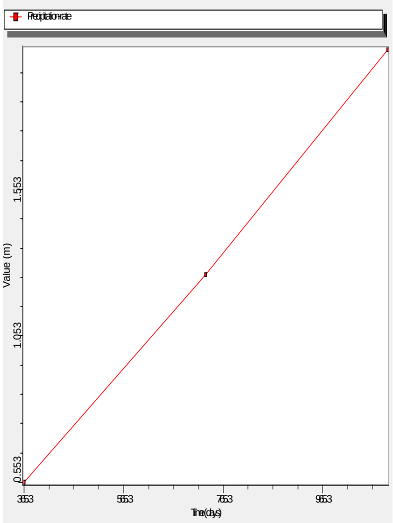
Top Slope Length: 70.0000
Bottom Slope Length: 0.0000
Top Slope: 4.0000
Bottom Slope : 0.0000

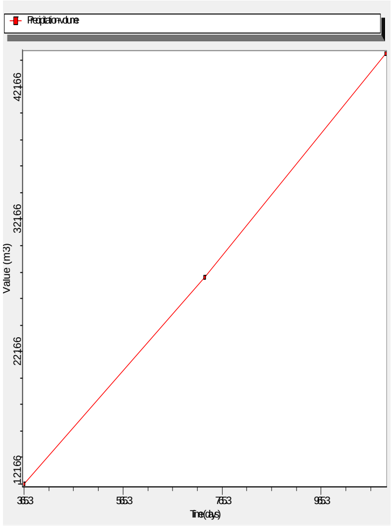
[HELP] Barrier Soil Liner Parameters

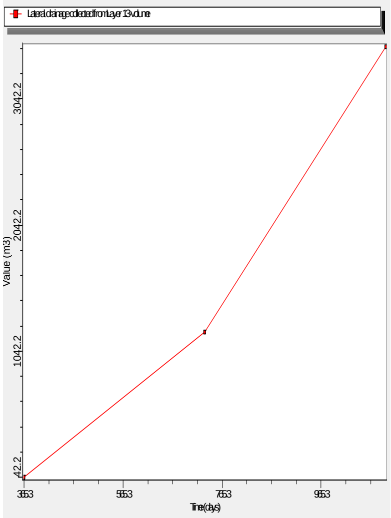
Parameter	Value	Units
total porosity	0.4750	(vol/vol)
field capacity	0.3780	(vol/vol)
wilting point	0.2650	(vol/vol)
sat.hydr.conductivity	0.00095	(cm/day)
subsurface inflow	0.0000	(cm/day)

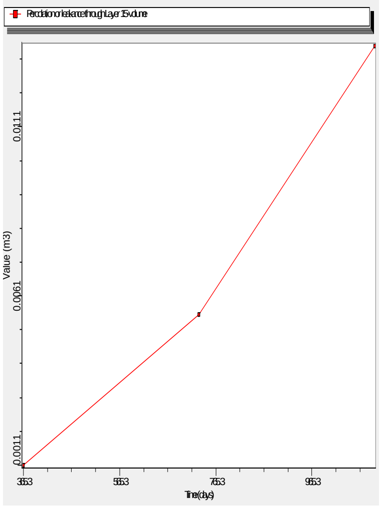
Results:











Annual Totals rate (m)

	Year-1 (m)	**Year-2 (m)**	**Year-3 (m)**	**Total (m)**
Precipitation (m)	5.5300E-01	7.0930E-01	7.6890E-01	2.0312E+00

Runoff (m)	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Evapotranspiration (m)	5.1278E-01	6.6270E-01	6.4910E-01	1.8246E+00
Change in water storage (m)	3.8306E-02	-5.5595E-03	1.6801E-02	4.9547E-02
Water budget balance (m)	-8.3052E-09	-1.0653E-08	-1.1548E-08	-3.0506E-08
Soil water (m)	4.3010E+00	4.2954E+00	4.3122E+00	1.2909E+01
Snow water (m)	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Lateral drainage collected from Layer 13 (m)	1.9188E-03	5.2162E-02	1.0300E-01	1.5708E-01
Percolation or leakance through Layer 15 (m)	4.9800E-08	2.0220E-07	3.6111E-07	6.1311E-07
Average head on top of Layer 14 (m)	5.2466E-05	1.4430E-03	2.8360E-03	
Average head on top of Layer 17 (m)	1.1628E-06	9.7719E-05	1.6290E-04	

Annual Totals volume (m3)

	Year-1 (m3)	**Year-2 (m3)**	**Year-3 (m3)**	**Total (m3)**
Precipitation (m3)	1.2166E+04	1.5605E+04	1.6916E+04	4.4686E+04
Runoff (m3)	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Evapotranspiration (m3)	1.1281E+04	1.4579E+04	1.4280E+04	4.0141E+04
Change in water storage (m3)	8.4273E+02	-1.2231E+02	3.6961E+02	1.0900E+03
Water budget balance (m3)	-1.8271E-04	-2.3436E-04	-2.5405E-04	-6.7112E-04
Soil water (m3)	9.4621E+04	9.4499E+04	9.4869E+04	2.8399E+05
Snow water (m3)	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Lateral drainage collected from Layer 13 (m3)	4.2213E+01	1.1476E+03	2.2660E+03	3.4558E+03
Percolation or leakance through Layer 15 (m3)	1.0956E-03	4.4484E-03	7.9445E-03	1.3489E-02

Accumulated rate (m)

	Year-1 (m)	**Year-2 (m)**	**Year-3 (m)**
Precipitation (m)	5.5300E-01	1.2623E+00	2.0312E+00
Runoff (m)	0.0000E+00	0.0000E+00	0.0000E+00
Evapotranspiration (m)	5.1278E-01	1.1755E+00	1.8246E+00
Lateral drainage collected from Layer 13 (m)	1.9188E-03	5.4081E-02	1.5708E-01
Percolation or leakance through Layer 15 (m)	4.9800E-08	2.5200E-07	6.1311E-07

Accumulated volume (m3)

	Year-1 (m3)	**Year-2 (m3)**	**Year-3 (m3)**
Precipitation (m3)	1.2166E+04	2.7771E+04	4.4686E+04
Runoff (m3)	0.0000E+00	0.0000E+00	0.0000E+00
Evapotranspiration (m3)	1.1281E+04	2.5860E+04	4.0141E+04
Lateral drainage collected from Layer 13 (m3)	4.2213E+01	1.1898E+03	3.4558E+03
Percolation or leakance through Layer 15 (m3)	1.0956E-03	5.5440E-03	1.3489E-02

Peak daily values

	Rate (m)	**Volume (m3)**	**Day**	**Year**
Precipitation	5.4900E-02	1.2078E+03	45	3
Runoff	2.9364E-03	6.4602E+01	200	3
Lateral drainage collected from Layer 13	9.4313E-09	2.0749E-04	200	3
Percolation or leakance through Layer 15	0.0000E+00	5.5440E-03	0	0
Snow water	7.3540E-03	1.3396E+01	0	0