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VOLUME IV

Environmental Assessment - Whytes Gully New Landfill Cell

Submitted to:
NSW Department of Planning and Infrastructure



REPORT

Report Number. 117625003_159_R_Rev1

wollongong
city of innovation

Golder Associates

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APPENDIX O

Preliminary Design Report

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WHYTES GULLY NEW LANDFILL CELL

Report for Preliminary Design

Submitted to:
Wollongong City Council

REPORT

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Distribution:

Wollongong City Council
Golder Associates

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1.0 INTRODUCTION

1.1 Report Context

This design report has been prepared on behalf of Wollongong City Council and presents a preliminary design (at 50% design status) for the proposed New Landfill Cell expansion project at the Whytes Gully Resource Recovery Park (RRP) near Kembla Grange, NSW. This design report forms part of the Environmental Assessment (EA) documentation for the proposed project.

This design report makes extensive reference to other relevant documents as listed in Table 1 below.

Table 1: Documents Relevant to Proposed New Landfill Cell Design

Document	Description	Location
Preliminary Design Documents		
Preliminary Design Drawings	engineering drawings (preliminary) with landfill construction details; refer Section 1.2 below	Appendix A
Preliminary Technical Specification	technical specifications for landfill construction materials and construction works (preliminary); includes construction quality management requirements	Appendix B
Information Documents - appended to this report		
Interpretative Geotechnical Investigation Report for 50% Design	interpretative report with geotechnical parameters for landfill design; includes slope stability and settlement analysis for the proposed project	Appendix C
International Peer Review	international peer review letter for the preliminary design	Appendix D
Information Documents - appended to Environmental Assessment (EA) document		
Environmental Site Assessment Reports relevant to the preliminary design	site assessments relevant to landfill design and operations with information on flora and fauna, site contamination, noise, and air quality	EA document- Appendices: - F: flora and fauna - G: site contamination - D: noise generation - H: air quality
Hydrogeological Site Investigation Report	report on results of the hydrogeological investigation at the site	EA document - Appendix G
Geotechnical Site Investigation Report	report on results of the geotechnical investigation at the site	EA document - Appendix G
Leachate Generation and Water Balance Modelling	report on estimated leachate generation rates and storage requirements	EA document - Appendix G
Surface Water Assessment Report	report on site surface water conditions and storage and management requirements	EA document - Appendix G
Landscape Strategy	plan and approach to revegetation of the final landform	EA document - Appendix N
LEMP– Draft Landfill Environmental Management Plan	draft documentation of environmental objectives and management strategies for landfill site operations; includes planned landfill staging; includes post-closure monitoring and maintenance protocols	EA document - Appendix P

1.2 Preliminary Design Drawings

The preliminary design drawings in Appendix A comprise 23 sheets which are referred to frequently in this report. For ease of reference, the drawing list is presented in the table below.

Table 2: List of Preliminary Design Drawings

Drawing No.	Revision No.	Drawing Title
Existing Information		
D001	B	Site Locality and Drawing List
D002	B	Site Plan
D003	B	Existing Contours and Easements
D004	B	Approximate Bottom of Existing Waste Plan
Final Landform		
D011	B	Waste Cutback Plan and Sections
D012	B	Staging and Subgrade Preparation Plan
D013	B	Subgrade Preparation Sections
D014	B	Final Cap Profile
D015	B	Final Landform Indicative Sections – Sheet 1
D016	B	Final Landform Indicative Sections – Sheet 2
D017	B	Indicative Sections Along Landform Edge – Sheet 1
D018	B	Indicative Sections Along Landform Edge – Sheet 2
D019	B	Indicative Sections Along Landform Edge – Sheet 3
Cell Base		
D021	B	New Cell Cross Sections
D022	B	Cell Base Liner Details
Piggy Back		
D031	B	Piggy Back Liner Details
Leachate Collection		
D041	B	Leachate Collection System Plan
D042	B	Leachate Collection System Details – Sheet 1
D043	B	Leachate Collection System Details – Sheet 2
Surface Water Management		
D051	B	Surface Water Management System Concept Plan
D052	B	Bench and Drop Structure Details
Final Capping		
D061	B	Capping Details
Landfill Gas Management		
D071	B	Piggy Back Gas Venting System Plan

1.3 Report Organisation

The remainder of this report is organised as follows:

- site conditions that are relevant to the design are presented in Chapter 2;
- the design approach is presented in Chapter 3;
- design features are described in Chapter 4;
- key issues for construction and for operation and maintenance are outlined in Chapters 5 and 6;
- technical references are given in Chapter 7; and
- limitations of this report are described in Chapter 8.

Supporting information is provided in the appendices of this report, including a letter resulting from an international peer review of this report (Appendix D).

2.0 SITE CONDITIONS

2.1 General

Whytes Gully RRP is located approximately 10 km to the south west of the Wollongong CBD and is approximately 65 ha in size. Whytes Gully RRP is generally bounded by Reddalls Road to the south and west, rural residential lands to the north, north-east and north-west, and a water treatment plant to the south east. Dapto Creek is also located to the immediate west of the site. The site vicinity is indicated in Drawing D001.

The wider area around Whytes Gully RRP includes the Illawarra escarpment to the north and west, and an industrial area to the south and south west of the site. The residential suburb of Farmborough Heights is located to the north east over a ridgeline, with the closest residents of this suburb approximately 360 m from Whytes Gully RRP. Two individual residences are within 120 m of the site boundary - one to the north of the Eastern Gully landfill and the other to the west of the Western Gully landfill - as visible in the aerial photograph presented in Drawing D002.

The site information provided in this chapter is relevant to preliminary landfill design. Detailed site information is provided in the documents identified in Table 1.

2.2 Topography and Hydrology

The west-northwest and eastern extents of the landfill area are bounded by ridgelines, referred to as the western ridge and eastern ridge. A central north-south trending ridgeline, referred to as the central ridge, separates the two existing landfill areas, the Western Gully landfill and Eastern Gully landfill (refer Section 2.6). The site rises from RL 15 m at the south west to RL 100 m at the north east. Refer to Drawing D003.

The current surface of the Western Gully landfill is generally sloped at approximately 5H:1V, with indistinct benches at 5 m to 10 m vertical intervals. The landfill surface above RL 80 m has gentler slopes, generally flatter than 10%.

The current surface of the Eastern Gully landfill has an upper platform portion where active landfilling is taking place, as well as a southwest-facing batter portion. The batter portion has an average slope of approximately 4H:1V and is terraced with benches at 2m to 3m vertical intervals, bench widths at 3m to 5m, and slope inclinations of 2H:1V to 3H:1V between benches.

The general surface water drainage direction on the site is from the north east towards the south west. The catchment area of the site is approximately 65 ha and extends from a ridge to the north of the site to Reddalls Road to the south. Run-on to the site is minimal due to the site being bounded by ridgelines.

Surface water runoff from covered areas of the Western and Eastern Gully landfills is captured by swales on the landfill surface. The swales divert the runoff towards drains around the perimeter of the landfills and to a central drain between the Eastern and Western Gully landfills. Runoff from the natural slope above the northern edge of the Eastern Gully landfill is also directed to the central drain.

Surface water runoff reports to the surface water ponds at the southwest corner of the site before discharge to Dapto Creek. Additional information on hydrology and surface water management is provided in Section 2.5.4 and in the Surface Water Assessment Report in Appendix G of the EA document.

2.3 Subsurface Conditions

2.3.1 Geology and Seismicity

Based on the 1:100,000 geological map 'Wollongong-Port Hacking', the site is on the boundary of two major geological formations. The southern part of the site is underlain by alluvial sands, silts and clays associated with nearby Dapto Creek, with sandstone of the Budgong Sandstone formation underlying these alluvial soils. The central part of the site is underlain by red, brown and grey lithic sandstone that forms part of the Budgong Sandstone formation. The northern portion of the site is underlain by interbedded lithic sandstone, coal, carbonaceous claystone, siltstone and claystone of the Pheasants Nest Formation. It appears that the Pheasants Nest formation is mainly encountered on the ridgelines.

The EIS (1982) for the Western Gully landfill indicates that prior to land-filling, volcanic sandstone covered most of the site with a transition to andesitic sandstone with coal seams, carbonaceous shale and mudstone in the higher section (above approximately RL 100 m) and a zone of alluvium, gravels and sands in the lower sections (below approximately RL 30 m). Bedrock is reported at the surface in the upper sections of the site.

The EIS (1992) for the Eastern Gully landfill notes that a relatively thick layer of colluvium was found along the base of the Eastern Gully. Soils are discussed further in Section 2.3.2.

The potential seismicity for the site has been assessed using Australian Standard AS1170.4-2007, specifically Structural design action Part 4: Earthquake actions in Australia. The Peak Ground Acceleration (PGA), probability factor, and hazard factor are obtained from AS1170.4 2007 Section 3, as follows:

- The design earthquake adopted for the site is equivalent to an event with an annual probability of occurrence of 1 in 500; and the Probability Factor (*kp*) associated with a 1/500 annual probability event is 1.0. Refer to Table 3.1 AS1170.4 2007 for values; and
- The earthquake hazard factor (*z*) is equivalent to an acceleration coefficient with an annual probability of exceedence in 1/500, and in the Wollongong vicinity is equal to 0.09. Refer to Table 3.2 AS1170.4 2007 for values.

The proposed design PGA for the Whytes Gully RRP site is therefore 0.09 g (α).

2.3.2 Stratigraphy

As indicated in Appendix C, the inferred subsurface stratigraphy generally consists of soil fill materials, landfill waste, colluvial / alluvial soils, residual soils and sandstone and siltstone rock.

The thickness of the soil and fill units varies throughout the site. The depth to sandstone and siltstone rock in the existing natural slope areas is relatively small, typically 3m or less.

Relevant information on soil and fill materials is given in the table below, with additional detail provided in Appendix C.

Table 3: General Description of Soil and Fill Materials

Material	Description
Fill - general	Fill was encountered in zones of the proposed Cell 1 to 4 area at the southern edge of the proposed landfill (refer Drawing D004). This area is also referred to as the new cell floor area. This fill had variable thickness and comprised clayey soils with sands. Observation indicates that thickness may be up to 5m in the vicinity of the existing landfill access road and recycling area.
Fill – existing landfill cap	Fill in the existing landfill cap comprises mixed soils (clays/sands) with pockets of gravels, slag and coal-wash. Thickness generally ranges from 0.5m to 2.0m.
Existing Landfill Waste	Landfill Waste is present beneath the existing landfill cap material in both the Eastern and Western Gully landfills. Maximum thickness is approximately 50 m in the Eastern Gully Landfill and 35 m in the Western Gully Landfill. Refer to Section 2.6 for additional information.
Colluvial and Alluvial soils	These soils comprise mostly silty clay and clay with zones of sands and gravels and traces of cobbles. Soils within 2 m to 3 m of the surface are soft to firm in parts and strength improves with depth. Clear distinction between the Colluvial soils on the lower slopes and the Alluvial soils at the base of the slopes is not generally possible. The maximum combined thickness of colluvial/alluvial soils within the proposed landfill footprint is approximately 16 m. Additional discussion is provided below.
Residual soil	Residual soil is mostly clay with varying quantities of gravel, silt and sand. The clay is medium plasticity and generally stiff to very stiff with zones of medium dense to dense sand. The maximum thickness of this material in natural areas of the site is approximately 2m. Additional discussion is provided below.

Discussion of colluvial soils

The "Geology and Natural Slope Stability Zones in the City of Greater Wollongong, Figure 19, Sheets 1 and 2" (Rec. Geol. Surv. NSW, 14(2): Bowman, 1972) characterise the upper natural slopes at the site as "moderately unstable, generally topographically high-relief land underlain by potentially unstable material requiring thorough investigation before development" and the site area at the toe of the natural slopes as "stable land with no landslip problems." This 1972 categorisation for the upper natural slopes is likely due to the observed presence of colluvium. Further, historical photographs taken from ground-level in the Eastern Gully at a time before landfill development, which have been provided to Golder by Council, show surface topography and conditions that are generally consistent with the presence of colluvial soils and potentially perched groundwater levels within the gully slopes.

We understand that colluvial and residual soil were excavated from the sloping portions of the Eastern and Western Gully landfill areas during preparation works prior to landfill development. This is based on discussion and photographs from with Mr. L. Monaghan of Council, who was involved in this operation. It appears that the slopes are likely to have been almost completely stripped to rockhead. However, it appears that colluvium and residual soils were only partially removed at the base of the natural slopes.

2.3.3 Groundwater

As indicated in the Site Hydrogeological Investigation Report (Appendix G of EA document), groundwater occurrence at the Whytes Gully RRP is generally associated with two shallow systems: groundwater present in the upper weathered and fractured profile of the local bedrock geology, and groundwater present in the colluvium/alluvium deposits that infill the two gullies at the site at the toe of the sloping topography. Water levels measured in wells installed within the shallow weathered bedrock in the sloping northern portion of the site generally range from 5 to 10 metres below ground level (mbgl), whereas water levels in wells installed in both the shallow bedrock and unconsolidated material in the flatter southern portion of the site are shallower, generally on the order of 1 to 3 mbgl.

Anecdotal information suggests that isolated springs were present in the mid and upper slopes of the two gullies prior to landfilling of these areas. The specific locations and characteristics of such springs are unknown.

2.4 Climate

Climate data for the Whytes Gully RRP site is presented in reports within Appendix G of the EA document, and also in the Draft LEMP (Appendix P of the EA document). Major climate factors are summarised below.

- Rainfall
  - annual rainfall: mean approximately 1.3 m; 90th percentile approximately 1.8 m.
  - The rainfall distribution throughout the year is higher for summer, with winter and spring months experiencing drier weather.
- Temperature
  - Average maximum air temperature (°C) is in the mid-to-high twenties in summer months and in the mid-to-high teens in winter months.
  - Freezing air temperatures are rare.
- Wind – Wind direction at the site is seasonal and is characterised by strong westerly winds during the winter months. North easterly winds dominate during the remainder of the year.

With regard to design and construction of the New Landfill Cell project, key climate considerations are that the site experiences relatively high rainfall, and can be hot and windy at times.

2.5 Site Infrastructure

2.5.1 Landfill Roads

The existing landfill access road is shown in Drawings D002 and D003. It is a two-lane, paved road extending approximately 1.7 km from the existing weighbridge at approximate elevation RL 20 m to the northern edge of the Eastern Gully Landfill at approximate elevation RL 75 m. The road traverses existing Western Gully waste for a distance of approximately 250 m at approximate elevation RL 65 m.

Access tracks suitable for 4WD vehicles extend: (a) from the landfill toe up the central ridge to the landfill access road; and (b) up the eastern ridge. These tracks are visible in Drawing in D002.

2.5.2 Easements

Easements within the New Landfill Cell project footprint are shown on Drawing D003. These are summarised below.

- An easement for the 132 kV overhead power transmission line which runs east to west across the site, situated south of the Eastern Gully landfill and north of Reddalls Road.
- A private power line easement is present in the northern part of the site and crosses the Western Gully landfill. It is understood this line is de energised and due for decommissioning.

In addition, although not in easements, overhead power lines and telephone lines run along Old Reddalls Road and water pipes service the staff amenities building.

2.5.3 Leachate Management

Leachate is collected from the Eastern Gully Landfill and Western Gully Landfill as described in Section 2.6 below and is piped to the Primary Leachate Pond. In the Primary Leachate Pond, the leachate is mixed and aerated and transferred to either the Leachate Treatment Plant or, depending on plant capacity, to the Secondary Leachate Pond for storage.

The Primary and Secondary leachate ponds are lined with 1.5 mm HDPE geomembrane liner and have a capacity to store 18,000 cu.m leachate with a 300 mm freeboard. Both ponds contain surface aerators located on pontoons. The primary leachate pond also contains an axial mixer. The design of the ponds is detailed in design drawings prepared by Forbes Rigby (2003).

The Leachate Treatment Plant is a biological treatment process using sequencing batch reactor (SBR) technology, with the capacity to treat up to 250 kL per day. The design of the leachate treatment plant is detailed in work as executed drawings prepared by URS Australia (URS, 2006). Treated leachate is discharged to sewer under a Trade Waste Agreement with Sydney Water.

Irrigation of leachate over landfill areas has historically been undertaken at the site but has not been practiced in recent years.

Additional information is provided in the Leachate Generation and Water Balance Modelling Report in Appendix G of the EA document.

2.5.4 Surface Water Management

As indicated in Section 2.2, surface water runoff from covered areas of the Western and Eastern Gully landfills is captured by swales on the landfill surface. The swales divert the runoff towards drains around the perimeter of the landfill and to a central drain between the Eastern and Western Gully landfills. Runoff from the natural slope above the northern edge of the Eastern Gully landfill is also directed to the central drain.

The perimeter drain around the Eastern Gully Landfill is grass lined. The perimeter drain around the Western Gully Landfill is mostly grass lined. The central drain is lined with a reno mattress.

Ponds originally constructed for the Western Gully landfill are located at the toe of the landfill (Drawing D002). The ponds comprise two surface water ponds with a capacity of 3,000 cu.m and 4,200 cu.m,

respectively and a former leachate pond with a capacity of 8,000 cu.m. These three ponds are currently used for temporary surface water storage. A fourth surface water pond, located at the toe of the Eastern Gully Landfill, collects surface water but also drainage from the groundwater underdrain system in the Eastern Gully Landfill (refer Section 2.6.2). These ponds are within the proposed footprint of the New Landfill Cell Project and will be decommissioned during construction of its first stage.

All surface water flows are eventually directed to the surface water pond system located on the south western portion of the site. The system is located in the south west corner of the site and comprises three reed beds (Reed Beds 1 through to 3) and an upper and lower surface water polishing pond. The total capacity of the surface water ponds system is 40,000 cu.m. Discharge from the ponds is to Dapto Creek.

Additional information is provided in the Surface Water Assessment Report in Appendix G of the EA document.

2.5.5 Other

An amenities building for site staff is located near the toe of the Eastern Gully landfill as indicated in Drawing D002. A car park is located outside this building. The building and its foundations will be demolished and its services decommissioned during construction of the first stage of the New Landfill Cell Project.

The previous site weighbridge is located on the landfill access road near the amenities building. The weighbridge and its foundations will be demolished during construction of the first stage of the New Landfill Cell Project.

2.6 Existing Landfill

The existing landfill comprises two filling areas located in the Western and Eastern Gullies. Filling of the Western Gully Landfill commenced in 1984 and finished in 1993, when filling of the Eastern Gully Landfill commenced. Filling of the Eastern Gully is projected to finish at the end of 2013. The development and existing engineering features of the two landfill areas are summarised in the following subsections.

2.6.1 Western Gully

Lining - The Western Gully Landfill is unlined.

Leachate Collection –Collection of leachate was initially via a central 100 mm diameter perforated pipe located at the base of the landfill. From discussions with Council staff we understand that this pipe did not have filter protection and became non-functional very early in the landfilling process. These discussions also indicate that an alternate leachate collection system was constructed with the following features:

a. leachate collection horizons were established successively at approximate 5m vertical intervals within the landfill mass; the first (lowest) horizon was at approximately RL 40 m and the last (highest) horizon was at approximately RL 60 m;
b. each horizon comprised a network of finger drains constructed of windrows of railway ballast-size gravel with no filter protection;
c. prior to constructing the finger drains at each horizon, the working landfill surface was prepared by placement and smooth rolling of a layer of silty coal washery rejects to create a fall toward a low point on the landfill batter (i.e., the southern batter);
d. at the low point on each horizon, flows in the finger drains enter a shallow 300 mm concrete or HDPE pipe and are conveyed to the base of the landfill batter; a pipe pit was installed at each horizon; and
e. at the toe of the landfill batter the shallow 300 mm pipe extends through the landfill bund wall to the current main leachate collection pit near the landfill access road; this pipe is indicated as an “existing leachate pipe” on Drawing D041. The shallow 300mm pipe will be replaced and upgraded prior to construction of the first stage of the New Landfill Cell project (refer Section 3.3.4); and the main leachate collection pit will be removed and the existing leachate flow directed into the new leachate collection system (refer 4.3.4).

The effectiveness of the alternate leachate collection system is uncertain. Measurements of current water levels in abandoned gas wells and observation of high surface moisture conditions and occasional surface

seepage on portions of the landfill batter suggest that accumulated leachate may be present within the Western Gully waste mass below RL 40m and possibly in local perched layers at higher elevations. This condition is discussed further in Section 3.3.4.

Volume - The Western Gully Landfill received approximately 980,000 cubic meters (cu.m.) of waste during its 9.5 year life from 1984 to 1993 (Forbes Rigby, 2001).

Filling **-** Landfilling commenced following the construction of a large soil bund wall at the toe of the landfill with a height of 5 m and a crest elevation of RL 35 m. The bund wall extends from one side of the Western Gully to the other. After site preparation, waste was subsequently placed in the gully behind the bund wall. Once waste was placed to the height of the bund wall, a second, smaller, bund wall was placed to an elevation of approximately RL 37.5 m. Waste was then placed to the crest level of the second bund wall. This filling technique of bund construction followed by waste filling was continued throughout the life of the landfill with each bund wall being approximately 2.5 m high. The maximum waste thickness is approximately 30 m.

Footprint – The approximate footprint of landfilling (i.e., extent of waste placement) is indicated in Drawing D003. The footprint area of the Western Gully Landfill is approximately 10 ha.

Bund wall and cover material was won from site preparation works prior to filling of each lift. The external bund wall surfaces were subsequently vegetated following completion of each lift.

Capping – the Western Gully Landfill is covered with a varying depth of cover materials comprising generally low to medium plasticity sandy clay ranging in thickness from 0.3 m to 2.5 m (Appendix C).

Landfill Gas Collection – Approximately 40 vertical landfill gas extraction wells were previously installed and operated in all areas of the Western Gully Landfill. These gas wells were abandoned in approximately 2005. Some or all of these wells may be exposed, renovated, and reactivated to restore active gas extraction prior to the start of construction for the New Landfill Cell project.

2.6.2 Eastern Gully

Leachate Barrier - The Eastern Gully landfill was constructed as a lined landfill, with the barrier component of the lining system comprising a high density polyethylene (HDPE) geomembrane liner (2 mm thickness). The HDPE geomembrane liner has a textured surface in sloped areas to enhance landfill stability. It is noted that the geomembrane liner was installed directly on top of a blanket underdrain, described below.

The Eastern Gully leachate barrier can be classified as a ‘single geomembrane liner’. We note that if the geomembrane liner had been installed on top of low-permeability soil layer, then the leachate barrier would be classified as a ‘single composite liner’ and would be expected to have significantly higher resistance to leachate leakage.

Groundwater Underdrain - The HDPE geomembrane liner is underlain by a groundwater drainage layer comprising an approximate 500 mm thick fine gravel layer that is intended to collect any groundwater seepage from natural materials below the liner. This layer incorporates an HDPE collection pipe that drains by gravity to the surface water pond at the toe of the Eastern Gully landfill, as indicated in Section 2.5.4 above. This pipe is identified as the “existing groundwater pipe” on Drawing D041. We understand that, for reasons outlined in Section 2.6.3 below, when high water levels develop in the surface water pond, the pond is pumped out to the leachate ponds rather than released into the surface water management system.

Leachate Collection - The HDPE geomembrane liner is overlain by a blanket leachate drainage layer comprising an approximate 300 mm thick clean sand layer. This layer incorporates two 300 mm diameter HDPE leachate collection pipes that drain by gravity to the toe of the landfill – one pipe drains Eastern Gully Stage 1 and the other pipe drains Eastern Gully Stage 2 (refer below for stage description). Each of these two pipes is identified as an “existing leachate pipe” on Drawing D041. These pipes currently pass through the HDPE geomembrane liner and are then connected to external pipes that drain to the current main leachate collection pit near the landfill access road at the toe of the Western Gully Landfill. These external pipes and the main leachate collection pit will be removed and the existing leachate flow directed into the new leachate collection system (refer Section 3.3.4 and Section 4.3.4).

Base lining and Filling – Base lining and landfilling has been undertaken in four stages. Stage 1 commenced in 1993 and was located in the upper portion of the Eastern Gully. Stage 2, located on the lower section of the Eastern Gully commenced in 2001. Stages 1 and 2 together received approximately 1,250,000 cu.m. of waste to the year 2004. Stage 3 is located over the Stage 1 and Stage 2 filling area and had an estimated 610,000 cu.m. capacity over a five year period (2004 to 2009). Stage 4, located in the upper portion of the gully over Stage 3 and Stage 1 is currently underway and has an estimated 750,000 cu.m. capacity over a four year period (2009 to 2013) with completion of filling expected in 2013. The maximum waste thickness at the completion of planned filling is anticipated to be approximately 50 m.

Footprint – The approximate footprint of landfilling (i.e., extent of waste placement) is indicated in Drawing D003. The footprint area of the Eastern Gully Landfill is approximately 10 ha.

Capping - Capping materials encountered had a variable composition of materials throughout the existing cap. The measured thickness of the capping ranges from 0.1 m (GAHA04) to 0.6 m (GAHA01) across the Eastern Gully landfill (Appendix C).

Landfill Gas Collection – Approximately 30 vertical landfill gas extraction wells were previously installed and operated in the Eastern Gully Landfill, primarily in the Stage 3 portion. These gas wells were abandoned in approximately 2005.

Rainforest Area – An area between the current northern limit of the Eastern Gully Landfill and the property boundary has been identified as an Endangered Ecological Community (EEC) - "Illawarra Subtropical Rainforest." This is discussed further in Chapter 13 of the EA document.

2.6.3 Discussion of Existing Eastern Gully Landfill Liner

The collection pipe for the groundwater underdrain in the Eastern Gully Landfill was described in the preceding section. Recent sampling and testing of outflow from the groundwater pipe, as well as previous observations by landfill staff, suggests that water collected in the groundwater underdrain is likely impacted by leachate. The source of leachate is not known and it could hypothetically arise from: (i) leachate seepage travelling from the unlined base of the Western Gully Landfill through natural materials and into the underdrain; or from (ii) leakage of leachate collected at the base of the Eastern Gully Landfill through flaws in the overlying HDPE geomembrane liner into the underdrain.

Due to the likely presence of leachate, the groundwater collection pipe will connected into the new leachate collection system during construction of the first stage of the New Landfill Cell project (refer Section 3.3.4 and Section 4.3.4).

Further, because identification of the leachate source and location of entry into the underdrain is not practicable at this time, we have adopted for the preliminary design a classification of "uncertain" for the current performance of the existing Eastern Gully leachate barrier. The performance and environmental risks associated with the existing Eastern Gully leachate barrier may be considered further at the time that the project is advanced to detailed design.

2.6.4 Settlement Potential

Compared to most natural foundation materials, landfill waste has a high potential to exhibit large short-term and long-term settlements, as well as lateral deformations, due to its high compressibility and decomposition potential. Settlement potential of waste depends on a number of material characteristics including age since placement, composition, organic content, total thickness, degree of initial compaction, and moisture content.

Waste settlement is typically considered over both 'short term' and 'long term' time frames. Short-term refers to settlement occurring in response to loading and generally within a few months of load application. Attributed mechanisms for short-term waste settlement are physical, primarily particle breakage and/or rearrangement into a denser structure. Long-term refers to settlement that generally occurs over a period of decades, at a diminishing rate, and is not directly associated with any load application. Attributed mechanisms for long-term waste settlement are chemical/biological rather than physical, being primarily decomposition of organic materials resulting in conversion of solid mass to landfill gas.

Evaluation of the potential effects of waste settlement on the proposed engineering features of the New Landfill Cell Project, particularly landfill lining and capping systems, is a key component of the design process. Such evaluation should include if practicable a site-specific assessment of waste compressibility through measurement and analysis of ongoing surface settlements and/or through surface loading trials conducted in previously landfilled areas. Measurements and loading trials are underway at the site at the time of preparation of this preliminary design report, and results will be incorporated at the time of detailed design. For this preliminary design, evaluations have been performed using typical published values for waste settlement potential. To put the issue in context, preliminary values calculated for long-term settlement of the existing waste materials range up to a maximum of approximately 5 m (refer Appendix C), confirming that waste settlement is a significant issue for the project.

3.0 DESIGN APPROACH

3.1 Project Capacity Requirements

3.1.1 Waste Type and Landfilling Rate

Current estimates indicate that the currently approved plans will provide landfilling capacity until late 2013. This existing capacity is available in the upper elevation of the Eastern Gully landfill. The New Landfill Cell project is required to provide ongoing landfill capacity, after the existing capacity is exhausted, for placement of up to 180,000 tonnes of Council municipal solid waste and cover soils per year. This tonnage rate is assumed to correspond to a volumetric rate of 140,000 cubic metres per year (i.e. average landfill density of 1.3 t/cu.m.).

Please refer to the Chapter 8 of the EA for further information on waste types and anticipated quantities.

3.1.2 Landfill Capacity and Staging

The term “airspace” refers to the available volume for landfill material placement between an upper and a lower surface, with the upper surface typically corresponding to the design levels for the top of a planned landfill. The New Landfill Cell project is required to develop additional landfill airspace that is sufficient to provide for 40 years or more of landfill operations at the rate indicated above (i.e. airspace consumption rate of 140,000 m^3/yr). The project is required to be developed in a number of workable stages with each stage providing at least two years of landfill airspace.

Please refer to the Chapter 4 of the EA for additional discussion of the required additional landfill capacity.

3.1.3 Geometric Constraints

Key geometric constraints for the landform to be created for the New Landfill Cell project are given below.

- The landform will be completely within the current property boundaries, with sufficient setback for a full perimeter access track and drainage channels, as well as for a 5 m wide area for potential nature strip planting on the western ridge boundary.
- The landform will remain between the natural eastern and western ridge lines.
- The maximum landform elevation is to be generally consistent with the current design which has a maximum elevation of RL 105 m as indicated in Drawing D003.
- The southern extent of the landform will not impinge on the easement for the 132 kV overhead power transmission line (Section 2.5.2), except for the portion of the existing Eastern Gully Landfill that currently extends approximately 5 m into the easement (Drawing D003).
- The northern extent of the landform at the eastern gully will not impinge on the “Illawarra Subtropical Rainforest” flora in this vicinity (refer Section 2.6.2), except for a small area near the central ridge where the detailed flora assessment, presented in Appendix F of the EA document, has concluded that disturbance will not result in a significant impact.

3.1.4 Piggy Back Filling

In order to satisfy the landfill capacity requirement and geometric constraints identified above, the preliminary design includes placement of a substantial thickness of new waste over the existing waste in the Eastern Gully and Western Gully Landfill areas. This is referred to as piggy back filling, and is depicted in the cross sections on Drawings D015 and D016. The maximum piggy back fill thickness is approximately 40 m above the Western Gully Landfill and 30 m above the Eastern Gully Landfill.

Piggy back filling of existing landfill areas may require specific engineering measures for environmental protection. In particular, lining systems are sometimes constructed at the interface between the existing waste and the overlying new waste. Such lining systems are commonly referred to as “piggy back” systems. The use of piggy back lining for the New Landfill Cell project is described in Section 3.3.2 below.

3.2 Environmental Requirements

3.2.1 Overall Environmental Assessment

Potential environmental impacts arising from construction and operation of the New Landfill Cell Project are comprehensively assessed in the EA document. The assessments have considered the features of the preliminary design (e.g. overall geometry, progressive stages of construction and landfilling, construction requirements, engineering features) and have identified environmental mitigation measures, where required, for the most critical stages of construction and operation. The assessments have also considered the features of the Eastern Waste Cutback (refer Section 4.2.3). It is noted that initial results from some of the assessments resulted in design changes which were then reflected in the final assessment results.

The environmental assessments have included the following:

- air quality, including potential odour and dust generation;
- noise;
- flora and fauna;
- heritage;
- traffic;
- visual amenity; and
- soil and water.

Additional information is provided in the relevant sections and appendices of the EA document.

3.2.2 Regulatory Design Requirements

NSW Guidelines

The preliminary design for the New Landfill Cell is generally consistent with the NSW EPA *Environmental Guidelines: Solid Waste Landfills 1996* (Landfill Guidelines). These are the most current NSW guidelines considered applicable to the project.

An assessment of the preliminary design with respect to the Landfill Guidelines benchmark techniques is provided within the Cover Statement of the Draft LEMP document. We consider that all benchmark techniques are met or exceeded, or suitable alternatives proposed. It is noted that the Landfill Guidelines do not contain specific requirements for piggy back filling and/or piggy back liners.

Surface water management elements of the preliminary design have been developed in relation to the NSW Department of Environment & Climate Change guidelines *Managing Urban Stormwater, Soils and Construction – Volume 2B Waste Landfills 2008* (Landfills Blue Book).

Best Practice Design

The preliminary design for the New Landfill Cell project incorporates measures to reflect “best practice landfill design and operation”, as suggested by Clause 123 of the NSW *State Environmental Planning Policy (Infrastructure) 2007*. For design aspects where Golder considers that the 1996 Landfill Guidelines do not reflect current best practice, the Victoria EPA document *Best Practice Environmental Management: Siting, Design, Operation and Rehabilitation of Landfills 2010* (herein referred to as the BPEM) has been used as a guiding document for best practice. The BPEM is believed to be the most recent Australian regulatory guideline that adopts current generally accepted international best practices.

BPEM guidelines have been adopted for most aspects of the liner system and leachate collection system design, and for other landfill design elements where indicated in this Design Report. It is noted, however, that the BPEM does not contain specific guidelines for piggy back filling and/or piggy back liners and Golder

has therefore adopted a design approach that extends the BPEM liner design guidance and is consistent with our project experience.

3.3 Key Design Issues

3.3.1 General

In addition to satisfying the landfill capacity requirements, site geometric constraints, and regulatory requirements identified in the preceding sections, the preliminary design addresses key design issues as described below.

3.3.2 Need for Piggy Back Lining System

Landfilling of new waste for the New Landfill Cell project will occur in both: (i) areas underlain by existing waste, i.e. piggy back filling areas as indicated in Section 3.1.4; and (ii) areas of natural ground. Different base lining systems will be required to suit these different underlying conditions. The use of piggy back lining in the areas underlain by existing waste is described in this section. The base lining system proposed for areas of natural ground is not discussed in this section as it is not considered a key design issue for the site, but is discussed in Section 4.3.4.

Construction of a piggy back lining system in both the Eastern Gully and Western Gully piggy back fill areas is considered prudent for the project based on the existing landfill conditions (Refer Sections 2.6.1 to 2.6.3) and the environmental factors outlined below.

Leachate Control

Leachate generated within new waste placed above the existing landfill areas is generally expected to migrate vertically downward by gravity. In the case that no piggy back lining is constructed then leachate from new waste would eventually report to the base of the existing landfill with the following potential consequences:

- Western Gully Landfill – leachate reporting to the base of the existing landfill could potentially cause an impact to groundwater due to the lack of a base lining system in the Western Gully Landfill.
- Eastern Gully Landfill - leachate reporting to the base of the existing landfill could potentially cause an impact to groundwater due to the uncertain current performance of the existing Eastern Gully leachate barrier (Section 2.6.3). Further, even without the performance uncertainty, the existing Eastern Gully leachate barrier is classified as a ‘single geomembrane liner’ and does not meet the current best practice design standards of “single composite liner” (Section 4.3.1).

In the case that a piggy back lining is constructed then leachate from new waste in both the Eastern Gully and Western Gully piggy back fill areas could be collected in a new leachate collection system installed on top of the piggy back lining. The new leachate collection system would be designed to function independently of the existing leachate collection systems. If the piggy back lining and leachate collection systems are designed to comply with best practice standards (i.e.,BPEM) then the risk of groundwater impact from new waste would be considered acceptable..

Implications for Landfill Gas Control

Landfill gas generated from new waste could be drawn upward with active gas extraction systems and its fate would not depend on the presence or absence of a piggy back lining. However, collection and/or migration of landfill gas generated in existing waste would be affected by the presence of a piggy back lining as indicated below.

- Movement of gas currently being generated in the existing waste is not controlled and migration pathways are uncertain. It is likely that installation of a piggy back liner would affect migration with a bias toward increased lateral migration.
- Although there are currently no gas extraction wells in existing waste at the site, we understand that there are plans to initiate active gas extraction from existing waste in both the Eastern Gully and

Western Gully Landfills, via vertical wells, prior to the start of construction for the New Landfill Cell project. A piggy back lining system would interrupt such vertical wells. In addition, it will not be possible to install vertical gas wells into existing waste in areas of piggy back lining after the piggyback lining is in place because such wells would penetrate and locally disrupt the piggy back lining.

In order to address these issues, design of the piggy back lining will include both: (i) gas collection vents beneath the piggy back lining to reduce the risk of increased lateral gas migration; and (ii) features to allow ongoing collection of gas from any vertical extraction wells that may be installed prior to piggy back lining construction. Refer to Section 3.3.3.3 for additional discussion.

3.3.3 Piggy Back Lining Design Considerations

Certain design issues may be of key importance for a piggy back lining system, although they are often insignificant for typical base liners established on natural ground. Key issues relevant to the proposed piggy back lining for piggy back fill areas are presented below. Piggy Back Lining design features are discussed further in Section 4.3.3.

3.3.3.1 Potential for Deformation of Piggy Back Lining System

Compared to most natural foundation materials, landfill waste has a high potential to exhibit large short-term and long-term settlements due to its high compressibility and decomposition potential (refer Section 2.6.4). Such settlements can result in distortion of the original geometry of the lining system, through differential movements, and overall changes in lining system slopes, through total settlement. Waste can also exhibit large lateral deformations that depend on the geometry of the existing and new waste masses, and that can have similar effects on lining systems.

Settlement and lateral deformation potential of waste depends on a number of material characteristics including age since placement, composition, organic content, total thickness, degree of initial compaction, and moisture content.

Design for piggy back liners must address the potential effects of long term foundation settlement and lateral deformations, considering the waste material characteristics (as above) and geometry. For detailed design, this should ideally include a site-specific assessment of waste compressibility through analysis of historical settlements in previously filled areas and/or through surface loading trials conducted in previously filled areas. Settlement measurements and loading trials are underway at the site at the time of preparation of this preliminary design report, and results will be considered at the time of detailed design.

3.3.3.2 Effect of Deformation on Lining System Integrity

Behaviour and Analysis

Any differential movements imposed on the piggy back lining system will distort its original geometry and thereby induce strains in the lining system materials. This will include tensile strain, compressive strain, and shear strain. The lining system will come to equilibrium with the imposed deformations, including locally redistributing strains depending on the stiffness properties of the lining system materials and the interfaces between layers. Strain redistribution can also be affected by local variations in lining system geometry or waste thickness and by the presence of vertical gas wells or other gas collection infrastructure below the lining system.

In general, if equilibrium strains are within the allowable range for the materials comprising the barrier layers (i.e., very low-permeability layers) within the lining system, then shear or tensile failure of materials will be prevented and lining system integrity maintained.

Design of the piggy back lining should therefore consider the range of conditions across the piggy back fill area and should ideally include the following design/analysis items:

a) identification of characteristics and geometry of existing waste, existing capping soil materials that will form the lining subgrade, and new waste;

b) selection of lining system materials and thicknesses;

c) estimation of imposed differential movements due to waste deformation;

d) calculation of corresponding equilibrium strains including local strain redistribution; and

e) assessment against allowable strains of lining system materials.

We note that items c) and d) will require a displacement-based analysis such as finite element or finite difference analysis.

Design Considerations

Piggy back lining system design often includes selection of materials for barrier layers that have relatively high allowable tensile strains. For example, linear low-density polyethylene (LLDPE) geomembranes and geosynthetic clay liners (GCLs) are often selected. Compacted clay layers are not generally selected because their allowable tensile strains under some confining stress states can be significantly lower than other available materials.

Design features that may reduce the strain levels that develop in piggy back lining system materials include: (i) a lining subgrade layer constructed of engineered fill; (ii) incorporation of high tensile stiffness geosynthetic materials (i.e. geogrid) into the lining subgrade; and (iii) provision of preferential slip layers. A preferential slip layer is a very low stiffness and/or shear strength interface between adjacent lining system materials such that deformation-induced shear strains cannot transfer across the interface and induce significant tensile strains within barrier layer materials. In effect, shear strains can be localised along the preferential slip layer to shield the barrier layers.

However, due to the hillside configuration of the existing waste surface in much of the piggy back fill area with slopes of 4H:1V to 5H:1V (refer Section 2.6), slope stability requirements dictate that preferential slip layers are not advisable for the project. Therefore, design features (i) and (ii) indicated above have been considered in detail for the New Landfill Cell project. Slope Stability is discussed further in Section 3.3.6.

3.3.3.3 Landfill Gas Collection

Continuing operation of any vertical gas extraction wells that are installed in the existing waste prior to the start of construction for the New Landfill Cell project may be a factor that will affect the piggy back liner design. In general, the need to maintain gas extraction would depend on the quantum of future gas generation expected at the time of piggy back lining construction. As indicated in Section 3.3.2, the piggy back lining system design will include features to allow ongoing collection of gas from vertical wells in underlying waste.

Such design features would need to address the potential large magnitude of settlement and lateral deformation that will likely occur in the piggy back lining system after construction and overlying waste placement (refer Section 3.3.3.1). In addition, the top of any vertical gas well pipe will not settle as much as the piggyback lining system (i.e. pile effect), resulting in locally large differential settlements. Differential lateral deformation is not considered to be as significant an issue as differential settlement because of the relatively small lateral stiffness of the gas well pipe.

General options for these design features are described below.

- *Well Cut Off*: (i) Cut off vertical well below piggyback lining elevation; (ii) construct a lateral extraction flowline, below the piggyback lining, to the edge of the piggy back fill area; and (iii) install a high flexibility connection between the top of the cut off well and the lateral flowline. Major technical issues to be addressed with this approach include identifying a safe depth below the piggy back lining for the vertical well cut off and designing a sufficiently flexible connection, with both these issues are dependent on the potential magnitude of differential settlement. Other issues for this option include potential challenges in achieving extraction over the long flowline distance that would be needed to reach the northern edge of the landform (i.e., up to 300 m) and managing gas condensate within such a long flowline. An advantage of this option is that the piggy back lining at the gas well location would be continuous at the time of installation.

- *Piggy Back Penetration*: This option would comprise an engineered penetration of the piggy back lining system to provide for vertical extension of the gas well through overlying new waste and to accommodate differential settlement between the gas well and the piggy back lining. Major technical issues to be addressed with this approach include maintaining drainage in the piggy back leachate collection system at the penetration and minimising the potential for vertical leachate migration through the penetration, with both these issues dependent on the potential magnitude of differential settlement. An advantage of this option is that reliable gas extraction is more likely to be maintained because the typical vertical well configuration is preserved.

The preliminary design does not identify a preferred design option. It is appropriate to address this issue at the time of detailed design when additional information is available regarding the actual or likely locations of gas wells in the existing waste and the results of the settlement loading trial and detailed surface settlement measurements that are currently being undertaken at the site.

3.3.3.4 Effect of Deformation on Leachate Collection System

Any differential movements imposed on the piggy back lining system will alter the drainage grades within the leachate collection system and also induce strains in the leachate collection system materials.

With respect to drainage grades, the piggy back lining would generally be constructed on the relatively steep existing landfill slopes of 4H:1V to 5H:1V. In this circumstance, downslope leachate drainage is anticipated to be maintained in the long-term. It is considered highly unlikely that waste deformation could alter the lining system geometry to a degree that overall down slope leachate drainage was disrupted on the slopes. This has been assessed for the preliminary design. A relatively flatter area of piggy back lining will need to be constructed on the northern portion of the Western Gully Landfill, and for this area a minimum grade will be established during detailed design to address long-term (i.e., post-settlement) requirements for positive leachate drainage.

With respect to material strains, there are a number of candidate materials for the piggy back leachate collection layer, in particular drainage aggregate/sand with filter geotextile and geocomposite drain. A geocomposite drain comprises a polymer geonet drainage core sandwiched between filter geotextiles. Both candidate materials have relatively high allowable tensile strains, but differ in other characteristics. In particular, they may differ significantly in thickness and internal and interface shear strength. The preliminary design has considered these factors.

3.3.3.5 Short-Term Lining System Stability

The risk for the piggy back lining to become unstable, or to locally uplift, due to pressure from landfill gas or leachate generated in the waste beneath the lining will be assessed as part of the design. This risk may be present due the nature of the barrier layer materials in the lining system to restrict gas and liquid flow. This is considered a short-term issue because the risk is generally significant only immediately after lining construction before substantial confining stresses have developed from material placement above the piggy back lining.

The gas pressure risk can be managed as part of detailed design through selection of lining system materials with appropriate material and interface properties and with gas depressurisation measures. As indicated in Section 3.3.2, the piggy back lining system design will include the following gas management measures which will provide the required depressurisation: (i) gas collection vents beneath the piggy back lining; and (ii) features to allow ongoing collection of gas from any vertical extraction wells that may be installed prior to piggy back lining construction.

Leachate seepage on the existing landfill slopes, for example from perched leachate within the existing waste, may also present a short- term risk for destabilising uplift pressure on the piggy back lining system in local areas. This would be managed by temporary shallow subsurface drainage of any observed local saturated/seepage zones, to be determined at the time of piggy back liner construction. On the Western Gully slope, where surface seepage is more likely, another management option is installation of local shallow subsurface drainage with connection to the shallow leachate collection system that is proposed to be replaced as indicated in Section 3.3.4.

3.3.4 Leachate Management

Key design issues for leachate management for the New Landfill Cell project are discussed below.

Gravity Drainage

Given the hillside nature of the site, the design can incorporate leachate collection system drainage grades such that leachate from all new waste areas will be collected and removed from the landfill via gravity flow. No internal pumping wells with leachate risers through the waste mass are needed. This approach will generally provide a passive, high-reliability, drainage system with minimal long-tem maintenance and power requirements.

Existing Leachate Drainage - Eastern Gully Landfill

The existing leachate collection system and groundwater underdrain for the Eastern Gully Landfill were described in Section 2.6.2 and Section 2.6.3.

The design will provide for ongoing collection of leachate from the two existing leachate collection pipes by directly connecting these pipes into the new leachate collection system. It is noted that connection of the existing leachate collection pipe from Eastern Gully Stage 2 will first require locating the point where the pipe penetrates the existing HDPE geomembrane liner and then excavating soil materials to expose the pipe just outside the penetration point. The design will also provide for ongoing collection of water, which is likely impacted by leachate, from the existing groundwater underdrain collection pipe by directly connecting this pipe into the new leachate collection system (refer Section 4.3.4).

Existing Leachate Drainage - Western Gully Landfill

The existing leachate collection system for the Western Gully Landfill was described in Section 2.6.1 to have uncertain effectiveness such that accumulated leachate may be present within the Western Gully waste mass below RL 40m and possibly in local perched layers at higher elevations.

The preliminary design has been prepared assuming that the measures outlined below will be implemented prior to the start of construction of the New Landfill Cell project. These proposed measures would be intended to reduce environmental risks associated with potential for leachate migration into groundwater and surface water.

- The first proposed measure is construction of a drainage collection trench to the base of the existing waste along the alignment of the uphill side of the existing soil bund wall at the landfill toe (approximate trench length 100 to 150m). The outlet from the drainage trench would be a pipe installed to extend from the base of the trench, through the existing soil bund wall, to a point at the downhill toe of the berm (approximate pipe length 40 m). This proposed pipe is identified as the “proposed leachate pipe for existing Western Gully Landfill” on Drawing D041.

- The second proposed measure is replacement of the existing 300 mm shallow leachate drainage pipe and pits on the landfill slope that are described in Section 2.6.1. The current effectiveness of this pipe is uncertain. Further, the concrete elements of the pipe and pits will pose a protrusion and/or puncture risk to the piggy back lining system and are generally strain intolerant and likely to function less effectively after piggy back filling of the area due to differential settlements and stress increases that will develop.

  The existing pipe is proposed to be replaced with a flexible pipe (HDPE), without pits, in order to minimise protrusion and/or puncture risks for the piggy back lining system and to provide a system with high strain-tolerance so that leachate collection and drainage can be maintained after piggy back filling. Construction would also include enhancement with new shallow finger collection drains to areas of known high surface moisture and/or surface seepage. A supplemental benefit of this measure is to reduce the likely occurrence of saturated surface conditions that could lead to difficulties in preparing the subgrade for piggyback lining construction.

The preliminary design provides for ongoing collection of leachate from the proposed drainage trench outlet pipe and replacement shallow leachate drainage pipe by directly connecting these two pipes into the new leachate collection system (refer Section 4.3.4).

The need for the proposed measures outlined above may be further assessed during detailed design if additional information on existing leachate levels and waste thickness within the lower portion of the Western Gully Landfill is obtained.

Leachate Management System Capacity

The capacity of the existing leachate management system has been assessed as part of the preliminary design. Recommendations for the New Landfill Cell project have been developed, including site operational measures to reduce leachate generation rates and modifications to the existing leachate storage and treatment system. This information is presented in the Leachate Generation and Water Balance Modelling Report in Appendix G of the EA document.

3.3.5 Groundwater Separation

A key issue for the design of the New Landfill Cell project is achieving an acceptable vertical separation between the bottom of new landfill waste and the top of the groundwater table in all areas. Although various approaches can be adopted with respect to minimising risk of groundwater contamination from landfill leachate, and construction of landfill liners below the groundwater table is suitable in some circumstances, it is generally accepted that greater separation distances result in reduced risk.

Measured groundwater levels at the site that have been used to develop the preliminary design are discussed in Section 2.3.3. It is noted that construction of the New Landfill Cell project is generally anticipated to result in falling groundwater levels beneath the liner.

Based on BPEM guidance (Table 5.1 in BPEM), the preliminary design has been developed to maintain a 2 m vertical separation distance between waste and the groundwater table. The separation distance primarily impacts design of the new cell areas as indicated below.

- In the lower lying areas of new base liner for the project, specifically the southern portion of Cells 1 to 4 shown in Drawing D012, measured groundwater levels may as high as 1 m below ground level. Therefore, in these areas the design requires placement of imported fill VENM (virgin excavated natural material) to raise liner subgrade levels such that the elevation of the base of waste in the lowest areas, at the leachate sumps, will maintain the target separation distance and such that suitable grades are achieved for leachate drainage.

- In the areas of the existing Central Ridge and Western Ridge , being Cells 2A, 2B, and 4A shown in Drawing D012, measured groundwater levels generally range from 5 m to 10 m below ground level. Therefore, in these areas the preliminary design limits the depth of excavation to establish liner subgrade levels to 5 m. This is considered appropriate to maintain the target separation distance in almost all areas and will be subject to modification as needed during detailed design. It is noted that the excavation depth limit of 5 m also results in a limit to the quantity of natural material that will be excavated for potential use in landfill construction and operational.

3.3.6 Slope Stability

Slope stability is a key design issue for several elements of the New Landfill Cell project. The hillside nature of the site and the presence of colluvial and alluvial soils in some areas accentuate the need to consider this issue. Further, the site is in an identified seismic zone and therefore slope stability under earthquake loading conditions will be assessed.

Slope stability requirements are expected to significantly influence the landfill elements given below.

- Final landform batter angle: maximum slope angle permissible for global stability of the final landform and for stability of the final capping system

- Interim landform batter angle: maximum slope angle permissible for stability of temporary landfill slopes at various stages of landfill development
- Lining Systems: shear strength requirements for materials, and interfaces between materials, within both the piggy back lining system and the cell base lining system
- Final Capping System: shear strength requirements for materials, and interfaces between materials, within the capping system; and also the water drainage capacity of these materials

Target slope stability factors of safety for the analyses are as given in the table below. The selected target factors of safety for slope stability are consistent with those commonly accepted by the geotechnical profession to provide an acceptably low risk of slope instability.

Table 4: Target Slope Stability Factors of Safety for Preliminary Design

Landfill Element	Loading: Static or Earthquake	Material Shear Strengths: Peak or Residual	Target Minimum Factor of Safety
Global stability of final landform slopes	static	peak	1.5
	static	residual	1.2
	earthquake	peak	1.1
	earthquake	residual	1.0
Global stability of interim landform slopes	static	peak	1.3

The target values in the table above for final landform slopes will also apply for veneer slope stability analysis of the final capping system that will be prepared during final design (refer Section 4.4.2).

Slope stability analysis results are discussed subsequently in Section 4.8. Analysis details are provided in Appendix C.

3.3.7 Surface Water Drainage

Given the hillside nature of the site and the relatively high rainfall environment, a key issue for the design of the New Landfill Cell project is achieving a passive and high-reliability surface water drainage system that will minimise the potential for interaction between surface water and landfill waste. Required features for such a system are to include:

- unrestricted storm water flow paths without water storage or detention, except within the existing surface water ponds system;
- all flow by gravity with no pumping required;
- open channel stormwater flow with no piped flow, except at road culverts;
- no run-on to landfilled areas; and
- permanent drainage channels located outside the landfill footprint.

In the context of achieving these required features, a very significant issue for the project design is management of surface water at the northern boundary of the Eastern Gully Landfill area. Further, minimal disturbance of the identified EEC rainforest in this area is also a design requirement (refer Section 3.1.3). Landform design options relating to this issue are discussed in the Chapter 5 of the EA document with the selected option requiring major works, i.e., implementation of the Eastern Waste Cutback (refer Section 4.2.3) as part of the project.

3.3.8 Excavated Materials

Soil and highly weathered rock materials will be generated from excavations to prepare the site for landfill construction. These materials will be generally suitable for landfill operational use, primarily as daily cover material. This is a significant issue due to the high cost of importing, and particularly paying the NSW landfill levy, for the large quantity of daily cover material needed for landfill operation.

In existing natural slope areas, excavation for landfill construction will generally be limited by the relatively thin soil thickness, typically 3 m or less (refer Section 2.3.2), and the relatively high groundwater table as noted in Section 3.3.5.

Existing fill and excess landfill cover soils which are present in some developed areas, and which have lost VENM status due to landfilling operations, are likely suitable for excavation and re-use as daily cover.

Excavated materials are also discussed in Section 4.3.5.

3.3.9 Landfill Staging

Given the hillside nature of the site and associated surface water management issues (refer Section 3.3.7), and the proposed size and longevity of the New Landfill Cell project, landfill staging is a key design issue.

The general activities identified below will occur progressively at the site during the lifetime of the project. It is noted that construction works activities will be episodic, likely executed through a series of individual construction contracts, while landfilling will be continuous.

- Landfill base construction – comprising construction of lining system, perimeter bunds and surface water channels, intercell bunds, and leachate collection system.
- Landfilling – normal landfill operation and environmental management, including landfill gas extraction and temporary capping.
- Final Capping construction – comprising capping construction and revegetation of capped areas.

In addition, the Eastern Waste Cutback works will occur as a major works activity early in the project.

The New Landfill Cell project is to be developed in a series of stages that accommodate the activities listed above and allow for the following site controls to be continuously implemented;

- maintaining controlled surface water drainage from the landfill footprint and upslope areas;
- minimising leachate generation;
- maintaining effective leachate management; and
- maintaining acceptable site stability, particularly for interim waste batters.

Another requirement is that suitable access roads are needed at all times for landfilling, and also needed simultaneously for all episodes of construction works. For example, the current landfill access road (refer Drawing D003) passes though the area where landfill base construction will occur in first stage of the New Landfill Cell Project, i.e. Cell 1. Therefore, a replacement landfill access must be constructed in another area prior to liner base construction.

Due to the relatively large elevation difference between the lower areas of the site, at approximate RL 20 m, and the higher areas, at approximate RL 100 m, maintaining acceptable grades on access roads is a significant issue. Loaded waste transport trucks and some construction plant cannot transit excessively steep grades.

The preliminary staging plan developed in consideration of the issues and requirements given above, and the need for feasible site operations, is discussed further in Section 4.2.5.

4.0 DESIGN FEATURES

4.1 Environment Protection Measures

An overview of the principal environmental protection measures incorporated into the New Landfill Cell design is provided in the table below. These measures are described subsequent sections.

Table 5: Principal Environmental Protection Measures incorporated into New Landfill Cell Design

System	Protection Measure	Function
Cell Base Liner	Barrier	Limit infiltration of leachate through the cell base
	Leachate collection system	Remove leachate from above the base liner and thereby limit the potential for contaminant migration through the base liner
Piggy Back Liner	Gas collection system	Remove landfill gas from beneath the piggyback liner to prevent pressure build up and discourage lateral migration
	Barrier	Limit infiltration of leachate from new waste into existing waste
	leachate collection system	Remove leachate from above the piggyback liner and thereby limit the potential for contaminant migration through to existing waste
Cell Capping	gas collection system	Remove landfill gas from beneath the cap
	barrier	Limit infiltration of water and oxygen into the landfill and contain waste
	subsurface drainage system	Drain infiltrating rainwater from above the barrier liner
	topsoil (vegetation growth medium)	Support vegetation growth to limit erosion from the cap and to provide visual amenity; provide sufficient thickness to reduce potential for human contact with cell materials
Surface Water	cap drainage	Collect and convey runoff from rainfall on the landfill
	perimeter drain	Collect and control runoff from cap drainage and run-on from upslope areas

A construction quality management system will be in place for landfill construction because the performance of these environmental protection measures, particularly the cell liner, piggy back liner and cap barrier, is known to be highly dependent on the quality of their construction (refer Section 5.1).

These measures are designed to be operated and maintained to provide long-term performance (refer Section 6.0).

4.2 Landform

4.2.1 Overall Characteristics

The proposed final project landform is shown in Drawing D014, which includes final cap contour levels and landform extent, or footprint. Overall characteristics of the landform are summarised in the table below. Slope stability is discussed in Section 4.8.

Table 6: Characteristics of Final Landform for New Landfill Cell Project

Characteristic	Description
Footprint	The landform footprint is roughly rectangular and measures approximately 850 m (E-W) by 550 m (N-S), extending between the crests of the natural eastern and western ridge lines at the site. The footprint includes pulling back from the current extent of waste by up to 35m in the area of the proposed Eastern Waste Cutback (Drawing D011). The total landform footprint area is approximately 35 ha.
Elevation	The peak of the landform is at elevation RL 111 m. From the high point, slopes extend to the north to meet the natural ground surface at RL 75m to RL 95m. The lowest point of the landform is at RL 19 m along the southern edge, with a 500 m length of the southern edge at RL 25m or less.
Piggy Back Filling	Approximately half of the landform footprint is piggy back fill area where new waste will be placed over the existing Eastern Gully and Western Gully Landfills. The piggy back fill area is approximately 17 ha and is indicated by the region labelled 'piggy back area" on Drawing D012. Piggy back filling is indicated in the cross sections in Drawings D015 and D016 where new waste overlies existing waste and piggy back liner is present. For the Eastern Gully Landfill, the maximum existing waste thickness is approximately 50 m and the maximum new waste thickness is approximately 30 m. The maximum new waste thickness occurs on the eastern edge of the Eastern Gully, with the maximum new waste thickness along the gully centreline limited to approximately 15 m. For the Western Gully Landfill, the maximum existing waste thickness is approximately 30 m and the maximum new waste thickness is approximately 40 m.
Batter Slopes	The principal landform batter is south and southwest-facing with a maximum height of greater than 80 m and a 4.5H:1V average inclination. North and east-facing batters have an average inclination of 4H:1V and a maximum height of 30 m. Landform batters will include near-horizontal slope benches at 10 m vertical intervals, resulting in slope inclinations between benches 4H:1V on the principal batter (refer Drawing D014, section G) and as steep as 3.5H:1V on the north and east-facing batters. The purpose of the slope benches is to reduce runoff velocity and erosion potential for the final capping system, to increase overall landform slope stability, and to provide access on the slope for capping system and gas extraction system inspection and maintenance. A small area near the peak of the landform has relatively flat design grades (5%).
Access and Perimeter Features	The landform design allows for access around the entire site perimeter and to the landform summit for groundwater monitoring, site inspection and maintenance, and bushfire protection, with road details to be developed during final design. The design also includes surface water drains along the entire perimeter, with combined drains/access tracks in some areas. In addition, the design setback distance of 20 m along the western ridge property boundary also provides space for a nature strip if required. Typical edge details for the landform are given on Drawings D017 to D019. The distance between from the design limit of landfill waste placement to the closest adjacent residence buildings is approximately 70 m for the residence near the western ridge and 160 m for the residence to the north of the Eastern Gully Landfill area. It is noted the design limit of landfill waste placement is approximately 10 m inside the edge of the landform footprint.

4.2.2 Airspace

The design provides a total new landfill volume of approximately 6 million cu.m., measured between the liner subgrade surface (Drawing D012) and the final cap profile (Drawing D014). This corresponds to approximately 40 years of landfill life based on an airspace consumption rate of 140,000 cu.m. per annum (refer Section 3.1.1), therefore satisfying the project lifespan requirement identified in Section 3.1.2.

4.2.3 Eastern Waste Cutback

In order to achieve gravity drainage of surface water around the perimeter of the final landform, the design includes that the existing eastern batter of the Eastern Gully Landfill will be excavated (cutback) and the waste material relocated to Stage 1 of the project. These works are shown in Drawing D011 with key design elements described below.

- 300,000 cu.m. (approximate) of existing waste material would be excavated and relocated.
- The total footprint area of the cutback is approximately 40,000 sq.m. A minority of this area will have its entire thickness of existing waste excavated, identified by the shaded area labelled with Note 2 on Drawing D012, while the majority of this area will have partial waste excavation.
- The cutback will establish a drainage channel alignment on natural ground extending from the northern edge of the landform at elevation RL 75 m to a location at elevation RL 73 m on the eastern ridge. The drainage channel length will be approximately 400m with an average design slope of 0.5%, which is a small slope but considered acceptable.
- Edge details for the cutback area are shown in Drawing D019.

Cutback works should begin as soon as sufficient lined areas in Stage 1 are available to accommodate the relocated waste, simultaneously with normal waste placement operations. When the cutback is complete and surface water drainage can be directed along the eastern edge of the landform, then any temporary diversion channels on the existing Western Gully Landfill surface can be decommisioned (e.g. the diversion channel shown in Section F on Drawings D013).

4.2.4 Power Transmission Easement

Along the southern edge of the landform, the design provides for a 5 m separation distance between the 132 kV power transmission easement and the landform. This is depicted on Drawing D018 (Section F) where the final cap profile is shown terminating 5 m outside the easement, with the perimeter access road and the outer perimeter drain within the easement. In preliminary discussions, the easement owner has indicated the proposed design is acceptable. This will required confirmation from the easement owner at the time of detailed design.

The portion of the existing Eastern Gully Landfill liner that currently extends approximately 5 m into the easement (Drawing D003) will be considered further at the time of. Given that this occurs in a relatively steeply sloping area of the eastern ridge, and is more than 100 m from the nearest transmission tower, it is considered likely that this will not affect easement access and will not require modification. This will required confirmation from the easement owner at the time of detailed design.

4.2.5 Staging

Overview

The design provides for the New Landfill Cell project to be constructed in five major stages as indicated in Drawing D012 - Stage 1, Stage 2A, Stage 2B, Stage 3 and Stage 4. The staging generally advances from east to west, with a combination of new base liner cell and piggyback liner cell construction and waste placement and piggy back filling. As filling in each stage is completed, capping can occur, resulting in progressive rehabilitation proceeding from east to west throughout the life of the project. A summary of the each stage is provided in the table below.

Table 7: Stage Volumes and Timelines for the New Landfill Cell Project

Stage	Base Liner Cells	Piggy Back Liner Cells	Total Stage Area (m^2)	Available Stage Airspace [1] (cu.m.)	Approximate Life of Stage [2] (Years)	Proposed Construction Start
1	1	1	82,000	912,000	4.4 [3]	2013
2A	2A	2A	22,500	343,000	2.4	2017
2B	2, 2B	2B	81,200	2,134,000	15.2	2019
3	3	3	67,200	1,589,000	11.3	2035
4	4, 4A	NA	69,000	1,007,000	7.2	2046
TOTAL			**321,900**	**5,985,000**	**40.5**	

Notes: 1. Available airspace within each stage assumes interim landfill batters sloped at 3H:1V (refer below)
2. Based on average airspace consumption rate of 140,000 cu.m. per annum.
3. Stage 1 includes placement of 300,000 cu.m. of waste relocated from Eastern Waste Cutback.

The Overall staging sequence is summarised as follows:

- Stage 1 covers the Eastern Gully landfill, a section of the Western Gully landfill and a non-landfilled area at the foot of the Eastern Gully landfill that is occupied by roads, buildings, and stormwater infrastructure.

  In order to divert stormwater from the northern side of the Eastern Gully landfill to the southern side, approximately 300,000 cu.m. of waste will be removed from the eastern portion of the Eastern Gully landfill (i.e. Eastern Waste Cutback). This waste will be placed into the Stage 1 area..

- Stage 2 covers part of the Western Gully landfill, a non-landfilled area at the toe of the Western Gully landfill that is occupied by roads and stormwater infrastructure and also the non-landfilled central ridge.

- Stage 3 covers part of the Western Gully landfill and a non-landfilled area at the toe of the Western Gully that is occupied by roads, the green waste process area and stockpiling areas.

- Stage 4 covers an area to the west of the Western Gully landfill that has previously not been landfilled as well as a non-landfilled area at the toe of the Western Gully landfill that is currently occupied by roads and the Primary and Secondary Leachate Ponds.

Interim Landfill Batters

As the project advances from east to west, the leading edge will generally comprise west-facing landfill batters. These leading-edge batters are temporary and each will be subsequently covered by landfilling during the subsequent stage. The design has adopted a slope inclination of 3H:1V for all temporary landfill batters, which is steeper than the average final landform batters of 4.5H:1V, based on the need to maximise available airspace within each stage and maintain acceptable levels of slope stability. With respect to slope stability, it is noted that the west-facing temporary landfill batters have a generally favourable alignment in that hillside slopes are predominately south-facing.

Slope stability is discussed further in Section 4.8

Staging Feasibility - Access and Surface Water Management

As indicated in Section 3.3.9, the hillside nature of the site must be fully considered in establishing a feasible landfill staging plan. This is because site topography can create constraints to effective storm water drainage and to providing access roads with acceptable grades for both project construction (episodic) and for landfilling operations (continuous).

To confirm the feasibility of the design staging plan, a series of staging drawings have been developed that depict the site at eleven stages of project development, that is with approximately two sub stages for each of

the five major stages. These staging drawings are presented in the Landfill Master Plan which is part of the Draft LEMP (Appendix P of the EA document). These staging drawings include the elements listed below.

- Temporary landfill batters
- Temporary access roads
- Permanent access roads
- Landfilling areas
- Liner construction areas
- Final capping areas

Storm water runoff drainage paths for each stage are also presented in Drawing D051 and discussed in Section 4.5.

4.3 Base of New Landfill

4.3.1 Lining System Configuration

The Victoria BPEM indicates that the leachate barrier at the base of a municipal waste landfill should comprise a single composite liner (Table 6.1 in BPEM). The term “single composite liner” refers to a two-component liner where the upper layer is a welded geomembrane placed in intimate contact with a lower layer of low-permeability clay. The performance of composite lining systems in minimising leachate escape from landfills is known to be significantly better than that of single-component lining systems (e.g., Rowe, 2005). This is particularly true of composite liners using a geosynthetic clay liner (GCL) as the lower component.

Use of a single composite liner exceeds the standard indicated by the NSW Landfill guidelines but is considered consistent with modern international practice for landfill design. Therefore, the base liner design for this project has adopted the more stringent approach from BPEM to provide a single composite liner in all new lining areas (both cell base liner and piggy back liner). The design also provides a continuous blanket leachate collection layer directly above the liner, consistent with both the NSW Landfill Guidelines and the BPEM.

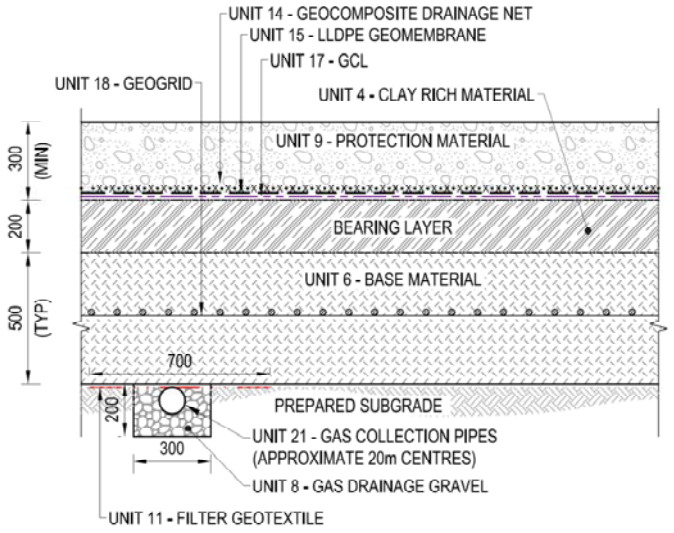
Selection of lining system and leachate collection system materials for the design has also considered the following requirements:

- materials must be durable and resistant to degradation from potential long-term exposure to cell leachate in the temperature and pressure range expected at the cell base;
- materials must maintain acceptable performance when subjected to anticipated deformations, particularly within the piggy back lining system (refer Section 3.3.3); and
- Internal shear strengths and interface shear strengths must be consistent with project requirements to maintain acceptable levels of slope stability.

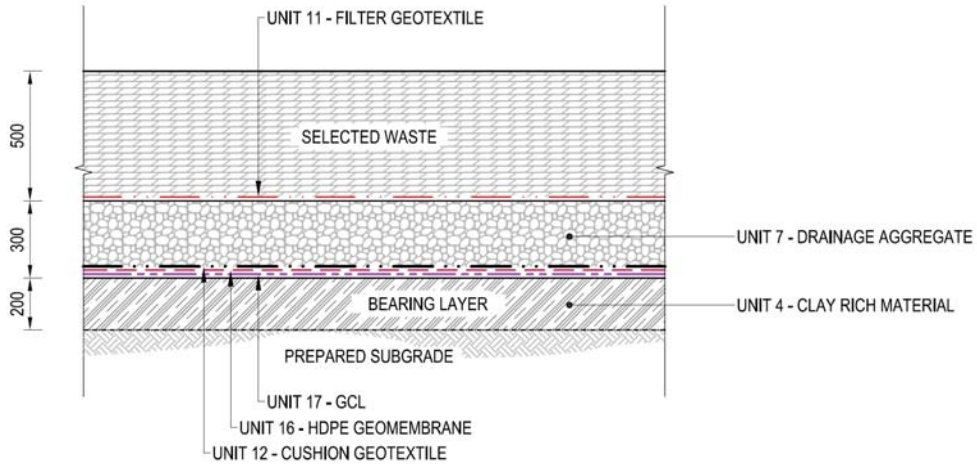
4.3.2 Design Elements

The primary components for the design and construction of landfill base areas are summarised in the following table. Lining system profiles are indicated in Figure A below (refer Drawings D022 and D031). Additional detail is provided in subsequent sections 4.3.3 to 4.3.5.

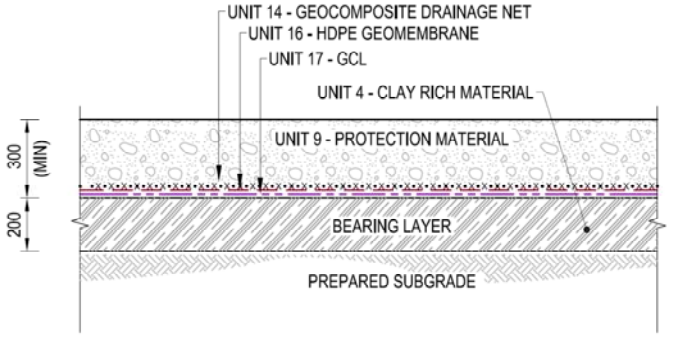
Figure A – Lining System Details



PIGGY BACK LINER



CELL BASE LINER FOR CELLS 1 TO 4



CELL BASE LINER FOR CELLS 2A, 2B & 4A

Table 8: Summary of Landfill Base Components

Component [listed from bottom to top]	Base Lining System for Southern Extension [Cells 1, 2, 3 & 4]	Base Lining System for Ridge Areas [Cells 2A, 2B & 4A]	Piggy Back Lining System for Piggy Back Fill Areas [PB Cells 1, 2A, 2B, & 3]
Subgrade Preparation	a. Cut/fill natural and fill materials in higher areas to create smooth liner grades. b. Fill in lower areas to achieve target groundwater separation distance, including at sumps. c. Proof roll and replace or recompact identified soft zones.	a. Cut natural material to achieve liner grades. b. Maximum 5 m cut depth to maintain target groundwater separation. c. Proof roll and replace identified soft zones.	a. Minor cut/fill existing cover soil in W. Gully area to create smooth liner grades. b. Cut existing cover soil and terrace bunds in E. Gully area to create smooth liner grades. c. Proof roll and replace or recompact identified soft zones.
Base Elevation	a. Establish suitable grades for leachate drainage; allow for foundation soil settlement. b. Establish suitable grades such that sumps will gravity drain to an external drain line with acceptable invert depth	a. Grades for leachate drainage will be readily achieved due to the sloping nature of the area.	a. Liner elevation generally corresponds to existing landfill surface. b. Grades for leachate drainage will be readily achieved due to the sloping nature of the area.
Landfill Gas Collection (beneath lining system)	None. Landfill gas collection not needed. No existing waste in this area.	None. Landfill gas collection not needed. No existing waste in this area.	a. Features to allow continuing collection of gas from vertical wells in existing waste (refer Section 3.3.3.3). b. Gravel trenches (periodic) with venting pipes.
Foundation Layer	None. Not needed.	None. Not needed.	Compacted base material (500 mm) with geogrid reinforcement
Liner Bearing Layer	Compacted clay soil (200 mm)	Compacted clay soil (200 mm)	Compacted clay soil (200 mm)
Lining System	Single composite liner: textured HDPE geomembrane overlying GCL	Single composite liner: textured HDPE geomembrane overlying GCL	Single composite liner: textured LLDPE geomembrane overlying GCL
Leachate Collection	Drainage aggregate (300 mm) with periodic collection pipes	Geocomposite drainage layer with periodic collection pipes	Geocomposite drainage layer with periodic collection pipes
Lining System Cover	None. Not needed.	Protection material (300 mm)	Protection material (300 mm)

4.3.3 Piggy Back Lining System

This section presents the preliminary design for the lining system in piggy back areas. The piggy back areas are those shaded in Drawing D012, comprising Piggy Back Cells 1, 2A, 2B and 3. This section concludes with Table 11 which presents the major components and key properties of the piggy back lining system.

Settlement and Deformation Analyses

The potential for settlement and deformations in the existing waste below the piggy back lining system to affect the integrity of the system was discussed in Section 3.3.3. Therefore, settlement and deformation analyses have been conducted to predict the magnitude of long-term tensile strains for the preliminary design of the piggy back lining system (refer Appendix C), comprising: (i) settlement analyses along cross sections through the proposed landform; (ii) deformation analyses, by the finite element method, along a

critical cross section through the proposed landform; and (iii) deformation analyses, by the finite element method, at hypothetical local areas of higher deformation in the existing waste (i.e. soft spots).

For the cross-sectional analyses (i) and (ii), the existing waste is assumed to be homogenous such that differential settlements/deformations arise from the changes in waste geometry along the cross section. For the local soft spot analysis, differential settlements/deformations arise from the predicted formation of a circular settlement depression centred on the soft spot. It is noted that the analyses were conducted in stages, with initial results leading to design changes which were then reflected in the final analyses results that are presented in Appendix C.

Results of the analyses are summarised in the following tables. The results indicate that the soft spot scenario is the most severe with respect to tensile strains in the piggy back lining system and that the design features given in the following subsection are required to address this scenario.

Table 9: Cross-Sectional Settlement & Deformation Analysis Results - Piggy Back Liner (Long-Term)

Analysis Type [1]	Cross Section Location [2]	Max. Settlement	Max. Tensile Strain in Lining System
Settlement	W. Gully centreline (Section F-F')	4.0 m	0.5 % [3]
Settlement	E. Gully centreline (Section H-H')	5.0 m	0.2 % [3]
Deformation	W. Gully centreline (Section F-F')	3.1 m	2.2 %

Notes: 1. Settlement analysis considers vertical displacements only. Deformation analysis considers both horizontal and vertical displacements.
2. Cross section locations indicated in Appendix C (i.e., within App. A of that document)
3. Strain reflects average value in 25 m intervals between settlement calculation points.

Table 10: Local 'Soft Spot' Deformation Analysis Results - Piggy Back Liner (Long-Term)

Scenario	Max. Tensile Strain in LLDPE Geomembrane [1] and GCL [2]	Max. Tensile Strain in Geogrid Reinforcement [1]	Max. Settlement at Centre of Soft Spot [3]	Radius of Settlement Depression (approx.)	Max. Settlement at Edge of Settlement Depression [3]
Soft Spot – 'Base' case	2.7 %	1.1 %	2.2 m	8 m	1.9 m
Soft Spot – 'Softened Landfill' case	8.8 %	3.6 %	3.3 m	6 m	2.2 m

Notes: 1. Computed max. tensile strain occurs at the 'shoulder' of the circular settlement depression.
2. GCL strain assumed equal to that in adjacent LLDPE geomembrane
3. Settlement of LLDPE geomembrane at indicated location

The waste compressibility parameters used in the settlement and deformation analyses were based on the indicative value range presented by Gourc and Olivier (2005) for waste of 'intermediate' compressibility, with values from the 'high to very high' range used for the soft spot waste. These analyses may be revised at the time of detailed landfill design to reflect any design changes and to consider site-specific waste compressibility parameters obtained from the results of the settlement measurements and loading trials that are underway at the site at the time of preparation of this preliminary design report.

Design of Foundation Layer

The maximum long-term tensile strain for the LLDPE geomembrane and GCL from the analyses is 8.8%, as given in Table 10 above. This value can be compared to a maximum allowable tensile strain value of 8% for textured LLDPE geomembranes as identified in the Victoria BPEM guidance (Table D2 in BPEM). For GCL materials, no specific tensile strain limits are identified in the Victoria BPEM, however, published technical

information indicates that typical GCL materials are capable of undergoing more than 10% tensile strain without significant reduction in ability to maintain very low permeability performance, including performance across GCL overlap joints (LaGatta et al., 1997). For the purpose of preliminary design, the computed tensile strains are considered to be acceptable, subject to further design refinement during detailed design regarding strain in the LLDPE geomembrane.

The analyses indicate that a relatively stiff foundation layer for the piggy back lining is required to be constructed on the prepared subgrade material in order to attenuate the differential deformations arising from compression of the soft spot waste. The foundation layer also provides additional separation distance between the soft spot waste material and the lining system. The foundation layer adopted for the preliminary design has the following characteristics:

- 500 mm thick layer of compacted soil that is well-graded and predominately coarse-grained, with significant gravel content to interlock with the reinforcement material (see note regarding layer thickness at end of this sub-section); and
- incorporating at mid-layer a geosynthetic reinforcement material, most likely a biaxial geogrid, with a minimum long-term design tensile stiffness of 500 kN/m in the relevant tensile strain range (i.e., max. 5% strain); note: the stiffness value is to reflect the average for the four principal directions in the plane of the material, being MD (machine direction), XMD (cross machine direction), and the two diagonal directions between the MD and XMD.

These design features will be used in all piggy back lining areas because the hypothetical occurrence of a soft spot is taken as equally likely in all areas.

The analyses in Appendix C also considered whether differential movements in the piggy back lining system could reverse drainage grades within the leachate collection system. The cross-sectional analyses concluded that there were no grade reversals for the piggy back lining system suggested by the analysis results. This issue will be further considered during detailed design, including assessment of leachate drainage along additional cross sections perpendicular to the centrelines of the Eastern and Western Gully.

The soft spot analyses indicate potential for the LLDPE geomembrane to settle up to 1.1 m more at the centre of the soft spot than at the edge of the settlement depression approximately 6 m away (refer ‘Softened Landfill’ case in Table 10) . This indicates a differential settlement of 1:5.5, suggesting that positive leachate drainage will be maintained where the overall slope of the piggy back liner is steeper than this value, which is the case for the large majority of the piggy back liner area. This result supports the need for the foundation layer design features outlined above. For the purpose of preliminary design, the computed grade changes are considered to be acceptable, subject to further consideration during detailed design of grade changes arising from hypothetical soft spots in the flatter portions of the piggy back liner.

It is noted that the soft spot analyses in Appendix C have been performed using a foundation layer thickness of 300 mm, rather than the thickness of 500 mm that has been conservatively adopted for preliminary design. One aspect of detailed design will be to assess the effect of this favourable thickness difference on calculated tensile strains and grade changes in the lining system.

LLDPE Geomembrane

The piggy back lining system design includes a 1.5 mm textured LLDPE geomembrane. LLDPE material has been selected, in preference to HDPE, primarily due to its higher allowable tensile strain. Specifically, the Victoria BPEM identifies, as indicated in the previous sub-section, a maximum allowable tensile strain of 8% for textured LLDPE geomembrane but only 4% for textured HDPE geomembrane. The difference in allowable strain arises because LLDPE has superior multi-axial strain characteristics, and in particular has an indistinct tensile yield point and therefore more resistance to stress cracking.

Although HDPE is known to have superior resistance to chemical degradation, and higher stiffness and strength that gives it superior ability to span foundation voids, these advantages are considered insufficient to outweigh the higher allowable strain of LLDPE. The higher extensibility of LLDPE is a major advantage for tolerating significant foundation differential settlement, as is expected in the piggy back lining system. A

potential disadvantage of LLDPE, its greater susceptibility than HDPE to local puncture due to its lower stiffness and strength, has been addressed in the design through selection of non-aggressive geosynthetics and soils as the surrounding materials in the lining system. The potential for the LLDPE geomembrane to be indented by the ribs of the geonet component (HDPE) of the geocomposite drain has been identified as a hypothetical risk and will be assessed during detailed design, and addressed if necessary.

Leachate Collection System for Piggy Back Liner

The preliminary design of the piggy back lining system includes placement of a blanket leachate collection layer over the entire piggy back lining area, as indicated in Section 4.3.1. Candidate materials for this blanket layer were discussed in Section 3.3.3.4 and comprise a drainage aggregate layer or a geocomposite drain. For the relatively steep slopes of the piggy back lining, up to 4H:1V, we consider that a geocomposite drain will provide the better balance of flow capacity, constructability, and shear strength. The system also includes a network of slotted leachate collection pipes to intercept and remove leachate flowing within the geocomposite drain.

The preliminary arrangement for the Leachate Collection System is shown on Drawing D041. The contours on this drawing are from Drawing D012 and represent the top of prepared subgrade for lining system construction, and therefore reflect the design grades for leachate drainage. The operational concept for leachate collection from new waste is via drainage solely under gravity as follows: (a) migration downward into the blanket geocomposite drainage layer; (b) lateral flow within the geocomposite in the direction of the top of liner grade with an approximate 50 m (maximum) flow distance from point of entry into the blanket to the nearest slotted leachate collection pipe; (c) flow into a pipe and then along the leachate collection pipe network; and (d) flow (within pipe) across the cell base liner area into one of four leachate sumps in Cells 1 to 4. Leachate flow out of the sumps is described in Section 4.3.4.

This operational concept generally presumes that leachate flowing within the geocomposite drain will be intercepted at the nearest slotted leachate collection pipe. Flow interception promotes: (i) rapid removal of leachate, through pipe flow; (ii) minimising leachate head build up on the geomembrane; and (iii) reducing the required flow capacity of the geocomposite drain because leachate collected in higher areas of the geocomposite drain does not need to be conveyed through lower areas of the geocomposite drain (i.e., downslope flows are not additive). The detail shown in Drawing D043 “leachate collection pipe for piggy back cell cross-slope pipes” promotes flow interception because the geocomposite drain for the higher area terminates at the leachate collection pipe, and is not directly connected into the geocomposite for the lower area. The detail indicates a gap of approximately 1 m between the higher and lower geocomposite drains.

Geocomposite Drainage Layer: The preliminary design includes a geocomposite drain comprising a non-woven filter geotextile bonded to both sides of an HDPE geonet drainage core. The primary purpose of the lower geotextile, which will be placed in contact with the underlying textured LLDPE geomembrane, is to enhance the shear strength of the geocomposite-geomembrane interface. A secondary purpose is to cushion the geomembrane from contact with the geonet core. The primary purpose of the upper geotextile is to act as a filter to restrict migration of fine particles into the leachate collection system and therefore provide protection against blinding and/or clogging of the system. Internal and interface shear strength of the geocomposite drain is discussed in Section 4.8

The type of geocomposite products suitable for the project will be manufactured with selvage (roll edge) construction with both geotextiles extending beyond the geonet core. This allows secure joining of adjacent sheets by overlapping the lower geotextiles, butting and tying together the geonet cores, and overlapping and seaming the upper geotextiles via field sewing or hot-air (thermal) tacking.

For the preliminary design, the required geocomposite drainage material flow capacity has not been selected. This will be done during detailed design, taking into account potential leachate collection rates and factors that affect geocomposite design flow capacity, such as clogging potential, intrusion of the upper and lower geotextile into the geonet core, normal stress and expected temperature range (relevant to compression and creep of the geonet core), and drainage grades/gradients. It is noted that typical pre-settlement grades in the piggy back lining will be 5H:1V or steeper, but that minimum grades will be approximately 3% in the upper portion of the Western Gully landfill. Suitable geocomposite drains for the piggy back lining system will likely be from the high end of available product ranges.

Leachate Collection Pipes: The preliminary design includes cross-slope and down-slope perforated leachate collection pipes, with the layout in Drawing D041. The pipes will be manufactured with high grade HDPE to provide chemical durability and high flexibility. Each pipe will be installed with a gravel surround, as shown in the details on Drawing D043, in order to provide physical protection for the pipe as well as provide a contingency flow path in the case of local pipe failure or blockage. Pipe socks will not be permitted due to their known clogging potential in landfill leachate collection systems – rather the gravel surround will include a non-woven geotextile wrap for filtration protection. Pipe perforations will be relatively large, approximately 10 mm to 15 mm diameter drilled holes, to minimise clogging potential.

For the preliminary design, the pipes have not been sized. This will be done during detailed design, taking into account potential leachate flow rates, clogging potential, dimensions/wall thickness needed for long-term crushing resistance under piggy back fill loads, and pipe grades. It is noted that typical pre-settlement pipe grades will be 2% or greater. Based on project experience, it is likely that HDPE leachate pipes in commonly available diameters (typically 200 mm to 300 mm) and wall thicknesses will be suitable. This diameter range is also large enough to allow pipe inspection and clean out.

The pipe system layout provides for access to main collection pipes for inspection and clean out tools, such as water jetting rigs, at fifteen perimeter points and at the five leachate sump risers. These locations allow for major segments of the pipe system to be accessed without having to negotiate sharp bends or corners.

Landfill Gas Collection

The preliminary design includes a landfill gas venting system to provide for drainage of gas present immediately beneath the piggy back lining system in order to prevent pressure build up and discourage lateral migration (refer Section 3.3.2). This system can be considered to provide a contingency in the case that the planned active gas extraction systems for the existing waste are incomplete, ineffective, or out of service. The preliminary design of the gas venting system comprises (i) cross-slope gas venting trenches on relatively close spacing, approximate 20 m centres; with the trenches connected into (ii) upslope gas venting header pipes (refer Drawing D071). The venting trench spacing will be finalised during detailed design.

- Each gas venting trench will comprise a shallow trench, excavated into the prepared subgrade for the piggy back lining system, containing a perforated gas collection pipe surrounded by gas drainage gravel. A gas venting trench detail is shown as part of the piggy back liner detail on Drawing D031. . The gas collection pipes will be perforated 110 mm diameter HDPE pipes. The gravel will be durable natural gravel, crushed rock, or recycled concrete.

- The design includes seven gas venting header pipes. These pipes will be will be solid wall and designed and sized during detailed design. The top of each header pipe will be connected to the active gas extraction system infrastructure. The bottom of each header pipe will be connected to the leachate collection system (Drawing D071) to provide free drainage of any leachate/gas condensate entering the header pipe.

Internal Bunds

Internal bunds between cells and sub-cells in the piggy back lining system will be constructed to provide a physical barrier to waste and water movement during sequential lining and landfilling. An example is illustrated in Section F on Drawing D013. The location of the primary internal bunds is shown on Drawing D012. An internal bund detail is presented in Drawing D031.

Lining System Components

Each primary component of the piggy back lining system and leachate collection system is described in Table 11. Additional material requirements are provided in the preliminary Technical Specification (Appendix B).

Table 11: Piggy Back Lining System Primary Components

Key Material Requirements [refer Drawing D031]	Purpose	Discussion
Foundation Layer [500 mm thickness]		
▪ Clean (uncontaminated), well-graded sandy or gravelly soil; free of organic matter ▪ Gradation: max. particle size 40 mm; retained on 4.75 mm sieve > 30 %; Fines > 5% and < 25% ▪ Compacted to > 98% SMDD ▪ Mid-layer geosynthetic reinforcement material (e.g., biaxial geogrid) with stiffness properties as discussed in sub-section above "Design of Foundation Layer"	▪ Provide stiff layer to attenuate differential deformations arising from waste 'soft spots' ▪ Provide surface to facilitate compaction of the overlying liner bearing layer	Refer sub-section above "Design of Foundation Layer" .
Liner Bearing Layer [200 mm thickness]		
▪ Clean (uncontaminated) clayey soil; free of organic matter ▪ Gradation: Max. particle size 16 mm; Passing 2.4 mm sieve > 90%; Fines > 30% ▪ Plasticity index>15% ; Liquid Limit > 25% ▪ Emerson crumb classification > 4 ▪ Compacted to > 95% SMDD and within ±2% SOMC	▪ Provide appropriate surface for deployment of GCL ▪ Supplement composite liner effect achieved by GCL-geomembrane liner	*Surface Preparation*: The bearing layer material must be compacted and prepared to provide an appropriately smooth and even surface for deployment of the GCL. The maximum particle protrusion from the prepared surface will be limited to 10 mm. The maximum particle size limitation will minimise installation damage to the GCL. *Clayey Soil*: A clayey soil is specified for the bearing layer to provide an additional layer of relatively low-permeability soil to supplement the composite liner effect of the primary liner (i.e., GCL and geomembrane).
GCL - Geosynthetic Clay Liner [reinforced] [Layer of bentonite clay sandwiched between geotextile layers; overlapped sheets]		
GCL Product: • Internally reinforced by needle punching • mass (dry): total> 4000 g/m^2; bentonite >3700 g/m^2 • tensile strength > 4 kN/m; peel strength > 360 N/m • permeability (cross-plane): 100kPa effective confining stress: tap water: k < 5 x 10^{-11} m/s; deionised water with 0.1M $CaCl_2$: k < 5 x 10^{-10} m/s, conducted after permeation with tap water	▪ Provide very low permeability mineral barrier layer ▪ Produce composite liner effect in combination with overlying geomembrane ▪ Provide smooth surface for deployment of geomembrane	Refer to the Technical Specification regarding requirements for: *GCL deployment*: overlap dimensions and treatment between adjacent rolls; orientation such that the upper surface of the GCL comprises a non-woven geotextile to enhance interface shear strength with the overlying textured geomembrane *Covering*: immediate placement of overlying geomembrane to prevent premature hydration; placement of layer of protection material within 24 hours to prevent unconstrained swell; and prohibition on trafficking on GCL *Permeability Testing*: Permeability testing will be performed at an effective confining stress representative of base liner conditions. The permeability testing includes

Key Material Requirements [refer Drawing D031]	Purpose	Discussion
• Internal shear strength: refer Section 4.8 Bentonite clay: • swell index> 24 ml/2g ; fluid loss< 18 ml • form: natural sodium bentonite or >80% sodium as activated bentonite Geotextiles: • at least one geotextile is nonwoven • mass of nonwoven geotextile > 200 g/m^2 • mass of woven geotextile (if any) > 100 g/m^2	▪ Protect geomembrane from puncture by underlying materials	permeation with a calcium chloride solution to confirm that any increase in permeability upon exposure to divalent cations (i.e. calcium) is relatively small. The requirements for GCL properties are consistent with international standards, including Victoria BPEM (Section E3 in BPEM), and are intended to reflect a high quality "standard" GCL product. Technical publications indicate that these requirements are capable of providing GCL physical performance as indicated below: - *Extensibility:* The installed GCL product is expected to be capable of undergoing at least 10% tensile strain without significant increase in permeability. - *Internal Shear Strength and Interface Shear Strength:* refer to Section 4.8.
LLDPE Geomembrane [1.5 mm thick, textured] [linear low-density polyethylene; welded sheets]		
▪ LLDPE product density < 0.939 g/cm3 ▪ Base resin: density > 0.915 g/cm3 and < 0.926 g/cm3; melt flow index < 1.0 g/10min ▪ Product textured both sides; asperity height >0.25mm ▪ Tensile strength at break > 16 kN/m ▪ Elongation at break > 250% ▪ Modulus at 2% strain < 630 kN/m ▪ Tear resistance > 150 N ▪ Puncture resistance > 300 N ▪ Axi-symmetric break resistance strain > 30% ▪ Oxidative Induction Time (OIT): >100 minutes at std. pressure >400 minutes at high pressure ▪ Oven aging at 85ºC for 90 days: OIT retained >35% at std. pressure OIT retained >60% at high pressure	▪ Provide very low permeability geosynthetic layer with very high chemical resistance ▪ Produce composite liner effect in combination with underlying GCL	Refer to the Technical Specification regarding requirements for: - *Deployment*: installation requirements are provided to protect the geomembrane from puncture, scratching or other construction damage during deployment on the GCL, and also to protect the GCL from damage; the geomembrane will be rolled out in an upslope-downslope alignment to minimise seaming in a cross slope orientation. - *Wrinkles:* Wrinkles will form in the geomembrane prior to covering due to installation stresses and to thermal expansion of the material. The Technical Specification includes requirements to reduce and manage wrinkle formation - *Seaming:* CQA requirements for seam welding, seam testing and documentation - *Covering*: requirements are provided to protect the geomembrane from puncture, scratching or other construction damage during placement of the leachate drainage geocomposite and leachate collection pipes; restriction of trafficking on geomembrane - *Intimate Contact*: Intimate contact must be achieved and maintained between the geomembrane and the GCL to achieve the favourable composite liner effect. The LLDPE material requirements for physical, chemical and durability characteristics are consistent with international standards, including Victoria BPEM (Section D4 in BPEM), and reflect a high quality material with robustness, strength, and chemical resistance suitable for long-term service in municipal landfill lining systems, and particularly under deformable foundation conditions. Technical publications indicate these requirements provide geomembrane physical performance as indicated below: - *Extensibility:* The installed LLDPE geomembrane product is expected to be capable of undergoing at least 8% tensile strain without significant increase in permeability

Key Material Requirements [refer Drawing D031]	Purpose	Discussion
		(refer sub-section above "Design of Foundation Layer") - *Interface Shear Strength:* Material is textured on both sides. Refer to Section 4.8.
Leachate Collection Layer [Geocomposite drain comprising geonet drainage core sandwiched between two filter geotextile layers; overlapped sheets]		
Geocomposite Product: ▪ Geonet –HDPE material ▪ Geotextiles thermally bonded to geonet ▪ Ply adhesion (i.e., peel strength) >180 g/cm ▪ Requirements to be established during detailed design: o Thickness and Mass per unit area o Hydraulic flow rate; and Hydraulic Flow Rate Reduction Factor for Creep, RF_{CR} o Tensile strength and elongation Geotextiles: ▪ Geotextiles - non-woven structure, PET or PP material ▪ Mass per unit area > 130 g/m^2 (note: > 200 g/m^2 if sheets joined by hot-air seaming) ▪ Equivalent Opening Size < 90 µm	▪ Drain leachate from above the liner to reduce potential for migration of leachate through liner ▪ Protect underlying geomembrane from direct contact with overlying materials ▪ Note: Leachate collection pipes discussed in sub-section above "Leachate Collection System for Piggy Back Liner"	Refer to the Technical Specification for material and installation requirements. *Deployment:* The leachate collection layer material will be placed directly on the geomembrane. Installation requirements are given to avoid geomembrane damage. *Joining*: Adjacent sheets will be joined by overlapping the lower geotextile, overlapping and tying the geonet core, and seaming the upper geotextile. Upper geotextile seaming may be by sewing or hot-air (thermal) seaming. The required properties provide for a durable material that will be essentially non-reactive with anticipated leachate and will have very high initial permeability, high clogging resistance due to the large spaces in uniform net, and ability to withstand long-term stresses. Additional discussion of physical properties is given below. - *Resistance to creep under compressive load* – Manufacturers' data indicates that geocomposite products are available that can reliably sustain the maximum long-term compressive loads anticipated within the cell, in the order of 500 kPa. - *Internal Shear Strength and Interface Shear Strength:* refer to Section 4.8.
Lining System Cover [Protection Material: 300 mm thickness]		
▪ Soil material with max. particle size 13.2 mm. ▪ Natural or recycled material acceptable ▪ Capable of being spread smoothly in a 300mm layer without damaging underlying geocomposite drain ▪ Compaction limited to tracking with the spreading plant ▪ Strength sufficient to maintain layer stability from the time of installation until the start of waste placement.. ▪ Permeability: 5×10^{-5} m/s < k < 1×10^{-3} m/s	▪ Protect lining system from physical disturbance, temperature changes, and UV degradation ▪ Provide ballasting weight to prevent wind uplift ▪ Provide confining stress to restrict potential for GCL swelling and to promote intimate contact between geomembrane and GCL	Refer to the Technical Specification for material and installation requirements. *Placement:* The material will be placed directly on the geocomposite drain. Installation requirements include spreading in a single layer and compaction by tracking with the spreading plant in order to avoid disturbance of the geocomposite. *Stability*: Material (as placed) must have sufficient internal friction and cohesion to maintain stability for the range of piggy back liner slope angles and heights. Note: These slopes are generally 4H:1V or flatter, but local slopes are as steep as 1H:1V at internal bunds. Different material may be required in different areas. *Permeability*: Material (as placed) must have a min. permeability to maintain free drainage into the geocomposite, in order to avoid saturation during rainfall, and a max. permeability lower than that of the geocomposite.

4.3.4 Cell Base Lining System

This section presents the preliminary design for the lining system in cell base areas. The cell base areas comprise Cells 1 to 4 (southern extension cells) and Cells 2A, 2B and 4A (natural ridge cells) (refer Drawing D012). This section concludes with Table 14 which presents the major components and key properties of the cell base lining system.

Settlement Analyses

Lining system foundation materials in the cell base areas comprise natural soils, with some fill soils (non-landfill) in portions of Cells 1 to 4, as described in Section 2.3.2. These foundation materials are significantly less prone to settlement and deformation than the existing landfill wastes which form the foundation in the piggy back liner areas. In a large portion of the base liner areas, soils are of limited thickness and unlikely to undergo significant settlement, and settlement analysis was not considered necessary in these areas. Settlement analyses have been conducted, however, for preliminary design in the Cells 1 to 4 area where the thickness of colluvial/alluvial foundation soils is significant, up to 16 m. These analyses were performed to predict the magnitude of long-term tensile strains and grade reversal induced by differential foundation settlement of the base liner system. These analyses were performed along a critical cross section through the proposed final landform (Refer Appendix C).

Results of the analyses are summarised in the following table. The results indicate that computed differential settlements are relatively insignificant with respect to lining system strain, but potentially significant with respect to lining system grade reversal. It is noted that the calculated maximum grade reversal occurred in a generally north-south direction and within 75 m of the southern edge of Cells 1 to 4. Grade reversal is discussed in the "Leachate Collection System for Cell Base Liner" sub-section below.

Table 12: Settlement Analysis Results – Cell Base Liner in Cells 1 to 4 Area (Long-Term)

Cross Section Location [1]	Max. Settlement	Max. Tensile Strain in Lining System	Max. Grade Reversal in Lining System
W. Gully centreline (Section F-F')	0.8 m	0.2 % [2]	1.4 % [2]

Notes: 1. Cross section location indicated in Appendix C (i.e., within App. A of that document)
2. Strain and grade reversal reflects average value in 25 m intervals between settlement calculation points.

HDPE Geomembrane

The cell base lining system design includes a 2.0 mm textured HDPE geomembrane. HDPE has been selected, given the relatively small lining system tensile strains indicated in the previous sub-section and the maximum allowable tensile strain of 4% for textured HDPE geomembrane identified in the Victoria BPEM guidance (Table D2 in BPEM).

Leachate Collection System for Cell Base Liner

The preliminary design of the cell base lining system includes a blanket leachate collection layer over the entire area, as indicated in Section 4.3.1. The leachate collection blanket includes a network of slotted leachate collection pipes to intercept and remove leachate flowing within the blanket. The leachate collection blanket differs in the Cells 1 to 4 area versus the natural ridge areas (Cells 2A, 2B and 4A) as indicated below.

- Cells 1 to 4: The leachate collection blanket will comprise a 300 mm thick layer of high porosity drainage aggregate. This layer will also include an underlying cushion geotextile to protect the HDPE geomembrane and an overlying filter geotextile.
- Cells 2A, 2B and 4A (natural ridge areas): The leachate collection blanket will comprise a geocomposite drainage layer. This will be the same material as in the piggy back lining system (refer Section 4.3.3).

Factors affecting the selection of drainage aggregate for the leachate collection blanket in Cells 1 to 4 area are: (i) constructability - The area generally has flat lining system slopes where stable placement of a drainage aggregate layer is straightforward as opposed to sloping areas where placement may be

problematic; (ii) resistance to clogging - The area forms the lowest portion of the overall leachate collection system and contains the leachate sumps; (iii) geomembrane puncture protection – Use of drainage aggregate creates a puncture risk for the HDPE geomembrane, requiring a cushion geotextile between the aggregate and geomembrane. Overall, the substantial clogging and blinding resistance provided by the large total pore space within a high-porosity drainage aggregate layer is preferred in this area to the lesser pore space within a geocomposite drainage layer. The detailed design will also confirm, as a matter of course, that the blanket 300 mm thick drainage aggregate layer has sufficient leachate flow capacity. The detailed design will consider the guidance in the Victorian BPEM regarding cushion geotextile functions and properties (Appendix F in BPEM).

The preliminary arrangement for the Leachate Collection System is shown on Drawing D041. The contours on this drawing are from Drawing D012 and represent the top of prepared subgrade for lining system construction, and therefore reflect the design grades for leachate drainage. The operational concept for leachate collection within the cell base areas is via drainage solely under gravity as follows: (a) migration downward into the blanket drainage aggregate layer; (b) lateral flow within the layer in the direction of the top of liner grade with an approximate 50 m (maximum) flow distance from point of entry into the blanket to the nearest slotted leachate collection pipe; (c) flow into a pipe and then along the leachate collection pipe network into one of four leachate sumps in Cells 1 to 4.

The preliminary design for the base lining in the Cells 1 to 4 area provides minimum pre-settlement grades of 2% toward the leachate sumps, with grades typically 3% or steeper. This will allow for positive north-south drainage to be maintained, after foundation settlement, within the leachate collection blanket layer and along leachate collection pipes. The previous sub-section indicated that settlement-induced grade reversal could be as high as 1.4% within 75 m of the southern edge of Cells 1 to 4. Therefore, the 2% minimum design grade is considered suitable for preliminary design and will be confirmed during detailed design.

Leachate Sumps: The leachate sumps are essentially local depressions within the leachate collection blanket (refer Drawing D042). The sumps are relatively shallow, only 500 mm deep, in order to facilitate maintaining the target groundwater separation distance (refer Section 3.3.5). Other key features of the sumps are indicated below.

- The cell base lining design is enhanced at the leachate sumps because, although the footprint area of the sumps is small, the sumps are considered high risk areas for leachate leakage for the following reasons: (i) being the lowest points in the leachate collection system, it is more likely that leachate will be present in the sump than in other areas; and (ii) the intricate geometry of the relatively small sump area increases the likelihood of geomembrane installation defects. The lining enhancements comprise the placement of a double thickness of GCL (i.e. two layers placed together) below the HDPE geomembrane and the addition of a 500 mm thick low-permeability (i.e., $k<1x10^{-9}$ m/s) compacted clay liner below the double GCL layer.

- Each sump drains via gravity through a leachate sump outlet pipe to a leachate sump riser outside the perimeter bund. This requires the leachate sump outlet pipe to penetrate the cell base lining system, as indicated in Detail 1 on Drawing D042.

- The leachate sump outlet pipe includes a elbow bend as it enters the leachate sump riser to provide a water seal (trap) so that atmospheric oxygen is restricted from entering the leachate sump and landfill gas is restricted from entering the leachate sump riser.

- The elbow bend in the leachate sump outlet pipe is removable to improve access for pipe clean out and inspection. Further, the leachate sump outlet pipe is continuous with the north-south leachate collection pipe entering the sump to provide access to the north-south pipe.

Each leachate sump riser is subsequently drained via gravity through the leachate drainage pipe, which is external to the landfill lining system (i.e., completely outside the perimeter bund). The leachate drainage pipe flows to a single external leachate pumping pit for pumping to the leachate ponds, at the point labelled “to new leachate pond” on Drawing D041. It is noted that for the first stages of the New Landfill Cell Project,

the existing leachate well east of the leachate ponds will be the pumping location; while in subsequent stages a new pumping pit will be constructed at the identified point.

The design features of the leachate sump outlet pipes and leachate drainage pipe are presented in a sub-section below.

Leachate Collection Pipes: The preliminary design for the leachate collection system in the cell base lining areas includes a network of perforated leachate collection pipes, with the layout in Drawing D041. The pipes will be manufactured of the same material used for the leachate pipes in the piggy back lining system, i.e. high grade HDPE. Placement of the pipes differs in the Cells 1 to 4 area versus the natural ridge areas (Cells 2A, 2B and 4A) as indicated below and in the details on Drawing D043.

- Cells 1 to 4: The leachate collection pipes will be placed within 300 mm thick leachate collection blanket.
- Cells 2A, 2B and 4A (natural ridge areas): The leachate collection pipes will be installed with a gravel surround, similar to that used in the piggy back lining system.

Pipe socks will not be permitted due to their known clogging potential in landfill leachate collection systems – rather the leachate collection blanket or gravel surround will include a non-woven geotextile for filtration protection. Pipe perforations will be relatively large, approximately 10 mm to 15 mm diameter drilled holes, to minimise clogging potential.

For the preliminary design, the pipes have not been sized. This will be done during detailed design, taking into account potential leachate flow rates, clogging potential, dimensions/wall thickness needed for long-term crushing resistance under new waste fill loads, and pipe grades. Based on project experience, it is likely that HDPE leachate pipes in commonly available diameters (typically 200 mm to 300 mm) and wall thicknesses will be suitable. This diameter range is also large enough to allow pipe inspection and clean out.

The pipe system layout provides for access to main collection pipes for inspection and clean out tools, such as water jetting rigs, at fifteen perimeter points and at the five leachate sump risers. These locations allow for major segments of the pipe system to be accessed without having to negotiate sharp bends or corners.

Connection of Existing Leachate Collection System Pipes

The preliminary design provides for connection of existing leachate drainage lines into a new Leachate Drainage Pipe within Cell 1, as summarised in the table below and in Section 3.3.4, and as indicated on Drawings D041 and D071.

Table 13: Leachate Drainage Pipe in Cell 1– Connections beneath Cell Base Lining System

Item to be Connected	No.	Status	Discussion
Deep Leachate Drainage Pipes from Eastern Gully Landfill	2	existing	Connection point will be outside of the limit of the existing HDPE geomembrane liner.
Deep Groundwater Drainage Pipe from Eastern Gully Landfill	1	existing	Pipe is beneath existing HDPE geomembrane liner. Flow in pipe is likely impacted by leachate.
Shallow leachate drainage line from Western Gully Landfill	1	existing, replacement proposed	Replacement of the existing drainage line is proposed to occur prior to start of Stage 1 construction.
Deep leachate drainage pipe from Western Gully Landfill	1	proposed	Construction is proposed to occur prior to start of Stage 1 construction.
Gas Header Pipes (refer Section 4.3.3)	3	landfill preliminary design	Connect lower end of header pipe to provide drainage for any leachate and/or gas condensate.

The invert levels of the pipes to be connected are such that, in order to maintain gravity drainage, the connections must occur beneath the cell base lining system in Cell 1. Therefore, because any leakage at the connections, or from the Leachate Drainage Pipe itself, would not be contained by the lining system, the design of the connections and pipe must be suitably robust and leak resistant. The design features of the leachate drainage pipe are discussed in the sub-section "Leachate Drainage Pipe" below.

It is noted that lowering the cell base lining system design grades so that the pipe connections could be made above the cell base lining system is not compatible with lining system design goals of full gravity drainage (refer 3.3.4) and groundwater separation (refer 3.3.5). Such an approach would also require undesirable pipe penetrations through the cell base lining system.

The pipes indicated in the above table that are to be connected from the Eastern Gully Landfill were installed at the time of liner construction for Stage 1 (1993) and Stage 2 (2001) of the Eastern Gully Landfill. One element of the New Landfill Cell project design is to consider whether these pipes will maintain their structural stability when subjected to the additional loading from the new piggy back waste fill to be placed in Eastern Gully. Information regarding the magnitude of vertical stress that the pipes were originally designed to accommodate is not available.

In terms of total thickness of landfill overlying the alignment of these pipes, the current Eastern Gully Landfill design has a maximum thickness of approximately 50 m, increasing to a maximum of approximately 65 m with the addition of the proposed piggy back fill for the New Landfill Cell project. This suggests that the proposed piggy back fill may result in maximum vertical stresses on the pipes that are approximately 30% larger than would be present without the piggy back fill. Based on the pipe material (HDPE) and pipe bedding materials (clean sand and fine gravel) as indicated in Section 2.6.2 and the modern dates of pipe design and installation, and considering that the increase in maximum vertical stress due to piggy back filling is limited to approximately 30%, we consider it likely that the pipes will maintain their structural stability under piggy back filling and capping. Further, in the unlikely case that pipe collapse were to occur in highly stressed areas, multiple alternate leachate flow paths are available through the bedding materials. The issue of structural stability of the existing Eastern Gully pipes will be considered further, to the degree practicable, during detailed design.

Leachate Sump Outlet Pipes

The leachate sump outlet pipes will connect each of the leachate sumps to the adjacent leachate sump riser, as indicated on Drawings D041. These pipes are shown in Drawing D042 and have discussed above in the sub-section "Leachate Sumps." Each pipe will be solid wall and approximately 10 m long.

For the preliminary design, the leachate sump outlet pipes have not been sized. This will be done during detailed design, taking into account potential leachate flow rates, clogging potential, dimensions/wall thickness needed for long-term crushing resistance, and pipe grades. Based on project experience, it is likely that HDPE leachate pipes in commonly available diameters (typically 200 mm to 300 mm) and wall thicknesses will be suitable. This diameter range is also large enough to allow pipe inspection and clean out.

Detailed design will evaluate the inclusion of specific leak protection measures, such as low-permeability pipe bedding to reduce leak potential and use of a stainless steel pipe section at the penetration into the sump riser pipe to reduce the thermal expansivity contrast between the pipe (HDPE) and the riser pipe (concrete). The inclusion of such measures will be considered with respect to the pipes' leakage risk and accessibility for inspection and repair, noting that the accessibility of these pipes is generally good because of their short length and relatively small depth of burial. It is noted that inclusion of specific leak protection measures for the sump riser pipes will also be evaluated during detailed design.

Leachate Drainage Pipe

The leachate drainage pipe (Drawing D041) has two distinct portions:

- Portion within Cell 1: This portion of the leachate drainage pipe has a length of approximately 250 m and is designed to gravity drain the leachate collection pipes from the existing waste, as well as the gas header pipes beneath the piggy back lining system, as indicated in Table 13 above. This portion of the

pipe will be positioned beneath the cell base lining system in Cell 1. This portion of the pipe terminates at the eastern most leachate sump riser pipe.

- Portion outside southern edge of Cells 1 to 4: This portion of the leachate drainage pipe has a length of approximately 350 m and is designed to connect and gravity drain the leachate sump risers toward the pumping point labelled “to new leachate pond” on Drawing D041. This portion of the pipe will be positioned outside of the landfill perimeter bund, i.e. external to the landfill lining system. The design provides for the invert of this pipe to remain above the groundwater table.

For the preliminary design, the leachate drainage pipe has not been sized. This will be done during detailed design, taking into account potential leachate flow rates, clogging potential, dimensions/wall thickness needed for long-term crushing resistance, and pipe grades. Based on project experience, it is likely that HDPE leachate pipes in commonly available diameters (typically 200 mm to 300 mm) and wall thicknesses will be suitable. This diameter range is also large enough to allow pipe inspection and clean out

Detailed design for the leachate drainage pipe will evaluate the inclusion of specific leak protection measures, similar to the approach for the leachate sump outlet pipes discussed in the previous sub-section. With respect to pipe leakage risk and accessibility for inspection and repair, conditions will differ in the two portions of the pipe. The portion outside the southern edge of Cells 1 to 4 will be highly accessible in that it has no overlying waste or landfill liner/cap and is at shallow depth. Conversely, the portion of the leachate drainage pipe within Cell1 is essentially inaccessible because it will be overlain by the cell base lining system, up to 30 m of new waste, and the landfill capping system. Therefore, it is expected that design of the portion of the leachate drainage pipe within Cell1 will incorporate substantially more robust connections and leak protection measures than the portion outside the southern edge of Cells 1 to 4.

Bunds

Internal Bunds: Internal bunds between cells and sub-cells in the cell base lining system will be constructed to provide a physical barrier to waste and water movement during sequential lining and landfilling. The location of the primary internal bunds is shown on Drawing D012. An internal bund detail is presented in Drawing D022.

Perimeter Bund: The perimeter bund along the southern edge of Cells 1 to 4 provides the perimeter termination point for the cell base liner, and also for the final capping system. The bund is 1 m high, with a 4 m crest width, and will be not only a barrier to waste and water movement during lining system construction, but also a prominent physical feature indicating the limit of landfilling. The perimeter bund is illustrated in Drawing D042. The perimeter bund material will be clayey soil that generally meets the same specification as that for the bearing layer material (refer Table 14).

Lining System Components

Each primary component of the cell base lining system and leachate collection system is described in Table 14. Additional material requirements are provided in the preliminary Technical Specification (Appendix B).

Table 14: Cell Base Lining System Primary Components

Key Material Requirements [refer Drawing D022]	Purpose	Discussion
Liner Bearing Layer [200 mm thickness] Liner bearing layer is the same as in the piggy back lining system. Refer to Table 11.		
GCL - Geosynthetic Clay Liner [reinforced] [Layer of bentonite clay sandwiched between geotextile layers; overlapped sheets] GCL is the same as in the piggy back lining system. Refer to Table 11.		
HDPE Geomembrane [2 mm thick, textured] [high-density polyethylene; welded sheets]		
▪ HDPE product density > 0.94 g/cm3 ▪ Base resin: density > 0.932 g/cm3; melt flow index < 1.0 g/10min ▪ Product textured both sides; asperity height >0.25mm ▪ Yield tensile strength> 29 kN/m; yield elongation> 12% ▪ Tear resistance > 249 N; Puncture resistance > 534 N ▪ Oxidative Induction Time (OIT): >100 minutes at std. pressure >400 minutes at high pressure ▪ Oven aging at 85ºC for 90 days: OIT retained >55% at std. pressure OIT retained >80% at high pressure ▪ Stress Cracking Resistance (performed on smooth portion of sheet) NCTL>300hr	▪ Provide very low permeability geosynthetic layer with extremely high chemical resistance ▪ Produce composite liner effect in combination with underlying GCL	Refer to the Technical Specification for material and installation requirements. Requirements for HDPE geomembrane installation, including deployment, wrinkle management, seaming, covering, and maintaining intimate contact will be similar to those for the LLDPE geomembrane in the piggy back lining system (refer Table 11). The HDPE material requirements for physical, chemical and durability characteristics are consistent with international standards, including Victoria BPEM (Section D3 in BPEM), and reflect a high quality material with robustness, strength, and chemical resistance suitable for long-term service in municipal landfill lining systems. Technical publications indicate these requirements provide geomembrane physical performance as indicated below: - *Extensibility:* The installed HDPE geomembrane product is expected to be capable of undergoing at least 4% tensile strain without significant increase in permeability (refer sub-section above "HDPE Geomembrane") - *Interface Shear Strength:* Material is textured on both sides. Refer to Section 4.8.
Leachate Collection Layer in Cells 1 to 4 [Drainage Aggregate: 300 mm thickness, with overlying filter geotextile and underlying cushion geotextile]		
Drainage Aggregate: ▪ Washed uniform gravel or crushed rock of natural geologic origin and high durability	▪ Drainage aggregate: (i) Drain leachate from above the liner to reduce	Refer to the Technical Specification for installation requirements. -*Placement*: installation requirements are provided to protect the underlying geomembrane from puncture, scratching or other construction damage during

Key Material Requirements [refer Drawing D022]	Purpose	Discussion
▪ Free of organics, carbonates and clay balls ▪ Permeability: k > 1 x 10^{-3} m/s ▪ Particle Angularity: no high angularity particles ▪ Gradation: uniform (high porosity) 20 mm gravel o max. particle size 26.5 mm o retained on 19 mm sieve < 20% o retained on 13.2 mm sieve < 10% o percentage fines < 3% ▪ Aggregate strength/durability: o min. wet strength 80 kN o max. wet/dry strength variation 30% Filter Geotextile: non-woven, PET or PP material ▪ Mass per unit area > 200 g/m^2 ▪ CBR puncture strength > 2100 N ▪ Equivalent Opening Size < 110 µm Cushion Geotextile: non-woven, PET or PP material ▪ Requirements to be established during detailed design: o Mass per unit area- indicative value > 550 g/m^2 o Trapezoidal tear strength- indicative value> 900 N o CBR puncture strength- indicative value > 6000 N	potential for migration of leachate through liner; (ii) Provide protection and confining stress for liner, as indicated for the "Lining System Cover" layer in Table 11. ▪ Filter geotextile: Restrict migration of fine particles into drainage aggregate ▪ Cushion geotextile: (i) Protect underlying geomembrane from damage or puncture; (ii) minimise local strains in geomembrane at drainage aggregate contact points ▪ Note: Leachate collection pipes discussed in sub-section above "Leachate Collection System for Base Liner"	drainage aggregate placement and geotextiles deployment. -*Trafficking*: Restrictions on trafficking on the surface of the drainage aggregate after placement are included to minimise potential for damage to the underlying geomembrane. Refer to the Technical Specification for material requirements. The required drainage aggregate properties provide for a strong, durable, and high porosity material that is suitable for long-term service in municipal landfill lining systems. Gradation and angularity requirements may be revised depending on the detailed design of the cushion geotextile The required filter geotextile properties provide a material with suitable physical properties to withstand installation stresses and suitable geometry to restrict fines migration into the drainage aggregate and therefore reduce the potential for clogging within the leachate collection blanket and pipes. The cushion geotextile properties provided reflect a typical heavy non-woven geotextile material, often suitable for cushion applications. Cushion geotextile requirements may be revised during detailed design.
Leachate Collection Layer in Cells 2A, 2B and 4A (natural ridge areas) [Geocomposite drain comprising geonet drainage core sandwiched between two filter geotextile layers; overlapped sheets] Geocomposite drain is the same as in the piggy back lining system. Refer to Table 11.		
Lining System Cover in Cells 1 to 4 Lining system cover not used because functions are fulfilled by the leachate collection layer.		
Lining System Cover in Cells 2A, 2B and 4A (natural ridge areas) [Protection Material: 300 mm thickness] Protection material is the same as in the piggy back lining system. Refer to Table 11.		

4.3.5 Lining System Subgrade Preparation

The preliminary design includes different types of subgrade preparation for the lining system across the site, as indicated in Drawings D012 and D013, and discussed below. Subgrade preparation is also summarised in Table 8 above. In general, design subgrade levels for the lining system are established to provide suitable grades for liner installation and leachate drainage (refer Sections 4.3.3 and 4.3.4), to achieve the target groundwater separation distance of 2m (refer Section 3.3.5), to minimise fill placement, and to allow excavated material recovery where appropriate.

The top of subgrade levels for the preliminary design are shown on Drawing D012. The contour levels on this drawing represent the top of prepared subgrade for lining system construction, and therefore reflect the design grades for leachate drainage. This drawing indicates the location of cross sections A to E, which depict different subgrade preparation approaches on Drawing D013. Each subgrade preparation approach from Drawing D013 is described below.

- Cross-Section A: Western Gully Landfill (piggy back lining system). Subgrade preparation generally comprises smoothing (i.e. minor cut/fill) of the existing cover soils on the landfill surface to create continuous grades (3% min) for lining system installation and leachate drainage. This will also involve cutting to form small benches for cross-slope leachate collection pipes as indicated in detail "Leachate Collection Pipe for Piggy Back Cell Cross-Slope Pipes" on Drawing D043. Comparison of the existing levels on Drawing D003 and the top of subgrade levels on Drawing D012 indicates that Western Gully subgrade preparation will involve an average cut of approximately 0.3 m, generating approximately 25,000 m3 of non-VENM (virgin excavated natural material) materials that are assumed suitable for use as daily cover for landfill operations.

- Cross-Sections B and E: Natural Ridges – Cells 2A, 2B and 4A (cell base lining system). Subgrade preparation generally comprises excavation of natural materials to approximate 5 m depth using 1.5H:1V excavation batters. This slope batter was identified as an acceptable temporary excavation batter for these areas in the geotechnical report in Appendix C. Excavation depth reduces to zero along the southern edges of these areas to maintain downslope leachate drainage. Comparison of the existing levels on Drawing D003 and the top of subgrade levels on Drawing D012 indicates that Cells 2A, 2B and 4A subgrade preparation will involve an average cut of approximately 4 m, generating approximately 225,000 m3 of VENM materials that are assumed suitable for use as daily cover for landfill operations or as general fill for landfill construction.

- Cross-Section C: Eastern Gully Landfill (piggy back lining system). Subgrade preparation generally comprises excavation to remove the existing cover soil terrace bunds on the landfill surface to create continuous grades (4H:1V average) for lining system installation and leachate drainage. This will also involve cutting to form small benches for cross-slope leachate collection pipes as indicated in detail "Leachate Collection Pipe for Piggy Back Cell Cross-Slope Pipes" on Drawing D043. Comparison of the existing levels on Drawing D003 and the top of subgrade levels on Drawing D012 indicates that Eastern Gully subgrade preparation will involve an average cut of approximately 0.9 m, generating approximately 55,000 m3 of non-VENM (virgin excavated natural material) materials that are assumed suitable for use as daily cover for landfill operations.

- Cross-Section D: Southern extension area- Cells 1 to 4 (cell base lining system). Subgrade preparation in this area is further illustrated in cross-sections G to K on Drawing D021. Subgrade preparation generally comprises cut and fill of existing natural soils and previous fill soils to create continuous grades (2% min) for lining system installation and leachate drainage. Comparison of the existing levels on Drawing D003 and the top of subgrade levels on Drawing D012 indicates that Cells 1 to 4 subgrade preparation will involve an average fill of approximately 0.2 m, requiring approximately 20,000 m3 of VENM fill. Maximum cut and fill depths are approximately 8 m and 4 m, respectively, generally with cutting in the northern portions and filling in the southern portions.

In all areas, subgrade preparation will begin with vegetation and topsoil removal. Proof rolling, followed with excavation and replacement of any identified soft soil areas, will be performed on all excavated surfaces. All imported materials used as fill will be VENM.

4.4 Cell Capping

4.4.1 Cover for Landfill Operations

The use of daily and intermediate cover materials during landfilling operations provides a number of environmental benefits including minimisation of: (i) windblown litter: (ii) water infiltration, leading to leachate generation; (iii) runoff from exposed waste, leading to leachate generation; (iv) landfill fire potential; (v) access for animal vectors such as sea gulls or rodents; and (vi) gas emissions and odour generation. With respect to landfill design, operational cover use primarily affects leachate generation, as indicated below.

Daily Cover: Daily cover is placed on exposed waste areas at the end of each day of landfill operations (hence the term "daily"). It typically comprises soil, or other granular material, placed in a minimum 150 mm thick layer. Plastic sheets or tarps are also used at some sites. Daily cover materials are stripped for re-use, to the degree practicable, at the start of the next day of landfilling in order to preserve landfill airspace and to avoid the development of relatively impermeable layers within the landfill that could potentially lead to local perched leachate zones. Landfill lids, which are moveable roof structures that serve as daily cover, have also been used in local areas of waste placement at the Whytes Gully RRP site.

The rate of leachate generation from infiltrating rainfall can be very high in soil daily cover areas because daily cover is generally not well controlled with respect to gradation, degree of compaction, and surface grading. This is reflected in the infiltration rate of 60% of incident rainfall used in the leachate water balance calculations described in Section 4.7. To mitigate the high infiltration rate, landfill operation measures include for maintaining daily cover areas at the smallest practicable size.

Intermediate Cover: Intermediate cover is placed over daily cover in areas where landfilling has been temporarily completed and where no additional waste will be placed for more than 90 days. For example, the west-facing interim landfill batters that will be present during project (eg. Drawing D013, Section F) will have intermediate cover. Intermediate cover will be stripped for re-use, to the degree practicable, at the resumption of landfilling in the area in order to preserve landfill airspace and to avoid the development of relatively impermeable layers within the landfill that could potentially lead to local perched leachate zones. By definition, intermediate cover will remain in place for at least 90 days and, in some areas, it will remain in place for several years until waste placement resumes in the area.

Intermediate cover typically comprises soil placed in a minimum 300 mm thick layer. The rate of leachate generation from infiltrating rainfall is generally moderate in intermediate cover areas because intermediate cover material generally excludes high permeability granular soils, has controlled compaction, and is graded to promote runoff and direct it away from daily cover areas. This is reflected in the infiltration rate of 20% of incident rainfall used in the leachate water balance calculations described in Section 4.7.

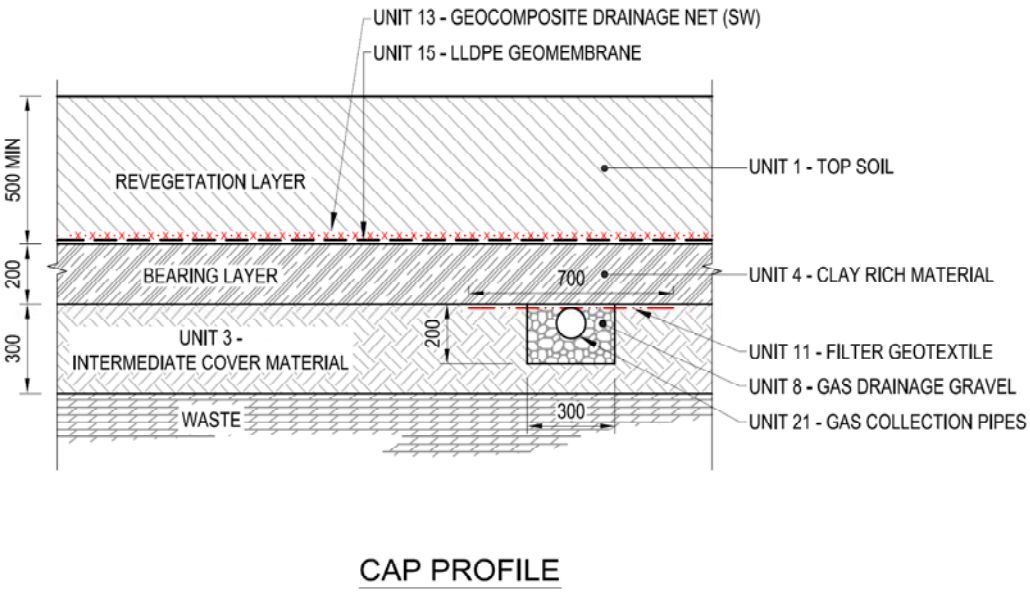
4.4.2 Final Capping System

Overview

The final capping system profile for the preliminary design is shown in Figure B below (refer Drawing D061). The system will be constructed upon the uppermost intermediate cover layer in each landfill area. The system incorporates measures for infiltration control, landfill gas control, and support of vegetation growth, as described in the following sub-sections.

The design presumes that the post-capping land use will be as passive open space, with no development other than, possibly, local access tracks and footpaths. No services are to be installed.

Figure B – Final Capping System Details



Infiltration Control

Infiltration Barrier: The primary purpose of the infiltration barrier within the final capping system is to provide a continuous barrier to limit rainwater infiltration into the landfill, thus reducing the potential for leachate generation. The infiltration barrier also serves to limit movement of atmospheric oxygen into the landfill thus reducing fire potential and increasing landfill gas collection efficiency. The current NSW Landfill Guideline standards for capping indicate a single clay liner (500m thick with maximum permeability 1 x 10^{-8} m/s).

The infiltration barrier design comprises two components as given below.

- *Bearing Layer*: Comprises a 200 mm thickness of compacted clayey soil with a maximum particle size of 9.5 mm to limit puncture potential for the overlying geomembrane. The soil will have gradation and plasticity requirements such that it would classify as an SC or CL soil in the USCS classification system. Although the design does not specify a maximum permeability value for this soil, the material and compaction requirements are expected to result in a material with an as-placed permeability in the order of 1 x 10^{-8} m/s.

- *Geomembrane*: Comprises a 1.0 mm thick LLDPE geomembrane. The geomembrane will be textured on both sides to provide high interface shear strength, as discussed in the sub-section below "Capping System Stability".

The bearing layer serves two functions as follows: (i) it provides an appropriate surface for deployment of the geomembrane and protects the geomembrane from puncture damage because it will be smoothly compacted and will not contain significant gravel particles; and (ii) it works in combination with the geomembrane to provide a composite liner effect whereby the rate of water leakage through any defects in the geomembrane will be significantly less than if the geomembrane was placed on more permeable soil. Because the development of a full composite liner effect (i.e., an order of magnitude or more reduction in leakage rate) is typically known for clayey soil layers that are thicker than 200 mm, we consider that only a partial composite effect will be effectively achieved with the design. However, such a partial composite effect is expected to result in an infiltration rate at least several times lower than for a single clay liner or single geomembrane. In addition, because the upper component is a geomembrane the design infiltration barrier will not be vulnerable to desiccation or root penetration, as are single clay liners.

Additional description regarding material and installation requirements is provided in Table 15 below.

On this basis, and considering that a blanket subsurface drainage system is incorporated in the final capping system (refer next paragraph) to provide further infiltration control, the proposed infiltration barrier design is considered to exceed current NSW Landfill Guideline standards and reflect good practice.

Subsurface Drainage: The primary purpose of the subsurface drainage system within the final capping system is to remove infiltrating rainwater from above the infiltration barrier and thereby limit the potential for leakage through the infiltration barrier and into the landfill and associated leachate generation. A secondary benefit of the system is that removal of infiltrating rainwater from above the infiltration barrier increases the slope stability of the capping system on the landfill batters through reduction in downslope seepage forces.

The system design comprises a blanket drainage layer installed overlying the infiltration barrier. The drainage material will be a geocomposite drainage layer. A subsoil drainage pipe will be connected to the geocomposite drainage layer along the toe of each of the 10 m-high batter sections of the final landform, with the drainage pipe connected to outlet pipes that discharge collected infiltration water to the surface drainage system on the final landform benches (refer Drawing D052).

Additional information on the components of the subsurface drainage system is given below.

- *Geocomposite Drainage Layer:* The preliminary design includes a geocomposite drainage layer comprising a non-woven filter geotextile bonded to both sides of an HDPE geonet drainage core. The primary purpose of the lower geotextile, which will be placed in contact with the underlying textured LLDPE geomembrane, is to enhance the shear strength of the geocomposite-geomembrane interface. The primary purpose of the upper geotextile is to act as a filter to restrict migration of fine particles into the system and therefore provide protection against blinding and/or clogging of the system. Internal and interface shear strength of the geocomposite drain is discussed in the sub –section below “Capping System Stability”.

  The type of geocomposite products suitable for the project will be manufactured with selvage (roll edge) construction with both geotextiles extending beyond the geonet core. This allows secure joining of adjacent sheets by overlapping the lower geotextiles, butting and tying together the geonet cores, and overlapping and seaming the upper geotextiles via field sewing or hot-air (thermal) tacking.

  For the preliminary design, the required geocomposite drainage material flow capacity has not been selected. This will be done during detailed design, taking into account potential rainwater infiltration rates and factors that affect geocomposite design flow capacity, such as clogging potential, intrusion of the upper and lower geotextile into the geonet core, normal stress and the typical drainage grades/gradients of 4H:1V on the landform batters. It is noted that the normal stress within the final capping system will be small, approximately 10 to 20 kPa, and have much less impact on geocomposite drainage material selection than within the piggy back lining system. Numerous geocomposite drainage products are likely to be suitable for subsurface drainage of the capping system.

- *Subsoil Drainage Pipes:* The preliminary design includes subsoil pipes to convey and discharge the water that infiltrates into the geocomposite drainage layer. These pipes and their connections are shown in the detail on Drawing D052 and will be manufactured with polyethylene or PVC.

  A perforated pipe will run along the toe of each batter section and will be connected to the geocomposite drainage layer on the batter. The fall along the pipe will be equal to the fall of the surface water drain along each bench. Efficient transfer of water flowing within the geocomposite drainage layer into the pipe at each landform bench level is important to minimise the potential for water pressure build up within the geocomposite drainage layer, which could result in undesirable local effects such as surface seepage ta benches or reduction in capping system stability. The connection detail includes the following features to promote efficient water transfer: (i) geocomposite drainage layer terminates at pipe and is not continuous under the bench to the next lower batter section; (ii) the pipe has a drainage aggregate surround to provide a large contact area with the geocomposite drainage layer; (iii) the upper geotextile of the geocomposite drainage layer is removed within the drainage aggregate surround so as not to impede flow into the drainage aggregate; (iv) the drainage aggregate surround is wrapped by a

welded geomembrane flap that creates a very low permeability barrier to restrict water flow out of the drainage aggregate surround (except flow into the pipe). Pipe socks will not be permitted.

Solid wall outlet pipes will be connected to the perforated pipe. The distance between outlet pipes will be determined during detailed but is expected to be in the order of 10 m to 20 m, likely selected based on providing redundant drainage outlets rather than on required flow capacity. Each outlet pipe will be approximately 2 m long and will be installed with a minimum 2% fall toward its discharge into the surface water drain along the bench.

For the preliminary design, the subsoil drainage pipes have not been sized. This will be done during detailed design, taking into account potential flow rates, dimensions/wall thickness needed for crushing resistance under construction and installation loads, and pipe grades. Based on project experience, it is likely that the pipe diameters will be approximately 100 mm.

Landfill Gas Control

The final capping system is intended to promote effective landfill gas management during active landfill gas extraction (the predominant condition) as well as during any periods when active extraction is absent. During active extraction the final capping system will need to restrict air entry into the landfill in order to reduce landfill fire potential and avoid diluting the energy content of collected landfill gas . During periods when active extraction is absent the final capping system will need to minimise uncontrolled passive emissions of landfill gas. and also to minimise gas pressure build up which could reduce capping system stability. Both of these functions are enhanced when the final capping system includes a reliable near-airtight element, such as the LLDPE geomembrane included in the preliminary design as described above.

The preliminary design also includes gravel-filled gas venting trenches, with HDPE gas collection pipes, installed beneath the infiltration barrier. These venting trenches will allow for passive removal of any gas accumulating beneath the final capping system and generating higher-than-atmospheric pressures. The gravel material for these trenches may be recycled concrete or aggregate material because it will be placed beneath the capping system and subjected to relatively low applied stresses. It is noted that these venting trenches may need to be equipped with one-way venting valves to prevent their acting as air entry points during active gas extraction, when lower-than-atmospheric pressures may be imposed. The spacing and layout of the venting trenches, provision for drainage of any perched leachate, gas collection pipe sizing, and any one-way valve requirements will be determined during detailed design, after consultation with the landfill gas extraction system designer.

The gas extraction system designer will consider the need for gas infrastructure components such as wells, flow lines, manifolds, and headers to penetrate the final capping system and will minimise penetrations to the degree practicable. Where penetrations are required, appropriate design and construction details will be needed to preserve the integrity and function of the final capping system.

Vegetation Support

Revegetation Layer: The primary purpose of the revegetation layer is to support vegetation growth that will: (i) limit erosion from the cell landform; and (ii) provide suitable visual amenity. The layer also provides substantial thickness that will reduce the potential for unanticipated human and animal contact with landfill materials. Further, the combination of vegetation growth, layer thickness, and capillary break achieved at the interface with the subsurface drainage layer, will enhance removal of infiltrating rainwater by plant evapotranspiration, thus reducing leachate generation potential within the landfill.

The revegetation layer will comprise two sub-layers as described below.

- *Lower Topsoil*: Soil layer with thickness 350 mm to 850 mm placed on top of the geocomposite drainage layer drain in the subsurface drainage system. Material to be clean (uncontaminated) soil with physical characteristics and nutrient content appropriate for deep support of the plant species planned for revegetation.

- *Upper Topsoil*: Soil layer with thickness 150 mm placed on top of the lower topsoil. Material to be clean (uncontaminated) soil with physical characteristics and organic and nutrient content appropriate for germination and shallow support of the plant species planned for revegetation.

The total thickness of the revegetation layer is 500 mm to 1000 mm. When combined with the thickness of the other elements of the final capping system (200 mm) and with the underlying intermediate cover material layer (300 mm minimum), the total separation distance between the final surface and landfilled waste materials will be approximately 1.0 m to 1.5 m. This separation distance is considered suitable based on the planned site end use as passive open space.

Plants: Plants for revegetation will be shallow rooted native grasses and shrubs and small tress that are of local provenance in accordance with the Landscape Strategy (Appendix N of EA document). Engineered erosion and sediment control measures for the final landform can be decommissioned once revegetation is successfully completed.

Infiltration Rate

The leachate water balance calculations described in Section 4.7 have used an assumed infiltration rate of 1% of incident rainfall for areas with final capping. This infiltration rate will be further assessed during detailed design using HELP model calculations. Based on project experience, the assumed rate is considered to be conservative for the designed final capping system, which includes a blanket subsurface drainage system and an LLDPE geomembrane installed with modern construction quality management control.

Capping System Stability

Slope stability is a key design issue for the final capping system. The potential failure mechanism to be considered is downslope sliding of the capping system between benches along a surface within the capping system. This mechanism is sometimes referred to as 'veneer' stability. The veneer stability of multi-layer capping systems is known to depend on the shear strength of capping materials and interfaces between materials and on the effectiveness of the subsurface drainage and gas venting systems in minimising pore pressure build up within the system.

Veneer stability calculations will be performed during detailed design. These calculations will consider potential slip surfaces both above and below the textured LLDPE geomembrane component and will include static stability, earthquake stability, and stability during large storm events. Potential slip surfaces above the geomembrane could potentially be subjected to destabilising water forces from infiltrating rainwater (pore pressures and seepage forces), although no significant pore pressure build up is anticipated given the blanket subsurface drainage system design described above. Potential slip surfaces below the geomembrane can potentially be subjected to destabilising gas pressures from within the cell, although no significant gas pressure accumulation is anticipated given the gas venting trench design described above.

Target slope stability factors of safety for the veneer stability analyses will the same as those given previously in Table 4 for global stability of the final landform.

The slope inclination between benches of the final landform for the preliminary design is predominantly 4H:1V, or 14 degrees, but as steep as 3.5H:1V, or 16 degrees, in some areas (refer Table 6). Numerous features of the preliminary design will promote veneer stability at these slope inclinations, including the following: (i) maximum vertical interval of 10 m between benches; (ii) subsurface drainage system design (refer above); (iii) gas venting system design (refer above); and (iv) use of LLDPE geomembrane with texturing on both sides to increase interface shear strength. Given these features, and project experience, we consider that the detailed design will provide suitable veneer stability within the final capping system through typical specifications for capping products, soil materials, and capping system construction methods.

Capping System Settlement

The final capping system will be subject to substantial settlement arising from ongoing decomposition of emplaced waste. Settlement analyses at points along the upper ridge of the final landform indicated total

settlement magnitudes ranging from 1.5 m to 3.0 m (Appendix C). Differential settlements were not estimated. Additional analyses of total and differential settlements of the final capping system will be performed during detailed design.

For preliminary design, the approach adopted to address potential differential settlement of the final capping system is to specify strain-tolerant components, specifically the LLDPE geomembrane component of the infiltration barrier and the geocomposite drainage layer component of the subsurface drainage system.

System Components

Each primary component of the final capping system is described in Table 15. Additional material requirements are provided in the preliminary Technical Specification (Appendix B).

Table 15: Final Capping System Primary Components

Key Material Requirements [refer Drawing D061]	Purpose	Discussion
Liner Bearing Layer [200 mm thickness]		
▪ Clean (uncontaminated) clayey soil; no organic matter ▪ Gradation: Max. particle size 9.5 mm; Passing 2.4 mm sieve > 90%; Fines > 30% ▪ Plasticity index>15% ; Liquid Limit > 25% ▪ Emerson crumb classification > 4 ▪ Compacted to > 95% SMDD and within 0% to =3% SOMC	▪ Provide appropriate surface for deployment of geomembrane ▪ Produce partial composite liner effect in combination with overlying geomembrane	*Surface Preparation*: The bearing layer material must be compacted and prepared to provide an appropriately smooth and even surface for deployment of the geomembrane. The maximum particle protrusion from the prepared surface will be limited to 5 mm. The maximum particle size limitation will minimise installation damage to the geomembrane. *Clayey Soil*: A clayey soil is specified for the bearing layer to produce a partial composite liner effect in combination with the overlying geomembrane.
LLDPE Geomembrane [1.0 mm thick, textured] [linear low-density polyethylene; welded sheets]		
▪ LLDPE product density < 0.939 g/cm3 ▪ Base resin: density > 0.915 g/cm3 and < 0.926 g/cm3; melt flow index < 1.0 g/10min ▪ Product textured both sides; asperity height >0.25mm ▪ Tensile strength at break > 11 kN/m ▪ Elongation at break > 250% ▪ Modulus at 2% strain < 420 kN/m ▪ Tear resistance > 100 N ▪ Puncture resistance > 200 N ▪ Axi-symmetric break resistance strain > 30% ▪ Oxidative Induction Time (OIT): >100 minutes at std. pressure >400 minutes at high pressure ▪ Oven aging at 85ºC for 90 days: OIT retained >35% at std. pressure OIT retained >60% at high pressure	▪ Provide very low permeability geosynthetic layer with very high chemical resistance ▪ Produce partial composite liner effect in combination with underlying liner bearing layer	Refer to the Technical Specification for material and installation requirements. Requirements for LLDPE geomembrane installation, including deployment, wrinkle management, seaming, covering, and maintaining intimate contact will be similar to those for the LLDPE geomembrane in the piggy back lining system (refer Table 11). As with the piggy back lining system, the material requirements for the LLDPE geomembrane in the final capping system for physical, chemical and durability characteristics are consistent with international standards, including Victoria BPEM (Section D4 in BPEM), and reflect a high quality material with robustness, strength, and chemical resistance suitable for long-term service in municipal final capping systems. Technical publications indicate these requirements provide geomembrane physical performance as indicated below: - *Extensibility:* The installed LLDPE geomembrane product is expected to be capable of undergoing at least 8% tensile strain without significant increase in permeability (refer sub-section above “Capping System Settlement”) - *Interface Shear Strength:* Material is textured on both sides. Refer to refer sub-section above “Capping System Stability”.

Key Material Requirements [refer Drawing D061]	Purpose	Discussion
Subsurface Drainage Layer [Geocomposite drain comprising geonet drainage core sandwiched between two filter geotextile layers; overlapped sheets]		
Geocomposite Product: ▪ Geonet –HDPE material ▪ Geotextiles thermally bonded to geonet ▪ Ply adhesion (i.e., peel strength) >180 g/cm ▪ Requirements to be established during detailed design: o Thickness and Mass per unit area o Hydraulic flow rate o Tensile strength and elongation Geotextiles: ▪ Geotextiles - non-woven structure, PET or PP material ▪ Mass per unit area > 130 g/m^2 (note: > 200 g/m^2 if sheets joined by hot-air seaming) ▪ Equivalent Opening Size < 90 µm	▪ Drain infiltrating rainwater from above the infiltration barrier to: o reduce potential for leakage into landfill o increase slope stability of the capping system ▪ Provide limited puncture protection for underlying geomembrane ▪ Note: Subsurface drainage system pipes discussed in sub-section above "Infiltration Control"	Refer to the Technical Specification for material and installation requirements. Requirements for geocomposite drain installation, including deployment, protection of the underlying geomembrane, and joining will be similar to those for the geocomposite drain in the piggy back lining system (refer Table 11). The required properties provide for a durable material that will have very high initial permeability and high clogging resistance due to the large spaces in uniform net. , and ability to withstand long-term stresses. Internal shear strength and Interface shear strength requirements will be confirmed during detailed design.
Revegetation Layer [Topsoil: 500 mm to 1000 mm thickness]		
Lower topsoil portion - 350 mm to 850 mm thick ▪ Clean (uncontaminated) soil ▪ Capable of being spread smoothly without damaging underlying geocomposite drain with max. particle size for first lift of 13.2 mm ▪ Requirements to be established during detailed design: o organic and mineral nutrient content o gradation and permeability Upper topsoil portion - 150 mm thick ▪ Clean (uncontaminated) soil ▪ Requirements to be established during detailed design: o organic and mineral nutrient content o gradation and permeability	▪ Support plant growth for erosion protection and visual amenity ▪ Protect capping system from physical disturbance ▪ Provide confining stress to promote intimate contact between geomembrane and liner bearing layer	Refer to the Technical Specification for material and installation requirements. Lower Topsoil: *Placement:* The lower topsoil material will be placed directly on the geocomposite drain. Installation requirements include spreading of first lift in a single layer to minimise potential for damage of the underlying geocomposite drainage layer. *Compaction*: Light compaction by tracking only to minimise the potential for damage of the underlying geocomposite drainage layer and to preserve the vegetation support capability of the material. Upper Topsoil: *Placement:* The material will be spread with no compaction to preserve the vegetation support capability of the material.

4.5 Surface Water Management

Overview

Required features for surface water drainage are presented in Section 3.3.7. Concepts for surface water drainage paths for each stage of landfill development are discussed in Section 4.2.5 and illustrated in Drawing D051.

The preliminary design of surface water management features for the project, consistent with the identified concepts and required features, is discussed in the Surface Water Assessment Report that is presented in Appendix G of the EA document. A summary is provided below.

Three main types of stormwater would be generated by the project :

- Clean stormwater runoff from undisturbed and rehabilitated / revegetated areas of the site;
- Potentially sediment-laden stormwater runoff from disturbed areas of the site; and
- Leachate that has come into contact with waste (including runoff from daily cover).

Staging

The surface water management controls would be progressively developed as the landfilling areas are developed. A drainage philosophy has been designed based on the construction staging of the proposed project and offsite discharge constraints. The following summarises the staged approach.

Stage 1 and Stage 2A: The drainage philosophy up to the completion of Stage 2A is to discharge the entire 50 ha catchment to the existing sediment pond. There is sufficient capacity in the existing surface water management system for the whole 50 ha catchment. A minor existing discharge offsite from the Western Ridge would be maintained.

Stage 2B: After completion of Stage 2B the Eastern Gully would become fully capped and therefore surface runoff would become 'clean' runoff. During Stage 2B a new 'clean' drain can be constructed to bypass the sediment pond and discharge directly to the Dapto creek outfall. This drain would be constructed between the existing leachate treatment plant and the surface water ponds. On completion of stage 2B, approximately 24 ha will discharge directly to Dapto Creek and 26 ha to the existing sediment pond.

Stage3: On completion of Stage 3, approximately 30 ha will be discharged directly to Dapto Creek and 20 ha to the existing sediment pond. Due to the extent of the Stage 4 works the existing leachate ponds will require relocating towards the end of Stage 3. At this stage it is proposed that the leachate pond is relocated to the footprint of the two reed bed ponds and downsize the existing surface water pond. The downsizing of the surface water pond at this stage is possible due to approximately 60 percent of the original 50 ha catchment now discharging directly to the Dapto Creek outfall.

Stage 4: The downsized surface water pond is designed for a 20 ha catchment. The clean 30 ha catchment would discharge unrestricted to the Dapto Creek outfall. The surface water pond would be made up of sediment pond and onsite surface water detention pond. The outflow from the pond to the Dapto Creek outfall would be restricted to meet discharge constraints and the resultant attenuated runoff detained within the surface water pond.

Landfill Benches and Drop Structures

The preliminary approach and design details for surface water drainage from the landfill final cap, including drainage benches and drop structures, are illustrated in Drawings D051 and D052.

The benches will be 5 m wide with a cross fall of 5%. The benches will be gravel surfaced and will include a 500 mm high safety bund on the outer edge to protect vehicles, which will also act as a flow channel boundary. The bench has been designed to convey up to a 100 yr ARI storm event.

A series of drop structures will convey surface water runoff from the bench structures to the perimeter drainage at the landfill toe. These drop structures will be constructed using a rock-filled Reno mattress to

reduce water velocities and prevent riling. The drop structures will be trapezoidal in cross section with a 1m base width and a depth of 300 mm to 400 mm. The drop structures are also designed for up to a 100 yr ARI storm event.

Perimeter Drainage Channels

The preliminary design for perimeter drainage channels are illustrated in Drawings D017 to D019. A temporary channel on the existing Western Gully Landfill surface is illustrated in Drawing D013 (Section F).

The drawings indicate that two perimeter drainage channels (cell side and outer side) on each side of a perimeter access road have been allowed for in most areas. The two channels are provided for separation of 'clean ' and 'potentially sediment-laden' runoff. In some areas a combined single drainage channel and access track is required due to lack of space at the property boundary.

The drainage channels will be vegetated with grass to stabilise the form and trapezoidal shape of the open channel. A grassed channel would also increase the friction coefficient of the drain and therefore reduce the potential for scouring caused by high velocities surface runoff and sediment migration. A flow velocity check carried out as part of the preliminary drainage design confirmed that a normal cover of grass will provide sufficient erosion resistance. However, at channel junctions and areas where there is a change in flow direction, the need for more robust erosion-resistant surfaces will be assessed during final design.

4.6 Landfill Gas Extraction and Management

Current plans are for active landfill gas (LFG) extraction to be implemented at the site according to the following phased approach:

- Phase 1 - Prior to start of the New Landfill Cell Project: Repair and/or replace the remnant LFG collection system in the existing Western Gully Landfill, install new vertical gas wells within the existing Western Gully Landfill, and commission a flare.
- Phase 2 – Prior to piggy back liner construction in the existing Eastern Gully Landfill : Install new vertical gas wells within the existing Eastern Gully Landfill.
- Phase 3 – During new waste placement: Collection of LFG from new landfill cells including the installation of sacrificial horizontal gas wells (initially) followed by vertical gas wells.

The scope of the preliminary design does not include the LFG extraction and management system. However, LFG management features have been included in the preliminary design of the piggy back lining system and the final capping system as described in Sections 3.3.2, 3.3.3.3, 4.3.3, and 4.4.2 of this report. These include (i) potential design features in the piggy back lining system to accommodate the continuing operation of vertical gas wells in the existing waste that will be installed in Phase 1 and Phase 2; (ii) gas collection vents beneath the piggy back lining system to reduce the risk of increased lateral gas migration developing after lining construction; and (iii) gas collection vents beneath the final capping system.

4.7 Leachate Management

Leachate Collection

Key issues for leachate collection system design are presented in Section 3.3.4. These issues include maintaining gravity-only drainage within the landfill footprint and connecting all existing leachate drainage pipes from the existing landfill. Preliminary design of the leachate collection and transmissions system, including features addressing these issues, is described in Section 4.3.3 for the piggy back areas and in Section 4.3.4 for the Cells 1 to 4 area. The design description for the Cells 1 to 4 area includes the leachate sumps, the leachate transmission pipes and risers outside the southern toe of the landfill, and connection of existing leachate drainage pipes.

Leachate Management

The capacity of the existing leachate management system (storage, treatment, and disposal) to function effectively for the New Landfill Cell project has been assessed as part of the preliminary design. The

assessment is presented in the Leachate Generation and Water Balance Modelling Report that is included in Appendix G of the EA document. A summary is provided below.

The two existing leachate ponds were designed in 2003 and are lined with 1.5 mm HDPE geomembrane liner and have a combined storage capacity of 18,000 cu.m. with a 300 mm freeboard. Both ponds contain surface aerators on pontoons. The primary pond also contains an axial mixer. The integrity of the ponds and liner is monitored through regular visual inspection and monitoring of down-gradient groundwater bores. Monitoring to date has not detected any groundwater contamination and will continue during the Project.

During the first year of the Project it is proposed there would be works undertaken at the site including operational changes that are expected to reduce current leachate generation rates. These works include capping and reprofiling the existing Eastern Gully landfill batter, capping of the current landfilling area, and commencement of the Piggy Back Liner in Stage 1.

Leachate generation rates over the lifetime of the project have been predicted using a site water balance model using a monthly time step and considering existing and proposed design conditions. Key model assumptions are indicated below.

- Annual rainfall: mean 1279 mm; 90th % 1767 mm. Annual evaporation from pond: 1385 mm.
- Project staging as outlined in Table 7, including progressive intermediate cover and final capping.
- Area of active filling (daily cover) maintained at 10,000 m^2 throughout the operational life of the landfill.
- Surface infiltration (% of incident rainfall): daily cover 60%; intermediate cover: 20%, final capping 1%.
- Leachate generation from existing waste reduces to 5% of current value after piggy back lining.
- No leachate recirculation.
- Discharge rate from the leachate ponds is 250 kL/day based on leachate treatment plant capacity.

The monthly leachate water balance using mean rainfall indicates that the existing leachate ponds have adequate capacity for Stages 1 to 3. For Stage 4, the existing ponds will have to be removed and new ponds constructed with a similar capacity and footprint would be adequate for Stage 4. Sensitivity analyses indicate that the existing leachate ponds have adequate capacity for two consecutive years of 90th percentile rainfall.

4.8 Slope Stability

Overview

Slope stability is a major design issue for the project (refer Section 3.3.6). Slope stability analyses are needed to demonstrate that the preliminary design will achieve suitable levels of stability. These analyses must take into account key design factors such as final landform geometry, soil stratigraphy, groundwater and leachate levels, existing and new waste characteristics, and design details for the piggy back lining system, cell base lining system and final capping system.

This section presents the results of slope stability analyses for the final landform slopes. Additional slope stability analyses will be performed during detailed design to consider: (i) interim landfill slopes that will be present at various stages of landfill development (refer Sections 4.2.5 and 5.3); (ii) final capping system stability (refer Section 4.4.2).

Final Landform Slopes

A summary of the slope stability analyses presented in Appendix C is provided below.

Slope stability analyses have been carried out on four cross-sections that are considered to present the highest relative risk of slope instability, based on geometry and subsurface conditions. The four sections encompass conditions across the entire final landform. The analyses considered a range of potential slip

surface shapes including deep and shallow circular surfaces and non-circular surfaces passing along existing and new lining systems.

The analyses used two-dimensional limit equilibrium methods, as typically employed in geotechnical slope stability calculations. The analyses considered peak and residual shear strength of soil and lining system materials and interfaces. Both long-term (static) loading and earthquake loading were analysed.

A summary of results of the slope stability analyses is provided in Table 16 below. The target factor of Safety (FoS) values in the table are the same as given in Section 3.3.6. Based on the analysis results, the preliminary design achieves the target factors of safety for global slope stability.

Table 16: Summary of Slope Stability Analysis Results for Final Landform Slopes

Potential Slip Surface Shape	Conditions	Target FoS	Calculated FoS
Circular through new landfill waste	Long-term	1.50	2.66 – 2.99
	Earthquake	1.10	2.14 - 2.41
Non-circular (sliding) along proposed piggy back and cell base liners at **peak** strength	Long-term	1.50	1.51 – 2.06
	Earthquake	1.10	1.24 – 1.47
Non-circular (sliding) along proposed piggy back and cell base liners at **residual** strength	Long-term	1.20	1.24 – 1.49
	Earthquake	1.00	1.01 - 1.09
Circular through existing landfill waste	Long-term	1.50	2.87 – 3.10
	Earthquake	1.10	2.23 – 2.50
Non-circular (sliding) along existing base liner in Eastern Gully Landfill	Long-term	1.50	1.99
	Earthquake	1.10	1.63
Circular below existing landfill waste (through natural soil)	Long-term	1.50	2.09 – 2.29
	Earthquake	1.10	1.25 - 1.67
Non-circular (sliding) below existing landfill waste (through natural soil)	Long-term	1.50	1.66
	Earthquake	1.10	1.31

For all of the four cross-sections analysed, the critical slip surface shapes for global stability of the final landform are non-circular surfaces passing along piggy back and cell base lining systems, predominantly on the cell base lining system in Cells 1 to 4. This is the case for both long-term conditions and under earthquake loading. Consequently, the stability of the final landform is sensitive to the shear strength of the weakest interface or component within the lining systems. The minimum lining system shear strengths required to support the design for global slope stability are given in Table 17.

Table 17: Shear Strength Requirements for Piggy Back and Cell Base Lining Systems

Lining System Area	Equivalent Shear Strength Parameters Required for Weakest Interface or Material within Lining System [1]			
	Peak Strength		Residual Strength	
	Friction Angle (degrees)	Cohesion (kPa)	Friction Angle (degrees)	Cohesion (kPa)
Piggy Back Lining System - overall	17	0	7	0

Lining System Area	Equivalent Shear Strength Parameters Required for Weakest Interface or Material within Lining System [1]			
	Peak Strength		Residual Strength	
Piggy Back Lining System – lower portion of Eastern Gully	17	0	14	0
Cell Base Lining System – Cells 1 to 4	17	0	11	0

Notes: 1. Shear strength requirement applies to both long-term (drained) loading and earthquake (undrained) loading

It should be noted that laboratory testing (interface shear and internal shear strength testing of each lining system component) will be required as part of the selection process of the components to confirm that the above shear strength requirements are met. This includes geomembranes, GCLs, and geocomposite drains. These requirements are included in the Technical Specification (Appendix B).

5.0 LANDFILL CONSTRUCTION

This Chapter outlines significant construction issues that have been considered for the preliminary design. In addition, requirements for construction of key landfill components are provided in the Technical Specification (Appendix B). Additional construction requirements and constraints will be documented during the course of detailed design.

5.1 Construction Quality Management

A construction quality management system will be in place for landfill construction because the performance of these environmental protection systems, particularly the lining and capping systems, is strongly dependent on the quality of their construction. This section summarises the system by providing an excerpt from the construction quality management portion of the Technical Specification (Appendix B). The excerpt comprises the remainder of this section including Table 18.

The construction quality management system for construction comprises Contractor requirements and Superintendent actions. Contractor requirements include preparing management plans, preparing work method statements, material testing, compaction testing, surveying, notifying for Inspection Points, and preparing Hold Point documentation and works-as-executed (WAE) documentation. Superintendent actions include review and approval of Contractor submittals and documentation, inspecting construction works, conducting audit testing, attending Inspection Points, and releasing Hold Points. Superintendent actions are typically referred to as Construction Quality Assurance (CQA).

A description of the approach for quality management of material properties is provided in Section 2.1.2 (of Appendix B), including description of approval of material sources, confirmation of as-delivered material properties, and audit testing. One example from Section 2.1.4 (of Appendix B) is that all material test results submitted to the Superintendent by the Contractor must be from a laboratory with NATA-accreditation for all tests performed; and all survey results submitted to the Superintendent by the Contractor must be from a registered surveyor.

Quality management requirements are summarised in the following table, with definition of the table headings given below.

- *Hold Point*: An identified point in the landfill construction sequence where the Contractor must halt work and provide required information to the Superintendent. The Contractor must not resume work until the Hold Point is released, in writing, by the Superintendent.
- *Full Time Inspection*: The Superintendent or in some cases the GITA (Geotechnical Inspection and Testing Authority), will be present on a full-time (continuous) basis for certain construction activities to provide additional confidence that construction is proceeding in accordance with Technical Specification requirements and design intent. Activities where full-time inspection is planned to be undertaken are identified in the Table 18 below.
- *Field Testing*: Certain cell construction activities will require real-time field testing during construction. Examples include testing for confirmation of as-delivered material properties, testing of geomembrane welds, and compaction testing (refer following bullet point).
- *Compaction Testing*: Testing for as-constructed density and moisture content will be routinely performed on all soil construction materials. The Contractor will be required to engage an independent GITA from a specified short list to inspect earthworks construction and perform compaction testing.
- *Survey*: Numerous requirements for surveying of constructed alignments , inverts, and constructed soil and geosynthetic material surfaces are include in the Technical Specification. The survey provides data for Works-as-Executed (WAE) documentation and for confirming that design layer thicknesses have been achieved in liner and capping systems.

- *Audit Testing*: The Superintendent will arrange, at his discretion, for sampling and testing of delivered and emplaced construction materials, including soils and geosynthetics, to provide material property measurements that are independent of measurements by the Contractor. Activities where audit testing is likely to be undertaken are identified in Table 18 below.

Table 18: Construction Quality Management System Summary

No.	Activity/Material	Hold Point	Full-Time Inspection	Field Testing	Survey	Audit Testing
A	**CONSTRUCTION MATERIALS**					
1	Source Approval (each material)	x				x
2	Confirmation of as-delivered material properties (each material)			x		x
B	**CONSTRUCTION ACTIVITIES**					
1	**Excavation of Onsite Materials and Formation of Subgrade**					
1.1	Removal of Vegetation and Topsoil, Work Method Statement	x				
1.2	Structures Demolition, Work Method Statement	x				
1.3	Excavation of Existing Eastern Gully Capping Materials, Work Method Statement, and WAE drawings	x		x	x	
1.4	*Subgrade Preparation*					
a	Work Method Statement	x				
b	Proof roll and placement of Unit 2 – general fill		x	x	x	x
c	Submission of subgrade WAE drawings and surface analysis	x			x	
2	**Cell Base Lining System Construction (Cells 1 to 4)**					
2.1	*Bearing Layer*					
a	Placement of Unit 4 – Clay Rich Material to form bearing layer		x	x		x
b	Survey and WAE	x			x	
2.2	*Perimeter Bund*					
a	Setout survey of perimeter bund alignment	x			x	
b	Placement of Unit 4 – Clay Rich Material for the bund		x	x	x	
c	Survey and WAE	x			x	
2.3	*Internal Bunds (refer item 2.2)*					
2.4	*Geosynthetics*					
a	Approval of qualified sub-contractor	x				
b	Geosynthetics quality control procedures manual	x				
c	Submission of data, statements, reports and certificates	x				

No.	Activity/Material	Hold Point	Full-Time Inspection	Field Testing	Survey	Audit Testing
d	Panel layout drawings for GCL and geomembrane	x				
e	Surface preparation for GCL placement	x				
f	Anchor trench				x	
g	Placement of Unit 17 – GCL		x			x
h	Placement of Unit 16 – HDPE Geomembrane		x	x	x	x
i	Placement of Unit 12 – Cushion Geotextile		x	x		x
2.5	*Leachate Collection System*					
a	Placement of Unit 23 – Leachate Collection Pipe		x			
b	Installation of leachate clean out access points	x	x			
c	Leachate collection pipe WAE drawings				x	
d	Unit 7 –Drainage Aggregate Work Method Statement	x				
e	Field placement trial		x	x		x
f	Placement of Unit 7 – Drainage Aggregate		x	x		x
g	Placement of Unit 11 – Filter Geotextile		x	x		x
h	Leachate collection layer WAE drawings	x			x	
2.6	*Construction of Leachate Sump*					
a	Leachate Sump Construction Work Method Statement	x				
b	Excavation of sump and formation of sump base		x	x	x	
c	Placement of Clay Material and Clay WAE	x	x	x	x	x
d	Geosynthetic Materials Installation		x	x		x
e	Installation of Unit 24 – Leachate Sump Outlet Pipe with liner penetration		x		x	
f	Placement of Unit 23 - Leachate Collection Pipe within sump		x		x	
g	Backfilling the sump by Unit 7 – Drainage Aggregate and covering by Unit 11 – Filter Geotextile		x	x	x	x
h	Leachate Collection WAE drawings (included in item 2.5 h)					
2.7	*Construction of Leachate Drainage System*					
a	Leachate Drainage System Construction Work Method Statement	x				
b	Installation of Unit 25 – Leachate Drainage Pipe and connection with existing leachate drainage pipes		x		x	
c	Excavation and Installation of Unit 27 – Leachate Sump Riser		x		x	
d	Connection of Unit 27 – Leachate Sump Riser with Unit 25 – Leachate Drainage Pipe and Unit 24 – Leachate Sump Outlet Pipe		x		x	
e	WAE drawings (included in item 2.5 c)					

No.	Activity/Material	Hold Point	Full-Time Inspection	Field Testing	Survey	Audit Testing
3	**Piggy Back Lining System Construction**					
3.1	*Gas Venting System*					
a	Placement of Unit 8 – Gas Drainage Gravel			x	x	
b	Placement of Unit 21 – Gas Collection Pipes				x	
c	Placement of gas venting header pipes				x	
d	Gas Venting System WAE and backfill pipes	x			x	
3.2	*Base Layer*					
a	Work Method Statement	x				
b	Placement of Unit 6 – Base Material and Unit 18 Geogrid	x		x		x
c	Submission of base layer WAE drawings and surface analysis	x			x	
3.3	*Bearing Layer (refer item 2.1)*					
3.4	*Perimeter Bund (refer item 2.2)*					
3.5	*Internal Bunds (refer item 2.3)*					
3.6	*Geosynthetics*					
a-f	Documentation and submittals (refer item 2.4, sub-items a to f)					
g	Placement of Unit 17 – GCL		x			x
h	Placement of Unit 15 – LLDPE Geomembrane		x	x	x	x
3.7	*Leachate Collection System*					
a	Placement of Unit 14 – Geocomposite Drainage Net (Leachate)		x	x		x
b	Placement of Unit 23 – Leachate Collection Pipe		x			
c	Installation of leachate clean out access points	x	x			
d	Leachate collection pipe WAE				x	
e	Placement of Unit 7 – Drainage Aggregate and Unit 11 – Filter geotextile pipe surrounds		x	x		x
3.8	*Protection Layer*					
a	Unit 9 – Protection Material Work Method Statement	x				
b	Field placement trial		x	x		x
c	Placement of Unit 9 – Protection Material		x	x		x
d	Protection layer WAE drawings	x			x	

No.	Activity/Material	Hold Point	Full-Time Inspection	Field Testing	Survey	Audit Testing
4	**Capping System**					
4.1	*Gas Venting System (refer item 3.1)*	*x*			*x*	
4.2	*Bearing Layer for Cap*					
a	Placement of Unit 4 – Clay Rich Material to form bearing layer		x	x		x
b	Submission of WAE drawings and documentation	x			x	
4.3	Placement of Unit 15 – LLDPE Geomembrane		x	x		x
4.4	*Placement of Drainage Layer*					
a	Placement of Unit 13 – Geocomposite Drainage Net (Surface Water)	x	x			x
b	Placement of Unit 26 – Subsoil Drainage Pipe and Unit 7 – Drainage Aggregate		x		x	
c	WAE drawings and documentation	x			x	
4.5	*Placement of Unit 1 – Topsoil*					
a	Work Method Statement for Unit 1 – Topsoil Installation	x				
b	Placement of Unit 1 – Topsoil		x	x	x	x
c	WAE drawings and documentation				x	
4.6	*Revegetation*					
a	Revegetation Plan	x				
b	Drop Structures	x		x	x	
c	Final Capping levels WAE	x			x	
	Additional Construction Quality Management items from future revegetation specification (to be determined)					

5.2 Eastern Waste Cutback

The preliminary design includes excavation of existing waste from the Eastern Gully Landfill and relocation during Stage 1 of the New Landfill Cell project, referred to as the 'Eastern Waste Cutback.' The quantity of existing waste involved is 300,000 cu.m. These works will provide for gravity drainage of surface water around the eastern perimeter of the final landform while also satisfying other site design constraints. The rationale for and scope of these works have been discussed in Sections 3.3.7 and 4.2.3 and shown in Drawings D011 and D019.

The waste excavation and relocation work during Stage 1 of the proposed new landfill cell will be undertaken over a period of approximately twelve months. The works will be staged to manage potential environmental impacts. In addition to landfilling environmental controls identified within the Draft LEMP (Appendix P of the EA document), additional environmental controls for the Eastern Waste Cutback will likely include those given below.

- *Leachate*: Leachate would be controlled at each excavation stage by constructing a leachate sump at a low point in the excavation floor. Leachate sumps may also be needed in local areas at the base of the excavation batter if perched leachate is encountered. The leachate collected at sumps would be pumped to the existing landfill leachate system.
- *Landfill Fire*: Test pitting would occur in advance of each excavation stage. The test pits would identify any high temperature waste with the potential to ignite on exposure to air. Prior to the main excavation, this material would be excavated and transported to a clay pad area where it would be watered down to cool the waste material prior to draining and placing it into the proposed new landfill cell at the tipping face.
- *Landfill Gas*: Landfill gas emissions would be monitored during the works in the waste excavation areas. If elevated readings are obtained work methods would be reviewed and changed as necessary.
- *Odour*: Odour generation would be minimised by keeping the exposed area of waste under excavation to approximately 2,500 m^2 and placement of intermediate cover over each excavation stage prior to commencing the next excavation stage.
- *Leachate Generation*: Temporary bunds would be constructed at the top of batters prior to batter excavation to stop clean surface runoff water running down excavation batters and onto the excavation floor and becoming impacted by the waste.
- *Run On*: Excavation will be staged such that runoff from upstream catchments does not drain along the eastern edge of the landform flow until the entire batter cutback is complete. This approach ensures major overland flows will not disrupt the works.

A detailed Construction Environmental Management Plan (CEMP) will be prepared for the works prior to construction.

5.3 Staging

The preliminary design for the New Landfill Cell provides for staged landfill construction and placement of landfill waste in order that the site can be progressively developed and rehabilitated Staging will generally proceed from east to west, in the five major stages shown in Drawings D012 and D051. Key issues for staging include landfill airspace availability, surface water management, and suitability of access roads for landfilling and liner and capping construction. Overall staging requirements, constraints and feasibility issues have been discussed in Sections 3.3.9 and 4.2.5, with staging for surface water management discussed in Section 4.5.

As indicated in Section 4.2.5, a series of staging drawings have been developed for the preliminary design to confirm staging feasibility. The staging drawings, which show liner construction areas, landfilling areas, final capping areas, access roads, and surface water drainage paths, depict the site at eleven points of time

during project development. These eleven points of time correspond to approximately two sub-stages for each of the five major stages. The preliminary staging drawings are presented in the Landfill Master Plan which is part of the Draft LEMP (Appendix P of the EA document).

The effect of site weather patterns on project staging, and sub-staging, will be considered during detailed design. Although weather issues will not affect the overall staging sequence, it is possible that schedule requirements for construction of some landfill sub-stages will be affected. This is because seasonal variations in rainfall and wind velocity/direction at the site (refer Section 2.4) will make some times of year more favourable for lining system and/or final capping system construction.

5.4 Surface Water Management

Design requirements and features for surface water management have been discussed in Sections 3.3.7 and 4.5. The preliminary design provides for separation of surface water into the following three categories at each stage of construction: (i) clean stormwater runoff from undisturbed and rehabilitated areas of the site (suitable for direct offsite discharge); (ii) potentially sediment-laden stormwater runoff from disturbed areas of the site (requiring retention/sediment removal prior to offsite discharge); and (iii) stormwater runoff that has come into contact with waste (requiring treatment as leachate). Overall drainage paths for different stages of the project are illustrated in Drawing D051 and channel and bench drain sections are depicted in Drawings D017 to D019, D013 (Section F), and D052. The full preliminary design assessment is given the Surface Water Assessment Report that is presented in Appendix G of the EA document.

Surface water management control measures will be progressively developed as lining system construction and landfilling proceeds. Key design principles for these control measures include those given below.

- Water in different quality categories will be kept separated.
- Clean runoff from areas that are unaffected by the development would be discharged directly to Dapto Creek. Runoff from fully rehabilitated areas, two years after rehabilitation, would also be discharged directly to Dapto Creek.
- Runoff from areas that are likely to generate sediment such as the new cell construction areas and stockpile areas would be directed into sedimentation ponds.
- Construct a perimeter bund and drain around the entire existing landfill area to prevent surface water run on. Extend the perimeter bund and drain as new areas are landfilled.
- Construct temporary diversion bunds and drains within the perimeter bund to separate and collect runoff from disturbed areas and runoff from active waste areas.

These principles will be incorporated into the detailed Construction Environmental Management Plan (CEMP) to be prepared for the works prior to construction.

6.0 LANDFILL OPERATION AND MAINTENANCE

6.1 Landfill Systems Monitoring and Maintenance

Monitoring and maintenance activities are required for some of the landfill systems in order to promote acceptable long-term performance.

The following table presents a summary of key requirements to be considered for landfill inspection, monitoring, and maintenance and/or repair. Many of these items are included in the Draft LEMP (Landfill Environmental Management Plan) that is presented as Appendix P of the Environmental Assessment document. This table does not include structures external to the landfill landform which are not included in the preliminary landfill design drawings (e.g., leachate ponds, surface water ponds, leachate treatment plant, landfill gas infrastructure).

Table 19: Summary of Potential Requirements for Landfill Systems Monitoring and Maintenance

ITEM	ACTIVITY	FREQUENCY
Landfill Final Cap (where installed)		
Vegetation		
Vegetation and erosion inspections	▪ Inspect benches and batters ▪ Locate, document & remediate erosion areas > 10 sq.m. ▪ Reseed areas without vegetation > 10 sq.m.	Quarterly during year 1, then annually
Weed Control	▪ Target invasive and/or deep rooted species and trees	Quarterly during year 1, then annually
Tree and Shrub Sapling Removal	▪ Remove unwanted tree and shrub saplings	24-monthly
Final Surface Levels and Subsurface Drainage		
Site Walkover Inspection	▪ Backfill depressions > 200 mm; Remediate Depressions > 500 mm including geomembrane replacement; Assess additional remedial measures if re-occurring ▪ Identify and document wet areas or seepage and assess remedial measures if re-occurring ▪ Inspect cap following strong earthquakes and maintain and repair cap if required	Quarterly during year 1, then 6-monthly and within 24 h of heavy rain (>100 mm/d)
Inspect subsurface drain pipe outlets within 24 h of heavy rain (>100 mm/d)	▪ Visually assess flow and document outlets with anomalously low flow; Assess additional remedial measures if re-occurring	within 24 h of heavy rain (>100 mm/d)
Leachate Collection System		
Leachate Collection Pipe Cleaning	▪ Water jetting (or similar) over accessible pipe length ▪ Use perimeter access points ▪ Use leachate sump risers for access; note: may require confined space entry and sump dewatering ▪ CCTV inspection of any uncleared blockages	After 1 year, then 5-yearly
Perimeter Drains		
Inspect Drain	▪ Remove thick vegetation and sediment >75mm ▪ Repair areas of erosion; Install erosion control mats where >100mm of erosion ▪ Repair drop structures or replace disturbed sections if required	6-monthly and within 24 h of heavy rain (>100 mm/d)

ITEM	ACTIVITY	FREQUENCY
Other Maintenance		
Maintain Site Security	▪ Maintain fencing, gates, locks ▪ Review and/or maintain other security measures	Ongoing
Environmental Monitoring		
Groundwater Levels and Quality	Refer to Section 6.2 below.	Refer to Section 6.2 below.
Surface Water Quality		
Leachate Quality and Quantity		
Landfill Gas Collections		
Landfill Gas Surface Emissions		
Landfill Gas Subsurface Migration		

6.2 Site Monitoring

The proposed environmental monitoring system for the site is presented in the Draft LEMP (Appendix P of EA document). During the operating life of the landfill, and after landfill closure, environmental monitoring is proposed as outlined below.

- Groundwater quality: Monitoring is proposed at approximately ten dedicated monitoring wells that are outside the final landfill footprint. In addition, approximately ten dedicated monitoring wells that are within the landfill expansion areas may continue to be monitored until they are decommissioned prior to landfill construction. The proposed monitoring wells comprise both existing and proposed wells located in both up gradient and down gradient locations.
- Surface water quality: Monitoring is proposed at six points along Dapto creek and the un-named channel draining from the landfill site into Dapto Creek. The six points include both upstream and downstream locations.
- Leachate characteristics: Monitoring is proposed for leachate quality and quantity at the terminal point of the leachate collection system. Leachate characteristics are needed to assist in identification of potential groundwater impacts and for leachate treatment plant operations.
- Landfill gas: Landfill gas collection volumes and emissions from the landfill surface would be measured as a matter of course for operation of the planned active landfill gas extraction system. A subsurface landfill gas monitoring network is proposed at the site to monitor potential gas migration. The proposed network would comprise an initial installation of 12 dedicated shallow monitoring wells in the eastern portion of the site, followed by approximately 25 additional wells installed progressively with the east-to-west landfill expansion. .

Any additional monitoring specified in the site Environment Protection License would also be conducted.

The Draft LEMP also provides for monitoring of final capped areas to include site walkovers to detect potential areas of cap degradation, excessive settlement, erosion and slumping, as reflected in Table 19 above. It also describes procedures for maintenance of the landfill surface and repairing damage to the capping system

The Draft LEMP also outlines contingency and remediation measures should environmental monitoring indicate that the landfill is impacting upon air quality, surface water quality, groundwater quality, or amenity of nearby residents.

7.0 REFERENCES

Gourc, J.P, and Olivier, F., March 2005, "Calibration of the Incremental Settlement Prediction Model (ISPM) from field monitoring campaigns," *International Workshop on Hydro-Physic- Mechanics of Landfills*, Grenoble University.

LaGatta, M.D., Boardman, B.T., Daniel, D.E., and Cooley, B.H., 1997, "Geosynthetic Clay Liners Subjected to Differential Settlement," *Journal of Geotechnical and Geoenvironmental Engineering*, Vol. 123, No. 5, pp. 402-410.

Rowe (2005) "Long-Term Performance of Contaminant Barrier Systems," *Geotechnique*, v. 55, no. 9, pp. 631-678.

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Report Signature Page





Gary Schmertmann
Associate

Jacinta McMahon
Project Manager

GRS/JM/grs

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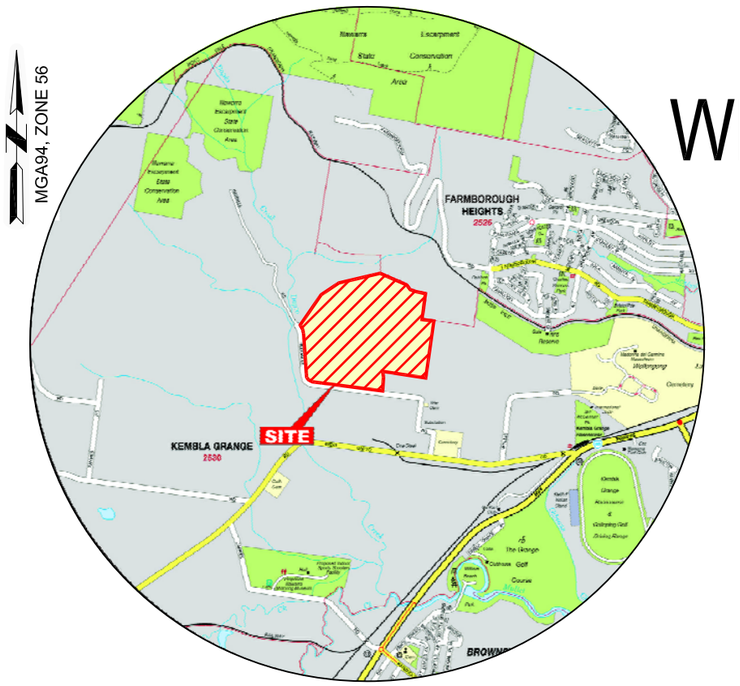
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APPENDIX A

Preliminary Design Drawings

WOLLONGONG CITY COUNCIL
WHYTES GULLY LANDFILL - NEW CELL DESIGN

MGA94, ZONE 56



LOCALITY PLAN
NOT TO SCALE

DRAWING LIST

DRAWING No.	TITLE
D001	SITE LOCALITY AND DRAWING LIST
D002	SITE PLAN
D003	EXISTING CONTOURS AND EASEMENTS
D004	APPROXIMATE BOTTOM OF EXISTING WASTE PLAN
D011	WASTE CUTBACK PLAN AND SECTIONS
D012	STAGING AND SUBGRADE PREPARATION PLAN
D013	SUBGRADE PREPARATION SECTIONS
D014	FINAL CAP PROFILE
D015	FINAL LANDFORM INDICATIVE SECTIONS - SHEET 1
D016	FINAL LANDFORM INDICATIVE SECTIONS - SHEET 2
D017	INDICATIVE SECTIONS ALONG LANDFORM EDGE - SHEET 1
D018	INDICATIVE SECTIONS ALONG LANDFORM EDGE - SHEET 2
D019	INDICATIVE SECTIONS ALONG LANDFORM EDGE - SHEET 3
D021	NEW CELL CROSS SECTIONS
D022	CELL BASE LINER DETAILS
D031	PIGGY BACK LINER DETAILS
D041	LEACHATE COLLECTION SYSTEM PLAN
D042	LEACHATE COLLECTION SYSTEM DETAILS - SHEET 1
D043	LEACHATE COLLECTION SYSTEM DETAILS - SHEET 2
D051	SURFACE WATER MANAGEMENT SYSTEM CONCEPT PLAN
D052	BENCH AND DROP STRUCTURE DETAILS
D061	CAPPING DETAILS
D071	PIGGY BACK GAS VENTING SYSTEM PLAN

MATERIAL LIST

UNIT 1	TOP SOIL
UNIT 2	GENERAL FILL
UNIT 3	COVER MATERIAL
UNIT 4	CLAY RICH MATERIAL
UNIT 5	CLAY MATERIAL
UNIT 6	BASE MATERIAL
UNIT 7	DRAINAGE AGGREGATE
UNIT 8	GAS DRAINAGE AGGREGATE
UNIT 9	PROTECTION MATERIAL
UNIT 11	FILTER GEOTEXTILE
UNIT 12	CUSHION GEOTEXTILE
UNIT 13	GEOCOMPOSITE DRAINAGE NET (SURFACE WATER)
UNIT 14	GEOCOMPOSITE DRAINAGE NET (LEACHATE)
UNIT 15	LLDPE GEOMEMBRANE
UNIT 16	HDPE GEOMEMBRANE
UNIT 17	GCL
UNIT 18	GEOGRID
UNIT 21	GAS COLLECTION PIPE
UNIT 22	GROUNDWATER DRAINAGE PIPE
UNIT 23	LEACHATE COLLECTION PIPE
UNIT 24	LEACHATE SUMP OUTLET PIPE
UNIT 25	LEACHATE DRAINAGE PIPE
UNIT 26	SUBSOIL DRAINAGE PIPE
UNIT 27	LEACHATE SUMP RISER
UNIT 31	BENTONITE

NOTES:

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2. ALL LEVELS ARE IN METRES TO AUSTRALIAN HEIGHT DATUM (AHD).
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5. DIMENSIONS AND LOCATION OF EXISTING STRUCTURES SHALL BE CONFIRMED ON SITE BY THE CONTRACTOR PRIOR TO COMMENCEMENT OF WORKS.
6. LOCATION AND DEPTH OF ALL SERVICES TO BE VERIFIED BY THE CONTRACTOR PRIOR TO COMMENCEMENT OF WORKS.
7. DIMENSIONS SHALL NOT BE SCALED OFF DRAWINGS.

LEGEND

- EXISTING MINOR CONTOUR
- EXISTING MAJOR CONTOUR
- DESIGN MINOR CONTOUR
- DESIGN MAJOR CONTOUR

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EJ JEET	J McMAHON	NOT TO SCALE	A3

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PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN
DRAWING TITLE: SITE LOCALITY AND DRAWING LIST

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LEGEND

PROPERTY BOUNDARY

BASE DRAWING TAKEN FROM K F WILLIAMS AND ASSOCIATES DRG.WHYTES PHOTOGRAMMETRY AND GROUND SURVEY 20-07-11.dxf DATED 20 JULY 2011.

SITE PLAN

SCALE 1:4,000

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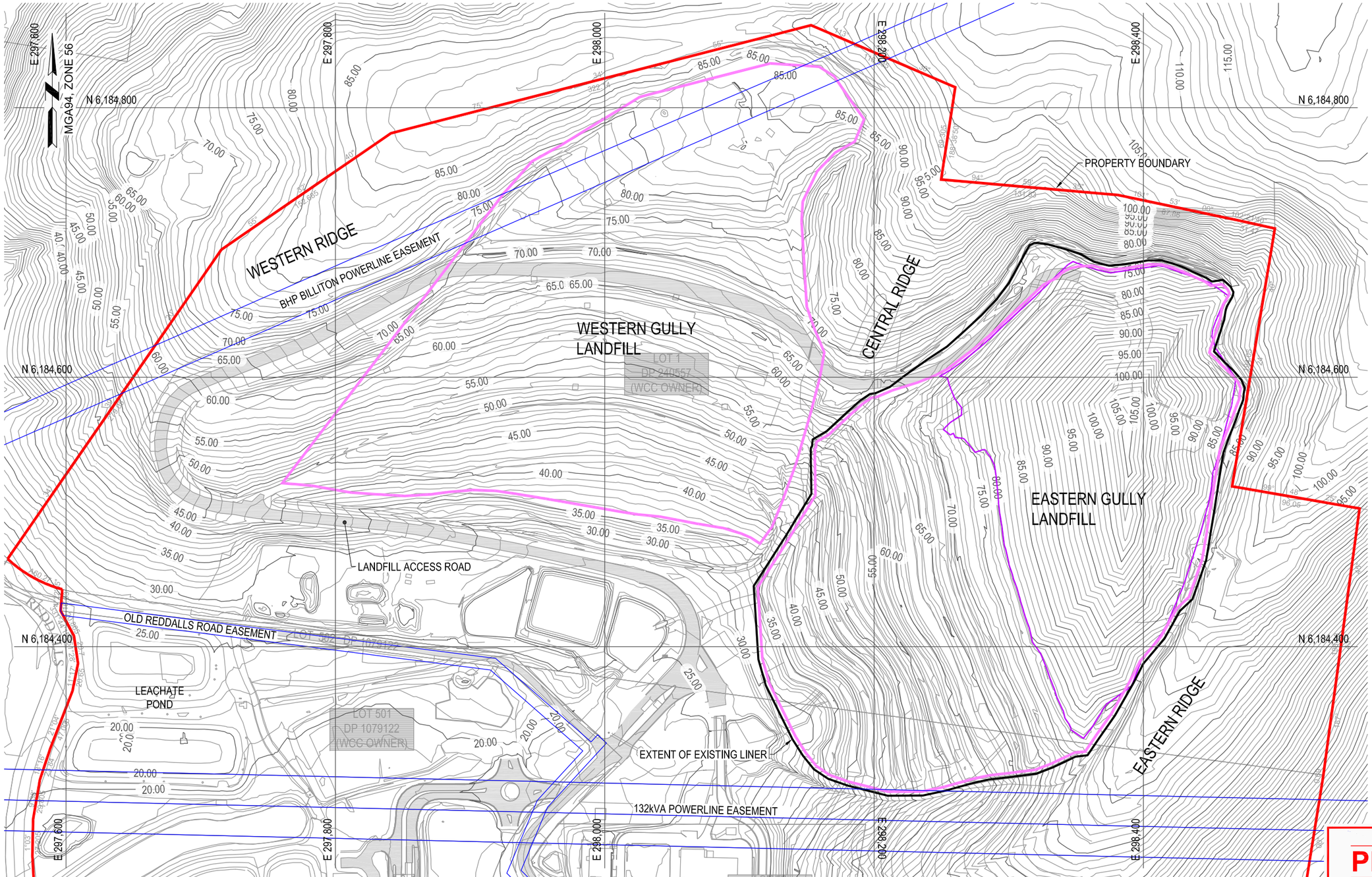
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- CURRENT FILLING AREA (REFER NOTE 2)
- APPROX. EXTENT OF WASTE (REFER NOTE 3)
- EASEMENT

NOTES:

1. EXTENT OF LINER IN EASTERN GULLY BASED ON "PACIFIC LINING CO. AUSTRALIA PTY. LTD PDF DRAWINGS 267 / 1 DATED NOV. 1996 AND 287 / 1 DATED MAY 1998"; "WOLLONGONG CITY COUNCIL AS BUILT SURVEY FOR HDPE LINER ON EASTERN GULLY LANDFILL, CADD DRAWING 'WHYTES GULLY 3D', RECEIVED 09-11-2011"; AND "K.F. WILLIAMS & ASSOCIATES PTY. LTD CADD DRAWING SV01 REV B DATED 26-07-2011".
2. EXTENT OF CURRENT FILLING AREA INDICATES AREA WHERE ADDITIONAL LANDFILL WILL BE PLACED TO RAISE LEVELS TO THE EXISTING FINAL PROFILE LEVELS. CONTOURS SHOWN WITHIN THIS AREA REPRESENT EXISTING FINAL PROFILE LEVELS (GOLDER DRAWING 097625103-006-R-F019-REVA).
3. APPROX. EXTENT OF WASTE BASED PRIMARILY ON SITE OBSERVATION AND INFORMATION FROM COUNCIL.

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EXISTING CONTOURS AND SITE LAYOUT

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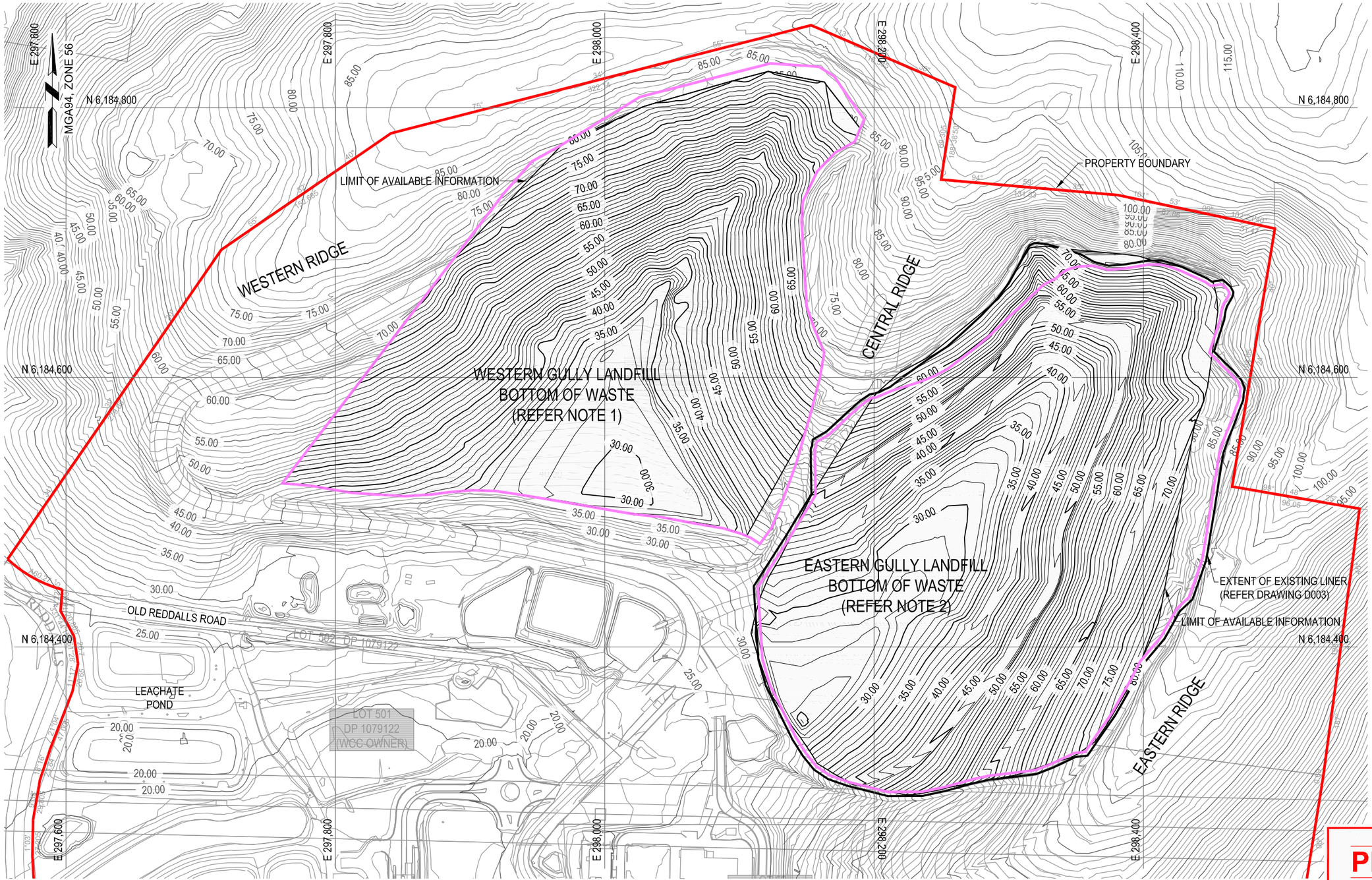
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PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

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- PROPERTY BOUNDARY
- APPROX. EXTENT OF WASTE (REFER DRAWING D003)

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2. BASED ON "WOLLONGONG CITY COUNCIL AS BUILT SURVEY FOR HDPE LINER ON EASTERN GULLY LANDFILL, CADD DRAWING 'WHYTES GULLY 3D', RECEIVED 09-11-2011".

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APPROXIMATE BOTTOM OF EXISTING WASTE

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REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
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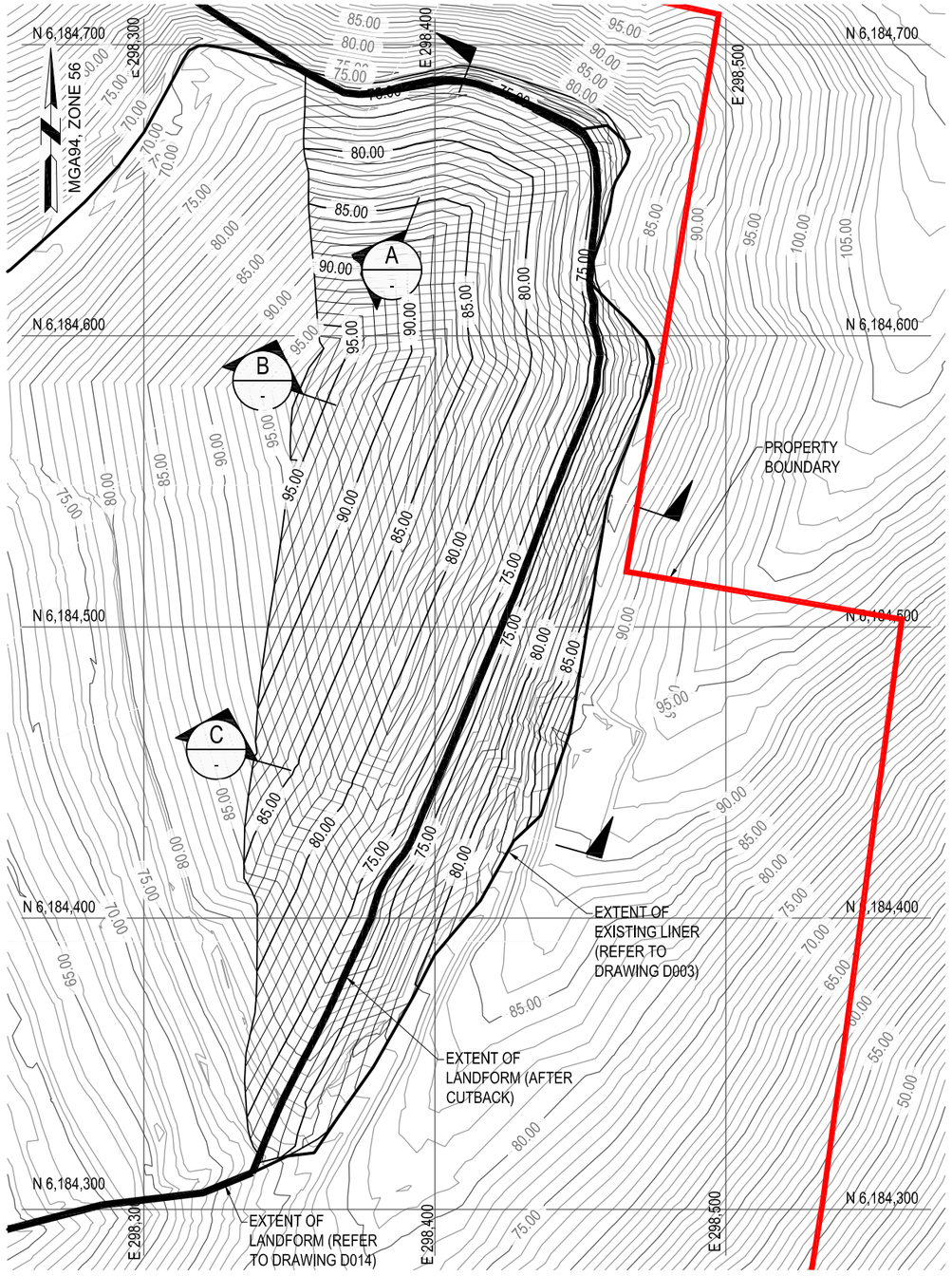
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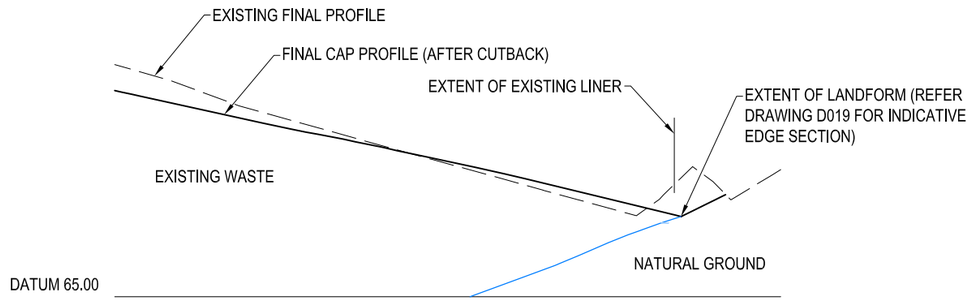
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CLIENT: WOLLONGONG CITY COUNCIL
PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN
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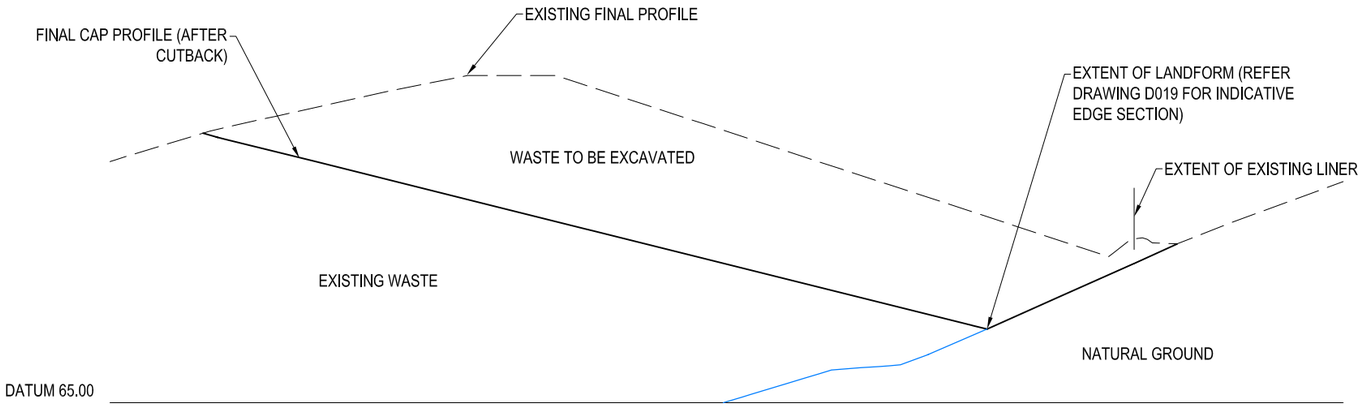
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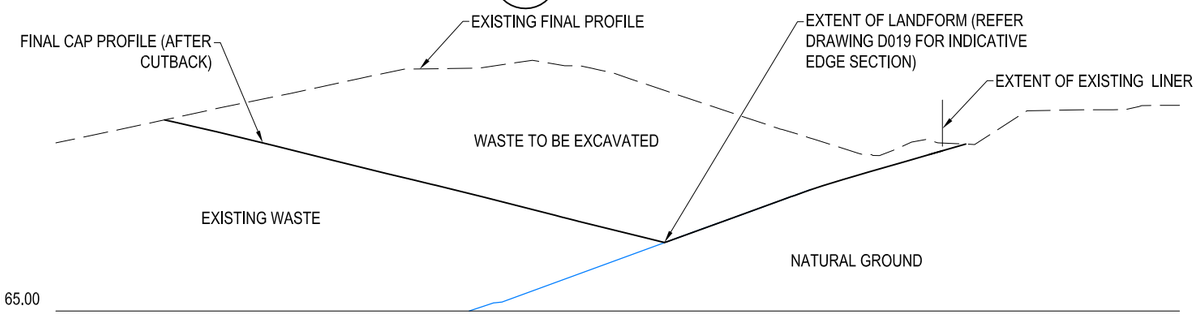




SECTION A
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SECTION B
SCALE 1:750



SECTION C
SCALE 1:750

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1:2,000 0 40 80 120m

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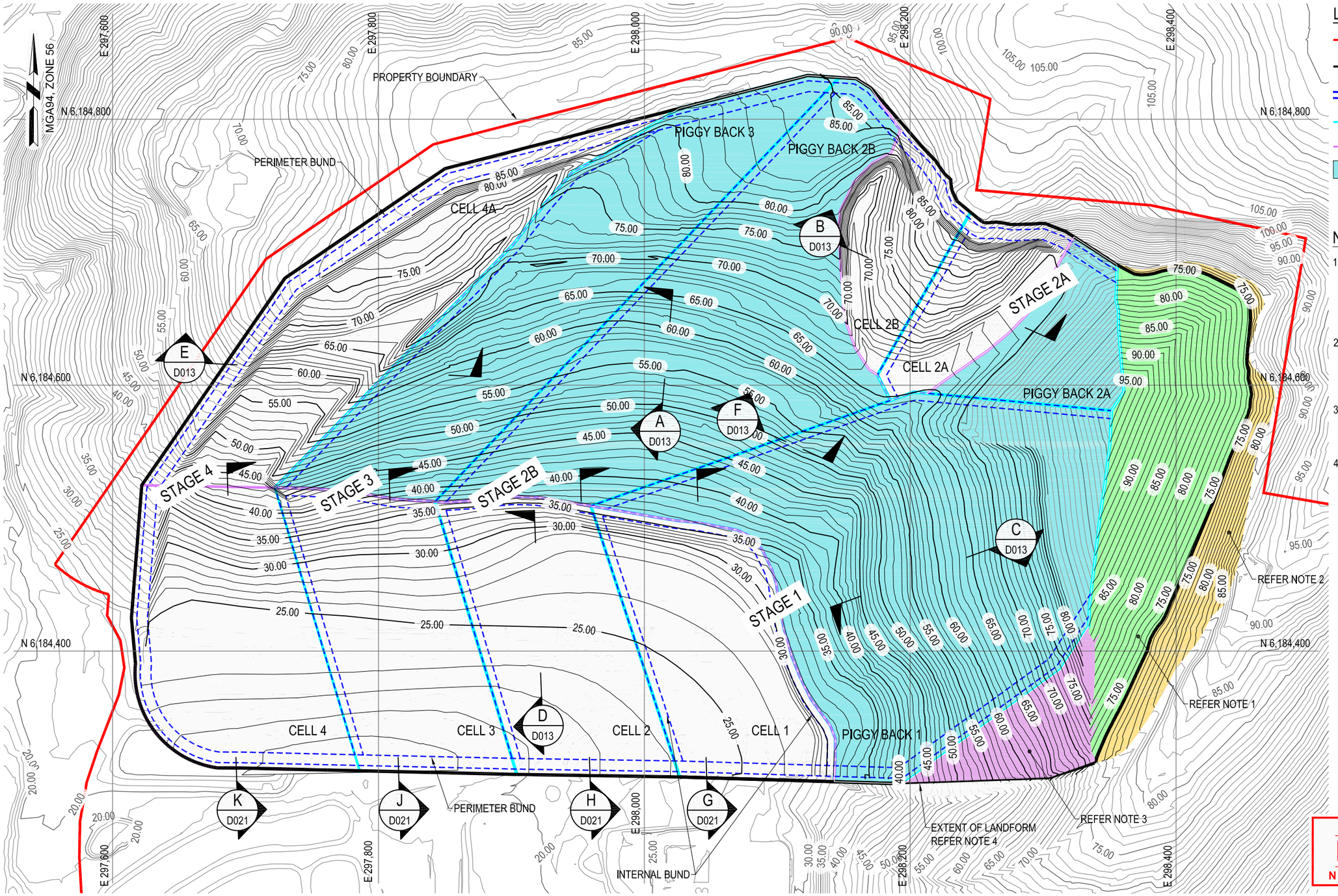
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PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: WASTE CUTBACK PLAN AND SECTIONS

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Xref: 117625003-XREF-EXISTING GROUND JULY MERGED WITH 2009 GOLDER DESIGN.dwg; 117625003-XREF-WASTE CUT BACK TO EXISTING.dwg; GAP_LOGO-A3.dwg; 117625003-XREF-SUBGRADE SECTIONS.dwg;



LEGEND

- PROPERTY BOUNDARY
- EXTENT OF LANDFORM
- PROPOSED BUNDS
- STAGING BOUNDARY
- CELL BOUNDARY
- PIGGY BACK AREA

NOTES:

1. SHADED AREA INDICATES PORTION OF WASTE CUTBACK WHERE A WASTE BATTER WILL REMAIN AFTER THE CUTBACK IS COMPLETE. CONTOUR LEVELS INDICATE THE WASTE BATTER SURFACE.
2. SHADED AREA INDICATES PORTION OF WASTE CUTBACK WHERE ALL WASTE WILL BE REMOVED. CONTOUR LEVELS INDICATE NATURAL GROUND AFTER WASTE REMOVAL.
3. SHADED AREA INDICATES AREA WHERE FINAL CAP WILL BE INSTALLED WITH NO ADDITIONAL WASTE PLACEMENT.
4. ADDITIONAL WASTE PLACEMENT TO OCCUR WITHIN THE EXTENT OF LANDFORM, EXCEPT WITHIN SHADED AREAS IDENTIFIED IN NOTE 1 AND NOTE 3.

ISSUED FOR
PRELIMINARY
NOT FOR CONSTRUCTION

1:3,000

0 60 120 180m

BASE DRAWING TAKEN FROM K F WILLIAMS AND ASSOCIATES DRG.WHYTES PHOTOGRAMMETRY AND GROUND SURVEY 20-07-11.dxf DATED 20 JULY 2011.

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
B	ISSUED FOR PRELIMINARY	EJ JEET	R HUYNH	R HUYNH	G SCHMERTMANN	G SCHMERTMANN	
A	DRAFT - ISSUED FOR CLIENT REVIEW	H CAMPBELL	R HUYNH	R HUYNH	G SCHMERTMANN	G SCHMERTMANN	23.01.2012

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WEB: www.golder.com

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE
EJ JEET	J McMAHON	1:3,000	A3

CLIENT: WOLLONGONG CITY COUNCIL

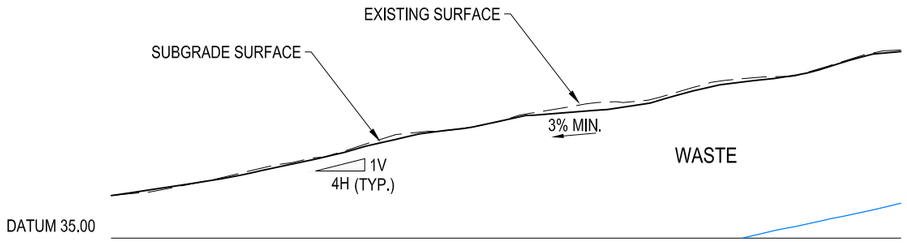
PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: STAGING AND SUBGRADE PREPARATION PLAN

PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
117625003	145	S	D012	B

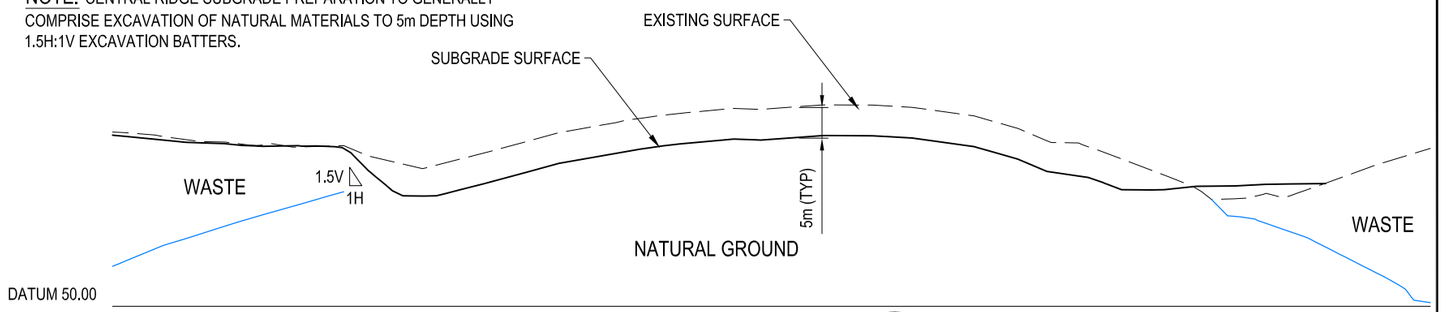
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Xref: 117625003-XREF-WASTE CUT BACK TO EXISTING.dwg; 117625003-XREF-SITE EXTENT BOUNDARIES.dwg; 117625003-XREF-SUBGRADE COMBINED.dwg; 117625003-XREF-EXISTING GROUND JULY MERGED WITH 2009 GOLDER DESIGN.dwg; 117625003-XREF-INTERNAL AND EXTERNAL BUND.dwg; GAP_LOGO-A3.dwg;

NOTE: WESTERN GULLY SUBGRADE PREPARATION TO GENERALLY COMPRISE SMOOTHING OF EXISTING LANDFILL SURFACE



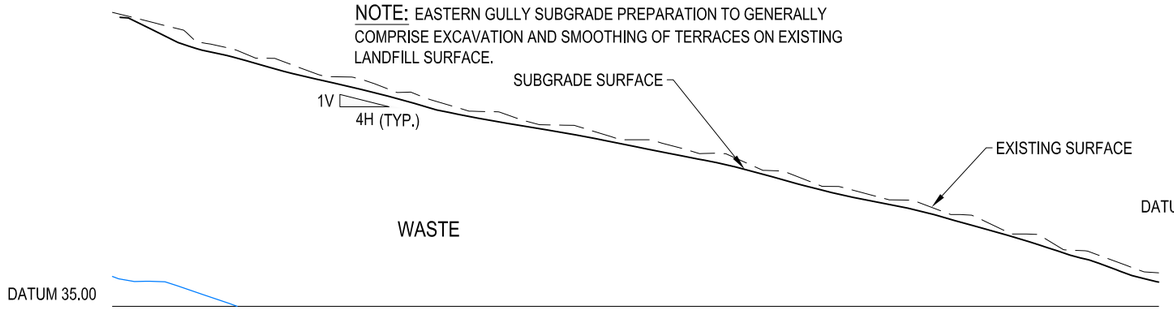
SECTION A — SCALE 1:1,000 — D012

NOTE: CENTRAL RIDGE SUBGRADE PREPARATION TO GENERALLY COMPRISE EXCAVATION OF NATURAL MATERIALS TO 5m DEPTH USING 1.5H:1V EXCAVATION BATTERS.



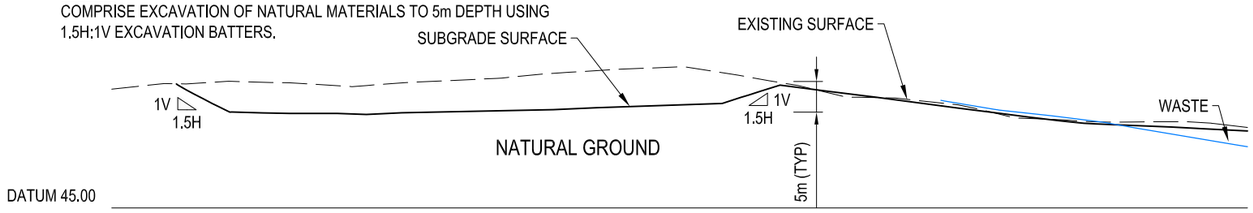
SECTION B — SCALE 1:1,000 — D012

NOTE: EASTERN GULLY SUBGRADE PREPARATION TO GENERALLY COMPRISE EXCAVATION AND SMOOTHING OF TERRACES ON EXISTING LANDFILL SURFACE.

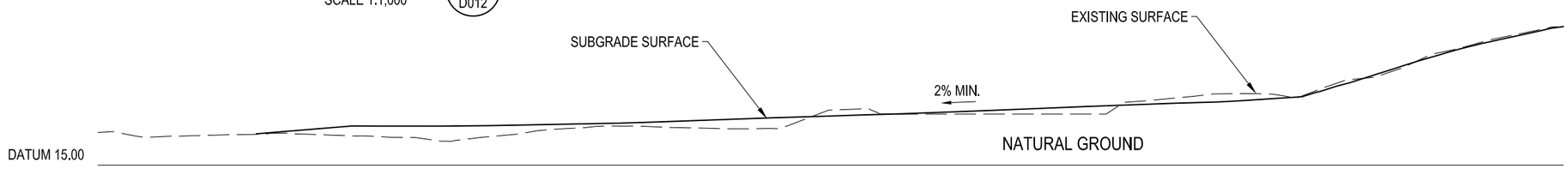


SECTION C — SCALE 1:1,000 — D012

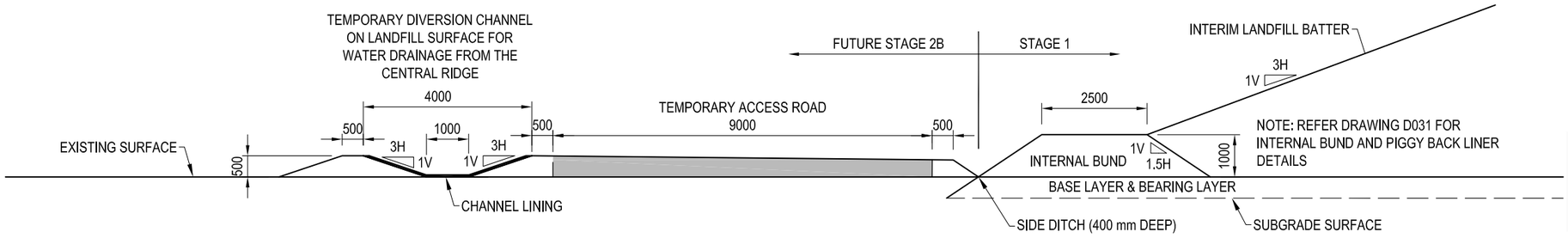
NOTE: WESTERN RIDGE SUBGRADE PREPARATION TO GENERALLY COMPRISE EXCAVATION OF NATURAL MATERIALS TO 5m DEPTH USING 1.5H:1V EXCAVATION BATTERS.



SECTION E — SCALE 1:1,000 — D012



SECTION D — SCALE 1:1,000 — D012



SECTION F — SCALE 1:125 — D012 — TYPICAL SECTION - TEMPORARY ACCESS ROAD AND DIVERSION CHANNEL (IN STAGE 1)

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1:1,000 — 0 20 40 60m

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
B	ISSUED FOR PRELIMINARY	EJ JEET	R HUYNH	R HUYNH	G SCHMERTMANN	G SCHMERTMANN	
A	DRAFT - ISSUED FOR CLIENT REVIEW	H CAMPBELL	R HUYNH	R HUYNH	G SCHMERTMANN	G SCHMERTMANN	23.01.2012

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LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE
EJ JEET	J McMAHON	1:1,000	A3

CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: SUBGRADE PREPARATION SECTIONS

PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
117625003	145	S	D013	B

Plot Date: 6 March 2012 Time:12:48:38 PM By: Jeet, Elvin Path: K:\Des\2011\117625003 WHYTES GULLY\DRAWINGS - File Name:117625003-145-S-D013-REVB.dwg
Xref: 117625003-XREF-SUBGRADE SECTIONS.dwg; GAP_LOGO-A3.dwg;



LEGEND

- PROPERTY BOUNDARY
- EXTENT OF LANDFORM
- APPROXIMATE ALIGNMENT OF FINAL LANDFORM ACCESS ROADS (REFER NOTE 3)

NOTES:

1. FINAL CAP PROFILE IN THIS AREA TO BE REVISED DURING FINAL DESIGN TO MATCH REST OF THE FINAL CAP SLOPE.
2. FINAL CAP PROFILE REPRESENTS AVERAGE SLOPES. SLOPE BENCHES TO BE INCLUDED DURING FINAL DESIGN. REFER SECTION G BELOW AND DRAWING D052.
3. ACCESS ROADS TO FINAL LANDFORM TO BE INCLUDED DURING FINAL DESIGN.

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1:1,000 0 20 40 60m

1:3,000 0 60 120 180m

BASE DRAWING TAKEN FROM K F WILLIAMS AND ASSOCIATES DRG.WHYTES PHOTOGRAMMETRY AND GROUND SURVEY 20-07-11.dxf DATED 20 JULY 2011.

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
B	ISSUED FOR PRELIMINARY	EJ JEET	R HUYNH	R HUYNH	G SCHMERTMANN	G SCHMERTMANN	
A	DRAFT - ISSUED FOR CLIENT REVIEW	EJ JEET	R HUYNH	R HUYNH	G SCHMERTMANN	G SCHMERTMANN	23.01.2012

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LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE
EJ JEET	J McMAHON	AS SHOWN	A3

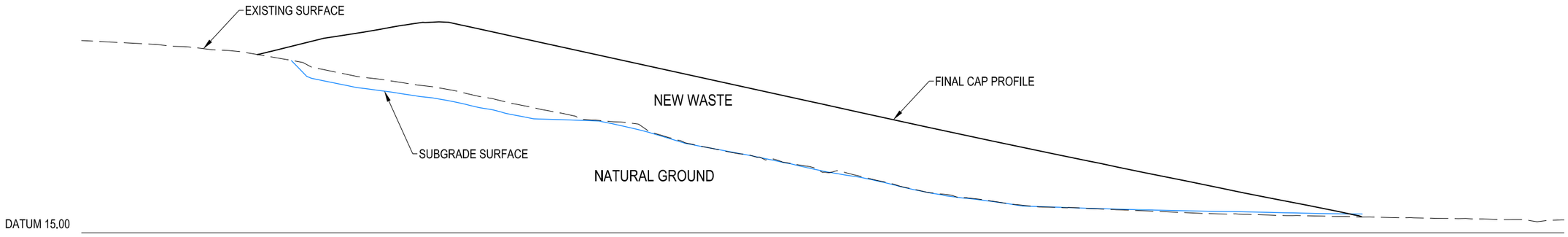
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

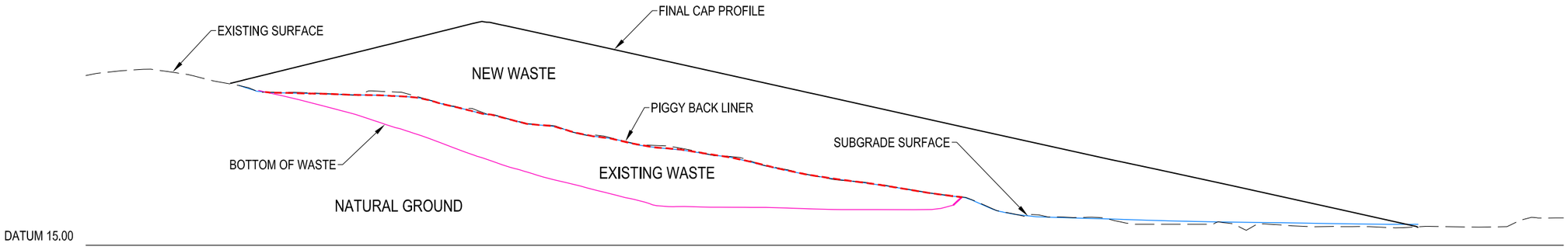
DRAWING TITLE: FINAL CAP PROFILE

PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
117625003	145	S	D014	B

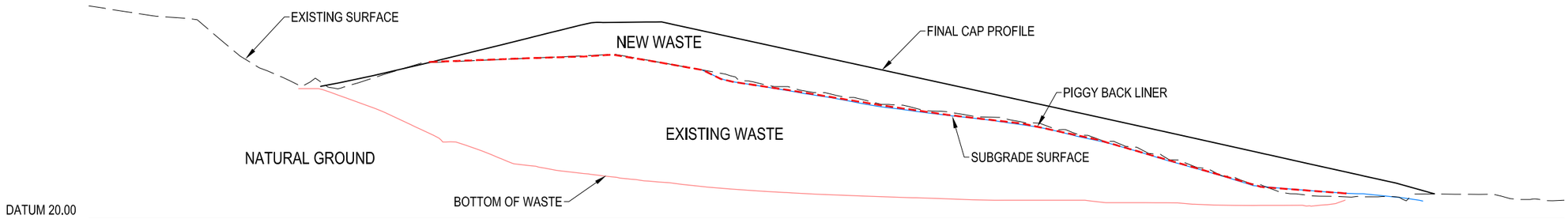
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Xref: GAP_LOGO-A3.dwg; 117625003-XREF-EXISTING GROUND JULY MERGED WITH 2009 GOLDER DESIGN.dwg; 117625003-XREF-LANDFORM FINAL AS OF 120116.dwg; 117625003-XREF-WASTE CUT BACK TO EXISTING.dwg; 117625003-XREF-SUBGRADE COMBINED.dwg;



DETAIL H
SCALE 1:2,000 D014



DETAIL J
SCALE 1:2,000 D014



DETAIL K
SCALE 1:2,000 D014

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PRELIMINARY
NOT FOR CONSTRUCTION

1:2,000

0 40 80 120m

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
B	ISSUED FOR PRELIMINARY	EJ JEET	R HUYNH	R HUYNH	G SCHMERTMANN	G SCHMERTMANN	
A	DRAFT - ISSUED FOR CLIENT REVIEW	EJ JEET	R HUYNH	R HUYNH	G SCHMERTMANN	G SCHMERTMANN	23.01.2012

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LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE
EJ JEET	J McMAHON	1:2,000	A3

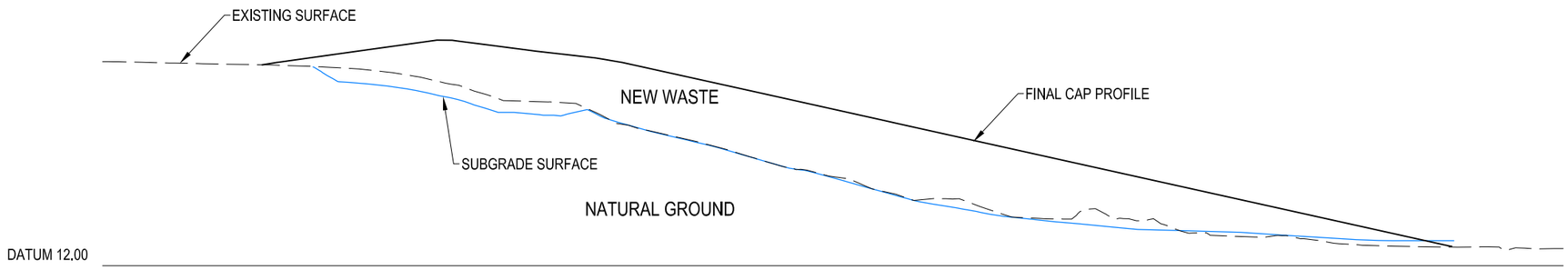
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

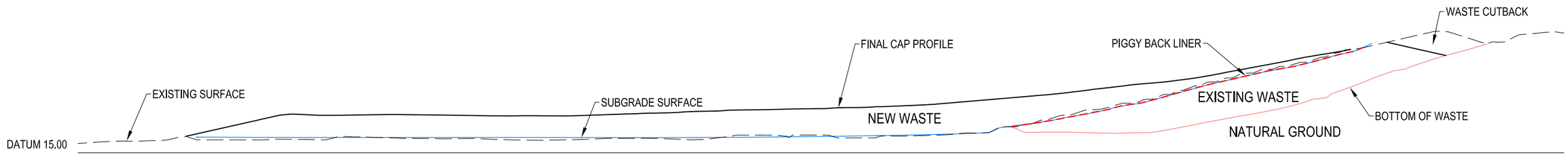
DRAWING TITLE: FINAL LANDFORM INDICATIVE SECTIONS SHEET 1

PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
117625003	145	S	D015	B

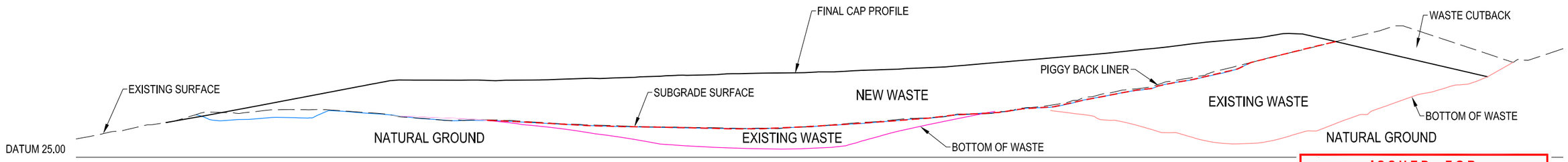
Plot Date: 5 March 2012 Time:10:30:58 AM By: Jeet, Elvin Path: K:\Des\2011\117625003 WHYTES GULLY\DRAWINGS - File Name:117625003-145-S-D015-REVB.dwg
Xref: 117625003-XREF-SUBGRADE SECTIONS.dwg; GAP_LOGO-A3.dwg;



DETAIL L
SCALE 1:2,000 D014



DETAIL M
SCALE 1:2,500 D014



DETAIL N
SCALE 1:2,500 D014

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PRELIMINARY
NOT FOR CONSTRUCTION

1:2,000 0 40 80 120m

1:2,500 0 50 100 150m

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
B	ISSUED FOR PRELIMINARY	EJ JEET	R HUYNH	R HUYNH	G SCHMERTMANN	G SCHMERTMANN	
A	DRAFT - ISSUED FOR CLIENT REVIEW	EJ JEET	R HUYNH	R HUYNH	G SCHMERTMANN	G SCHMERTMANN	23.01.2012

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LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE
EJ JEET	J McMAHON	AS SHOWN	A3

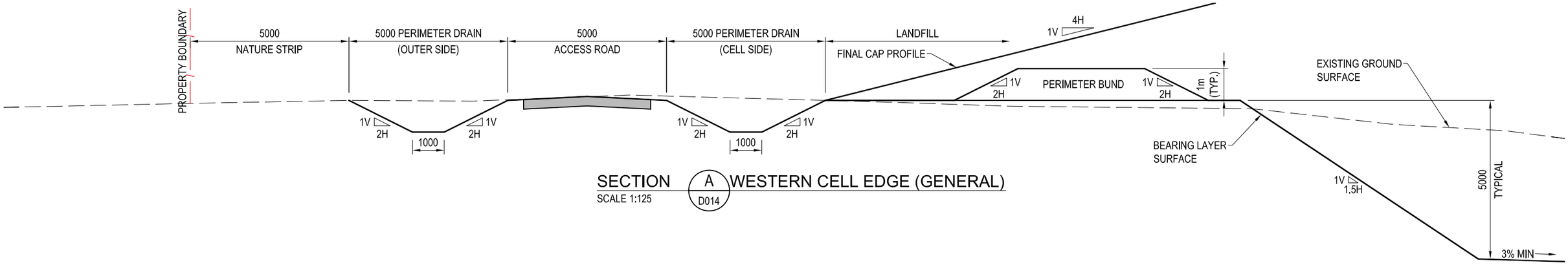
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

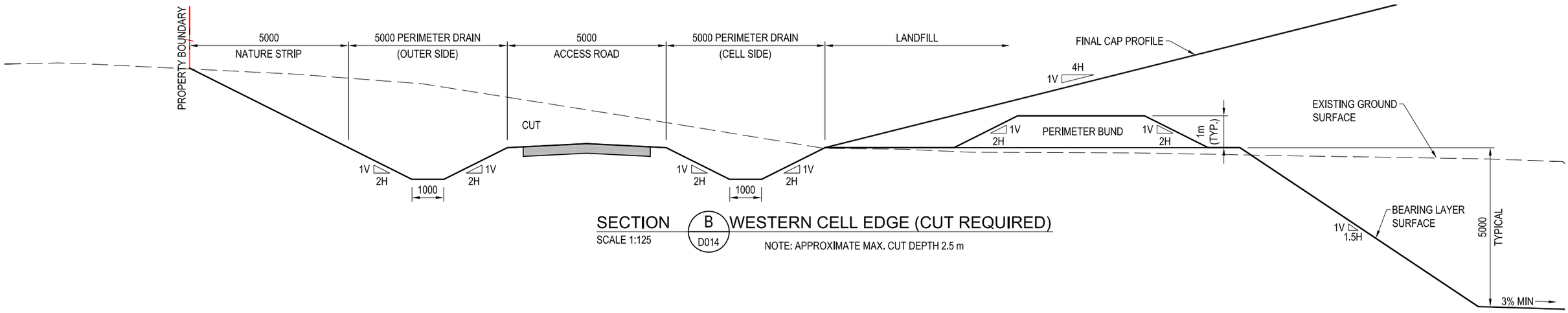
DRAWING TITLE: FINAL LANDFORM INDICATIVE SECTIONS SHEET 2

PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
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Plot Date: 5 March 2012 Time:10:29:54 AM By: Jeet, Elvin Path: K:\Des\2011\117625003 WHYTES GULLY\DRAWINGS - File Name:117625003-145-S-D016-REVB.dwg
Xref: 117625003-XREF-SUBGRADE SECTIONS.dwg; GAP_LOGO-A3.dwg;

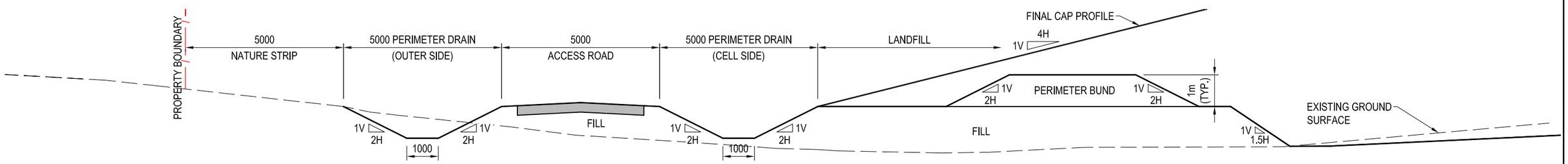


SECTION A WESTERN CELL EDGE (GENERAL)
SCALE 1:125 D014



SECTION B WESTERN CELL EDGE (CUT REQUIRED)
SCALE 1:125 D014

NOTE: APPROXIMATE MAX. CUT DEPTH 2.5 m



SECTION C WESTERN CELL EDGE (FILL REQUIRED)
SCALE 1:125 D014

NOTE: APPROXIMATE MAX. FILL THICKNESS 2,5 m

ISSUED FOR
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1:125 0 2.5 5 7.5m

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
B	ISSUED FOR PRELIMINARY	EJ JEET	R HUYNH	R HUYNH	G SCHMERTMANN	G SCHMERTMANN	
A	DRAFT - ISSUED FOR CLIENT REVIEW	C GIBCUS	R HUYNH	R HUYNH	G SCHMERTMANN	G SCHMERTMANN	23.01.2012

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LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE
EJ JEET	J McMAHON	1:125	A3

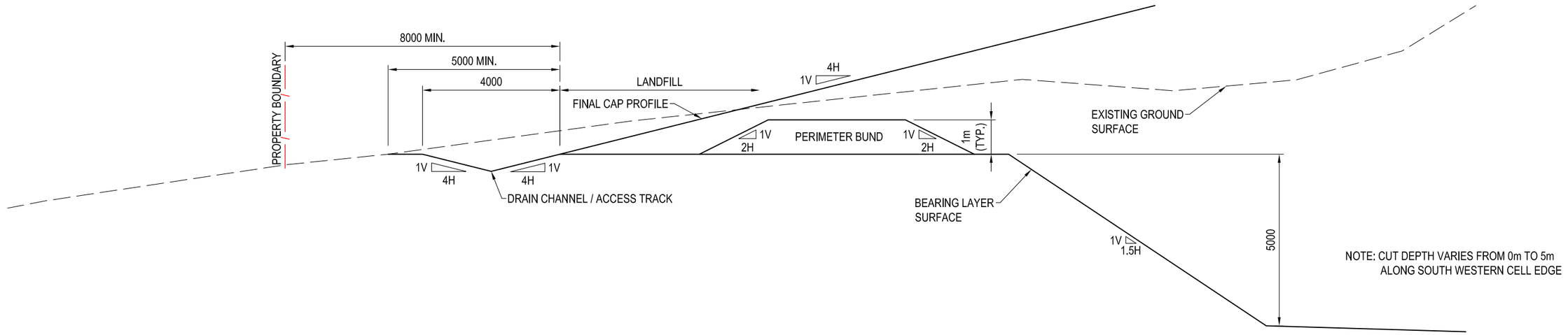
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: INDICATIVE SECTIONS ALONG LANDFORM EDGE SHEET 1

PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
117625003	145	S	D017	B

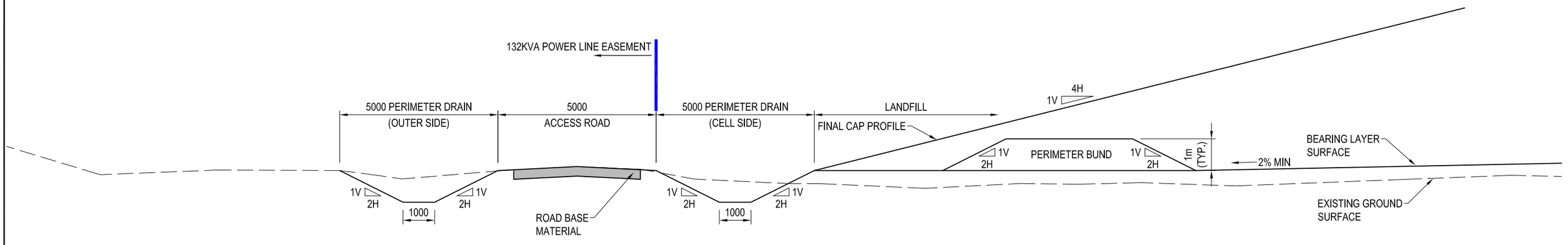
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Xref: GAP_LOGO-A3.dwg;



SECTION P SOUTH WESTERN CELL EDGE

SCALE 1:125

D014



SECTION F SOUTHERN CELL EDGE

SCALE 1:125

D014

ISSUED FOR
PRELIMINARY
NOT FOR CONSTRUCTION

1:125

0 2.5 5 7.5m

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
B	ISSUED FOR PRELIMINARY	EJ JEET	R HUYNH	R HUYNH	G SCHMERTMANN	G SCHMERTMANN	
A	DRAFT - ISSUED FOR CLIENT REVIEW	C GIBCUS	R HUYNH	R HUYNH	G SCHMERTMANN	G SCHMERTMANN	23.01.2012

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LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE
EJ JEET	J McMAHON	1:125	A3

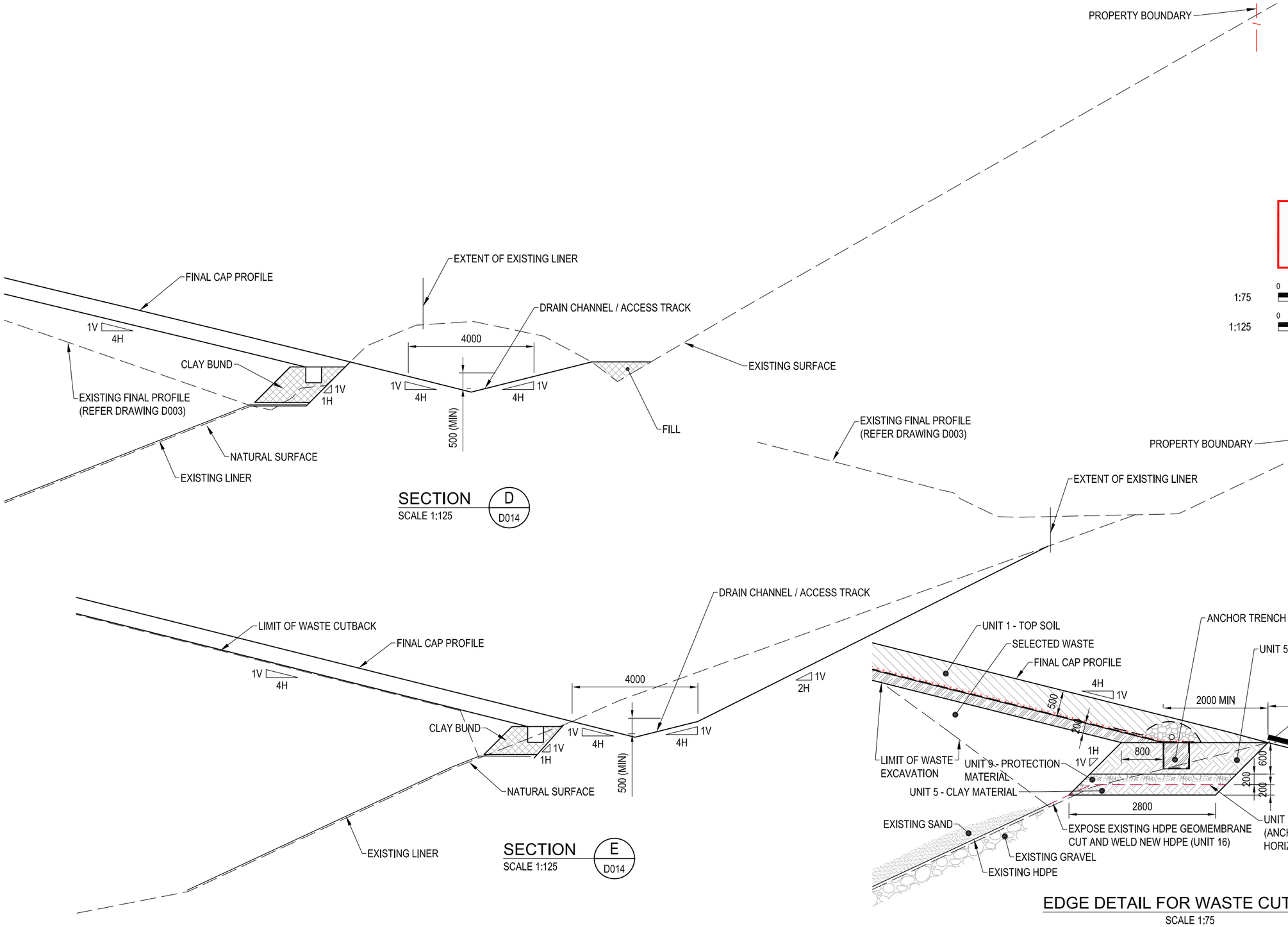
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: INDICATIVE SECTIONS ALONG LANDFORM EDGE SHEET 2

PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
117625003	145	S	D018	B

Plot Date: 5 March 2012 Time:12:02:35 PM By: Jeet, Elvin Path: K:\Des\2011\117625003 WHYTES GULLY\DRAWINGS - File Name:117625003-145-S-D018-REVB.dwg
Xref: GAP_LOGO-A3.dwg;



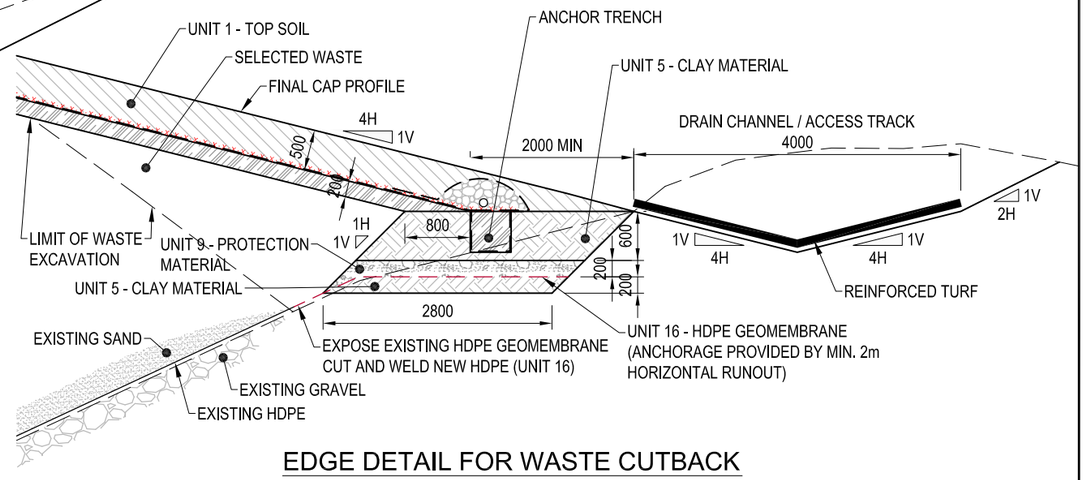
SECTION D
SCALE 1:125
D014

ISSUED FOR
PRELIMINARY
NOT FOR CONSTRUCTION

1:75 0 1,500 3,000 4,500mm

1:125 0 2.5 5 7.5m

SECTION E
SCALE 1:125
D014



EDGE DETAIL FOR WASTE CUTBACK
SCALE 1:75

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
B	ISSUED FOR PRELIMINARY	EJ JEET	R HUYNH	R HUYNH	G SCHMERTMANN	G SCHMERTMANN	
A	DRAFT - ISSUED FOR CLIENT REVIEW	H CAMPBELL	R HUYNH	R HUYNH	G SCHMERTMANN	G SCHMERTMANN	23.01.2012

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LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE
EJ JEET	J McMAHON	AS SHOWN	A3

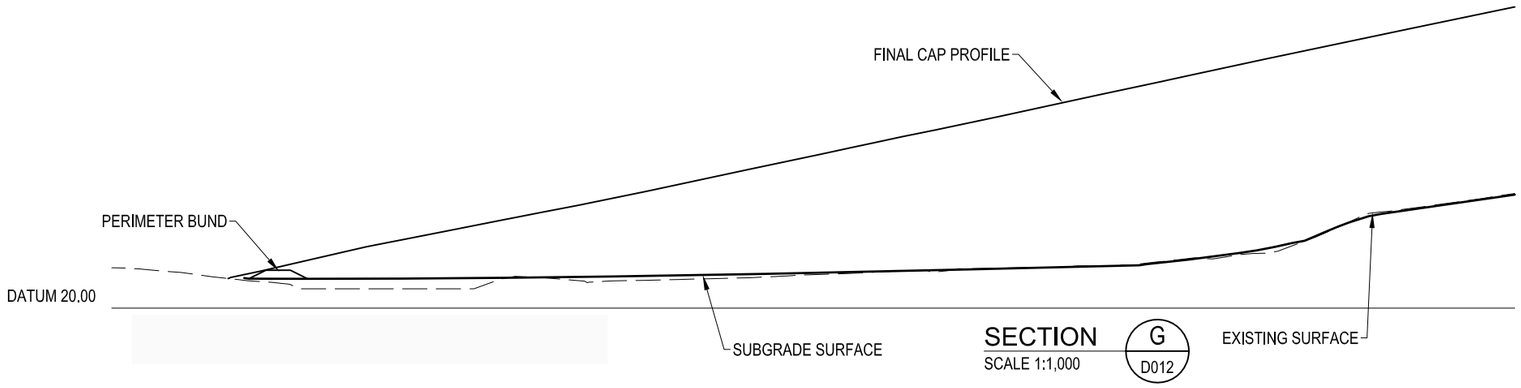
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

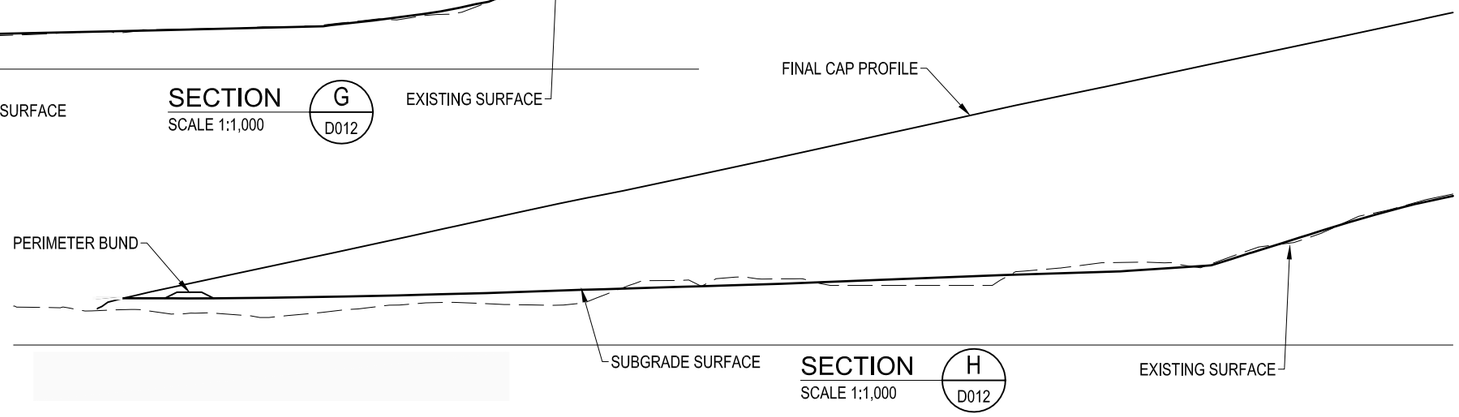
DRAWING TITLE: INDICATIVE SECTIONS ALONG LANDFORM EDGE SHEET 3

PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
117625003	145	S	D019	B

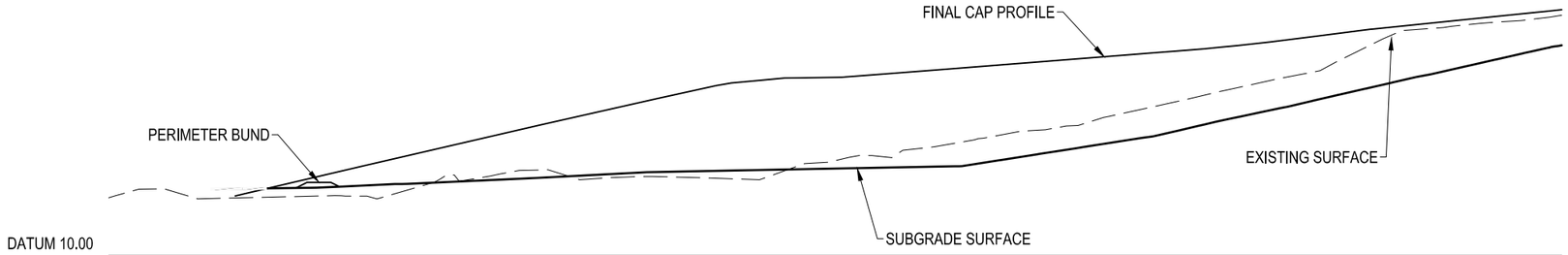
Plot Date: 5 March 2012 Time:12:08:12 PM By: Jeet, Elvin Path: K:\Des\2011\117625003 WHYTES GULLY\DRAWINGS - File Name:117625003-145-S-D019-REVB.dwg
Xref: GAP_LOGO-A3.dwg;



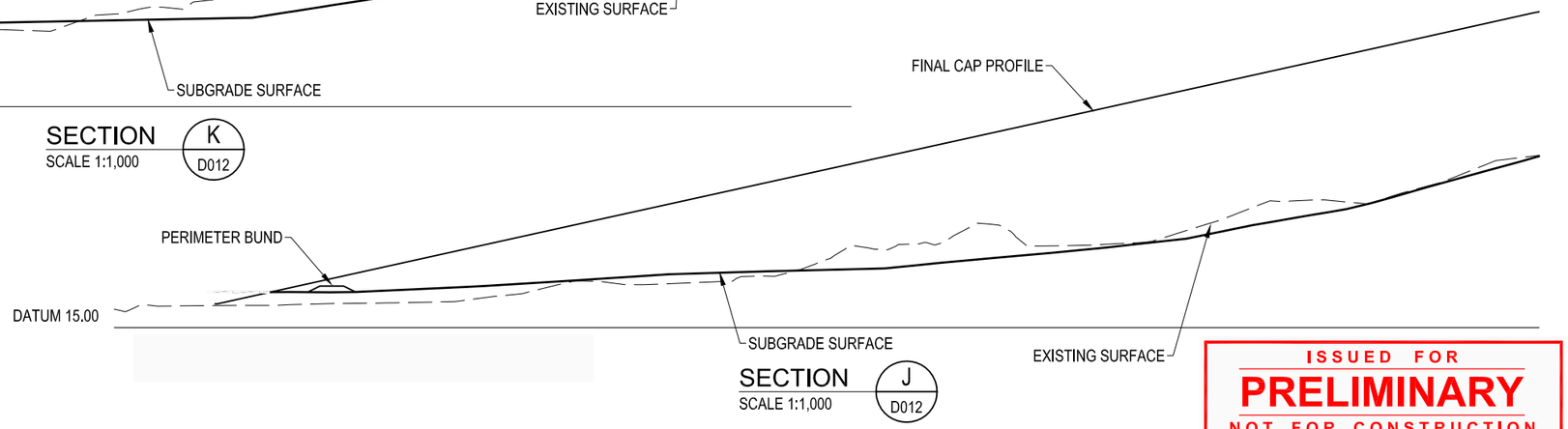
SECTION G
SCALE 1:1,000
D012



SECTION H
SCALE 1:1,000
D012



SECTION K
SCALE 1:1,000
D012



SECTION J
SCALE 1:1,000
D012

ISSUED FOR
PRELIMINARY
NOT FOR CONSTRUCTION

1:1,000

0 20 40 60m

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
B	ISSUED FOR PRELIMINARY	EJ JEET	R HUYNH	R HUYNH	G SCHMERTMANN	G SCHMERTMANN	
A	DRAFT - ISSUED FOR CLIENT REVIEW	H CAMPBELL	R HUYNH	R HUYNH	G SCHMERTMANN	G SCHMERTMANN	23.01.2012

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LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE
EJ JEET	J McMAHON	1:1000	A3

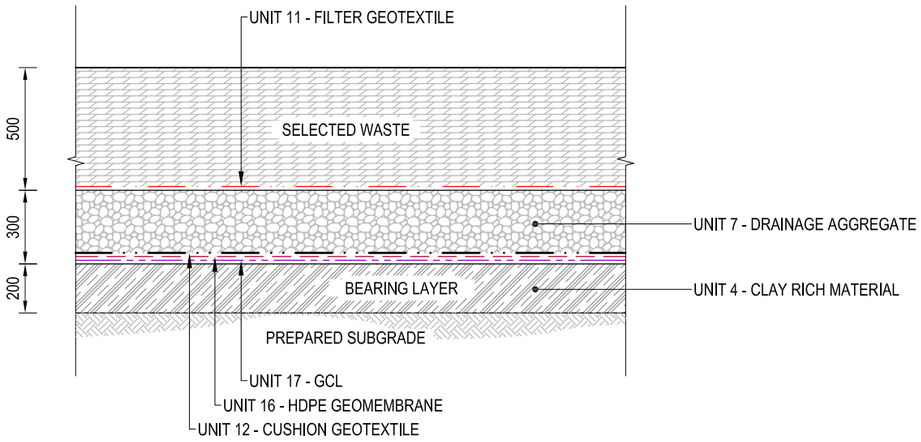
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: NEW CELL CROSS SECTIONS

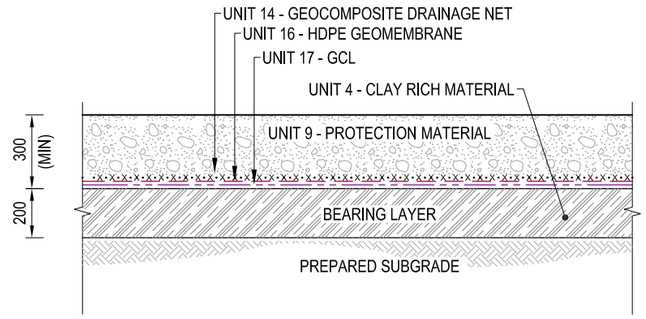
PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
117625003	145	S	D021	B

Plot Date: 5 March 2012 Time:12:09:39 PM By: Jeet, Elvin Path: K:\Des\2011\117625003 WHYTES GULLY\DRAWINGS - File Name:117625003-145-S-D021-REVB.dwg
Xref: 117625003-XREF-SUBGRADE SECTIONS.dwg; GAP_LOGO-A3.dwg;



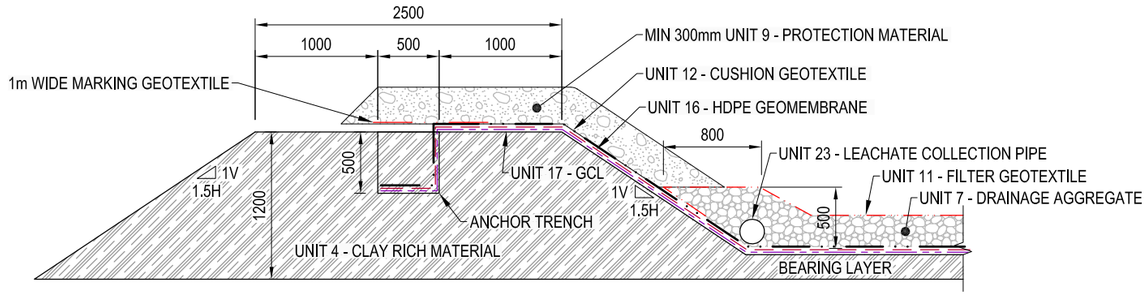
CELL BASE LINER FOR CELLS 1 TO 4

SCALE 1:25



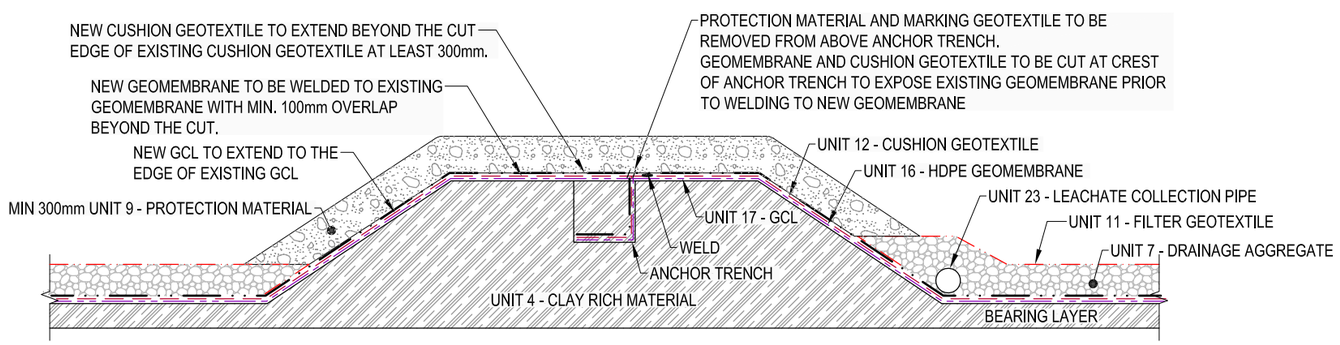
CELL BASE LINER FOR CELLS 2A, 2B & 4A

SCALE 1:25



BASE LINER - DETAIL FOR INTERIM TERMINATION AT INTERNAL BUND

SCALE 1:50



BASE LINER - INTERNAL BUND DETAIL

SCALE 1:50

ISSUED FOR
PRELIMINARY
NOT FOR CONSTRUCTION

1:25 — 0, 500, 1,000, 1,500mm

1:50 — 0, 1,000, 2,000, 3,000mm

NOTES:

1. REFER TO DRAWING D001 FOR GENERAL NOTES AND LEGEND

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
B	ISSUED FOR PRELIMINARY	EJ JEET	R HUYNH	R HUYNH	G SCHMERTMANN	G SCHMERTMANN	
A	DRAFT - ISSUED FOR CLIENT REVIEW	D TREMELLING	R HUYNH	R HUYNH	G SCHMERTMANN	G SCHMERTMANN	23.01.2012

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LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE
EJ JEET	J McMAHON	AS SHOWN	A3

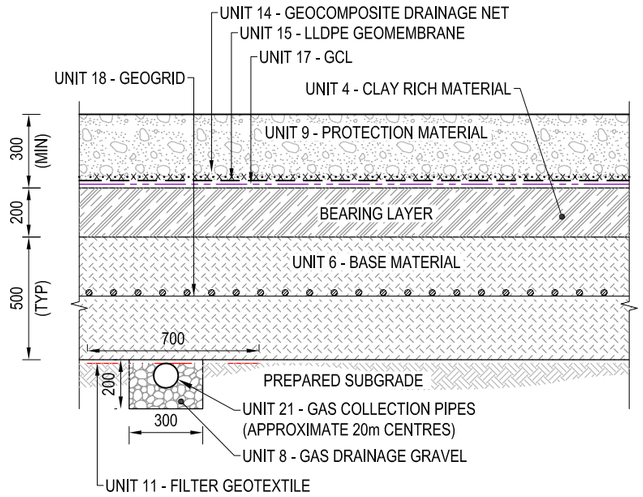
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: CELL BASE LINER DETAILS

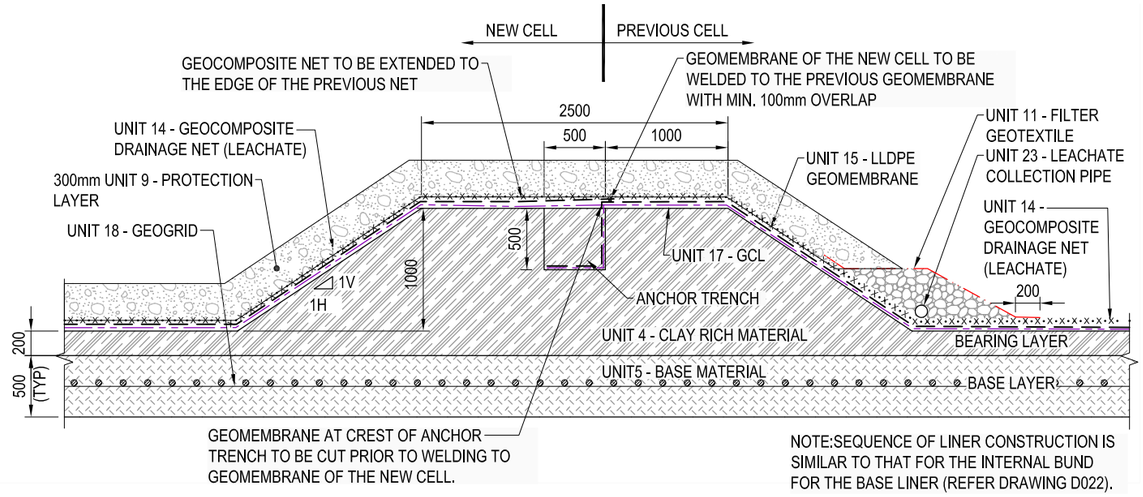
PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
117625003	145	S	D022	B

Plot Date: 6 March 2012 Time:12:48:06 PM By: Jeet, Elvin Path: K:\Des\2011\117625003 WHYTES GULLY\DRAWINGS - File Name:117625003-145-S-D022-REVB.dwg
Xref: GAP_LOGO-A3.dwg;



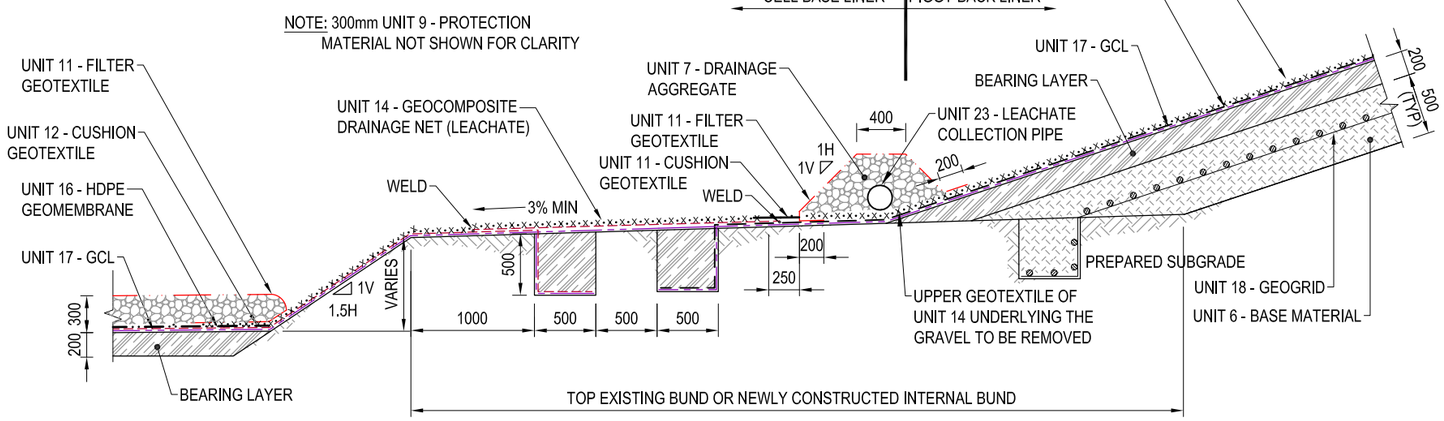
PIGGY BACK LINER

SCALE 1:25



PIGGY BACK LINER - INTERNAL BUND DETAIL

SCALE 1:50



CONNECTION BETWEEN CELL BASE LINER AND PIGGY BACK LINER - INTERNAL BUND

SCALE 1:50

NOTES:

1. REFER TO DRAWING D001 FOR GENERAL NOTES AND LEGEND

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PRELIMINARY
NOT FOR CONSTRUCTION

1:25 — 0, 500, 1,000, 1,500mm

1:50 — 0, 1,000, 2,000, 3,000mm

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
B	ISSUED FOR PRELIMINARY	EJ JEET	R HUYNH	R HUYNH	G SCHMERTMANN	G SCHMERTMANN	
A	DRAFT - ISSUED FOR CLIENT REVIEW	H CAMPBELL	R HUYNH	R HUYNH	G SCHMERTMANN	G SCHMERTMANN	23.01.2012

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LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE
EJ JEET	J McMAHON	AS SHOWN	A3

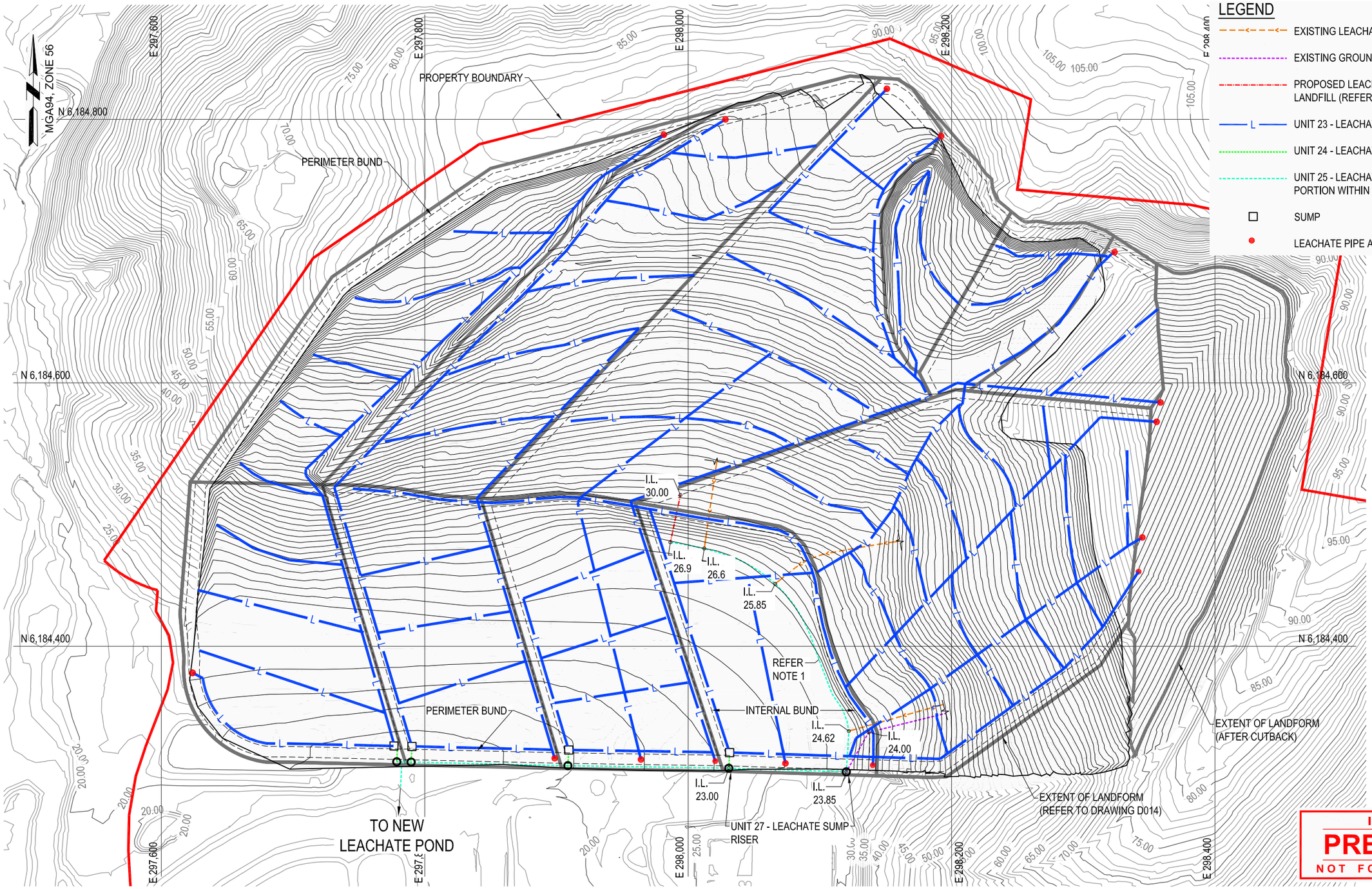
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: PIGGY BACK LINER DETAILS

PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
117625003	145	S	D031	B

Plot Date: 6 March 2012 Time:12:45:51 PM By: Jeet, Elvin Path: K:\Des\2011\117625003 WHYTES GULLY\DRAWINGS - File Name:117625003-145-S-D031-REVB.dwg
Xref: GAP_LOGO-A3.dwg;



LEGEND

- EXISTING LEACHATE PIPE (REFER NOTE 1)
- EXISTING GROUNDWATER PIPE (REFER NOTE 1)
- PROPOSED LEACHATE PIPE FOR EXISTING WESTERN GULLY LANDFILL (REFER NOTE 1)
- UNIT 23 - LEACHATE COLLECTION PIPE
- UNIT 24 - LEACHATE SUMP OUTLET PIPE
- UNIT 25 - LEACHATE DRAINAGE PIPE (REFER NOTE 1 FOR PORTION WITHIN CELL 1)
- SUMP
- LEACHATE PIPE ACCESS FOR CLEAN OUT

NOTES:

1. THE PROPOSED LEACHATE DRAINAGE SYSTEM FOR EXISTING LANDFILL TO BE CONSTRUCTED BENEATH THE CELL BASE LINER AND PIGGY BACK LINER.

ISSUED FOR
PRELIMINARY
NOT FOR CONSTRUCTION

1:3,000

0 60 120 180m

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
B	ISSUED FOR PRELIMINARY	EJ JEET	R HUYNH	R HUYNH	G SCHMERTMANN	G SCHMERTMANN	
A	DRAFT - ISSUED FOR CLIENT REVIEW	H CAMPBELL	R HUYNH	R HUYNH	G SCHMERTMANN	G SCHMERTMANN	23.01.2012

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LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE
EJ JEET	J McMAHON	1:3,000	A3

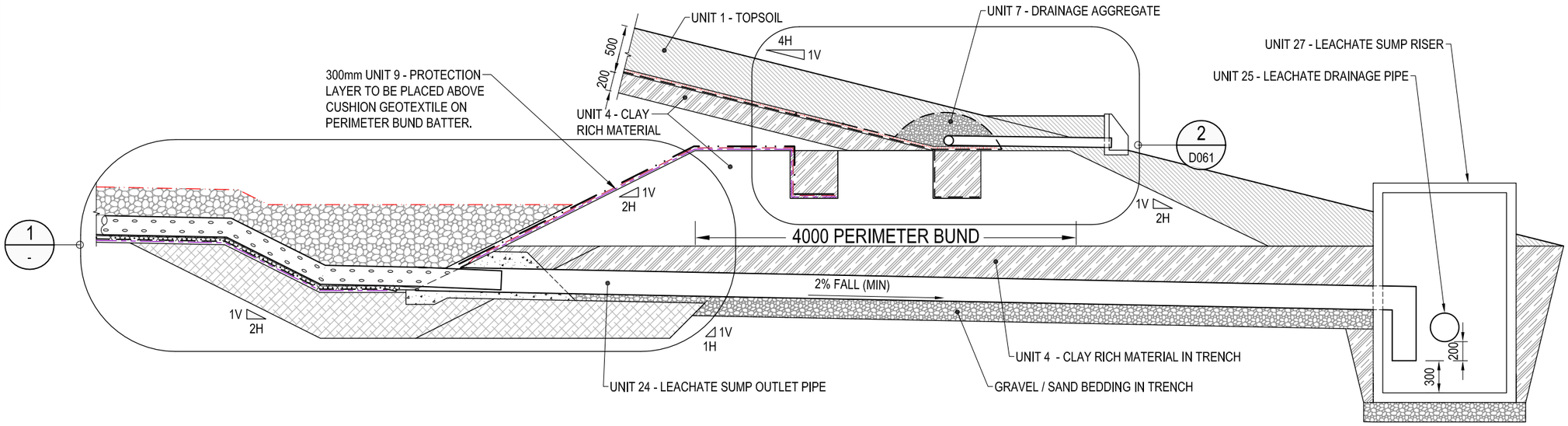
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

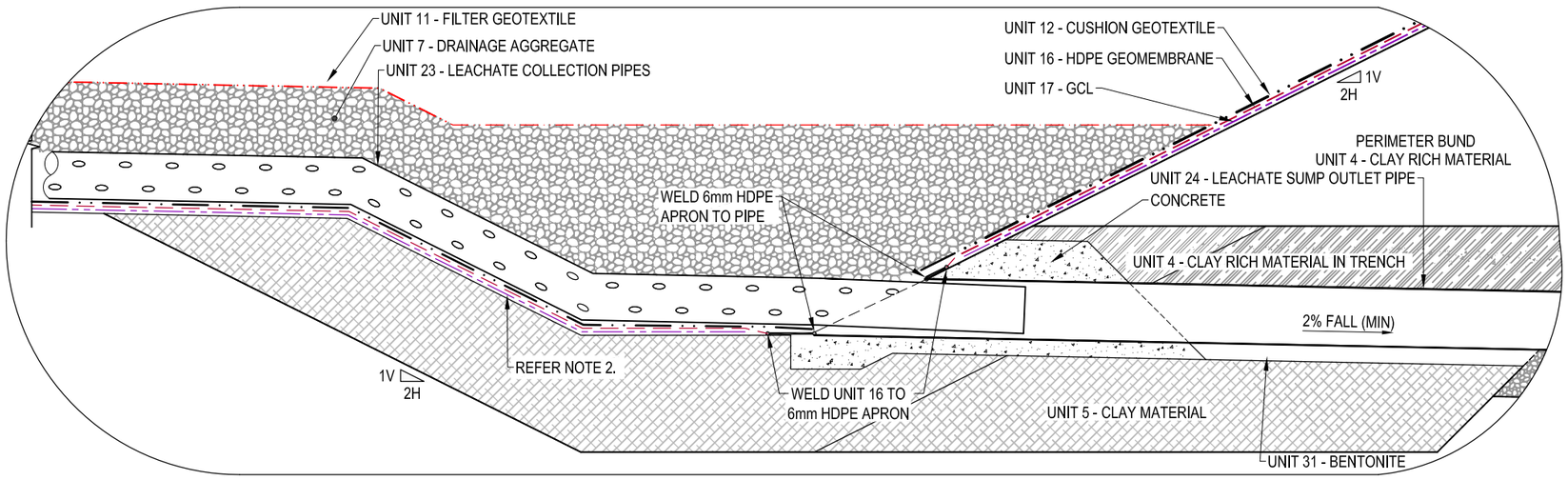
DRAWING TITLE: LEACHATE COLLECTION SYSTEM PLAN

PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
117625003	145	S	D041	B

Plot Date: 6 March 2012 Time:12:44:34 PM By: Jeet, Elvin Path: K:\Des\2011\117625003 WHYTES GULLY\DRAWINGS - File Name:117625003-145-S-D041-REVB.dwg
Xref: 117625003-XREF-WASTE CUT BACK TO EXISTING.dwg; 117625003-XREF-EXISTING GROUND JULY MERGED WITH 2009 GOLDER DESIGN.dwg; GAP_LOGO-A3.dwg; 117625003-XREF-SUBGRADE COMBINED.dwg;



LEACHATE SUMP
SCALE 1:50



DETAIL 1 - LEACHATE SUMP
SCALE 1:25

NOTES:

1. REFER TO DRAWING D001 FOR GENERAL NOTES AND LEGEND
2. DOUBLE THICKNESS OF GCL TO BE USED IN LEACHATE SUMP LINER
3. 300 mm UNIT 9 PROTECTION LAYER NOT SHOWN IN SOME DETAILS FOR CLARITY

ISSUED FOR
PRELIMINARY
NOT FOR CONSTRUCTION

1:25 — 0, 500, 1,000, 1,500mm

1:50 — 0, 1,000, 2,000, 3,000mm

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
B	ISSUED FOR PRELIMINARY	EJ JEET	R HUYNH	R HUYNH	G SCHMERTMANN	G SCHMERTMANN	
A	DRAFT - ISSUED FOR CLIENT REVIEW	H CAMPBELL	R HUYNH	R HUYNH	G SCHMERTMANN	G SCHMERTMANN	23.01.2012

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LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE
EJ JEET	J McMAHON	AS SHOWN	A3

CLIENT: WOLLONGONG CITY COUNCIL

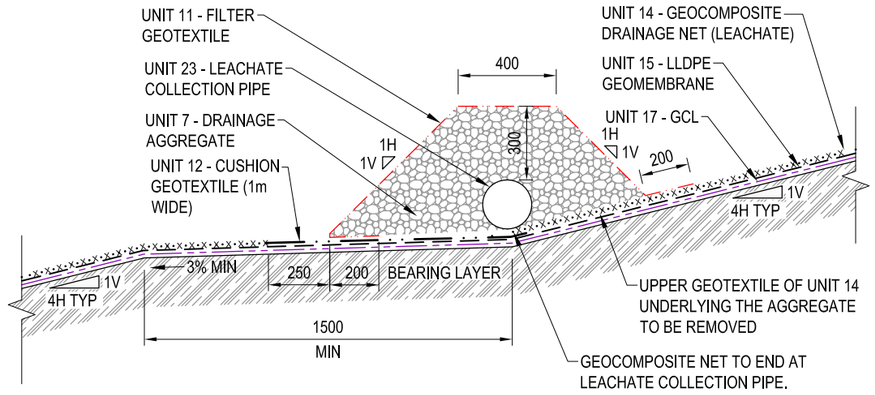
PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: LEACHATE COLLECTION SYSTEM DETAILS SHEET 1

PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
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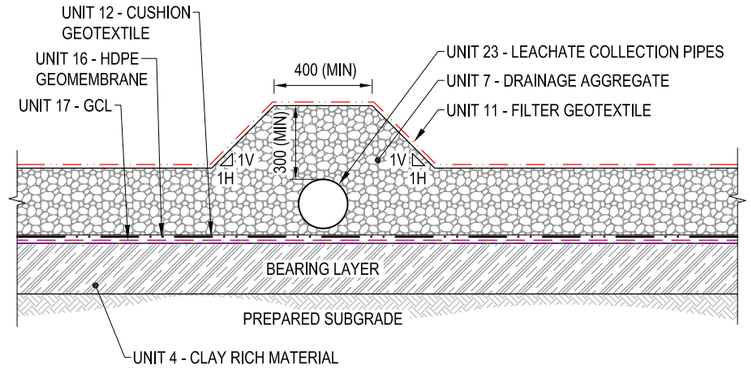
Plot Date: 22 March 2012 Time:9:41:10 AM By: Jeet, Elvin Path: K:\Des\2011\117625003 WHYTES GULLY\DRAWINGS - File Name:117625003-145-S-D042-REVB.dwg
Xref: GAP_LOGO-A3.dwg;

NOTE: 300mm UNIT 9 - PROTECTION MATERIAL NOT SHOWN



LEACHATE COLLECTION PIPE FOR PIGGY BACK CELL CROSS-SLOPE PIPES

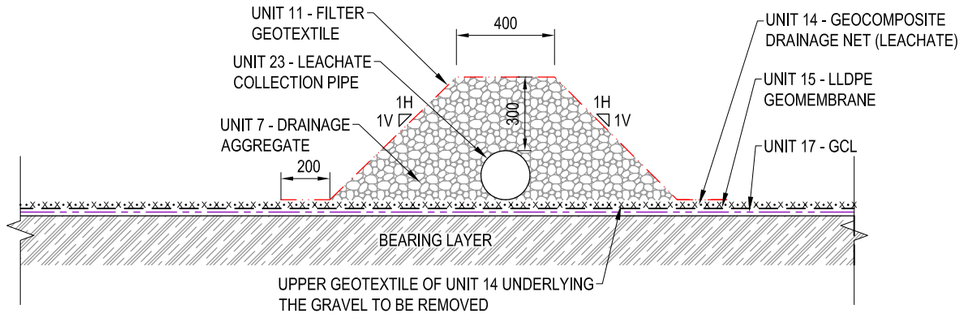
SCALE 1:25



LEACHATE COLLECTION PIPE FOR CELLS 1 - 4

SCALE 1:25

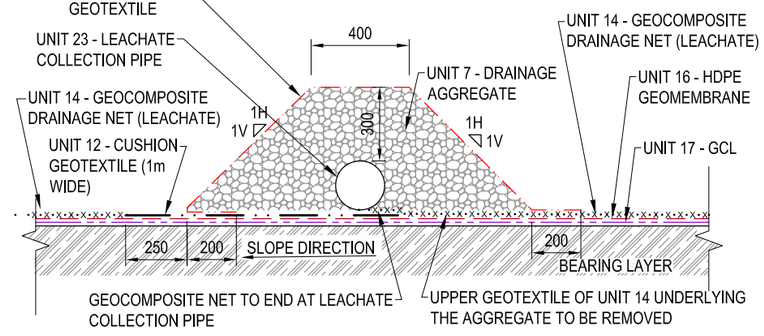
NOTE: 300mm UNIT 9 - PROTECTION MATERIAL NOT SHOWN



LEACHATE COLLECTION PIPE FOR PIGGY BACK CELL DOWN-SLOPE PIPES

SCALE 1:25

NOTE: 300mm UNIT 9 - PROTECTION MATERIAL NOT SHOWN



LEACHATE COLLECTION PIPE FOR CELL 2A, 2B & 4A

SCALE 1:25

NOTES:

1. REFER TO DRAWING D001 FOR GENERAL NOTES AND LEGEND

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PRELIMINARY
NOT FOR CONSTRUCTION

1:25 — 0 500 1,000 1,500mm

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
B	ISSUED FOR PRELIMINARY	EJ JEET	R HUYNH	R HUYNH	G SCHMERTMANN	G SCHMERTMANN	
A	DRAFT - ISSUED FOR CLIENT REVIEW	H CAMPBELL	R HUYNH	R HUYNH	G SCHMERTMANN	G SCHMERTMANN	23.01.2012

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LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE
EJ JEET	J McMAHON	1:25	A3

CLIENT: WOLLONGONG CITY COUNCIL

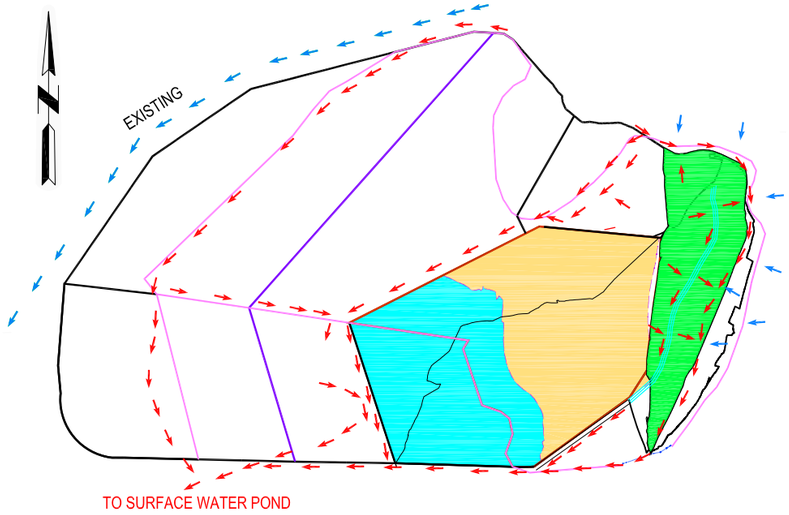
PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: LEACHATE COLLECTION SYSTEM DETAILS SHEET 2

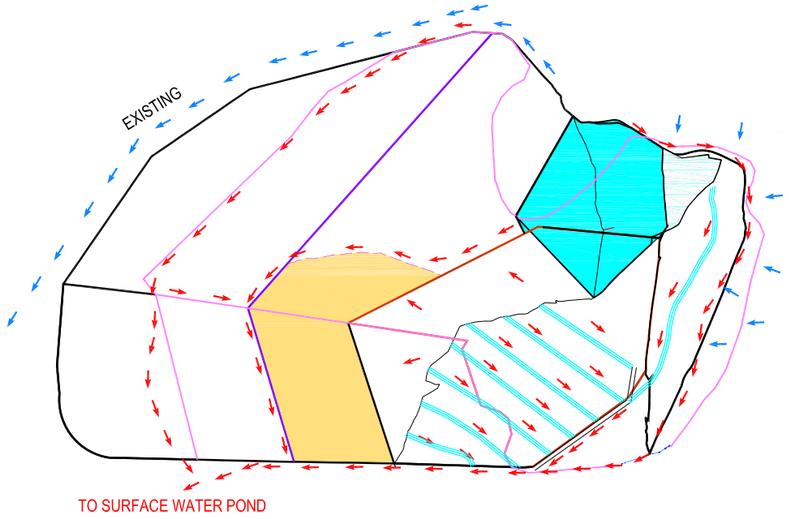
PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
117625003	145	S	D043	B

Plot Date: 22 March 2012 Time:9:39:23 AM By: Jeet, Elvin Path: K:\Des\2011\117625003 WHYTES GULLY\DRAWINGS - File Name:117625003-145-S-D043-REVB.dwg
Xref: GAP_LOGO-A3.dwg;

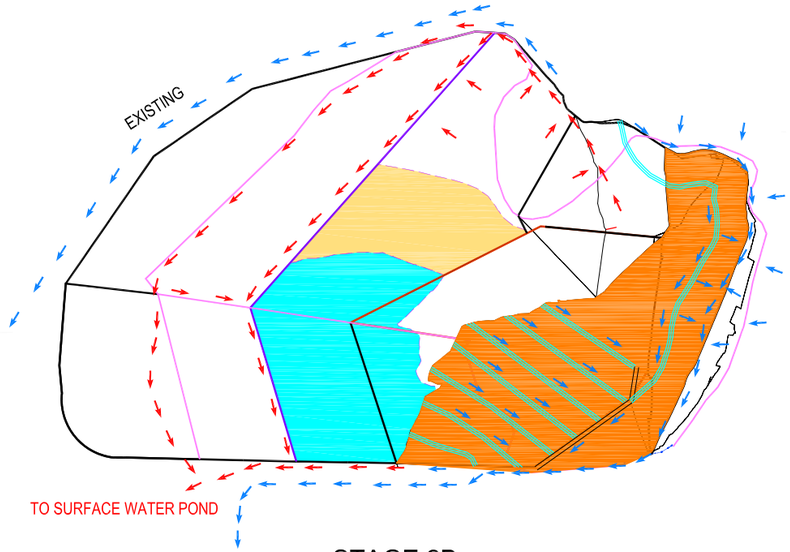
NOTE: DRAWINGS SHOW REPRESENTATIVE CONDITIONS AT AN INTERMEDIATE TIME DURING LINING AND FILLING OF EACH STAGE



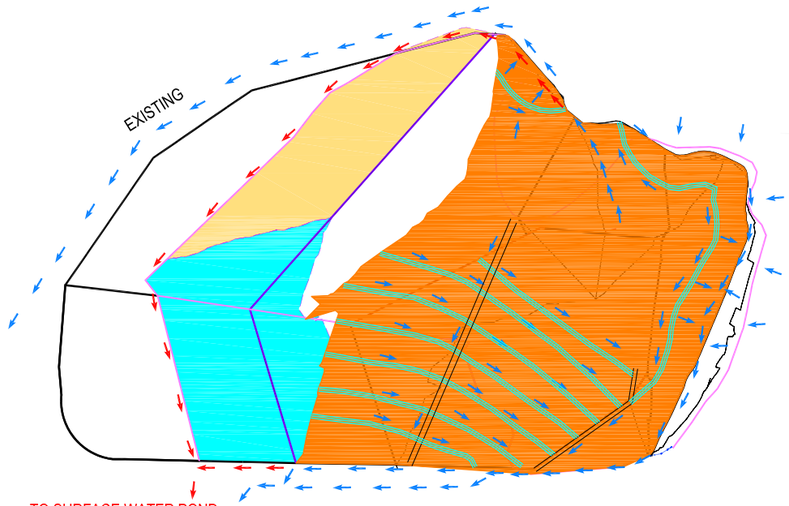
STAGE 1
SCALE 1:7,500



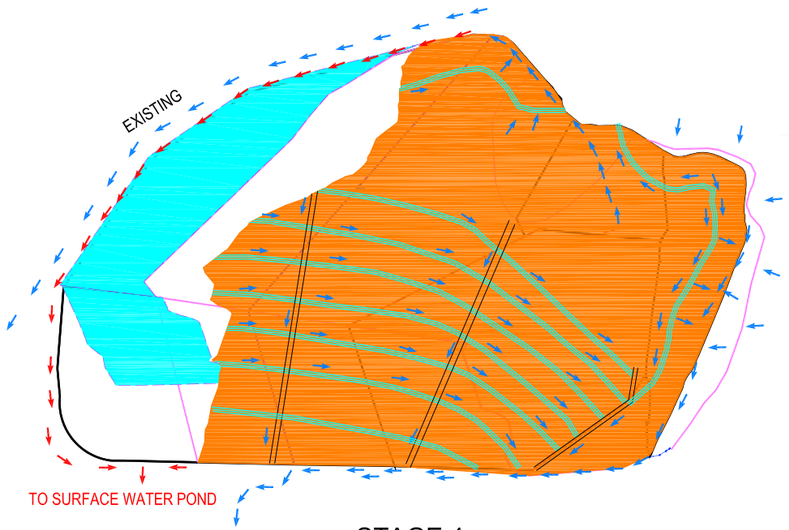
STAGE 2A
SCALE 1:7,500



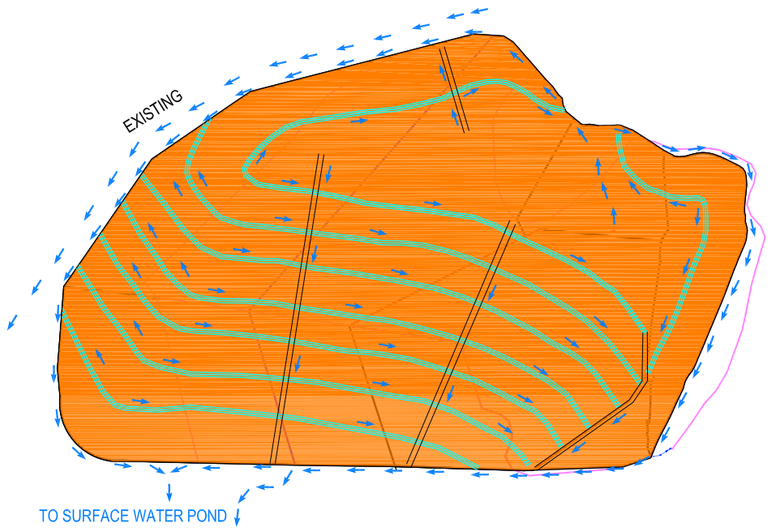
STAGE 2B
SCALE 1:7,500



STAGE 3
SCALE 1:7,500



STAGE 4
SCALE 1:7,500



STAGE FINAL
SCALE 1:7,500

LEGEND

- CLEAN WATER
- DIRTY WATER
- WASTE CUTBACK AREA
- ACTIVE FILLING AREA
- LINING AREA
- CAPPED AREA
- PROPOSED BENCHES
- PROPOSED DROP STRUCTURE

ISSUED FOR
PRELIMINARY
NOT FOR CONSTRUCTION

1:7,500 0 150 300 450m

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
	ISSUED FOR PRELIMINARY	E J JEET	R HUYNH	R HUYNH	G SCHMERTMANN	G SCHMERTMANN	
A	DRAFT - ISSUED FOR CLIENT REVIEW	C GIBCUS	R HUYNH	R HUYNH	G SCHMERTMANN	G SCHMERTMANN	23.01.2012

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LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE
EJ JEET	J McMAHON	1:7,500	A3

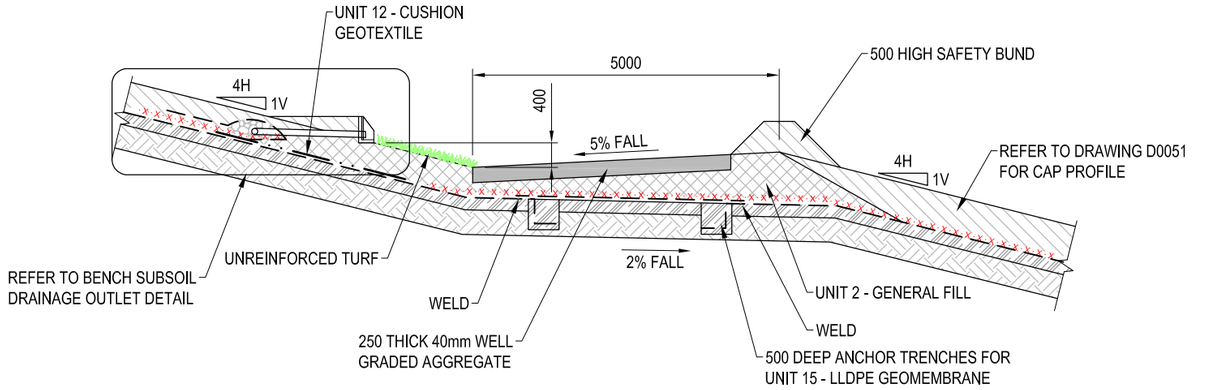
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: SURFACE WATER MANAGEMENT SYSTEM CONCEPT PLAN

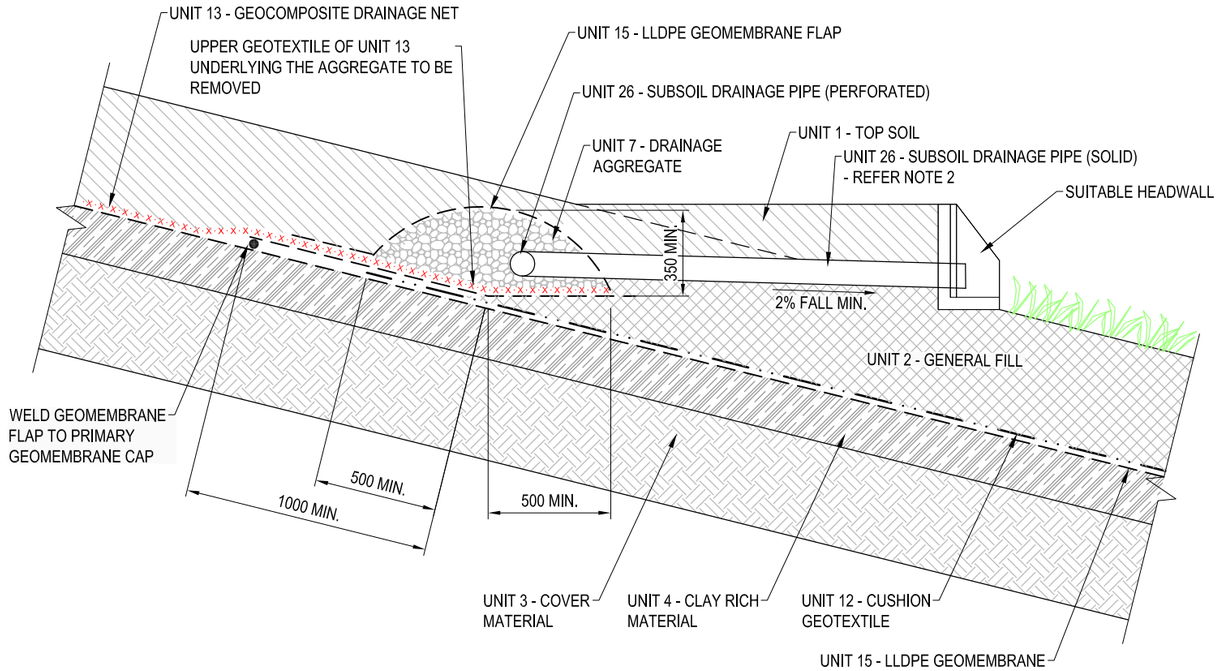
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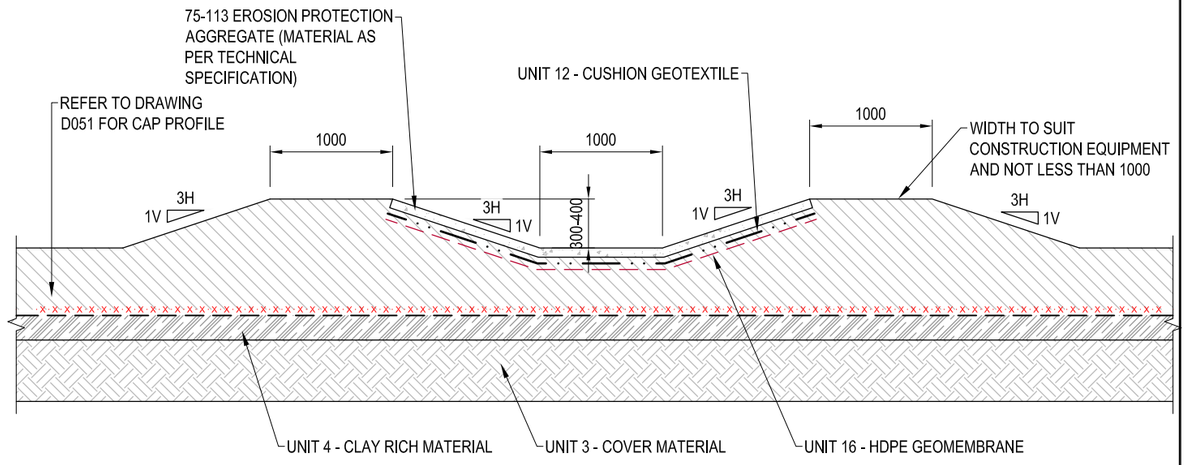
TYPICAL BENCH CROSS SECTION

SCALE 1:100



TYPICAL BENCH SUBSOIL DRAINAGE OUTLET DETAIL

SCALE 1:25



TYPICAL DROP STRUCTURE CROSS SECTION

SCALE 1:50

NOTES:

1. REFER TO DRAWING D001 FOR GENERAL NOTES AND LEGEND
2. SPACING BETWEEN SUBSOIL DRAINAGE OUTLET PIPES TO BE DETERMINED DURING DETAILED DESIGN.
3. REFER TO DRAWING D014 FOR INDICATIVE BENCH LOCATION.

ISSUED FOR
PRELIMINARY
NOT FOR CONSTRUCTION

1:25 0 500 1,000 1,500mm

1:50 0 1,000 2,000 3,000mm

1:100 0 2,000 4,000 6,000mm

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
B	ISSUED FOR PRELIMINARY	EJ JEET	R HUYNH	R HUYNH	G SCHMERTMANN	G SCHMERTMANN	
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EJ JEET	J McMAHON	AS SHOWN	A3

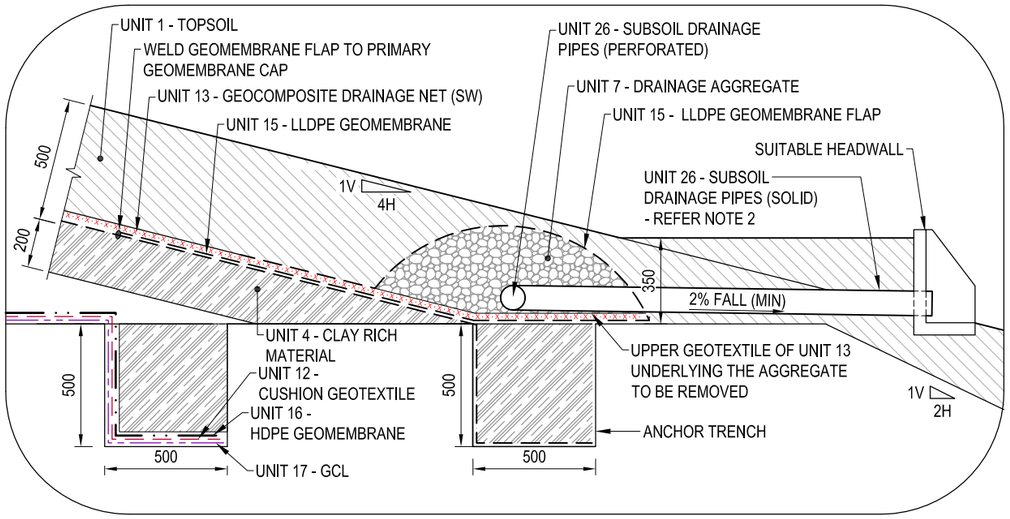
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: BENCH AND DROP STRUCTURE DETAILS

PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
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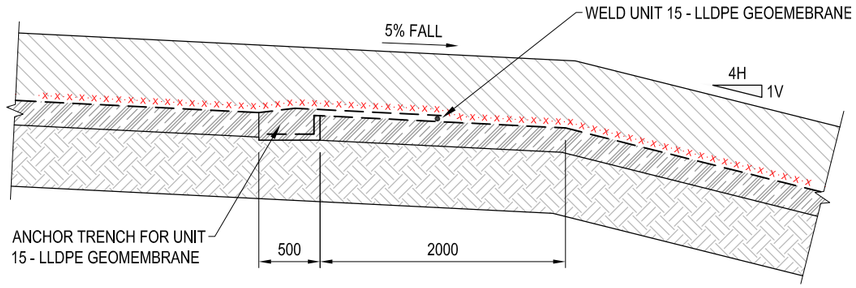
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NOTES: AT THE TIME OF CAP CONSTRUCTION, LLDPE GEOMEMBRANE IN CAP WILL BE CONNECTED TO HDPE GEOMEMBRANE IN BASE LINER USING A WELDED SECTION OF LLDPE GEOMEMBRANE EXTENDING BETWEEN THE TWO ANCHOR TRENCHES.

DETAIL 2 (D042) TYPICAL TOE SUBSOIL DRAINAGE OUTLET DETAIL

SCALE 1:25

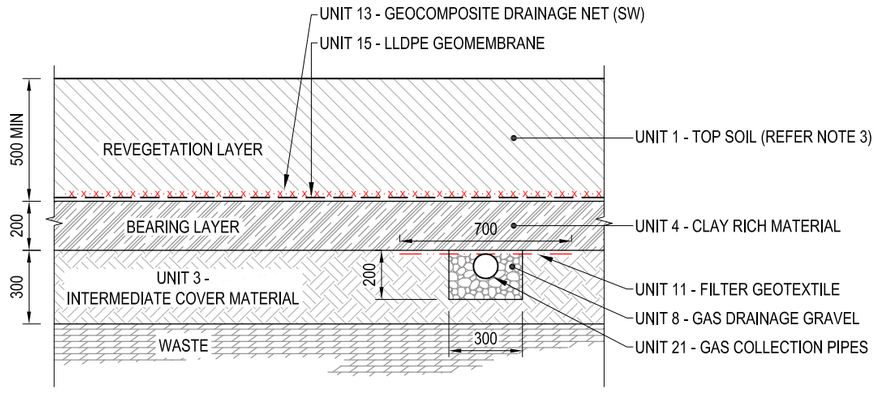


CREST OF LANDFORM

SCALE 1:50

NOTES:

1. REFER TO DRAWING D001 FOR GENERAL NOTES AND LEGEND
2. SPACING BETWEEN SUBSOIL OUTLET PIPES TO BE DETERMINED DURING DETAILED DESIGN.
3. TOPSOIL THICKNESS MAY BE VARIED FROM 500mm TO 1000mm DEPENDING ON VEGETATION TYPE.



CAP PROFILE

SCALE 1:25

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1:25 — 0, 500, 1,000, 1,500mm

1:50 — 0, 1,000, 2,000, 3,000mm

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
B	ISSUED FOR PRELIMINARY	EJ JEET	R HUYNH	R HUYNH	G SCHMERTMANN	G SCHMERTMANN	
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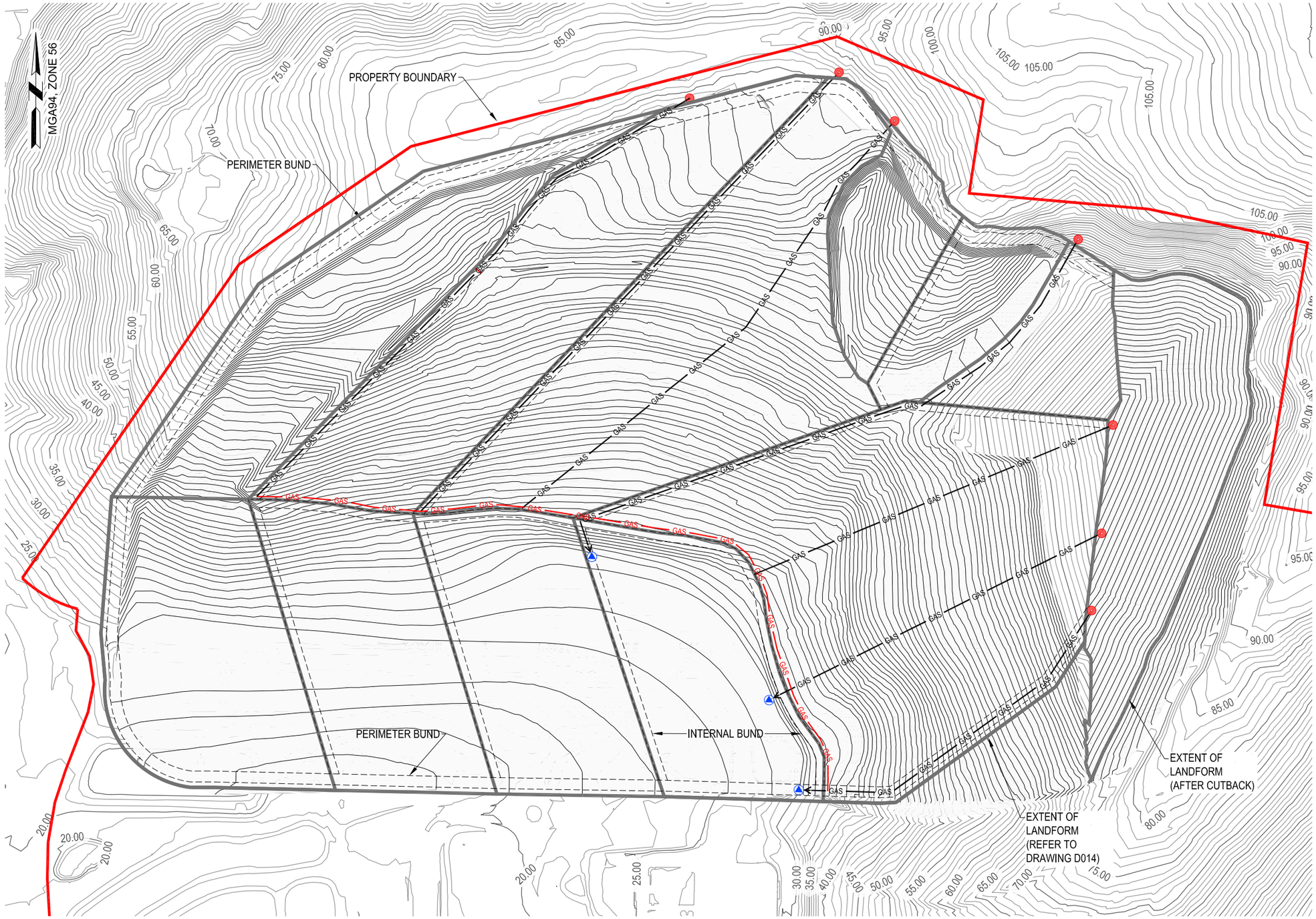
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: CAPPING DETAILS

PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
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Plot Date: 5 March 2012 Time:12:40:19 PM By: Jeet, Elvin Path: K:\Des\2011\117625003 WHYTES GULLY\DRAWINGS - File Name:117625003-145-S-D061-REVB.dwg
Xref: GAP_LOGO-A3.dwg;



LEGEND

- GAS — GAS VENTING HEADER PIPE (TO BE CONNECTED WITH ACTIVE GAS COLLECTION SYSTEM)
- GAS — DRAINAGE PIPE FOR WATER AND CONDENSATE ENTERING GAS VENTING SYSTEM (SOLID WALL)
- CONNECTING HEAD
- CONNECTION TO LEACHATE DRAINAGE PIPE (REFER DRAWING D041)

NOTES:

1. UNIT 21 - GAS COLLECTION PIPES ON APPROXIMATE 20m CENTRES ARE NOT SHOWN FOR CLARITY (REFER PIGGY BACK LINER DETAIL IN DRAWING D031).
2. LOCATION OF ACTIVE GAS WELLS THAT WILL PENETRATE PIGGY BACK LINER ARE NOT YET DETERMINED.

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PRELIMINARY
NOT FOR CONSTRUCTION

1:3,000

0 60 120 180m

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
B	ISSUED FOR PRELIMINARY	EJ JEET	R HUYNH	R HUYNH	G SCHMERTMANN	G SCHMERTMANN	
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EJ JEET	J McMAHON	1:3,000	A3

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PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: PIGGY BACK GAS VENTING SYSTEM PLAN

PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
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APPENDIX B

Preliminary Technical Specification

TECHNICAL SPECIFICATION

April 2012

WHYTES GULLY LANDFILL - NEW CELL DESIGN

Preliminary Technical Specification

Submitted to:
Wollongong City Council

Report Number. 117625003_145_S_RevC

Golder Associates

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1.0 SECTION 1 – PRELIMINARIES

1.1 Introduction

The basic concept for the proposed expansion of the Whytes Gully Landfill is that future waste will be placed within a lined and capped expansion area constructed over the existing landfill site, including:

- Overfilling of the existing Eastern and Western Gully Landfills (note: the term "piggy back liner" is used to refer to the proposed liner system to be constructed in overfill areas);
- Filling within existing natural areas on the Central Ridge and Western Ridge; and
- Filling within existing natural areas at the toe of the existing Eastern and Western Gully Landfills.

The proposed landfill expansion also includes: (i) capping of existing landfilled areas where no future waste is to be placed; and (ii) excavation and relocation of existing waste from a portion of the Eastern Gully Landfill ("Eastern Waste Cutback").

This Preliminary Technical Specification provides material and construction requirements for the project, including Construction Quality Management requirements. It has been prepared along with the Preliminary Design Drawings (refer Section 1.3 below). Landfill expansion construction will be staged to satisfy the landfilling constraints and requirements over an estimated period of approximately 40 years.

This Preliminary Technical Specification does not provide requirements for the proposed Eastern Waste Cutback. Relevant construction and environmental management requirements for this activity will be provided in separate documents to be prepared during detailed design.

Background information on site conditions, and the purpose of project can be found in the Preliminary Design Report for the project which provides a detailed description of design intent.

- Design Report – "Whytes Gully New Landfill Cell - Report for Preliminary Design" prepared by Golder Associates, April 2012, ref. 117625003 - 058 - R - RevA.

1.2 Definitions

The following parties are referred to in this Technical Specification.

Table 1: Parties relevant to the project

Superintendent	The party designated by the site owner to manage the Contractor in accordance with the construction contract. The Superintendent may delegate appropriate tasks to a Technical Superintendent.
Contractor	The party awarded the contract to complete the works described in this Technical Specification.
GITA	Geotechnical Inspection and Testing Authority: The party undertaking Level 1 inspection and testing of landfill earthworks in accordance with AS3798 -2007. The GITA shall be engaged by the Contractor, subject to Superintendent short list and approval, and shall be independent of the Contractor.
Regulator	The NSW state agency responsible for oversight of landfill construction and environmental management. This is anticipated to be OEH, the NSW Office of Environment and Heritage.

This Technical Specification includes 'Hold Points' and 'Inspection Points'. These are defined as follows:

- Hold Point – An identified point in the landfill construction sequence where the Contractor must halt work and provide required information to the Superintendent. The Contractor must not resume work until the Hold Point is released, in writing, by the Superintendent.
- Inspection Point – An identified point in the landfill construction sequence where the Contractor is required to provide written notification in advance of commencing work on identified items in order to allow the opportunity for the Superintendent to directly inspect the work; the notification must be provided when indicated and in no case less than 24 hours in advance of commencing the work.

The specific meaning of the term "Site" is defined in the construction contract.

1.3 Preliminary Design Drawings

Preliminary Design Drawings prepared along with this Technical Specification are listed in Table 2 below.

Table 2: Drawing List

Drawing No.	Revision No.	Drawing Title
Existing Information		
D001	B	Site Locality and Drawing List
D002	B	Site Plan
D003	B	Existing Contours and Easements
D004	B	Approximate Bottom of Existing Waste Plan
Final Landform		
D011	B	Waste Cutback Plan and Sections
D012	B	Staging and Subgrade Preparation Plan
D013	B	Subgrade Preparation Sections
D014	B	Final Cap Profile
D015	B	Final Landform Indicative Sections – Sheet 1
D016	B	Final Landform Indicative Sections – Sheet 2
D017	B	Indicative Sections Along Landform Edge – Sheet 1
D018	B	Indicative Sections Along Landform Edge – Sheet 2
D019	B	Indicative Sections Along Landform Edge – Sheet 3
Cell Base		
D021	B	New Cell Cross Sections
D022	B	Cell Base Liner Details
Piggy Back		
D031	B	Piggy Back Liner Details
Leachate Collection		
D041	B	Leachate Collection System Plan
D042	B	Leachate Collection System Details – Sheet 1
D043	B	Leachate Collection System Details – Sheet 2
Surface Water Management		
D051	B	Surface Water Management System Concept Plan
D052	B	Bench and Drop Structure Details
Final Capping		
D061	B	Capping Details
Landfill Gas Management		
D071	B	Piggy Back Gas Venting System Plan

1.4 Construction Materials

The table below presents the primary materials for cell construction. These materials are referred to in this Technical Specification by unit number. Additional construction materials are also named in this Technical Specification.

Table 3: Material List

GRANULAR MATERIALS
Unit 1 – Topsoil
Unit 2 – General Fill
Unit 3 – Intermediate Cover Material
Unit 4 – Clay Rich Material
Unit 5 – Clay Material
Unit 6 – Base Material
Unit 7 – Drainage Aggregate
Unit 8 – Gas Drainage Gravel
Unit 9 – Protection Material
GEOSYNTHETIC
Unit 11 – Filter Geotextile
Unit 12 – Cushion Geotextile
Unit 13 – Geocomposite Drainage Net (Surface Water) (for cap)
Unit 14 – Geocomposite Drainage Net (Leachate)
Unit 15 – LLDPE Geomembrane
Unit 16 – HDPE Geomembrane
Unit 17 – Geosynthetic Clay Liner (GCL)
Unit 18 – Geogrid
PIPE MATERIALS
Unit 21 – Gas Collection Pipe
Unit 22 – Groundwater Drainage Pipe
Unit 23 – Leachate Collection Pipe
Unit 24 – Leachate Sump Outlet Pipe
Unit 25 – Leachate Drainage Pipe
Unit 26 – Subsoil Drainage Pipe
Unit 27 – Leachate Sump Riser

OTHERS

Unit 31 – Bentonite

1.5 Responsibilities

Superintendent

Specific tasks for which the Superintendent is responsible include, but are not limited, those listed below. The Superintendent may delegate some tasks to a Technical Superintendent.

- Review and assessment of Contractor quality control test results, Work Method Statements, and Contractor information and submittals;
- Release of Hold Points;
- Implementation of Inspection Points;
- Auditing of the Contractor quality control procedures, conformance and validation testing;
- Design clarifications and nomination of additional Works;
- Monitoring Contractor compliance with the Contract and other contract administration requirements;
- Checking of Contractor compliance with site management plans (e.g., Environmental Management Plan, Safety Management Plan); and
- Certification of completed works and review of Contractor's construction documentation.

Contractor

The Contractor's responsibilities include but are not limited to the following:

- Compliance with site management plans (e.g., Environmental Management Plan, Safety Management Plan) throughout the duration of the Works;
- Implementation and compliance with the materials tracking system;
- Implementation of the Quality Plan required for the Works;
- Completion of all Works specified in this Specification and additional Works approved by the Superintendent in accordance with the requirements of the Contract;
- Development and implementation of appropriate construction procedures for all construction activities;
- Earthworks conformance testing for all filling operations (through GITA);
- Preparation of Work Method Statements for Superintendent review;
- Preparation of Hold Point Reports and other construction documentation for Superintendent review;
- Ensuring that it does not hinder, obstruct or disrupt other parties working at the site; and
- Comply with all requirements of the Contract.

1.6 Pre-Construction Submittals

The Contractor shall prepare, and submit for Superintendent review, prior to establishment at the Site, all information and management plans as indicated in the Contract. These plans shall meet Contract requirements and be consistent with the project approval and consent conditions, and any other relevant approvals. The Contractor shall be liable for all costs resulting from the failure to meet submittal deadlines or arising from determination, notifications of non-compliance, request for additional information, and/or rejection by the reviewing parties.

The management plans outlined below are anticipated to be included in the Contract requirements.

- *Construction Program*: The Contractor shall prepare a Construction Program in Gantt Chart format showing sufficient detail to allow monitoring of progress, including all necessary approvals, and demonstrating consistency with project staging plans compliance with Contract requirements.
- *Safety Plan*: The Contractor shall prepare a detailed Safety Management Plan, taking into account any existing Whytes Gully Landfill requirements.
- *Construction Environmental Management Plan (CEMP)*: The Contractor shall prepare a detailed CEMP.
- *Surface Water Management Plan*: The Contractor shall prepare a detailed Surface Water Management Plan, including erosion protection and sediment control measure, and taking into account the requirements of the Surface Water Management Strategy by others that is part of the Part 3A application submission.
- *Construction Traffic Management Plan*: The Contractor shall prepare a detailed Construction Traffic Management Plan for the site, taking into account any existing Whytes Gully Landfill requirements.
- *Construction Material Quality Control Procedures Manual*: The Contractor shall prepare a Construction Material Quality Control Procedures Manual as one element of his overall Quality Plan. The Manual will address the requirements as outlined in the Construction Quality Assurance Plan.

1.7 Site Preparation

Site preparation works shall be carried out by the Contractor in successive stages in accordance with the Contractor's approved Construction Program (refer Section 1.6).

1.7.1 Removal of Vegetation and Topsoil

Prior to the construction of the liner system of each area, existing vegetation shall be removed and disposed by the Contractor.

After vegetation removal, the upper layer of soil (topsoil) shall be removed by shallow scrape to a depth of approximately 200mm. The shallow scrape is intended to remove any remnant vegetation, shallow plant roots, and other shallow organic materials. The soil collected from the shallow scrape shall be stockpiled separately by the Contractor in designated areas for use by the site owner for landfill construction or operations.

The Contractor shall provide a work method statement presenting proposed methods for these activities, including vegetation disposal and methods to maximise topsoil recovery. Submission of the work method statement constitutes a HOLD POINT. These activities shall not commence until the Hold Point is released.

1.7.2 Services

The Contractor is responsible for confirming service locations, and also locating any unknown services, and establishing whether services are active or inactive prior to initiating work in any area of the site.

Active services are currently present within the construction area and vicinity. Known active services include power, water, and communication lines to the existing staff amenities building in the Cell 1 footprint (also potentially to the adjacent previous weighbridge building), power and communication lines along the Old Redalls Road alignment in the footprint of Cells 2 to 4, and power and control lines to the existing leachate ponds in the Cell 4 footprint.

These known active services will be decommissioned and/or de-energised by others prior to construction. The Contractor shall completely remove these services, including all service trench bedding materials.

In addition, 132 kVA overhead power lines are present along the southern edge of the proposed landfill construction area. These power lines are owned by Endeavour Energy and are to remain in service at all times. The Contractor must use appropriate work methods in the vicinity of these lines.

Known inactive services at the site include the overhead power line along the Western Ridge, owned by BHP Billiton. This line will be removed by others prior to construction.

In the case that previously unknown services are encountered during the course of works, the Contractor shall immediately take appropriate safety precautions, and shall inform the Superintendent. The Contractor is responsible for protecting any active services identified by the Contractor at the time of construction until they are decommissioned and/or de-energised by others. Once decommissioned and/or de-energised , the Contractor shall completely remove services, including all service trench bedding materials.

The Contractor shall prepare and submit documentation of all his activities to confirm, locate and remove services..

1.7.3 Structures Demolition

Prior to the construction of the lining system in each area, existing structures shall be demolished and removed by the Contractor. Structures include the existing staff amenities building and previous weighbridge in the footprint of Cell1, as well as small concrete items in other areas (i.e., pads, slabs, channel lining, pits).

The Contractor shall provide a work method statement presenting proposed methods for structure demolition, including identification of hazardous materials (if any), environmental management of demolition materials, and material disposal. Submission of the work method statement constitutes a HOLD POINT. These activities shall not commence until the Hold Point is released .

2.0 SECTION 2 – MATERIALS

2.1 General Material Requirements

2.1.1 Contractor Supply and Protection of Materials

The Contractor shall be responsible for supply, delivery, storage, placement and installation of all materials required to carry out the works in this Technical Specification. However, the Superintendent may direct that some materials will be supplied by others. Once incorporated in the Works, the Contractor shall protect the materials throughout the duration of construction to ensure they do not degrade or become damaged so as to change the intended performance or function of the materials.

2.1.2 Material Approval

Source Approval

The Contractor shall demonstrate that all materials proposed by the Contractor for the works will meet the requirements of this Technical Specification. This constitutes a HOLD POINT for each of the materials identified in the Technical Specification and in the Design Drawings. No material shall be imported to the site, and no on-site materials shall be handled, placed or stockpiled, until the Hold Point for the material is released.

Materials that are considered by the Superintendent to have excessive settlement potential, or the potential to undergo or contribute to chemical reactions adverse to landfill performance, will not be approved.

The Contractor shall prepare a submittal for Superintendent review for each material to demonstrate that the proposed material will comply with all requirements of this Technical Specification. Hold Point release will be dependent on the submittal providing a satisfactory demonstration. Each submittal shall identify the material source, or sources, and include relevant test results that satisfy the testing requirements of this Technical Specification, description of material uniformity, and other information needed to confirm required properties, including waste classification for soil materials. For manufactured products, manufacturer's specifications and quality control information shall also be submitted.

Confirmation of Properties of Materials Delivered to Site

The Contactor is responsible for confirming that all materials delivered to site from approved sources meet the material property requirements of this Technical Specification. This includes complying with all sampling and testing requirements in this Technical Specification, as well as performing additional sampling and testing as needed to confirm as-delivered material properties. This item is also referred to as 'field testing' in this Technical Specification.

The Superintendent may, at his discretion, conduct Audit sampling and testing of any materials at source or as-delivered to site. The Contractor must assist and facilitate the Superintendent in such activities. If Audit test results indicate that materials do not meet requirements then the Superintendent may direct that the materials be replaced at the Contractor's expense and that the Contractor pay the Audit sampling and testing costs.

2.1.3 VENM or ENM Requirement

All soil materials imported to the site and used to construct any portion of the landfill must meet the definition of virgin excavated natural material (VENM) or excavated natural material (ENM) under the Protection of the Environment Operations Act 1997 and the Protection of the Environment Operations Amendment 2008, unless otherwise permitted by this Technical Specification, consistent with the project approval conditions, and agreed with the Superintendent. If material other than VENM or ENM is proposed for import to the site, the Contractor shall be responsible for obtaining all relevant approvals, such as from the Regulator, prior to importing.

The Contractor shall commission a VENM/ENM assessment and waste classification for all imported soil material. The assessment and classification must be performed by a qualified person and be to the

satisfaction of the Superintendent. The assessment and classification shall comprise a material source inspection, an assessment of historical land use at the source site, and chemical testing at a frequency of at least one sample per material source or at least one sample per 1,000 m^3. The Superintendent may require more frequent sampling and testing at the Contractor's expense if the classification is considered incomplete or inadequate. Chemical testing shall comprise analysis for heavy metals, total petroleum hydrocarbons (TPH), benzene, toluene, ethylbenzene, xylenes (BTEX), polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs) and Organochlorine pesticides (OCPs). The provisions of NSW DECC Waste Classification Guidelines – Parts 1 & 2 (April 2008) shall apply.

The Contractor shall keep records of waste classification and quantity of all soil materials imported to site.

The Contractor may submit non-VENM or non-ENM soil materials from on site to be considered for use in landfill construction, provided that these materials meet Technical Specification requirements. The Contractor submittal for on-site materials must address the requirements in Section 2.1.2, as for import materials.

2.1.4 Reporting

Reporting of all material test results shall be in accordance with the Contractor's Construction Material Quality Control Procedures Manual (refer Section 1.6) and other contract requirements. However, in all cases material test results shall be made available to the Superintendent no later than 1 week after each test is performed.

All material test results submitted to the Superintendent by the Contractor must be from a laboratory with NATA-accreditation for all tests performed. All survey results submitted to the Superintendent by the Contractor must be from a registered surveyor.

2.2 Material Properties

2.2.1 Unit 1 – Topsoil

The required properties of Unit 1 – Topsoil will be provided in a detailed revegetation specification that will be issued for the cell construction tender. The specification will include a requirement for Emerson Class No. (AS1289.3.8.1) greater than four (4) in order to provide a soil with relatively low dispersion potential. The specification will include different requirements for upper and lower topsoil sub-layers.

A general description of the required characteristics of Unit 1 is provided in Section 4.4 of the Design Report.

The following table shows the testing requirements for this material.

Table 4: Material Testing Requirements for Unit 1 - Topsoil

Property	Test method	Frequency	
		Source approval	As-delivered
In accordance with future revegetation specification	Various	Two tests per source	One test per 500 m^3 , minimum 2 tests per source
Emerson Class Number	AS 1289.3.8.1	Two tests per source	One test per 500 m^3 , minimum 2 tests per source

2.2.2 Unit 2 – General Fill

Unit 2 – General Fill shall comprise clay, silt, sand, gravel or any combination thereof or other approved materials. This material shall contain no organic matter. This material shall have a low erosion potential with an Emerson Class number greater than 4 (AS 1289.3.8.1), although the Superintendent may agree to reduce the Emerson Class number requirement where the fill will not be exposed to potential erosion. This material shall have a maximum particle size of 53mm and a smooth gradation that results in minimal visible voids once compacted.

Source approval for Unit 2 will primarily require the Contractor to identify the source, describe the material, provide two representative Emerson Class test results and gradation test results (AS1289.3.6.1), and, for import material, provide an acceptable VENM/ENM classification.

Confirmation of the properties of as-delivered Unit 2 shall be by Contractor inspection and documentation of each incoming load, and by sampling and Emerson Class testing and gradation testing at a frequency of at least one testing event per 1,000 m^3 of material placed, with a minimum of one testing event per source.

2.2.3 Unit 3 – Intermediate Cover Material

The Unit 3 – Intermediate Cover Material is material will be sourced, handled and placed by the landfill operator. The Contractor will not be responsible for this material.

2.2.4 Unit 4 – Clay Rich Material

Unit 4 Clay Rich Material shall clayey soil, free of organic matter, capable of being compacted to a dense condition. The material shall have the following index properties:

- Index properties:
  - Plasticity Index > 15%;
  - Liquid Limit > 25%.
- Emerson crumb classification > 4

The material shall have differing gradation requirements in different applications as indicated below.

A. Bearing Material in Cell Base: This application provides a surface for GCL placement

- Gradation:
  - Maximum particle size 16 mm;
  - Passing 2.4 mm sieve > 90%;
  - Percentage fines (passing 0.075mm sieve)> 30%.

B. Bund – Main Body of Bund. This application is for perimeter bund material that is not in contact with GCL material

- Gradation:
  - Maximum particle size 26.5 mm;
  - Passing 19 mm sieve > 90%;
  - Percentage fines (passing 0.075mm sieve) > 30%.

C. Bund – Batters and top surface: This application provides a surface for GCL placement

- Gradation: same as category A above.

D. Bearing Layer in Final Capping System: This application provides a surface for LLDPE Geomembrane placement

- Gradation:
  - Maximum particle size 9.5 mm;
  - Passing 2.4 mm sieve > 90%;
  - Percentage fines (passing 0.075mm sieve)> 30%.

The following table shows the testing requirements for this material.

Table 5: Material Testing Requirements for Unit 4 – Clay Rich Material

Property	Test method	Frequency	
		Source approval	As-delivered
Atterberg Limits	AS1289.3.2.1	Two tests per source	One test per 2,000 m^3 material used on site, minimum 4 tests per source
Gradation	AS1289.3.6.1	Two tests per source	One test per 2,000 m^3 material used on site, minimum 4 tests per source
Emerson Class Number	AS1289.3.8.1	Two tests per source	One test per 2,000 m^3 material used on site, minimum 4 tests per source

2.2.5 Unit 5 – Clay Material

Unit 5 Clay Material shall clayey soil, free of organic matter, capable of being compacted to a dense condition. The material shall have the following index properties:

- Gradation:
  - Maximum particle size 9.5 mm;
  - Percentage fines (passing 0.075mm sieve)> 50%.
- Index properties:
  - Plasticity Index > 20%;
  - Liquid Limit > 40%.
- Emerson crumb classification > 4.
- When remoulded to a Standard Maximum Dry Density (SMDD) of 95% in accordance with AS1289.5.1.1 at Standard Optimum Moisture Content (SOMC) have a co-efficient of permeability, measured in a triaxial cell at an effective confining pressure of 50 kPa in accordance with AS1289.6.7.3 ,of no greater than 1 x 10^{-9} m/s.

The following table shows the testing requirements for this material.

Table 6: Material Testing Requirements for Unit 5 – Clay Material

Property	Test method	Frequency	
		Source approval	As-delivered
Atterberg Limits	AS1289.3.2.1	Two tests per source	One test per 200 m^3 material used

Property	Test method	Frequency	
		Source approval	As-delivered
			on site, minimum 4 tests per source
Gradation	AS1289.3.6.1	Two tests per source	One test per 200 m^3 material used on site, minimum 4 tests per source
Emerson Class Number	AS1289.3.8.1	Two tests per source	One test per 200 m^3 material used on site, minimum 4 tests per source
Permeability	AS1289.6.7.3	Two tests per source	One test per 200 m^3 material used on site, minimum 1 test per leachate sump, minimum 4 tests per source

2.2.6 Unit 6 – Base Material

Unit 6 Base Material shall be well-graded sandy or gravelly materials, free of organic matter, carbonates and clay balls and capable of being compacted to a dense condition. The material shall have a USCS classification of GW, GW-GM, GM, GW-GC, GC, SW, SW-SM, SM, SW-SC, or SC.

The material shall have the following index properties:

- Gradation:
  - Max. particle size 40 mm;
  - Percentage gravel (retained on 4.75 mm sieve) > 30%
  - Percentage Fines (passing 0.075 mm sieve) >5% and < 25%

Note: Gradation not yet finalised. Gradation may be revised during detailed design to be consistent with identified suitable material sources,

Source approval for Unit 6 will primarily require the Contractor to identify the source, describe the material, provide two representative gradation test results (AS1289.3.6.1), and, for import material, provide an acceptable VENM/ENM classification.

Confirmation of the properties of as-delivered Unit 6 shall be by Contractor inspection and documentation of each incoming load, and by sampling and gradation testing at a frequency of at least one testing event per 1,000 m^3 of material placed, with a minimum of one testing event per source.

The material shall have a minimum shear strength, at 25 kPa effective confining stress, equivalent to that of a drained friction angle of 32 degrees.

2.2.7 Unit 7 – Drainage Aggregate

The Unit 7 – Drainage Aggregate shall consist of high durability gravel or crushed rock of natural geologic origin, free of organic matter, carbonates and clay balls. The material shall be washed to remove fines. Recycled materials or materials of ash/slag origin are not permitted.

The material shall have particle characteristics such that the placed drainage layer is stable under compaction using a smooth drum roller. However, the material shall not include any high angularity particles.

The material shall have the following properties

- Gradation:
  - Max. particle size 26.5 mm;

- Passing 19 mm sieve < 20%
- Passing 13.2 mm sieve < 10%
- Percentage Fines (passing 0.075 mm sieve) < 3%

- Permeability > 1 x 10^{-3} m/s
- Strength (in accordance with AS.2758.1 – 1998):
  - minimum wet strength: 80 kN;
  - maximum wet/dry strength variation: 30%

The following material shall not be used as Unit 7 – Drainage Aggregate: volcanic breccia, mudstone, sandstone, shale and highly weathered or altered rocks.

The following table shows the testing requirements for this material.

Table 7: Material Testing Requirements for Unit 7 – Drainage Aggregate

Property	Test method	Frequency	
		Source approval	As-delivered
Geologic Origin	NA	Certificate is required for each material source	Inspect and document each batch delivered to site to confirm composition and lack of organics, carbonates, and clay
Strength	AS1141.22 - 2008	Two tests per source	One test per 500 m^3 material used on site, minimum 2 tests per source
Gradation	AS1141.11 / AS1141.12	Two tests per source	One test per 500 m^3 material used on site, minimum 2 tests per source
Permeability	AS1289.6.7.1	Two tests per source	One test per 1,000 m^3 material used on site, minimum 2 tests per source

2.2.8 Unit 8 – Gas Drainage Gravel

The Unit 8 – Gas Drainage Gravel shall consist of recycled concrete, natural gravel, crushed rock or combination thereof or other approved materials. This material shall be free of organic matter, carbonates and clay balls.

The material shall have the following properties

- Gradation:
  - Max. particle size 37.5 mm;
  - Passing 19 mm sieve < 20%
  - Passing 13.2 mm sieve < 10%
  - Percentage Fines (passing 0.075 mm sieve) < 2%
- Permeability > 1 x 10^{-3} m/s
- Strength (in accordance with AS.2758.1 – 1998):
  - minimum wet strength: 40 kN;

The following material shall not be used as Unit 8 – Gas Drainage Gravel: shale and highly weathered or altered rocks.

The following table shows the testing requirements for this material.

Table 8: Material Testing Requirements for Unit 8 – Gas Drainage Gravel

Property	Test method	Frequency	
		Source approval	As-delivered
Geologic Origin	NA	Certificate is required for each material source	Inspect and document each batch delivered to site to confirm composition and lack of organics, carbonates, and clay
Strength	AS1141.22 - 2008	Two tests per source	One test per 500 m^3 material used on site, minimum 2 tests per source
Gradation	AS1141.11 / AS1141.12	Two tests per source	One test per 500 m^3 material used on site, minimum 2 tests per source
Permeability	AS1289.6.7.1	Two tests per source	One test per 1,000 m^3 material used on site, minimum 2 tests per source

2.2.9 Unit 9 – Protection Material

Unit 9 Protection Material shall comprise a material:

- capable of being spread smoothly in a 300mm thick layer without damaging underlying geocomposite drain;
- with compaction limited to tracking by the spreading plant;
- with sufficient strength and cohesion to maintain a stable long-erm orientation on piggyback liner slopes, generally 4H:1V to 5H:1V; and
- with as- placed permeability within the identified range.

Natural and recycled materials will be considered.

The material shall have the following index properties:

- Gradation:
  - Max. particle size 13.2 mm;
- Permeability > 5 x 10-5m/s and < 1 x 10-3 m/s

Note: The intent of the required permeability range is to provide and intermediate permeability between that of the emplaced landfill waste and the drainage geocomposite.

Source approval for Unit 9 will primarily require the Contractor to identify the source, describe the material, provide two representative gradation test results (AS1289.3.6.1), and, two permeability test results (AS. 1289.6.7.1.

Confirmation of the properties of as-delivered Unit 9 shall be by Contractor inspection and documentation of each incoming load, and by sampling and gradation testing at a frequency of at least one testing event per 1,000 m^3 of material placed, with a minimum of one testing event per source.

2.2.10 Unit 11 – Filter Geotextile

Unit 11 – Filter Geotextile shall be woven or non-woven, polyester or polypropylene which has the following properties:

- Equivalent Opening Size < 110 µm (Typical Value)

- CBR puncture strength > 2100 N (Minimum Average Roll Value, MARV)
- Flow rate > 100 L/s/m^2 (cross-plane flow under 100 mm head) (Typical Value)
- Mass per unit area > 200 g/m^2 (MARV)

The following table shows the testing requirements for this material.

Table 9: Material Testing Requirements for Unit 11 – Filter Geotextile

Property	Test method	Frequency	
		Source approval	As-delivered
Mass	AS3706.1	Two tests per source	One test per roll used on site
Flow Rate (cross-plane flow under 100mm head)	AS3706.9	Two tests per source	One test per manufacturer batch
Equivalent Opening Size	AS3706.7	Two tests per source	One test per manufacturer batch
CBR Puncture Strength	AS3706.4	Two tests per source	One test per roll used on site

2.2.11 Unit 12 – Cushion Geotextile

Unit 12 – Cushion Geotextile shall be a non-woven, needle-punched polyester or polypropylene material. The material shall have the following properties:

- Thickness > 4 mm (Typical value)
- Mass per unit area> 550 g/m^2 (Minimum Average Roll Value, MARV)
- Trapezoidal tear strength > 900 N (MARV)
- CBR puncture strength > 6000 N (MARV)

The following table shows the testing requirements for this material.

Table 10: Material Testing Requirements for Unit 12 – Cushion Geotextile

Property	Test method	Frequency	
		Source approval	As-delivered
Thickness	AS3706.1	Two tests per source	One test per roll used on site
Mass	AS3706.1	Two tests per source	One test per roll used on site
Trapezoidal Tear	AS3706.3	Two tests per source	One test per 1,000 m^2 material placed on site
CBR Puncture Strength	AS3706.4	Two tests per source	One test per 1,000 m^2 material placed on site

2.2.12 Unit 13 – Geocomposite Drainage Net (Surface Water) (for cap)

Unit 13 – Geocomposite Drainage Net (Surface Water) shall be a geocomposite material comprising an HDPE geonet core (biplanar or triplanar) with non-woven, polyester or polypropylene needle punched, resin

or heat bonded geotextiles thermally bonded to both sides of the geonet core. The material shall have the following properties:

- Thickness > xxx mm at 20 kPa normal stress (Minimum Average Roll Value, MARV)
- Mass > xxx g/m^2 (MARV)
- Hydraulic flow rate for as-delivered material ≥ xxx m^3/s per metre width at 20 kPa with hydraulic gradient i = 0.25 (measured between rigid plates)
- Hydraulic flow rate for source approval ≥ xxx m^3/s per metre width at 20 kPa with hydraulic gradient i = 0.25 (measured between LLDPE geomembrane and Unit 1 Top Soil)
- Tensile strength > xxx kN/m (MARV)
- Elongation at peak > xxx% (MARV)
- Ply adhesion (peel strength of geotextile from geonet) > 180 g/cm (MARV); with no unbonded areas permitted

Note: *xxx: indicates that value to be established during detailed design.*

The geotextiles shall have the following properties:

- Mass per unit area> 130 g/m^2 (MARV) or 200 g/m^2 if sheets are to be joined by hot-air seaming
- Equivalent Opening Size < 90 µm (Typical value)

The following table shows the testing requirements for this material.

Table 11: Material Testing Requirements for Unit 13 – Geocomposite Drainage Net (Surface Water)

Property	Test method	Frequency	
		Source approval	As-delivered
Thickness at 20 kPa	AS 3706.1 / ISO 9863 / ASTM D-5199-01 / EN 964-1	Two tests per source	One test per 2 rolls used on site
Mass per unit area	AS3706.1 / ISO 9864 / ASTM D-5261-92 / EN 965	Two tests per source	One test per 2 rolls used on site
Tensile strength	AS3706.2 / ISO 10319 / ASTM 4595-01	Two tests per source	One test per 3,000 m^2 geocomposite material placed on site
Elongation	AS3706.2 / ISO 10319 / ASTM 4595-01	Two tests per source	One test per 3,000 m^2 geocomposite material placed on site
Hydraulic flow rate	AS 3706.10 / D-4716-01 / ISO-12958	Two tests per source	One test per 10,000 m^2 geocomposite material placed on site
Ply Adhesion	ASTM D7005	Two tests per source	One test per 1,000 m^2 geocomposite material placed on site Inspect and document each roll used on site to confirm requirement for no unbonded areas
Geotextile (both			

Property	Test method	Frequency	
		Source approval	As-delivered
sides)			
- Mass per unit area	AS3706.1 / ISO 9864 / ASTM D-5261-92	Two tests per source	One test per 1,500 m^2 geocomposite material placed on site
- Opening size	AS 3706.7 / D-4751-95 / ISO 12956	Two tests per source	One test per 10,000 m^2 geocomposite material placed on site

2.2.13 Unit 14 – Geocomposite Drainage Net (Leachate)

Unit 14 –Geocomposite Drainage Net (Leachate) shall be a geocomposite material comprising HDPE triplanar geonets and double-sided non-woven, polyester or polypropylene needle punched, resin or heat bonded geotextiles. The material shall have the followings properties:

- Thickness ≥ xxx mm at 200 kPa normal stress (Typical value)
- Mass > xxx g/m^2 (MARV)
- Hydraulic flow rate for as-delivered material ≥ xxx m^3/s per metre width at 500 kPa with hydraulic gradient i = 0.25 (measured between rigid plates)
- Hydraulic flow rate for source approval ≥ xxx m^3/s per metre width at 500 kPa with hydraulic gradient i = 0.25 (measured between LLDPE geomembrane and Unit 9 Protection Material)
- Hydraulic Flow Rate Reduction Factor for Creep, RF_{CR} < xxx (at 500 kPa normal stress, 100 years, 20°C) (Typical value)
- Tensile strength > xxx kN/m (MARV)
- Elongation at peak > xxx% (MARV)
- Ply adhesion (peel strength of geotextile from geonet) > 180 g/cm (MARV); with no unbonded areas permitted

Note: *xxx: indicates that value to be established during detailed design.*

The geotextiles shall have the following properties:

- Mass per unit area > 130 g/m^2 (MARV) or 200 g/m^2 if sheets are to be joined by hot-air seaming
- Equivalent Opening Size < 90 µm (Typical value)

The following table shows the testing requirements for this material.

Table 12: Material Testing Requirements for Unit 14 – Geocomposite Drainage Net (Leachate)

Property	Test method	Frequency	
		Source approval	As-delivered
Thickness	AS 3706.1 / ISO 9863 / ASTM D-5199-01 / EN 964-1	Two tests per source	One test per 2 rolls used on site
Mass	AS3706.1 / ISO	Two tests per source	One test per 2 rolls used on site

Property	Test method	Frequency	
		Source approval	As-delivered
	9864 / ASTM D-5261-92 / EN 965		
Tensile strength	AS3706.2 / ISO 10319 / ASTM 4595-01	Two tests per source	One test per 3,000 m^2 geocomposite material placed on site
Elongation strength	AS3706.2 / ISO 10319 / ASTM 4595-01	Two tests per source	One test per 3,000 m^2 geocomposite material placed on site
Hydraulic flow rate	AS 3706.10 / D-4716-01 / ISO-12958	Two tests per source	One test per 10,000 m^2 geocomposite material placed on site
Hydraulic Flow Rate Reduction Factor for Creep	extended AS 3706.10 / D-4716-01 / ISO-12958	Two tests per source	Not required
Ply Adhesion	ASTM D7005	Two tests per source	One test per 1,500 m^2 geocomposite material placed on site Inspect and document each roll used onsite to confirm requirement for no unbonded areas
Geotextile			
- Mass per unit area	AS3706.1 / ISO 9864 / ASTM D-5261-92	Two tests per source	One test per 1,500 m^2 geocomposite material placed on site
- Opening size	AS 3706.7 / D-4751-95 / ISO 12956	Two tests per source	One test per 10,000 m^2 geocomposite material placed on site

2.2.14 Unit 15 – LLDPE Geomembrane

Unit 15 –Linear Low Density Polyethylene (LLDPE) Geomembrane with a nominal thickness of 1.5mm for the piggy back liner system and 1.0 mm for the capping system shall have the following properties:

A. Piggy Back Liner System:

- Thickness > 1.45mm (minimum average roll value, MARV)
- LLDPE product density < 0.939 g/cm^3 (MARV)
- Base resin: density >0.915 g/cm^3 and <0.926 g/cm^3; melt flow index <1.0 g/10min
- Product textured on both sides with asperity height > 0.25mm (MARV)
- Tensile strength at break > 16 kN/m (MARV)
- Elongation at break > 250% (MARV)
- Modulus at 2% strain < 630 kN/m (max)
- Tear resistance > 150 N (MARV)
- Puncture resistance > 300 N (MARV)

- Axi-symmetric break resistance strain > 30% (min)
- Oxidative Induction Time (OIT):
  - > 100 minutes at standard pressure (MARV); and
  - > 400 minutes at high pressure (MARV)
- Oven aging at 85ºC for 90 days:
  - OIT retained > 35% at standard pressure (MARV); and
  - OIT retained > 60% at high pressure (MARV)
- Shear Strength Requirements - Refer to Section 2.2.17.

B. Capping System:

- Thickness > 0.95mm (minimum average roll value, MARV)
- LLDPE product density < 0.939 g/cm^3 (MARV)
- Base resin: density >0.915 g/cm^3 and <0.926 g/cm^3; melt flow index <1.0 g/10min
- Product textured on both sides with asperity height > 0.25mm (MARV)
- Tensile strength at break > 11 kN/m (MARV)
- Elongation at break > 250% (MARV)
- Modulus at 2% strain < 420 kN/m (max)
- Tear resistance > 100 N (MARV)
- Puncture resistance > 200 N (MARV)
- Axi-symmetric break resistance strain > 30% (min)
- Oxidative Induction Time (OIT):
  - > 100 minutes at standard pressure (MARV); and
  - > 400 minutes at high pressure (MARV)
- Oven aging at 85ºC for 90 days:
  - OIT retained > 35% at standard pressure (MARV); and
  - OIT retained > 60% at high pressure (MARV)
- Shear Strength Requirements - Refer to Section 2.2.17.

The following table shows the testing requirements for this material.

Table 13: Material Testing Requirements for Unit 15 - Textured LLDPE Geomembrane

Property	Test Method	Frequency	
		Source approval	As-delivered

Thickness	ASTM D 5994	Two tests per manufacture source	One test per roll
Density	ASTM D1505		One test per manufacture batch
Melt Flow Index	ASTM D 1238		One test per manufacture batch
Asperity Height (both sides)	GM12		Second roll or each roll if not in production sequence (note: to be measured at three or five locations across roll width)
Tensile Properties (each direction) - Strength at break - Elongation at break	ASTM D6693		One test for each property per roll
2% Modulus	ASTM D5323		One test per roll
Tear Resistance	ASTM D1004		One test per roll
Puncture Resistance	ASTM D4833		One test per roll
Axi-Symmetric Break Resistance Strain	ASTM D 5617		Not required
Oxidative Induction Time (OIT) - Standard OIT - High Pressure OIT	ASTM D 3895 ASTM D 5885		One test for each property per resin type or per 10,000 m^2 of geomembrane
Oven Aging at 85ºC for 90 days - Standard OIT - High Pressure OIT	ASTM D 5721 ASTM D 3895 ASTM D 5885		One test for each property per resin type or per 10,000 m^2 of geomembrane

2.2.15 Unit 16 – HDPE Geomembrane

Unit 16 – High Density Polyethylene (HDPE) Geomembrane with nominal thickness of 2 mm shall have the following properties:

- Thickness > 1.9mm (minimum average roll value, MARV)
- density > 0.94 g/cm^3 (MARV)
- Base resin: density >0.932 g/cm^3; melt flow index <1.0 g/10min
- Product textured on both sides with asperity height > 0.25 mm (MARV)
- Tensile strength at yield > 29 kN/m (MARV)
- Elongation at yield > 12% (MARV)
- Tear resistance > 249 N (MARV)

- Puncture resistance > 534 N (MARV)
- Oxidative Induction Time (OIT):
  - > 100 minutes at standard pressure (MARV); and
  - > 400 minutes at high pressure (MARV)
- Oven aging at 85ºC for 90 days:
  - OIT retained > 55% at standard pressure (MARV); and
  - OIT retained > 80% at high pressure (MARV)
- Stress Cracking Resistance (performed on smooth portion of sheet) > 300hr (Typical value)
- Shear Strength Requirements - Refer to Section 2.2.17.

The following table shows the testing requirements for this material.

Table 14: Material Testing Requirements for Unit 16 – Textured HDPE Geomembrane

Property	Test Method	Frequency	
		Source approval	As-delivered
Thickness	ASTM D 5994	Two tests per manufacture source	One test per roll
Density	ASTM D 1505		One test per manufacture batch
Melt Flow Index	ASTM D 1238		One test per manufacture batch
Asperity Height	GM12		Every second roll or each roll if not in production sequence (note: to be measured at three or five locations across roll width)
Tensile Properties (each direction) - Strength at yield - Elongation at yield	ASTM D 6693		One test for each property per roll
Tear Resistance	ASTM D 1004		One test per roll
Puncture Resistance	ASTM 4833		One test per roll
Oxidative Induction Time (OIT) - Standard OIT - High Pressure OIT	ASTM D 3895 ASTM D 5885		One test for each property per resin type or per 10,000 m^2 of geomembrane
Oven Aging at 85ºC for 90 days - Standard OIT - High Pressure OIT	ASTM D 5721 ASTM D 3895 ASTM D 5885		One test for each property per resin type or per 10,000 m^2 of geomembrane
Environmental Tensile Load Crack Resistance	ASTM D 5397		One test per resin type, manufacture batch, or per geomembrane type

2.2.16 Unit 17 – Geosynthetic Clay Liner (GCL)

Unit 17 – Geosynthetic Clay Liner shall be a reinforced multi-layered system comprising at least two layers of geotextile encapsulating a layer of dry, sodium bentonite. The GCL shall be reinforced by needle punchingand be free of broken needles.

The bentonite layer in the GCL shall have the following characteristics:

- form: natural sodium bentonite or >80% sodium as activated bentonite
- carbonate content < 1 to 2% (by weight)
- montmorillonite content > 70% (by weight)
- particle size: if powdered >80% passing 0.075mm sieve; if granulated <1% passing 0.075mm
- cation exchange capacity > 70 meq/100g

The GCL material shall have the following properties:

- Total mass (dry) > 4000 g/m^2;
- Bentonite clay:
  - Bentonite mass (dry) > 3700 g/m^2;
  - Swell index > 24 ml/2g
- Fluid loss < 18 mlTensile strength > 4 kN/m
- Peel strength > 360 N/m
- Permeability: testing at 100kPa effective confining stress with the following permeants

a. tap water: k < 5 x 10^{-11} m/s

b. deionised water with 0.1M CaCl2 : k < 5 x 10^{-10} m/s

Shear Strength Requirements - Refer to Section 2.2.17.

Geotextiles component of the GCL shall have the following property:

- At least one geotextile is nonwoven
- Mass of nowoven geotextile >200 g/m^2
- Mass of woven geotextile (if any) >100 g/m^2.

The following table shows the testing requirements for this material.

Table 15: Material Testing Requirements for Unit 17 - GCL

Property	Test Method	Frequency	
		Source approval	As-delivered
Bentonite Clay: - Swell Index			
- Fluid Loss	ASTM D5890 ASTM D5891	Two tests per manufacture	Manufacturer certification for each batch represented

Total Mass (dry)	DIN 53854	source	One test per 2 rolls used on site
Bentonite Mass (dry)	ASTM D 5393		One test per 2 rolls used on site
Tensile Strength	ASTM D 4595		One test per 2 rolls used on site
Peel Strength	ASTM D 6496		One test per 2 rolls used on site
Permeability (using 100kPa effective confining stress): a. tap water b. deionised water, 0.1M $CaCl_2$ Note: Test b. to be conducted after permeation with deionised water.	ASTM D 5887		For test (a) tap water, one test per 20,000 m^2 of GCL installed at site, minimum 3 tests total For test (b) $CaCl_2$ – as delivered tests not required

2.2.17 Lining System Shear Strength Requirements

Capping and Piggy Back Liner System Shear Strength Requirement

The Contractor must include direct shear test results (ASTM D5321) in the submittal for Unit 13, Unit 14, Unit 15, Unit 16, and Unit 17 source approval that demonstrate that the lining and capping systems will achieve the required shear strengths for the test conditions defined in Table 16 below.

Table 16: Lining and Capping System Shear Strength Requirements

No.	Lining or Capping System	Required Minimum Equivalent Shear Strength Parameters	Direct Shear Test Cross Section	Direct Shear Test Conditions
A	Piggy Back Lining (Typical)	Peak Strength: Φ'= 17º , c'= 0 kPa Residual Strength: Φ'= 7º , c'= 0 kPa	■ lightly compacted sand to represent an initial lift of Unit 9 – Protection Material; ■ specific geocomposite proposed by the Contractor as Unit 14 – Geocomposite Drainage Net (Leachate); ■ specific 1.5mm thick textured geomembrane proposed by the Contractor as Unit 15 –LLDPE Geomembrane; ■ specific GCL proposed by the Contractor as Unit 17 – GCL; ■ well compacted clayey soil (95% standard compaction at +2% above optimum moisture) to represent the compacted Unit 4 – Clay Rich Material below the GCL;	■ Normal stress = 100, 300, and 500 kPa; ■ Shear rate = 0.1 mm/min; Total shear displacement > 75mm ■ Test specimen configuration: no pre-determined shear surface – construct test specimen to allow shearing to occur in actual weakest interface or material; and ■ Hydration and Consolidation: Apply normal stress to test specimen and then, while maintaining the normal stress, soak specimen in tap water for 7 days to allow GCL and soils to hydrate. Shear the hydrated specimen without interrupting the applied normal stress. Provide information on shear response and shear plane location
B	Piggy Back Lining (Lower Eastern Gully)	Peak Strength: Φ'= 17º , c'= 0 kPa Residual Strength: Φ'= 14º , c'= 0 kPa	same as test no. A	same as test no. A
C	Cell Base Lining in Cells 1 to 4 (Typical)	Peak Strength: Φ'= 17º , c'= 0 kPa Residual Strength: Φ'= 11º , c'= 0 kPa	■ specific gravel proposed by the Contractor as Unit 7 – Drainage Aggregate; ■ specific geotextile proposed by the Contractor as Unit 12 –Cushion Geotextile ■ specific textured geomembrane proposed by the Contractor as Unit 16 –HDPE Geomembrane; ■ specific GCL proposed by the Contractor as Unit 17	■ Normal stress = 100, 200, and 300 kPa; ■ Shear rate = 0.1 mm/min; ■ Test specimen configuration: no pre-determined shear surface – construct test specimen to allow shearing to occur in actual weakest interface or material; and ■ Hydration and Consolidation: Apply normal stress

No.	Lining or Capping System	Required Minimum Equivalent Shear Strength Parameters	Direct Shear Test Cross Section	Direct Shear Test Conditions
			– GCL; and ■ well compacted clayey soil (95% standard compaction at +2% above optimum moisture) to represent the compacted Unit 4 – Clay Rich Material below the GCL.	to test specimen and then, while maintaining the normal stress, soak specimen in tap water for 7 days to allow GCL and soils to hydrate. Shear the hydrated specimen without interrupting the applied normal stress. Provide information on shear response and shear plane location.
D	Cell Base Lining (Cell 1 East)	Peak Strength: Φ'= 17º , c'= 0 kPa Residual Strength: Φ'= 14º , c'= 0 kPa	same as test no. C	same as test no. C
E	Cell Base Lining (Cell 2A, 2B, 4A)	same as test no. A	same as test no. A	same as test no. A
F	Final Capping	to be determined during detailed design	■ lightly compacted clayey, silty sand soil (90% standard compaction at optimum moisture) to represent the initial lift of the Unit 1 – Topsoil placed in the cap; ■ specific geocomposite proposed by the Contractor as Unit 13 – Geocomposite Drainage Net (Surface Water); ■ specific 1.0 mm thick textured geomembrane proposed by the Contractor as Unit 15 – LLDPE Geomembrane; and ■ well compacted clayey soil (95% standard compaction at +2% above optimum moisture) to represent the compacted Unit 4 – Clay Rich Material below the LLDPE geomembrane.	■ Normal stress = 10, 15, and 20 kPa; ■ Shear rate = 0.1 mm/min; ■ Test specimen configuration: no pre-determined shear surface – construct test specimen to allow shearing to occur in actual weakest interface or material; and ■ Hydration and Consolidation: Spray both sides of textured LLDPE geomembrane with a fine mist of water immediately prior to constructing the test specimen. Apply normal stress to constructed test specimen and allow 24 hours for consolidation. After the consolidation period, shear the hydrated specimen without interrupting the applied normal stress. Provide information on shear response and shear plane location

2.2.18 Unit 18 – Geogrid

Unit 18 – Geogrid shall have a minimum long-term multiaxial tensile stiffness of 500 kN/m at a tensile strain of 5%. The multiaxial stiffness value is to reflect the average value when the stiffness is assessed in four principal directions in the plane of the material, being MD (machine direction), XMD (cross machine direction), and the two diagonal directions between the MD and XMD. Geogrid shall be a single layer of material. Multiple layers may be considered if Contractor proposes acceptable alternate installation measures to those in Sections 3.3.4 and 3.3.13.

The long-term stiffness shall be based on an appropriate test method, to be specified during detailed design, accounting for a 100-year design life and the effects of construction damage, tensile creep, and environmental degradation in a buried environment with potential exposure to leachate.

Note: Tensile stiffness calculated as the tensile load estimated to induce 5% strain over the design life divided by 0.05 (i.e. 5%).

The following table shows the testing requirements for this material.

Table 17: Material Testing Requirements for Unit 18 – Geogrid

Property	Test method	Frequency	
		Source approval	As-delivered
Tensile strength at 5% elongation (measured in 4 principal directions)	ISO 10319	Two tests per source	One test per 4,000 m^2 geogrid material placed on site
Evaluate stiffness reduction factors for long-term loading	[to be specified during detailed design]	One test per source	not required if manufacturer provides acceptable data

Pipe Materials

2.2.19 Unit 21 – Gas Collection Pipe

Unit 21 – Gas Collection Pipe shall comprise 110 mm diameter rating PN 6.3, HDPE (PE 100 material class) pipe or approved equivalent.

Where the pipes are required to be perforated, the pipes shall be drilled in accordance with the detail shown on the design drawing. All drill cuttings, including loose attachments and burrs, shall be removed from the perforated pipes before installation.

The pipe shall have perforations of no more than 15 mm diameter as shown on design drawing.

All connections and fittings for the pipes shall be manufactured from the same material and strength class as the pipe, and shall be solid wall units. All ends of the pipes shall be capped with HDPE caps.

Pipe joins shall be carried out using full face fusion bonding. No filter sock shall be used.

Material property certificates from the manufacturer shall be submitted for approval for each source of material prior to construction.

The Contractor shall provide the Superintendent with manufacturer's documentation certifying the properties of the material for each manufacture batch used on site.

2.2.20 Unit 22 – Groundwater Drainage Pipe

Unit 22 – Groundwater Drainage Pipe shall comprise 110 mm diameter rating PN 6.3, HDPE (PE 100 material class) pipe or approved equivalent.

All connections and fittings for the pipes shall be manufactured from the same material and strength class as the pipe, and shall be solid wall units. All ends of the pipes shall be capped with HDPE caps.

Pipe joins shall be carried out using full face fusion bonding

Material property certificates from the manufacturer shall be submitted for approval for each source of material prior to construction.

The Contractor shall provide the Superintendent with manufacturer's documentation certifying the properties of the material for each manufacture batch used on site.

2.2.21 Unit 23 – Leachate Collection Pipe

Unit 23 – Leachate Collection Pipe shall comprise 200 mm diameter rating PN 12.5, HDPE (PE 100 material class) pipe with an SDR < 14 or approved equivalent.

Where the pipes are required to be perforated, the pipes shall be drilled in accordance with the detail shown on the design drawing. All drill cuttings, including loose attachments and burrs, shall be removed from the perforated pipes before installation.

The pipe shall have perforations of no more than 15 mm diameter as shown on design drawing.

All connections and fittings for the pipes shall be manufactured from the same material and strength class as the pipe, and shall be solid wall units. All ends of the pipes shall be capped with HDPE caps.

Pipe joins shall be carried out using full face fusion bonding. No filter sock shall be used.

Material property certificates from the manufacturer shall be submitted for approval for each source of material prior to construction.

The Contractor shall provide the Superintendent with manufacturer's documentation certifying the properties of the material for each manufacture batch used on site.

2.2.22 Unit 24 – Leachate Sump Outlet Pipe

Unit 24 – Leachate Sump Outlet Pipe shall comprise 250 mm diameter rating PN 12.5, HDPE (PE 100 material class) pipe with an SDR < 14 or approved equivalent.

The pipes shall be solid wall pipes.

All connections and fittings for the pipes shall be manufactured from the same material and strength class as the pipe, and shall be solid wall units.

Pipe joins shall be carried out using full face fusion bonding.

Material property certificates from the manufacturer shall be submitted for approval for each source of material prior to construction.

The Contractor shall provide the Superintendent with manufacturer's documentation certifying the properties of the material for each manufacture batch used on site.

2.2.23 Unit 25 – Leachate Drainage Pipe

Unit 23 – Leachate Drainage Pipe shall comprise 315 mm diameter rating PN 12.5, HDPE (PE 100 material class) pipe with an SDR < 14 or approved equivalent.

The pipes shall be solid wall pipes.

All connections and fittings for the pipes shall be manufactured from the same material and strength class as the pipe, and shall be solid wall units.

Pipe joins shall be carried out using full face fusion bonding.

Material property certificates from the manufacturer shall be submitted for approval for each source of material prior to construction.

The Contractor shall provide the Superintendent with manufacturer's documentation certifying the properties of the material for each manufacture batch used on site.

2.2.24 Unit 26 – Subsoil Drainage Pipe

Unit 25 – Subsoil Drainage Pipe shall be slotted or perforated nominal 100 mm diameter drain coil pipes, manufactured from polyethylene or uPVC, or other material approved by the Superintendent. The pipe strength shall conform to at least Class SN8 and shall be slotted as per pipe Type 1 or 2, in accordance with AS 2439.1 - 2007. Pipe outlets shall be solid wall. Joints and bends in pipe shall be formed with similar strength units and may be solid wall units. Pipe joints may be spigot and socket joints, glued or fusion bonded joints. No filter sock shall be used.

Material property certificates from the manufacturer shall be submitted for approval for each source of material prior to construction.

The Contractor shall provide the Superintendent with manufacturer's documentation certifying the properties of the material for each manufacture batch used on site.

2.2.25 Unit 27 – Leachate Sump Riser

Unit 27 – Leachate Sump Riser shall be 1200 mm diameter precast concrete pipe with step irons manufactured in accordance with AS 4058:2007.

The cover and surrounds which will be used on top of the leachate sump shall be reinforced concrete, ductile iron cover and frame, ductile iron cast into a concrete surround, or other variations. Covers and surrounds shall be suitable for Class C (150kN) ultimate load applications in accordance with AS3996.

The riser pipe shall be placed into the sump on a 200 mm thick concrete base. The base shall be precast concrete, or cast in place, and coated with similar epoxy system as for the pipe. The strength of the base concrete shall be equivalent to that of the concrete used for the pipe.

Material property certificates from the manufacturer shall be submitted for approval for each source of material prior to construction.

The Contractor shall provide the Superintendent with manufacturer's documentation certifying the properties of the material for each manufacture batch used on site.

Other Materials

2.2.26 Unit 31 – Bentonite

Unit 31 - Bentonite pellets shall be nominal 6 mm, compressed dry bentonite pellets of a type used for sealing boreholes and monitoring wells. The bentonite shall have a swell index of at least 15 mL / 2g.

Material property certificates from the manufacturer shall be submitted for approval for each source of material prior to construction.

The Contractor shall provide the Superintendent with manufacturer's documentation certifying the properties of the material for each manufacture batch used on site.

3.0 SECTION 3 – CONSTRUCTION

3.1 General Management

Construction of the cell shall be achieved in compliance with site management plans identified in Section 1.6 and all other contract requirements. This will by necessity require the Contractor to stage his construction activities, particularly to comply with Environmental Management Plan and surface water management requirements, but also to provide for cost-effective construction. Considerations for the Contractor with respect to staging include, but are not limited to, those given below.

- Minimise disturbed areas to reduce generation of dust.
- Minimise potential for runoff to enter previously lined and landfilling areas.

As indicated in Section 1.6, the Superintendent may supply the Contractor with a staging plan for cell construction and landfilling as a guide for the preparation of the Contractor's construction program.

3.1.1 Stockpile Management

The Contractor will manage stockpiles in accordance with the requirements of the Contractor's CEMP for the project. There must be no unacceptable impact of the site as a result of stockpiling.

As a minimum, the following requirements must be met by the Contractor:

- All stockpiles must be managed to minimise the generation of dust;
- All stormwater must be managed in the vicinity of the stockpiles to minimise the volume of water coming into contact with the stockpiles; and
- Runoff from all stockpiles, other than contaminated material or waste stockpiles, shall be managed in the same way as other stormwater on the site according to the Contractor's CEMP.

Upon completion of the use of an area for stockpiling, the Contractor shall:

- Remove all remaining stockpiled material for reuse or placement in accordance with this Technical Specification; and
- The reinstated stockpile area is to be assessed by the Contractor to the satisfaction of the Superintendent to ensure that no waste materials remain.

3.1.2 Water Management during Construction

3.1.2.1 Surface Water

The Contractor shall manage surface water within the construction site in accordance with the CEMP, and approved surface water management plan. The surface water drainage system on site includes clean and dirty (i.e., potentially sediment-laden) water drains. The surface water collected from the construction area shall be discharged to the dirty water drainage system of the site.

The Contractor shall divert surface run-on to the construction area, and must prevent uncontrolled discharge of water originating in the construction area to the site surface water drainage system.

The Contractor shall ensure that his operations do not result in chemical contamination of surface waters.

The Superintendent (site owner) will be responsible for management of the existing major surface water ponds at the Whytes Gully site, surface water treatment, and controlled discharges from the ponds.

3.1.2.2 Leachate

The Contractor will be responsible for maintaining delivery of leachate in the existing leachate collection system in the Eastern and Western Gully Landfills to the existing leachate ponds during all stages of cell base and piggyback liner construction. This responsibility will also extend to leachate collected in each stage of the new leachate collections systems. The Contractor shall install temporary sumps, pumps and pumping lines as needed to meet these requirements. All temporary items must comply with the CEMP and be acceptable to the Superintendent.

The Superintendent (site owner) will be responsible for management of the existing leachate ponds at the Whytes Gully site, leachate treatment, and leachate discharge to sewer.

3.1.2.3 Dewatering

The Contractor shall manage, at his cost, any waters arising from groundwater dewatering activities in accordance with the CEMP and Contract requirements. Management requirements are likely to depend on water quality and quantity. In regard to the potential to transfer water arising from groundwater dewatering activities into the existing site surface water management and/or leachate management systems, any such transfer would be at the discretion of the Superintendent (site owner) and would depend on water quality and quantity and the capacity of the systems at the time.

3.1.3 Excavation of Materials before construction

3.1.3.1 Removal of Vegetation and Topsoil

Refer to the information in Section 1.7.1, including requirements for a Work Method Statement and HOLD POINT.

3.1.3.2 Excavation on Eastern Gully

Prior to construction of the piggy back liner system on the existing Eastern Gully Landfill batter, the Contractor shall excavate the existing terraced surface as follows:

- Removal of any topsoil as outlined in Section 1.7.1 above.
- Conduct test pitting in each local area on the existing surface to identify the thickness and distribution of the existing cover material.
- Excavation of existing cover materials on the existing surface using the design subgrade surface and test pitting results as a guide. Excavated materials are to be stockpiled by the Contractor in designated areas for use by the site owner in landfilling operations.
- The final surface shall be at least 300 mm above the existing waste level and provide an appropriate surface to construct the base layer. In case of over-excavation of the material, the area shall be reinstated with the excavated material or with Unit 2 – General Fill in the same manner as outlined in Section 3.3.1 at the Contractor cost to the satisfaction of the Superintendent.

The Contractor shall provide a work method statement presenting proposed methods for these activities. Submission of the work method statement constitutes a HOLD POINT. These activities shall not commence until the Hold Point is released.

The test pitting and excavation of the cover materials in each local area constitute INSPECTION POINTs. The Contractor is required to provide 24 hours notice before commencing or recommencing these activities.

The preparation of the excavated surface, including surveying, shall be in the same manner as outlined in Section 3.3.2.

3.2 Construction Quality Management

The Construction Quality Management system for construction comprises Contractor requirements and Superintendent actions. Contractor requirements include preparing management plans, preparing work method statements, material testing, compaction testing (through GITA), surveying, notifying for Inspection Points, and preparing Hold Point documentation and works-as-executed (WAE) documentation. Superintendent actions include review and approval of Contractor submittals and documentation, inspecting construction works, conducting audit testing, attending Inspection Points, and releasing Hold Points. Superintendent actions are typically referred to as Construction Quality Assurance (CQA).

A description of the approach for quality management of material properties is provided in Section 2.1.2, including description of approval of material sources, confirmation of as-delivered material properties, and audit testing. Details of material requirements and testing requirements are given in Chapter 2 of this document. For example, as indicated in Section 2.1.4, all material test results submitted to the Superintendent by the Contractor must be from a laboratory with NATA-accreditation for all tests performed; and all survey results submitted to the Superintendent by the Contractor must be from a registered surveyor.

Quality management requirements to be implemented during construction activities are described in the following section, with details provide in the remaining portions of Chapter 3 of this document.

Construction Quality Management Summary

Quality management requirements are summarised in Table 18, with definition of the table headings given below. Construction requirements are outlined in the following Section 3.3.

- *Hold Point*: This term is defined in Section 1.2.
- *Full Time Inspection*: The Superintendent or in some cases the GITA, will be present on a full-time (continuous) basis for certain construction activities to provide additional confidence that construction is proceeding in accordance with Technical Specification requirements and design intent. Activities where full-time inspection is planned to be undertaken are identified in Table 18 below.
- *Field Testing*: Certain cell construction activities will require real-time field testing during construction. Examples include testing for confirmation of as-delivered material properties, testing of geomembrane welds, and compaction testing (refer following bullet point).
- *Compaction Testing*: Testing for as-constructed density and moisture content will be routinely performed on all soil construction materials. The Contractor will be required to engage an independent GITA from a specified short list to inspect earthworks construction and perform compaction testing.
- *Survey*: Numerous requirements for surveying of constructed alignments , inverts, and constructed soil and geosynthetic material surfaces are include in the Technical Specification. The survey provides data for Works-as-Executed documentation and for confirming that design layer thicknesses have been achieved in liner and capping systems.
- *Audit Testing*: The Superintendent will arrange, at his discretion, for sampling and testing of deliverd and emplaced construction materials, including soils and geosynthetics, to provide material property measurements that are independent of measurements by the Contractor (refer Section 2.1.2). Activities where audit testing is likely to be undertaken are identified in Table 18 below.

Table 18: Construction Quality Management System Summary

No.	Activity/Material	Hold Point	Full-Time Inspection	Field Testing	Survey	Audit Testing
A	**CONSTRUCTION MATERIALS**					
1	Source Approval (each material)	x				x
2	Confirmation of as-delivered material properties (each material)			x		x
B	**CONSTRUCTION ACTIVITIES**					
1	**Excavation of Onsite Materials and Formation of Subgrade**					
1.1	Removal of Vegetation and Topsoil, Work Method Statement	x				
1.2	Structures Demolition, Work Method Statement	x				
1.3	Excavation of Existing Eastern Gully Capping Materials, Work Method Statement, and WAE drawings	x		x	x	
1.4	*Subgrade Preparation*					
a	Work Method Statement	x				
b	Proof roll and placement of Unit 2 – general fill		x	x	x	x
c	Submission of subgrade WAE drawings and surface analysis	x			x	
2	**Cell Base Lining System Construction (Cells 1 to 4)**					
2.1	*Bearing Layer*					
a	Placement of Unit 4 – Clay Rich Material to form bearing layer		x	x		x
b	Survey and WAE	x			x	
2.2	*Perimeter Bund*					
a	Setout survey of perimeter bund alignment	x			x	
b	Placement of Unit 4 – Clay Rich Material for the bund		x	x	x	
c	Survey and WAE	x			x	
2.3	*Internal Bunds (refer item 2.2)*					
2.4	*Geosynthetics*					
a	Approval of qualified sub-contractor	x				
b	Geosynthetics quality control procedures manual	x				
c	Submission of data, statements, reports and certificates	x				
d	Panel layout drawings for GCL and geomembrane	x				
e	Surface preparation for GCL placement	x				
f	Anchor trench				x	
g	Placement of Unit 17 – GCL		x			x
h	Placement of Unit 16 – HDPE Geomembrane		x	x	x	x
i	Placement of Unit 12 – Cushion Geotextile		x	x		x
2.5	*Leachate Collection System*					
a	Placement of Unit 23 – Leachate Collection Pipe		x			
b	Installation of leachate clean out access points	x	x			
c	Leachate collection pipe WAE drawings				x	
d	Unit 7 –Drainage Aggregate Work Method Statement	x				
e	Field placement trial		x	x		x

No.	Activity/Material	Hold Point	Full-Time Inspection	Field Testing	Survey	Audit Testing
f	Placement of Unit 7 – Drainage Aggregate		x	x		x
g	Placement of Unit 11 – Filter Geotextile		x	x		x
h	Leachate collection layer WAE drawings	x			x	
2.6	*Construction of Leachate Sump*					
a	Leachate Sump Construction Work Method Statement	x				
b	Excavation of sump; formation of sump base		x	x	x	
c	Placement of Clay Material and Clay WAE	x	x	x	x	x
d	Geosynthetic Materials Installation		x	x		x
e	Installation of Unit 24 – Leachate Sump Outlet Pipe with liner penetration		x		x	
f	Placement of Unit 23 - Leachate Collection Pipe within sump		x		x	
g	Backfilling the sump by Unit 7 – Drainage Aggregate and covering by Unit 11 – Filter Geotextile		x	x	x	x
h	Leachate Collection WAE drawings (included in item 2.5 h)					
2.7	*Construction of Leachate Drainage System*					
a	Leachate Drainage System Construction Work Method Statement	x				
b	Installation of Unit 25 – Leachate Drainage Pipe and connection with existing leachate drainage pipes		x		x	
c	Excavation and Installation of Unit 27 – Leachate Sump Riser		x		x	
d	Connection of Unit 27 – Leachate Sump Riser with Unit 25 – Leachate Drainage Pipe and Unit 24 – Leachate Sump Outlet Pipe		x		x	
e	WAE drawings (included in item 2.5 c)					
3	**Piggy Back Lining System Construction**					
3.1	*Gas Venting System*					
a	Placement of Unit 8 – Gas Drainage Gravel			x	x	
b	Placement of Unit 21 – Gas Collection Pipes				x	
c	Placement of gas venting header pipes				x	
d	Gas Venting System WAE and backfill pipes	x			x	
3.2	*Base Layer*					
a	Work Method Statement	x				
b	Placement of Unit 6 – Base Material and Unit 18 Geogrid	x		x		x
c	Submission of base layer WAE drawings and surface analysis	x			x	
3.3	*Bearing Layer (refer item 2.1)*					
3.4	*Perimeter Bund (refer item 2.2)*					
3.5	*Internal Bunds (refer item 2.3)*					
3.6	*Geosynthetics*					
a-f	Documentation and submittals (refer item 2.4, sub-items a to f)					
g	Placement of Unit 17 – GCL		x			x
h	Placement of Unit 15 – LLDPE Geomembrane		x	x	x	x
3.7	*Leachate Collection System*					
a	Placement of Unit 14 – Geocomposite Drainage Net (Leachate)		x	x		x
b	Placement of Unit 23 – Leachate Collection		x			

No.	Activity/Material	Hold Point	Full-Time Inspection	Field Testing	Survey	Audit Testing
	Pipe					
c	Installation of leachate clean out access points	x	x			
d	Leachate collection pipe WAE				x	
e	Placement of Unit 7 – Drainage Aggregate and Unit 11 – Filter geotextile pipe surrounds		x	x		x
3.8	*Protection Layer*					
a	Unit 9 – Protection Material Work Method Statement	x				
b	Field placement trial		x	x		x
c	Placement of Unit 9 – Protection Material		x	x		x
d	Protection layer WAE drawings	x			x	
4	**Capping System**					
4.1	*Gas Venting System (refer item 3.1)*	*x*			*x*	
4.2	*Bearing Layer for Cap*					
a	Placement of Unit 4 – Clay Rich Material to form bearing layer		x	x		x
b	Submission of WAE drawings and documentation	x			x	
4.3	Placement of Unit 15 – LLDPE Geomembrane		x	x		x
4.4	*Placement of Drainage Layer*					
a	Placement of Unit 13 – Geocomposite Drainage Net (Surface Water)	x	x			x
b	Placement of Unit 26 – Subsoil Drainage Pipe and Unit 7 – Drainage Aggregate		x		x	
c	WAE drawings and documentation	x			x	
4.5	*Placement of Unit 1 – Topsoil*					
a	Work Method Statement for Unit 1 – Topsoil Installation	x				
b	Placement of Unit 1 – Topsoil		x	x	x	x
c	WAE drawings and documentation				x	
4.6	*Revegetation*					
a	Revegetation Plan	x				
b	Drop Structures	x		x	x	
c	Final Capping levels WAE	x			x	
	Additional Construction Quality Management items from future revegetation specification (to be determined)					

3.3 Construction Activities

3.3.1 General Fill

Placement of Unit 2 - General Fill is required as part of several cell construction activities.

General Fill shall be placed with maximum 300 mm thick layers and compacted with suitable compaction equipment to achieve a minimum of 95% of SMDD (in accordance with AS1289.5.1.1 and 5.4.1) or a minimum HILF density ratio of 95% Standard (in accordance with AS1289.5.7.1) at a moisture content within the range of -3% to +3% of the Standard Optimum Moisture Content (SOMC). A trench roller is required for compaction within trenches.

The GITA shall provide “Level 1” supervision for material placement and moisture density testing. The frequency of field density and moisture testing during placement of all General Fill material shall as a minimum conform the following, whichever requires the most tests:

- 1 test per 500 m^3 per material type; or
- 2 tests per batch of work.

If the required density and moisture is not achieved, the compacted material shall be reworked in-situ to meet the density and moisture content requirements. If the density and moisture content requirements again cannot be achieved after reworking, the failed layer shall be removed for moisture conditioning at the material borrow area or at an approved designated area, or be discarded.

3.3.2 Subgrade Preparation

Subgrade preparation by the Contractor comprises cutting and filling from the final surface to create the subgrade surface shown in the Design Drawings. This work includes the cell base area, the leachate sumps, the base of the perimeter bund, portions of the perimeter drains and associated cuttings, and the Central and Western ridge.

The Contractor shall provide a work method statement presenting proposed methods for subgrade preparation activities, including cutting, filling, proof rolling, and undercutting and replacement. Submission of the work method statement constitutes a HOLD POINT. These activities shall not commence until the Hold Point is released.

3.3.2.1 Cutting

Cutting of soil and/or rock materials will be required in some areas to establish the subgrade surface, with rock materials most likely to be encountered in three areas, Central Ridge, Western Ridge and Lower Western Ridge. It is possible that these areas will be excavated to approximately subgrade level by others prior to the cell construction.

Rock excavation may be required in some areas. The Design Report contains general information on subsurface conditions and references to documents with more detailed subsurface information.

Dewatering (groundwater) may be required in some areas. The Design Report contains general information on hydrogeological conditions and references to documents with more detailed information.

The Contractor shall not excavate deeper than the subgrade surface and shall be responsible for costs of excess dewatering, management of excess cut material, and for reinstating any over-excavation with Unit 2 – General Fill as per Section 3.3.1 at Contractor cost and to the satisfaction of the Superintendent.

The base of all excavations in soil shall be proof rolled to identify soft materials that would form an unsuitable surface for fill placement or for the perimeter swale drain alignment. Remove and replace any such materials with Unit 2 – General Fill as per Section 3.3.1. Proof rolling of the soil/fill surface in each local area constitutes an INSPECTION POINT. The Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

Excavated materials are to be stockpiled by the Contractor in designated areas for use by the site owner for landfill construction or operations.

Benches for cross-slope leachate collection pipe platform

Narrow benches for cross-slope leachate collection pipes will need to be formed on the subgrade surface of the existing Eastern Gully and/or Western Gully Landfill during the subgrade preparation of the piggy back liner system.

The Contractor shall cut into the existing ground surface to form benches along the proposed leachate collection pipe alignments as shown on the Design Drawings where the pipe alignments are not located on existing benches. The bench shall have minimum dimensions of 1.5 m wide and 1% longitudinal slope. Details of the bench and leachate collection pipe are shown in the detail Design Drawings.

In case wastes are required to be removed to from the bench, the Contractor shall directly transport the waste to the existing landfilling area in Whytes Gully Landfill. The exposed area shall be immediately covered with a minimum 300 mm thick of Unit 4 – Clay Rich Material.

3.3.2.2 Filling

In areas where filling is required to establish the subgrade surface, the remediation surface shall be proof rolled prior to fill placement to identify soft materials that would form an unsuitable surface for fill placement. Remove and replace any such materials with Unit 2 – General Fill as per Section 3.3.1.

Proof rolling of the soil/fill surface in each local area constitutes an INSPECTION POINT. The Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

After the proof rolling activity, Unit 2 – General Fill material shall be placed to achieve subgrade levels as per Section 3.3.1, except that the minimum degree of compaction shall be 98% rather than 95%.

3.3.2.3 Survey

The Contractor shall survey final subgrade levels to provide works-as-executed (WAE) drawings and to demonstrate that the design levels have been achieved. The survey shall be conducted on an approximate 10m grid with additional survey points along the benches and at the leachate sumps. The Contractor shall submit the WAE drawings, an accompanying analysis demonstrating compliance with design levels, and for all fill placement a GITA certification statement . WAE drawings shall also include surveyed alignments and depths of all backfilled service trenches as well as locations and dimensions of soft areas identified during proof rolling. Submission of these items constitutes a HOLD POINT. Construction of the base layer or placement of the bearing layer shall not commence in an area until the Hold Point has been released for that area.

3.3.3 Landfill Gas Venting System

Landfill gas venting trenches, comprising gravel and collection pipes, and header pipes shall be constructed under the piggy back liner system and under the final capping system.

The landfill gas venting trenches shall be constructed by excavation into the prepared subgrade of the piggy back liner and on the intermediate cover layer under the proposed cap, as shown in the design drawings.

Trenches shall be nominally 200 mm deep and 300 mm wide. The excavated material shall be used appropriately during further works.

The following construction sequence is required (unless alternatives are agreed with the Superintendent):

- Excavate trench;
- Partially backfill the trench with Unit 8 – Gas Drainage Gravel;
- Place Unit 21 – Gas Collection Pipe and backfill balance of trench, at one end of the trench the Gas Collection Pipe shall be connected with the Gas Header Pipe; and
- Place Unit 11 – Filter Geotextile above the gravel and secure in place.

Placement of gas collection pipes constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

The Gas Header Pipes shall be installed in the same surface as the gas collection trenches as shown on the Design Drawings. The pipe shall be Unit 21 – Gas Collection Pipe but have solid wall and are not required to be surrounded with gravel. At the end of each header pipe, along the edge of the landform, the gas header shall be installed to connect with the active gas collection system (by others).

Installation of gas header pipe and connection the gas collection pipes constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

Following placement of gas collection and header pipes in each area, the Contractor shall survey all pipe alignments and inverts and submit works-as-executed (WAE) drawings demonstrating compliance with the design. Submission of this item constitutes a HOLD POINT. Construction of the base layer or bearing layer shall not commence in an area until the Hold Point has been released for that area.

3.3.4 Base Layer

The base layer shall be constructed within the piggy back liner footprint, in accordance with the design drawing. The Contractor shall provide a work method statement presenting proposed methods for base layer construction, including compaction and surface preparation, geogrid installation and joining, geogrid ballasting, and geogrid covering. Submission of the work method statement constitutes a HOLD POINT. Base layer construction shall not commence until the Hold Point is released.

The base layer shall be constructed with Unit 18 – Geogrid sandwiched in Unit 6 – Base Material to form a nominal 500 mm layer above the subgrade surface.

The material shall be placed in two lifts and compacted with suitable compaction equipment to achieve a minimum of 98% SMDD (in accordance with AS1289.5.1.1 and 5.4.1) or a minimum HILF density ratio of 98% Standard (in accordance with AS1289.5.7.1).

Placement of the first lift of Unit 6 - Base Material will include surface preparation to present a surface suitable for Unit 18 – Geogrid installation. Subsequently, Unit 18 – Geogrid shall be installed on the prepared surface as outlined in Section 3.3.13 of this Technical Specification.

The prepared surface with geogrid installation in each area shall constitute a HOLD POINT. The upper lift of Unit 6 – Base Material shall not be placed in the area until the Hold Point has been released by the Superintendent. Following the installation of Unit 18 – Geogrid, the second lift of Unit 6 – Base Material shall be placed and spread on top of the geogrid using a method that will not disrupt geogrid alignment and overlaps and will cause minimal damage to the geogrid. Placement and spreading of Unit 6 –Base Material on top of Unit 18 - Geogrid constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.The Contractor shall survey the final levels to provide works-as-executed (WAE) drawings and to demonstrate that the design levels have been achieved. The survey shall be conducted on an approximate 10 m grid. The Contractor shall submit the WAE drawings, an accompanying analysis demonstrating compliance with design levels, and a GITA certification statement. Submission of the WAE drawings and accompanying analysis constitutes a HOLD POINT. Placement of the next layer shall not commence in an area until the Hold Point has been released for that area.

3.3.5 Bearing Layer

The bearing layer shall be constructed within the piggy back liner and cell base liner footprint, in accordance with the design drawings.

The bearing layer shall be constructed with Unit 4 – Clay Rich Material with a minimum as-compacted thickness of 200 mm.

The material shall be placed in one layer and compacted with suitable compaction equipment to achieve a minimum of 95% SMDD (in accordance with AS1289.5.1.1 and 5.4.1) or a minimum HILF density ratio of 95% Standard (in accordance with AS1289.5.7.1) at a moisture content within the range of -2% to +2% of the Standard Optimum Moisture Content (SOMC).

The GITA shall provide "Level 1" supervision for material placement and moisture density testing. The frequency of field density and moisture testing during placement of the material shall as a minimum conform the following, whichever requires the most tests:

- 1 test per 2,500 m^2 per layer of material type; or
- 1 test per 500 m^3 per material type; or
- 3 tests per batch of work.

If the required density and moisture is not achieved, the compacted material shall be reworked in-situ to meet the density and moisture content requirements. If the density and moisture content requirements again cannot be achieved after reworking, the failed material shall be removed for moisture conditioning at the material borrow area or at an approved designated area, or be discarded.

The Contractor shall maintain the bearing layer in moist condition until Unit 17 - GCL is installed. Should the bearing layer surface have dried excessively (e.g. desiccation cracking>20mm depth) or wetted up excessively, as determined by the Superintendent, the affected materials shall be excavated to expose material that has moisture content within the specified tolerance. The excavated materials shall be returned to a designated area for moisture conditioning or be discarded, and the excavated bearing layer material replaced. Note that the surface of the bearing layer is designed to shed leachate and its shape should be maintained during formation in order to avoid temporary water ponding during construction. Consideration may be given to use of micro-mist sprayers to limit loss of moisture from the completed surface during hot weather.

Trafficked areas of the bearing layer surface are to be ripped, moisture conditioned and recompacted if, in the opinion of the Superintendent, the quality of these areas has deteriorated.

The finished surface shall be smooth and well-drained. Coarse materials shall not protrude from the surface of the bearing layer by more than 10 mm. No areas of ponding shall be accepted on the surface. Additional surface requirements are given in Section 3.3.9.3.

The Contractor shall survey the final levels to provide works-as-executed (WAE) drawings and to demonstrate that the design levels and layer thickness have been achieved. The survey shall be conducted on an approximate 10 m grid. The Contractor shall submit the WAE drawings, an accompanying analysis demonstrating compliance with design levels, and a GITA certification statement. Submission of the WAE drawings and accompanying analysis constitutes a HOLD POINT. Placement of GCL shall not commence in an area until the Hold Point has been released for that area, and all other contractual requirements have been fulfilled.

3.3.6 Perimeter Bund

The Contractor shall conduct a set-out survey of the alignment of the perimeter bund prior to construction and shall peg out the surveyed alignment. This constitutes a HOLD POINT. Construction of the bund shall not commence until the Hold Point has been released by the Superintendent.

The bund shall be constructed in accordance with the Design Drawings. The bund shall be constructed with Unit 4 – Clay Rich Material to form a 1-m high bund with a 4 m crest width and 2H:1V side batters. As indicated in Section 2.2.4, the required gradation of the Unit 4 material in the perimeter bund differs between the main body of the bund (i.e., max. particle size 26.5mm) and the inboard batter surface where the GCL will be placed (i.e., max. particle size 9.5mm). The finished surface where the GCL will be placed shall be smooth and well-drained with no protruding coarse materials, and with additional surface requirements given in Section 3.3.9.3.

The Unit 4 material shall be placed and compacted in nominal 200 mm thick lifts with suitable compaction equipment to achieve a minimum of 98% SMDD (in accordance with AS1289.5.1.1 and 5.4.1) or a minimum HILF density ratio of 98% Standard (in accordance with AS1289.5.7.1) at a moisture content within the range

of -2% to +2% of the Standard Optimum Moisture Content (SOMC). Prior to the placement of each lift of the bund, the top of the previous lift shall be thoroughly scarified and moisture conditioned if necessary to bond each lift together and prevent laminations at the lift interfaces.

Bund construction constitutes an INSPECTION POINT and the Contractor is required to provide 48 hours notice before commencing or recommencing this activity.

In addition, the GITA shall provide "Level 1" supervision for material placement and moisture density testing. If the GITA or Contractor detects material changes or variations then he shall undertake testing as necessary to assess the acceptability of the material. The frequency of field density and moisture testing during placement of the material shall as a minimum conform the following, whichever requires the most tests:

- 1 test per 2,500 m^2 per layer of material type; or
- 1 test per 500 m^3 per material type; or
- 3 tests per batch of work.

If the required density and moisture is not achieved, the compacted material shall be reworked in-situ to meet the density and moisture content requirements. If the density and moisture content requirements again cannot be achieved after reworking, the failed material shall be removed for moisture conditioning at the material borrow area or at an approved designated area, or be discarded.

Upon completion of the bund, the Contractor shall maintain the integrity of the bund by limiting the traffic movement over the clay surface and maintaining the surface of the clay in a moist condition until covered by the base liner GCL and geomembrane. Should the bund surface have dried excessively (e.g. desiccation cracking>20mm depth) or wetted up excessively, as determined by the Superintendent, the affected materials shall be excavated to expose material that has moisture content within the specified tolerance. The excavated materials shall be returned to a designated area for moisture conditioning or be discarded, and the excavated bund material replaced.

Trafficked areas of the bund shall to be ripped, moisture conditioned and re-compacted if, in the opinion of the Superintendent, the quality of these areas has deteriorated.

Following bund placement, the Contractor shall survey the finished surface level to provide works-as-executed (WAE) drawings and to demonstrate that the design geometry has been achieved. The WAE drawings shall include geosynthetic anchor trench alignments within the bunds. The Contractor shall submit the WAE drawings, an accompanying analysis demonstrating compliance with design geometry, and a GITA certification statement. Submission of the WAE drawings and documentation constitutes a HOLD POINT. Placement of liner materials or cap components on the surface of the berm shall not commence in an area until the Hold Point has been released for that area, and all other contractual requirements have been fulfilled.

3.3.7 Internal Bunds

Internal bunds between landfill cells and sub-cells will be constructed to provide a physical barrier for each stage and sub-stage of liner construction and waste filling. The locations of internal bunds between cells are shown on the Design Drawing, while the location of bunds between sub-cells are not shown but will be included for detailed design.

The internal bunds shall be constructed in the same manner as given in Section 3.3.6 for the perimeter bund.

3.3.8 General Requirements for Geosynthetics

3.3.8.1 Documentation

Specialist Installation Sub-Contractor

The Works described in the following sections shall be undertaken by an experienced geosynthetic installation specialist contractor approved by the Superintendent. The Contractor shall require that skilled sub-contractor personnel will supply, test and install all geosynthetic materials. The Contractor is responsible for all aspects of the work.

Prior to the installation of geosynthetics, the Contractor shall submit the proposed qualified subcontractor(s) to the Superintendent for approval. This submission constitutes a HOLD POINT. No geosynthetic material installation shall begin until the HOLD POINT is released. Any change to the geosynthetic supply or installation shall be subject to written approval from the Superintendent.

Alternative construction methods to those detailed in the following sections will be considered, subject to the approval of the Superintendent, provided they satisfy the intent of this Specification.

Quality Assurance and Quality Control

The Contractor shall be responsible for all quality assurance and quality control of the manufacture, transportation, storage and installation of the geosynthetic. This shall include the obtaining of material property details and certificates from the resin supplier and the geosynthetic manufacturer, the preparation of a quality control procedures manual and the undertaking of all inspections, non-destructive and destructive testing and repairs etc. and other activities detailed in this Specification.

The Contractor is responsible for compliance with this Specification; however, the Superintendent shall monitor installation of the geosynthetics. The Contractor shall accommodate all quality assurance activities described in this Specification and in the quality control procedures manual.

The Superintendent shall undertake audits of the quality control and assurance procedures. Should any areas of the works show non-conformances with the approved quality control procedures manual, then the Contractor shall cease work until the non-conformance is resolved by either presentation of the appropriate documentation or undertaking sampling and testing, or another activity approved by the Superintendent.

The Superintendent shall also undertake conformance tests on samples supplied by the Contractor in accordance with this Specification.

Quality Control Procedures Manual

The Contractor shall submit a quality control procedures manual to the Superintendent at least 10 days before the supply of any geosynthetic to the Site. The quality control procedures manual shall include the following items, as appropriate to each type of geosynthetic:

- The Contractor's organisational structure and personnel, and the qualifications and experience of the proposed installation personnel;
- Trial weld procedures;
- Measures to minimise wrinkles;
- Welding procedures, including equipment make and model;
- Weld repair procedures;
- Non-destructive testing procedures;
- Destructive testing procedures;
- Pro forma sheets for recording of installation and test results;

- Deployment equipment and procedures;
- Safety equipment;
- Supply transportation, storage and handling procedures;
- Vent flap details; and
- Any proposed changes with respect to this Specification.

The Superintendent will review this information to assess the suitability of the quality control procedures manual. Upon review of the quality control procedures manual, the Superintendent may request additional information specific to the project installation conditions.

The submission of the geosynthetic quality control procedures manual constitutes a HOLD POINT. No geosynthetic materials shall be imported to the Site until the HOLD POINT is released.

Data, Statements, Reports and Certificates

The Contractor shall submit the following information at least 7 days prior to the installation of any geosynthetic at the Site:

- The manufacturer's certifications, descriptive data, specification sheets;
- Manufacturer's test results for geosynthetic composition and properties;
- The origin (resin name and supplier's name, resin production plant), identification (brand name, number) and production date of the resin;
- A list of quantities and descriptions of materials other than the base polymer which comprise the geosynthetic;
- Copies of the quality control certificates issued by the resin supplier;
- A statement regarding recycled polymer content (if permitted by this Specification);
- A properties sheet including, at a minimum, all specified properties, measured using test methods indicated in these specifications, or equivalent;
- Reports of the tests, including sampling procedures, conducted by the manufacturer to confirm that the geosynthetic meets these Specifications. Tests shall be conducted at frequencies outlined in Chapter 2.0 of this Specification; and
- A quality control certification that property values given in the properties sheet are guaranteed by the geosynthetic manufacturer. The quality control certificate shall include roll numbers and identification, resin lot, batch numbers, sampling procedures and results of quality control tests.

The Superintendent will review this information to assess the suitability of the data, statements, reports and certificates. Upon review, the Superintendent may request additional information specific to the project conditions.

The submission of the data, statements, reports and certificates constitutes a HOLD POINT. Geosynthetic material installation shall not commence until the HOLD POINT is released.

3.3.8.2 Site Records and Drawings

The Contractor shall submit all quality forms, test results and other documentation indicated in the quality control procedures manual to demonstrate its compliance with the quality system for the project and to demonstrate compliance of the installed geosynthetics with this Specification.

Copies of these records and tests, as well as records of corrective action taken when results are unsatisfactory, shall be presented to the Superintendent in writing, within one working day following an inspection, test or action. To scale as-built drawings (i.e., WAE drawings) shall be provided of all panel layouts, anchor trenches, test positions and defects within 14 days of completing the liner.

The Contractor shall keep records sufficient to document in detail the progress and location of work undertaken.

3.3.8.3 Traffic over Geosynthetics

Construction traffic over geosynthetics is restricted or not permitted, to prevent damage and ensure the material performs its intended function. The construction of the different units with the general traffic limitations is as follows:

- GCL: No vehicle access over deployed GCL, only careful foot traffic, subject to footwear requirements.
- Geomembrane: No vehicle access over deployed geomembrane, only careful foot traffic, subject to footwear requirements.
- Geocomposite: No vehicle access over deployed geocomposite, only careful foot traffic, subject to footwear requirements.
- Geogrid: No vehicle access over deployed geogrid, only foot traffic.
- Geotextile: No vehicle access over deployed geotextile, only foot traffic.

The Contractor shall comply with geosynthetic manufacturer recommendations, as well as the requirements within this Specification, regarding limitations for periods of exposure for deployed geosynthetics prior to covering.

3.3.8.4 Anchor Trenches

The anchor trench for the base liner shall be used to anchor the GCL, geomembrane, and cushion geotextile at top of the perimeter bund. The installation of these units may require that the previous geosynthetic layer(s) is temporarily anchored while the next geosynthetic is installed.

The excavation of the anchor trench shall be presented to the Superintendent for inspection and approval before backfilling commences. This constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

The anchor trench for the base liner shall be located on top of the perimeter bund in accordance with the Design Drawings a dimension of 500 mm x 500mm. The anchor trenches of the cap liner shall be located on top of cap, having a dimension of 500mm x 300mm, and at the mid-slope bench and top of perimeter bund as shown in Design Drawings, having a dimension of 500mm x 500mm.

The geosynthetic placed in the anchor trench shall extend down one side. The geosynthetics shall not extend up the outer edge of the trench. Loose soil and ponded water shall not be permitted in the anchor trench. Anchor trenches shall be constructed and maintained so as to provide for free drainage of surface water flow and prevent ponding in or adjacent to anchor trenches.

The geosynthetics shall be placed against the side of the trench and the trench backfilled with excavated material. The backfill shall be placed in layers appropriate for the proposed construction equipment. The compaction shall be carried out in the presence of the GTA. The compacted material shall achieve at least dense or stiff consistency, as assessed by the GTA in accordance with AS 1726. Care shall be taken to not damage the geosynthetics during compaction of the backfill of the anchor trench. The Contractor shall propose equipment and method to demonstrate a low risk of damage to the geosynthetics.

The backfill of the trench shall be carried out using hand held compaction equipment, to achieve the consistency specified above.

3.3.9 Installation of Unit 17 – Geosynthetic Clay Liner (GCL)

3.3.9.1 Delivery, Storage and Handling

Unit 17 - GCL delivered to site shall be wrapped with weather and moisture resistant wrapping. The Contractor shall be responsible for the unloading, protection from the weather and storage of the delivered GCL. Rolls with damaged wrapping shall be inspected by the Superintendent to assess the extent of hydration of the GCL. Unit 17 - GCL with moisture content above 30% by weight (ASTM D5993) may be rejected. GCL rolls with damaged wrapping and moisture content lower than 30% shall be re-wrapped and sealed. All rolls of material shall be clearly marked with the type of GCL, unroll direction and batch number of manufacture.

All rolls of Unit 17 - GCL shall be delivered with the GCL tightly wrapped around a centre core, with the hole in the core suitable for the proposed spreader bar to be used during deployment. All rolls shall be stored off the ground on hard, dry, free-draining surface, with suitable bearers at closely spaced centres, suitably protected from runoff and other damage. Stacked rolls of GCL shall be covered with tarpaulins to promote runoff. GCL rolls shall not be rolled across the ground.

3.3.9.2 Acceptance Criteria for GCL

Delivery to Site

The Contractor shall supply, unload, store and protect the rolls of GCL.

Inspection of GCL after Unrolling

The Superintendent shall inspect the GCL as it is rolled out on the slope.

Where a roll of GCL has been damaged and the damaged area extends more than 300 mm across the deployed width of GCL, the roll may be rejected due to its reduced tensile strength. The Superintendent shall determine if the strength of the roll is unacceptable, based on the nature and location of the damage.

3.3.9.3 General Surface Preparation

Unit 17 - GCL shall be placed on the prepared surface of the liner subgrade. The liner subgrade comprises the upper surface of the bearing layer, the inboard slope of the perimeter bund, and internal bund slopes.

Portions of compacted liner subgrade that have deteriorated to an extent that has potentially compromised the quality of the layer, shall be reworked at the contractor's expense, and subjected to appropriate geotechnical testing in order to prove the required compaction.

The Contractor shall be responsible for preparing and maintaining the surface of the clay liner to provide a firm, unyielding foundation for the Unit 17 - GCL with no sudden, sharp or abrupt changes or breaks in grade, no wheel ruts/footprints, no standing water, and no voids and crack, to the satisfaction of the Superintendent.

The Contractor shall remove from the liner subgrade surface all particles that protrude from the surface by more than 10 mm, and sharp or angular particles to the satisfaction of the Superintendent. Significant voids created by removal of particles shall be filled with moist Unit 4 – Clay Rich Material. No standing water shall be allowed to accumulate on the surface of the base liner prior to installation of the Unit 17 - GCL. No GCL shall be placed onto an area that has become softened by prolonged precipitation.

The prepared surface shall constitute a HOLD POINT. No GCL shall be placed until the Hold Point has been signed off by the Superintendent. Only the area to be covered in the same day shall be signed off.

3.3.9.4 Placement

Rolls of Unit 17 - GCL shall be moved or deployed with a suitable spreader bar that is stiff enough to limit deflection over the width of the roll to ensure smooth uniform deployment of the GCL layer. The orientation

of the GCL, that is which side is installed facing downward, is to be confirmed by the Superintendent prior to any GCL installation.

Unit 17 - GCL shall only be installed in dry weather conditions.

The Contractor shall submit a panel layout and their proposed installation method to the Superintendent for the installation at least 10 days prior to the commencement of the GCL placement for approval by the Superintendent. A minimum side and end overlay of 300 mm is required between panels. The submission of panel layout drawings and proposed installation method constitutes a HOLD POINT. GCL installation shall not commence until the HOLD POINT is released.

If manufacturer recommendations differ from procedures in this Specification, these differences shall be brought to the attention of the Superintendent prior to placement of any GCL in the facility. The requirements of this Specification will apply, unless a variation is approved in writing in consultation with the Superintendent.

Exposed Unit 17 - GCL shall not be trafficked by vehicles. Unit 17 - GCL is to be covered with Unit 15 – LLDPE Geomembrane or Unit 16 – HDPE Geomembrane, which shall be deployed concurrently with the GCL (i.e. roll width after roll width) and on the same day as the GCL. This requirement is to minimise the potential for wetting of the GCL by rainfall or runoff. Further, the Contractor must stage liner installation such that the Unit 7 Drainage Aggregate layer or the Unit 9 Protection Material is in place over each area of the liner system within 24 hours of GCL placement. This requirement is to minimise the potential for GCL swelling due to lack of confining pressure.

All rolls of GCL shall include 300 mm wide pre-treated side overlaps, which comprises bentonite powder encapsulated in the geotextile. Overlaps shall be placed in down slope direction (roof tile effect). If an alternative joining procedure is proposed, details are to be provided to the Superintendent for consideration at least 17 days prior to purchase of the materials.

The Superintendent shall inspect and approve all overlaps prior to covering the overlap.

If wrinkles greater than 50 mm high occur in Unit 17 - GCL or where wrinkles extend to the edge of the roll due to manufacturing tolerances, the wrinkle shall be cut at the crest of the wrinkle. A layer 10 mm thick of bentonite paste shall be spread over the top of one flap of the cut and the other flap pushed over the paste to form an overlap. A 20 mm thick layer of bentonite paste shall be placed over the top of the overlap extending 100 mm beyond the edges of the cut and overlap. The paste shall be covered with a patch of Unit 11 - Filter Geotextile, and squeezed into the paste.

The exposed edges of deployed GCL shall be protected from rainfall runoff to prevent erosion of bentonite. Special care shall be taken to prevent flow of runoff or seepage under and/or over the geomembrane to prevent erosion of the bentonite in the GCL.

3.3.9.5 Repairs

Rolls or panels of GCL that have been damaged shall be brought to the attention of the Superintendent, who shall judge if the panel or roll is to be removed from site, or may be repaired. If the Superintendent decides the damage is minor the hole may be patched. If a roll is deployed with manufacturing defects, the entire roll shall be removed from site.

All defects and repairs shall be recorded and locations measured as the panels are deployed, to facilitate the timely deployment of the overlying geomembrane.

A patch of GCL shall be placed over any hole with a minimum overlay over the adjoining area of 300 mm. The repairs shall be joined to the main GCL in accordance with the following requirements:

All overlaps shall be made using a 10 mm thick layer of hydrated sodium bentonite paste between the GCL and the patch GCL. The Contractor shall submit details of the proposed bentonite paste to the Superintendent for approval prior to commencement of the GCL installation.

3.3.10 Installation of Unit 15 and Unit 16 - Geomembrane

3.3.10.1 Transport, labelling, handling and storage

Transportation

The Contractor is responsible for transportation of the geomembrane to the Site.

Labelling

Each geomembrane roll shall be clearly labelled with the following information:

- Material of the geomembrane;
- Thickness of the material;
- Length and width of the roll;
- Manufacturer's Name;
- Direction to unroll the material;
- Product identification;
- Batch number; and
- Roll number.

Any roll delivered to the Site without labelling shall be rejected and removed from the site by the Contractor. Each package of welding rod or extrusion welding beads shall be clearly labelled and shall include the Manufacturers name, product identification name/number, resin lot or batch number and the package number.

The Contractor shall also cross-reference each batch number and roll number of geomembrane delivered to site to the resin used and date of manufacture of the geomembrane.

Handling and On-site Storage

The Contractor is responsible for handling, storage and care of the geomembrane before and after installation at the Site. The geomembrane rolls shall be protected from dirt, mud, dust, fire and damage before installation. Rolls shall be stacked to provide access for roll identification and conformance testing as required. The integrity and legibility of roll labels must be maintained during storage.

Geomembrane materials shall be stored in accordance with the quality control procedures manual and the Manufacturer's recommendations. This may include covering of geomembrane rolls.

3.3.10.2 Surface Preparation

Unit 15 – LLDPE Geomembrane and Unit 16 – HDPE Geomembrane shall be placed on top of the GCL in the piggy back and cell base lining systems, respectively. The Contractor is responsible for meeting the 24-hour time window requirements for GCL, geomembrane, and cover placement given in Section 3.3.9.4, and for maintaining the surface of the GCL to provide a firm, unyielding foundation for the geomembrane with no sudden, sharp or abrupt changes or break in grade. No standing water or excessive moisture shall be allowed to accumulate on the GCL prior to geomembrane installation. No geomembrane shall be placed onto an area that has become deteriorated due to moisture changes.

Unit 15 – LLDPE Geomembrane shall be placed on top of Unit 4 – Clay Rich Material in the capping system. The Contractor is responsible for maintaining the surface to provide a firm, unyielding foundation for the geomembrane with no sudden, sharp or abrupt changes or break in grade, no wheel ruts/footprints, no standing water, and no voids and crack to the satisfaction of Superintendent. The Contractor shall remove from the bearing layer surface all particles protruding more than 5 mm, and sharp or angular particles or water to the satisfaction of the Superintendent. Significant voids created by removal of particles shall be

filled with moist similar material. No standing water or excessive moisture shall be allowed to accumulate on the surface prior to geomembrane installation. No geomembrane shall be placed onto an area that has deteriorated due to moisture changes.

3.3.10.3 Geomembrane Placement

During geomembrane installation the Superintendent will provide direct input and involvement as indicated in the following sections of this Specification. The Contractor is required to accommodate and allow for the Superintendent's identified role.

Layout Drawings

The Contractor shall submit geomembrane panel layout drawings at least 7 days before installation starts. The drawings shall indicate the panel configuration, the location of seams and the staging/direction of deployment. The layout drawings shall be suitable for use as construction drawings, to scale and include dimensions and details.

The submission of the panel layout drawings constitutes a HOLD POINT. Geomembrane installation shall not commence until the HOLD POINT is released.

Panel Identification

A field panel is the unit area of geomembrane to be welded in the field and shall be bounded by field welds or anchor trenches. Each field panel shall be numbered and the panel layout drawings shall show the panel numbers and the dimensions and area of each panel.

Field Panel Placement

Field panels are to be placed so that the boundaries do not intersect at one point and form a cross seam. A minimum 150 mm is required to offset the occurrence of a cross seam. The Contractor shall allow for the effects of changes in temperature with the resulting expansion and contraction of the panel, to prevent occurrence of a cross seam.

Installation Procedure

Field panels shall be installed using any one of the following procedures:

- field panels for one day's installation may be placed prior to field welding (to protect the subgrade from erosion by rain, or desiccation).
- field panels are placed one at a time and welded immediately (to minimise the number of unwelded field panels exposed to wind), or
- any combination of the above.

Weather Conditions

Geomembrane seaming and welding shall not be started if the ambient temperature is below 10ºC or above 35ºC, unless the Contractor demonstrates what special measures will be applied for welding outside this temperature range, and is authorised by the Superintendent. Both panels of geomembrane to be welded shall be allowed to equilibrate to the same temperature, before starting to weld.

Geomembrane jointing shall not be undertaken;

- in the presence of excessive moisture (i.e. rain, fog, dew);
- in an area of ponded water;
- or during periods of high wind or excessive dust.

If geomembrane placement and jointing is to be carried out at night, the entire area of deployment shall be illuminated. Installation should preferably be carried out during daylight hours. Installation work carried out at night shall be inspected and tested during daylight hours. All joints shall be tested during daylight hours.

Method of Placement

The Contractor shall ensure that:

- No more geomembrane is installed at any one time than can be reasonably welded in one day.
- Geomembrane rolls and/or factory panels shall be unrolled or unfolded in accordance with the instructions and the direction shown on the boxes or wrapping.
- No equipment used shall damage the geomembrane by handling, trafficking, leakage of hydrocarbons or other means.
- Personnel working on the geomembranes shall not smoke, use footwear, or engage in other activities that could damage the geomembrane. The Contractor shall protect the geomembrane from damage by equipment or personnel traffic associated with construction.
- Methods used to unroll panels shall not cause scratches or crimps in the geomembrane and shall not damage the underlying compacted clay liner and other layers.
- The prepared surface awaiting covering by geomembrane shall not be allowed to deteriorate and shall be maintained in a condition suitable for geomembrane placement.
- Methods used to place panels shall preclude folds, wrinkles that may become folds, bridging (trampolining) and differential wrinkles between adjacent panels.
- Temporary ballast (such as sand bags) shall be applied to prevent uplift during high wind conditions. Such loading shall be spread out and shall not damage the geomembrane. It is the contractor's responsibility to ensure the geosynthetic liners are sufficiently loaded.
- Vent flaps shall be sealed once the geomembrane has been covered with heavier materials and air trapped under the geomembranes during installation has been expelled.
- Joints shall be orientated so that overlaps are in the downslope direction (roof tile effect).
- All cutting of the geomembrane during installation shall be with a hooked blade to avoid damage.
- The Contractor shall implement procedures with its staff, to the satisfaction of the Superintendent to manage the risk of sharp particles being trapped in footwear or equipment that may or will move over the geomembrane.

Damage and Defects

Damage

The Superintendent shall inspect geomembrane panels for damage, after placement and prior to welding. The Contractor shall replace or repair a field panel or portion of a panel that is damaged (torn, twisted or crimped). Damaged panels or portions of damaged panels that have been rejected shall be removed from the work area. The Superintendent shall decide on the need to repair or replace damaged field panels.

Inspection of Geomembrane

The geomembrane shall be inspected by the Contractor during installation from the roll to identify unacceptable areas of material. Irregularities in the geomembrane material identified during inspection shall be repaired, or if excessive, the roll shall be rejected. The decision to either repair unacceptable areas or reject the roll shall be the Superintendent's. This decision shall generally be based on the following considerations.

Defects

The acceptance of the geomembrane shall be based on a maximum number of manufacturing defects. Manufacturing defects include "fisheyes", blemishes and shallow scratches.

A “fisheye” is a thinning of the geomembrane. The specified minimum thickness of the geomembrane also applies to “fisheyes”. The size of the fisheye is of no consequence, as it is the thinning or absence of the geomembrane inside the fisheye, which is of concern.

Surface blemishes are considered to be areas where the resin has not been properly mixed or filler can be noted on the geomembrane. The colour and surface texture of the geomembrane shall be uniform and consistent. Where changes occur in the surface texture or colour the contractor shall request the Superintendent to inspect the area. If the area is rejected as unacceptable, then the section of the geomembrane roll shall be removed and replaced.

Straight-line scratches that penetrate the geomembrane (approximately 0.1 mm) shall be pointed out to the Superintendent. The extent and depth of the scratch shall be examined by the Superintendent to decide if a defect is to be removed. The roll length where such a defect occurs shall be cut out and removed from site. All defects shall be patched or capped and subject to quality control testing, reporting and documentation by the Contractor.

If a roll has been rolled out and no fisheyes are present, the geomembrane will be accepted. If the end of a roll has a number of defects, then the end of the roll shall be cut off and removed from site. The Superintendent shall make the final decision on site.

Maximum number of manufacture defects per 300 m^2 of roll length shall be one, with the total number of manufacture defects for the liner to be less than 10 per ha. If more than one manufacture defect occurs over a local area of the geomembrane within a circular area of 0.5 m radius, the area shall be considered ‘one defect’ and be capped. Replacement of defective geomembrane is at the Contractor’s expense.

Manufacturer defects are considered separate to installation defects. Manufacturing defects and installation defects are the Contractor’s responsibility. The Superintendent shall decide if the number of installation defects over a certain area is too high, and whether the area should be cut out or capped.

All defects shall be patched or capped and subject to quality control testing, reporting and documentation by the Contractor.

3.3.10.4 Field Welding

Requirements of Personnel

Personnel performing welding operations shall be qualified as indicated below.

- Personnel performing welding operations shall be qualified by experience or by successfully passing welding tests and at least one welder shall have welded a minimum of 100,000 m^2 of geomembrane using the same type of welding apparatus in use at the site.
- The weld foreman, most experienced welder, shall directly supervise less experienced welders, as required.
- No field welding shall take place unless the weld foreman is present.

Welding Equipment and Products

Approved Processes for Field Welding.

Only extrusion welding or fusion welding, using equipment approved by make and model, shall be used. Alternative processes may be proposed and submitted to the Superintendent 14 days before the start of geomembrane deployment, for consideration for approval.

Extrusion Process

The extrusion apparatus shall be equipped with gauges giving the temperature in the apparatus and at the nozzle. The Contractor shall provide documentation for the extrudate to the Superintendent and shall certify that the extrudate is the same material as the geomembrane sheet to be welded. The extruder shall be purged before beginning a weld and until all heat-degraded extrudate has been removed from the barrel. Whenever, the extruder is stopped, the barrel shall be purged of all heat degraded extrudate.

Fusion Process

The fusion-welding apparatus must be automated vehicular-mounted devices. The fusion-welding apparatus shall be equipped with gauges giving the applicable temperatures and pressures. The edge of the cross seams to be fusion welded shall be ground to a smooth incline (top and bottom) prior to welding. A temporary movable protective layer shall be used directly below each overlap of geomembrane that is to be welded to prevent build up of moisture between the sheets.

Generator

The electric generator shall be placed on a smooth base such that no damage occurs to the geomembrane. Similarly, a smooth insulating plate or fabric shall be placed beneath the hot welding apparatus after usage to protect the geomembrane. The geomembrane should not be damaged during welding and the geomembrane shall be especially protected from damage in trafficked areas.

Seam Layout

The Contractor shall provide the Superintendent with a seam layout drawing i.e. a drawing of the area to be lined showing all expected seams. No panels shall be welded in the field without the Superintendent's approval. In addition, no panels not specifically shown on the seam layout drawing shall be used without the Superintendent's prior approval.

No seams shall be located in areas of potential stress concentrations.

No cross-shaped seams shall be allowed unless approved by the Superintendent. All fusion joints between panels are to form T-joints, with panel layouts being staggered to achieve this.

All seams and joints shall be surveyed and numbered or named, which shall be cross-referenced to field notes and records of the contractor. Seam numbers shall be marked on the seam layout drawing, and altered as required on the as-built drawings (refer Section 3.3.8.2).

Welding Method

The welding method to be employed shall be the dual-track fusion welding process. Extrusion welding shall be used for repairs and patches. Single-track fusion welding methods or possible other welding methods shall only be used with prior written approval from the Superintendent.

The Contractor shall maintain at least one spare, operable welding unit of each type employed on the project site at all times.

Weld Preparation

General weld preparation procedures, temporary bonding procedures, general equipment settings, including acceptable extrudate or wedge temperatures, rate or advancement, etc., and welding procedures, shall be specified in the quality control procedures manual.

Prior to welding, the weld area shall be clean and free of moisture, dust, dirt, debris, markings and foreign material.

Where abrading is required, the process shall be completed according to the Manufacturer's instructions within one hour of the welding operation and in a way that does not damage the geomembrane. Abrasion of the geomembrane surface shall not extend outside the weld bead or weld surface area.

Seams shall be aligned to minimise the number of wrinkles.

Artificially induced cooling of the extrudate welds using water or other means is not permitted. Care shall be exercised to ensure that non-destructive testing of the extrudate and/or other activities does not cause artificial cooling of the weld.

The Contractor shall record the following information on the geomembrane surface adjacent to the weld:

- Unique seam number.
- Welding device number and operating temperature.
- Welding technician's initials and
- Date and time.

This information must be recorded onto the Contractor's quality assurance documentation at the end of the day's welding activities.

Overlapping and Temporary Bonding

The panels of geomembrane shall be overlapped by a minimum of 75 mm for extrusion welding and 125 mm for fusion welding. The overlap shall be sufficient to allow peel tests to be performed on the weld, and to provide enough space to form a reliable air channel between dual fusion welds for testing.

The procedure used to temporarily bond adjacent panels together shall not damage the geomembrane; in particular, the temperature of the air at the nozzle of any spot welding apparatus shall be controlled such that the geomembrane is not damaged.

No solvent or adhesive shall be used unless the product is approved in writing by the Superintendent (samples shall be submitted for testing and evaluation).

General Welding Procedures

The general welding procedure used by the Contractor shall be as follows:

- For fusion welding, a movable protective layer of plastic shall be placed directly below each overlap of geomembrane that is to be welded. This is to prevent any moisture build-up between the sheets to be welded.
- Welding shall extend to the outside edge of panels to be placed in the anchor trench.
- Ends of dual fusion welds extending into anchor trenches and into joints or patches shall be welded closed.
- If required, a firm substrate shall be provided by using a flat board or similar hard surface directly under the seam overlap to achieve necessary support.
- Wrinkles at the seam overlaps shall be cut along the ridge of the wrinkle to achieve a flat overlap. The overlap shall be welded and any portion where the overlap is inadequate shall then be patched with an oval or round patch of the same geomembrane extending a minimum of 150 mm beyond the cut in all directions.
- All cuts and patches shall be formed with rounded edges and ends, to prevent stress concentrations in the geomembrane. All cuts shall be removed or be ended off with a round cut-out.

T-Joins

All T-joins shall be treated as a potential defect and be patched and subject to quality control procedures in accordance with this Specification.

3.3.10.5 Testing

Trial Welds

Each welding technician shall qualify to operate on a daily basis, by performing a trial weld prior to welding activities or at times designated by the Superintendent. These trial welds shall be performed using each type of welding device to be employed by the welding technician during that period. Additionally, a trial weld shall be made using each welding device on resumption of work after the lunch break or at an interval of no greater than five (5) hours, whichever is less. The Superintendent may also require that a trial weld be

performed using each device at the conclusion of welding activities. Welding devices that have not produced a passing trial weld will not be permitted to perform production welding.

Trial welds shall be made on "fragment" pieces of geomembrane liner to verify that welding conditions are adequate. The trial weld sample shall be at least 0.3 m wide and 3.0 m long for fusion welds or 1.0 m long for extrusion welds with 125 mm overlap, with the weld centred length-wise. All trial welds shall be performed under the same weather and subgrade conditions as production welding.

Three specimens each (25 mm) wide shall be cut by use of a die from the trial weld sample by the Contractor - one near each end and one near the mid-point. The two near end specimens shall be tested in peel and the mid-point sample tested in shear.

All trial weld specimens shall be tested in the field by the Contractor and in the presence of the Superintendent, using an electrically operated tensiometer where the force exerted is displayed. The Contractor shall supply evidence demonstrating that the tensiometer has been calibrated within the previous 12-month period.

The shear test specimen shall, at a minimum, meet a strength of ninety five percent (95%) of the tensile yield strength of the parent geomembrane material where it fails in the material (i.e. film tear bond). Both tracks of dual-track fusion welds shall be tested for peel adhesion. Peel strength of welds shall meet at least 65% of the tensile strength of the parent geomembrane material where it fails in the material.

All seams shall fail in the material, i.e. film tear bond. Trial seams shall meet the following minimum strength criteria:

Material (including weld type)	Peel	Shear
HDPE (fusion welds)	65%(1)	95%(1)
HDPE (extrusion weld)	60%(1)	95% (1)
LLDPE (fusion weld)	220 N/25 mm	265 N/25 mm
LLDPE (extrusion weld)	190 N/25 mm	265 N/25 mm

Note (1): Test results relative to the strength of the parent sheet strength

The tensile yield strength of the parent material will be determined before testing the trial welds by testing a 25 mm wide strip cut with a dye.

If any one of the three specimens fails, the entire trial weld is considered to have failed.

In the event that a trial weld fails, the entire trial weld procedure shall be repeated after the appropriate adjustments to the welding device and/or operator has been made. If a second trial weld fails, the welding device and/or the welding technician shall be rejected and shall not be used for welding until such time as the deficiencies are resolved, verification of the resolution is provided, and a successful trial weld performed.

Non-destructive Weld Continuity Testing

General

The Contractor shall non-destructively test all field and factory welds over their full length by the vacuum box method for testing continuity of extrusion welds, and air pressure test for double fusion welds only, or other approved method. The Contractor will be required to have back-up vacuum testing apparatus on the Site. A trial will be required in the presence of the Superintendent to demonstrate the effectiveness of the contractor's apparatus and method prior to field welding commencing. Vacuum testing and air pressure testing are described below. The purpose of the non-destructive test is to check the continuity of welds. It does not provide any information on weld strength. Continuity testing shall be done as the welding work progresses. Any welds that fail non-destructive testing shall be repaired in accordance with this Specification. Welds, which cannot be non-destructively tested because of seam geometry, shall be capped.

All test equipment shall be in calibration and conform to manufacturer's specifications. The Contractor shall submit current calibration certificates.

Vacuum Testing

The equipment shall comprise the following:

- A vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, port hole or valve assembly, and a vacuum gauge showing the pressure in the box;
- A steel vacuum tank and pump assembly equipped with a pressure controller and connections;
- A rubber pressure/vacuum hose with fittings, pressure gauge linked to the window housing and connections;
- A soapy solution to be applied over seam area.

Each section of the weld to be tested shall be tested to a vacuum pressure of at least minus 35 kPa. Each section of seam shall be vacuum tested for a period of not less than 10 seconds by examining the geomembrane through the viewing window for the presence of soap bubbles. Adjoining area shall to be tested with a minimum 75 mm overlap between sections.

Air Pressure Testing

The following procedures are applicable only to those processes that produce a double weld with an enclosed air channel. All double welds with an enclosed air channel shall be air pressure tested.

The equipment shall be comprised of the following:

- An air pump (manual or motor driven) capable of generating and sustaining a pressure of 180 to 200 kPa.
- A rubber hose with fittings and connections.
- A sharp hollow needle or other approved pressure feed device.
- A calibrated pressure gauge capable of reading pressures up to 250 kPa, with a tolerance of less than 5 kPa.

The following procedures shall be used for air pressure testing the HDPE Geomembrane:

- Seal both ends of the weld to be tested:
- Insert needle with pressure gauge, or other approved pressure feed device within 300 mm of one of the sealed ends, into the air channel created by the fusion weld:
- Energise the air pump and pressurise the channel to 200 kPa for a 25 mm wide channel or 350 kPa for a 13 mm wide channel. Close the valve and sustain the pressure for a minimum of 5 minutes. A pressure drop of less than 10 kPa is allowable, but the air pressure is still required to stabilise for a minimum of 5 minutes. Should a different width air channel be formed the Superintendent shall adjust the required minimum air pressure in the channel to achieve a similar stress on the weld as for a 25 mm wide channel.
- If loss of pressure exceeds 10 kPa, or does not stabilise, the faulty area should be located and repaired in accordance with this section. If, in the judgement of the Superintendent, significant changes in geomembrane temperature occur during the test (e.g., due to cloud cover), the test shall be repeated after the geomembrane temperature has stabilised.

- Cut end of weld opposite to the pressure gauge and observe that the pressure drops. If the pressure does not drop, locate the obstruction(s) in the weld, repair, and retest the weld.
- Remove needle or other approved pressure feed device and repair all holes and damage made to the air channel by extrusion welding over the damage.

The following procedures shall be used for air pressure testing the LLDPE geomembrane:

- Seal both ends of the weld to be tested.
- Insert needle with pressure gauge, or other approved pressure feed device within 300 mm of one of the sealed ends, into the air channel created by the fusion weld.
- Energise the air pump and pressurise the channel to 150 kPa for a 25 mm wide channel, or 200 kPa for a 13 mm wide channel. Close the valve and sustain the pressure for a minimum of 5 minutes. A pressure drop of less than 15 kPa is allowable, but the air pressure is still required to stabilise for a minimum of 5 minutes. Should a different width air channel be formed the Superintendent shall adjust the required minimum air pressure in the channel to achieve a similar stress on the weld as for a 25mm wide channel.
- If loss of pressure exceeds 10 kPa, or does not stabilise, the faulty area should be located and repaired in accordance with this section. If, in the judgement of the Superintendent, significant changes in geomembrane temperature occur during the test (e.g., due to cloud cover), the test shall be repeated after the geomembrane temperature has stabilised.
- Cut end of weld opposite to the pressure gauge and observe that the pressure drops. If the pressure does not drop, locate the obstruction(s) in the weld, repair, and retest the weld.
- Remove needle or other approved pressure feed device and repair all holes and damage made to the air channel by extrusion welding over the damage.

Alternative testing procedures may be considered by the Superintendent based on submission of relevant information by the Contractor. If an alternative testing procedure is to be considered the Contractor shall submit information to the Superintendent at least 14 days before the procedure is to be used.

Destructive Weld Continuity Testing

The Contractor shall perform destructive weld tests at selected locations. The Superintendent shall choose the test locations. The Superintendent reserves the right to vary the testing frequency depending on results of samples tested. The purpose of these tests is to evaluate field weld strength. Weld strength testing shall be done as the welding work progresses, not at the completion of all field welding.

Location and Frequency

Destructive test samples shall be collected at an average frequency of one test location per 150 m of seam length or at intervals designated by the Superintendent.

Test locations shall be determined during welding, and may be prompted by suspicion of excess crystallinity, contamination, offset welds, or any other potential cause of imperfect welding.

Sampling Procedure

The Contractor shall cut samples at locations designated by the Superintendent as welding progresses to obtain laboratory test results before the geomembrane is covered by another material. Each sample shall be numbered and the sample number and location surveyed and identified for inclusion on the as-built liner drawing (refer Section 3.3.8.2).

All holes in the geomembrane resulting from destructive weld sampling shall be repaired and tested in accordance with the repair procedures in this Specification. Cuts to remove the samples shall be rounded to prevent stress concentrations in the geomembrane.

Size of Samples

The samples shall be a minimum 0.3 m wide by 0.4 m long with the weld centred length-wise. The sample length shall be increased to provide material for additional laboratory testing or archiving. Two specimens shall be cut from each end of the sample for preliminary field tests. The remaining sample shall be retained by the Contractor pending instructions from the Superintendent which samples are to be subjected to laboratory testing.

Each portion of the test sample shall be labelled with a unique number for the sample, and referenced to the joint number from where the sample was taken. The sample number shall be noted on the as-built drawings (refer Section 3.3.8.2). The Superintendent may direct the Contractor to reduce the length of the sample removed from the welds, if the Superintendent is satisfied that field testing indicates high quality welds. Laboratory tests may be ordered by the Superintendent on random samples to compare to field test results.

Preliminary Field Testing

Weld Destructive Tests

Two (2) specimens, one from each end of the weld destructive sample, shall be removed and tested for peel adhesion by the Contractor in accordance with Standard GM13 while in the field. The results of this testing shall be evaluated in accordance with the criteria detailed in this Specification.

If either of the two field specimens fails, the entire destructive test is considered to have failed and additional destructive test samples shall be taken in accordance with the procedures of this specification.

If the laboratory destructive testing is to be performed on-site, the requirement for preliminary field weld destructive testing may be waived by the Superintendent.

Weld-end Tests

The Contractor may, if agreed by the Superintendent, perform an additional preliminary destructive test. This test shall take the form of a single specimen obtained from one end of the completed fusion weld. This will be a quality control test and, as such, shall be addressed in the quality control procedures manual.

Upon completion of a fusion weld, a specimen shall be removed from one or both ends and tested by the Contractor for peel adhesion in accordance with the procedures detailed in this Specification. Both tracks of the dual-track fusion weld shall be tested and evaluated. The weld shall not fail in the weld area. If one or both of these specimens fail, a complete destructive test sample shall be taken as previously detailed in this Specification.

Laboratory Weld Sample Destructive Testing

The destructive weld testing will be performed by the Contractor in an on-site or off-site geosynthetic testing laboratory, to be approved by the Superintendent. Typically tests performed by the laboratory shall be completed and the results reported to the Superintendent within 24 hours of receipt.

The Contractor shall conduct laboratory destructive testing on at least 10% of the destructive weld samples of the project, or at least five samples, whichever results in the greater number of tests.

Tests shall be performed on 10 specimens obtained from each field sample. From each sample 5 specimens shall be tested in shear and 5 specimens shall be tested in peel. The shear and peel specimens shall be selected from the sample alternately, so that no two adjacent specimens are tested in the same mode.

Weld Evaluation Criteria

Each weld sample must satisfy both the shear and peel criteria. All testing and evaluation shall be carried out in accordance with ASTM D 4437.

For both peel and shear tests the specimen shall fail in the geomembrane sheet and not in the weld area. This is referred to as “film tear bond,” (FTB). The specimen shall be defined as failing in the weld if any portion of the weld exhibits separation across more than 10% of the width. Each track of a dual-track fusion

weld shall be considered to be a separate weld for the purpose of calculating the percentage separation. If more than one specimen fails in shear, the entire weld destructive test sample shall be considered as failing.

Failed Destructive Sample Procedure

The Contractor shall reconstruct the deficient weld once the extent has been determined. All welds that are to be reconstructed shall be bound by passing destructive tests.

The Contractor shall trace deficient welds by grinding through the top sheet of the seam air channel, extrusion weld the channel, and pressure test sections of the seam between channel seal welds. Deficient extrusion welds shall be traced by taking field specimens from the weld at 3 m intervals until the Contractor has confidence that destructive samples which pass laboratory testing can be obtained. A full laboratory destructive sample will then be taken at that location and tested. If one or both of these samples fail the laboratory weld destructive test, then the procedure is repeated in that direction until passing laboratory results are obtained. For the purposes of tracing a weld, the weld is considered to be the path of the given fusion welding apparatus or extrusion welding device/technician combination and may, if necessary, extend beyond any given welding period. Tracing which requires obtaining more than 2 specimens in either direction from the location of the initial failed destructive weld sample shall be brought to the attention of the Superintendent. The Superintendent shall decide if the whole seam is to be rejected, or if the Contractor may continue identifying the segment of the defective seam.

At such time that the initial destructive sample failure rate of 10% or greater is reached, the Superintendent shall be notified so that a review of the Contractor's performance may be conducted.

3.3.10.6 Repairs

General

All weld and non-weld areas of the geomembrane shall be visually inspected by the Contractor for signs of damage, defective welds, blisters, punctures, undispersed raw materials, and any sign of contamination by foreign matter. Defective welds shall include completed welds that have been formed using equipment that is subsequently identified as being defective.

Any defective or flawed areas observed shall be marked, repaired, tested; or removed from the installation and disposed of. Unless otherwise approved by the Superintendent, all air channels produced by the dual track fusion welding process shall be sealed at both ends and at any location where the air channel is severed and made discontinuous. The appropriate parties shall agree upon the method of sealing. All repairs (patches, caps, etc.) may, at the discretion of the Superintendent, be destructively tested.

All defect locations shall be surveyed for inclusion on the as-built liner drawing (refer Section 3.3.8.2).

Patching

Patches shall be used to repair defects such as holes (including areas from which destructive test samples were obtained) and pinholes (exclusive of non-destructive testing air pressure needle holes) which penetrate the entire geomembrane thickness, tears and crazing. Small surface blemishes and localised flaws which do not penetrate the entire thickness of the geomembrane shall also be patched, or as instructed by the Superintendent.

Areas of crazing shall be cut longitudinally (along the length). The ends of all holes shall be rounded, to prevent further propagation, prior to patching. Patches may be used to cover areas of undispersed raw material or contaminated by foreign substances (gasoline, oil, etc.), if approved by the Superintendent. Patches shall extend a minimum of 150 mm beyond the limits of the defect and all corners of patches shall be rounded. Patches shall follow the contour of the defect area and remain free of crimping or pinching. The geomembrane material used for patches must, at a minimum, meet the requirements of this Specification.

Patches and defect areas shall be free of dirt, moisture, debris and markings. Patches shall be temporarily bonded by heat welding. Chemical adhesives and tape are prohibited without prior approval of the Superintendent. The perimeter of the patch shall be abraded with a hand-held grinder to produce a bevelled

edge. Patches shall be temporarily installed by heat welding along the entire perimeter of the patch and defect areas. The patch shall be installed flat along all edges with no wrinkles or folds. The patch weld area shall be abraded no more than 1 hour in advance of permanent welding. Heat welding and abrasion shall not cause excessive melting, wear or puncturing of the geomembrane material; such occurrences shall be considered defects and shall be repaired by patching.

Patching or repairs that require more than two passes of a welding procedure shall be considered as a defect, and be covered by a patch. Patches covering parts of other patches are not acceptable.

Capping

A cap is a patch of extended length and may be used to repair failed welds. Caps shall extend a minimum of 150 mm beyond the limits of the defective weld and all corners shall be rounded. Caps shall be installed as detailed in this Specification for patches.

A cap used to repair a failed weld or portion of weld shall be destructively tested if it exceeds 35 m in length or if the weld is of questionable quality. Caps over failed welds shall be carried out only with the approval of the Superintendent if no other method of repair is feasible. Where welds are being repaired by caps, the failed weld shall be cut out, and the cap shall be welded using fusion welding over most of the joint. The length of extrusion weld required to close-off the cap shall be kept to a minimum, and shall be closed-off after the fusion weld has been pressure tested.

Grinding and Welding

Grinding and extrusion welding shall be used to repair sections of defective extrusion weld less than 0.3 m in length. Areas requiring repair shall be abraded no more than 1 hour prior to the repair being made.

In consultation with the Superintendent, where the reason for a failed dual-track fusion weld has been determined with certainty, and is not related to faulty welding equipment, the failed part of the weld may be repaired (if less than 5 m long) by bevelling the edge (if required), abrading the sheet surface and applying an extrusion weld along the exposed edge (flap) of the seam. Failed welds repaired in this manner must conform to the requirements of this Specification. If the length of the failed portion of the fusion weld exceeds 5 m, or if the flap is not wide enough to allow destructive testing of the extrusion weld (without first testing through the fusion weld), then the weld must be reconstructed by capping.

Geomembrane Wrinkles and Bridging

Geomembrane wrinkle and bridge size and extent shall be minimised to the satisfaction of the Superintendent. Covering the geomembrane with the specified materials early in the morning when the temperature of the liner is low will reduce the extent and size of wrinkles. Wherever possible wrinkles shall be kept small and spread over the panel. In general, wrinkles which, when loaded, will result in a fold in the geomembrane are too large. Wrinkles or bridging larger than 300 mm high shall be cut and welded as a seam if the overlap is sufficient, in accordance with this Specification. Where the overlap is not sufficient, the wrinkle shall be cut and patched or capped as detailed in this Specification. Whenever it is not possible to manage wrinkles to less than specified, wrinkles shall be combined through accumulation so as to minimise the number of repairs being made.

Care shall be taken to minimise the occurrence of wrinkles over or across joins and welds to reduce stress concentrations near heat affected zones in the geomembrane.

3.3.11 Geotextiles

3.3.11.1 Description

Once delivered to the Site the Contractor shall recover samples from the rolls of geotextile, as indicated by the Superintendent. Samples from on site rolls shall be recovered at a frequency of one sample per 2000 m^2, or as varied by the Superintendent. The Contractor shall arrange for the testing of the samples to compare to both the design specifications and to the list of typical values of the properties provided by the manufacturer.

As a minimum, the following tests shall be performed on geotextiles (each type):

- Mass;
- Trapezoidal tear; and
- CBR puncture strength.

Other tests may be specified by the Superintendent.

3.3.11.2 Storage and Handling and Installation of Geotextiles

During shipment and storage, the geotextiles shall be protected from ultraviolet light exposure, precipitation or other inundation, spills of hydrocarbons, mud, dirt, dust, puncture, cutting or other damaging deleterious conditions.

The Contractor shall be responsible for the storage of the geotextile on the Site.

The geotextiles shall be secured and then rolled down the slope in such a manner as to continually keep the geosynthetic tension to preclude folds and wrinkles. All geotextiles shall be weighted with sandbags or the equivalent. Such sandbags shall be installed during placement and shall remain until replaced with cover material. Geotextiles shall be cut using an approved cutting method and approved equipment only.

Cushion Geotextile Installation

Where geomembranes are in place care shall be taken to protect this material from any damage that could be caused by the cutting of the geotextiles. During placement, care shall be taken not to entrap soil, stones, excessive dust, or moisture that could damage the geotextiles or the geomembrane, or hamper subsequent seaming or joining. The surface of the geomembrane shall be free of any larger than silt size particles, prior to placement of the geotextile.

An examination of the geotextile over the entire surface, after installation, shall be conducted to ensure that no potentially harmful foreign objects are present. Any foreign objects encountered shall be removed or the geotextile shall be replaced. If white coloured geotextile is used, precautions shall be taken to avoid “snow-blindness” of personnel.

The geotextile shall be deployed by rolling out by hand, with no vehicular traffic permitted over the underlying geomembrane.

The panels of geotextile shall be overlapped by at least 200 mm, and the overlap shall be tacked together by heat bonding or stitching. Overlaps shall be placed in a down-slope direction (roof tile effect). Stitching shall be carried out using a hand held stitching machine with thread of similar material to the geotextile. The joint shall have a tensile strength of not less than 50 % of the strength of the geotextile being joined. Where stitching is to be carried out, the contractor shall implement a needle management system, to the satisfaction of the Superintendent, to ensure no parts of needles remain in the stitched geotextile joints or on Site.

The geotextile shall be held in place to prevent uplift by wind. Temporary anchorage may be required to prevent displacement of the free-end of the geotextile.

The installation of the geotextile shall be carried out under the supervision of the geomembrane contractor to ensure no damage occurs to the geomembrane.

Placement of Unit 12 – cushion geotextile constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

The Contractor shall submit documentation related to the delivered and installed rolls of cushion geotextile to demonstrate that only the approved batch of geotextile was installed in the Works.

3.3.11.3 Ballast System for Geotextile

The geotextile shall be held in place to prevent uplift by wind by a ballast system that shall remain in place until the overlying layer covers the geotextile.

Mounds of soil may be placed to satisfy the ballast requirement. Material used for soil mounds shall conform to the same requirements of the material to be permanently placed over the geotextile. Proposed ballast configuration and details shall be submitted to the Superintendent for consideration before implementation.

Ballast shall be gently lowered onto the geotextile, with a maximum drop height of 500 mm. Vehicle traffic is not permitted on the geosynthetics, so the ballast shall be placed as each roll of material is deployed.

3.3.12 Geocomposites

3.3.12.1 Description

Once delivered to the Site the Contractor shall recover samples from the rolls of geocomposite, as indicated by the Superintendent. Samples from on site rolls shall be recovered at a frequency of one sample per 4000 m^2, or as varied by the Superintendent. The Contractor shall arrange for the testing of the samples in accordance with the testing requirements outlined in Section 2.2.12 or 2.2.13 of this Specification to compare to both the design specifications and to the list of typical values of the properties provided by the manufacturer.

3.3.12.2 Storage and Handling of Geocomposites

During shipment and storage, the geocomposites shall be protected from ultraviolet light exposure, precipitation or other inundation, spills of hydrocarbons, mud, dirt, dust, puncture, cutting or other damaging deleterious conditions. The Contractor shall be responsible for the storage of the geocomposite on the Site.

The geocomposites shall be handled in such a manner as to ensure it is not damaged in any way.

3.3.12.3 Installation of Geocomposites

The geocomposites shall be placed directly on top of the geomembrane. The surface of the geomembrane shall be free of any larger than silt size particles, prior to placement of the geocomposite.

Care should be taken during the placement to avoid damage to underlying geomembrane.

The geocomposites shall be secured and then rolled down the slope in such a manner as to continually keep the geosynthetic tension to preclude folds and wrinkles. All geocomposites shall be weighted with sandbags or the equivalent. Such sandbags shall be installed during placement and shall remain until replaced with cover material. Geocomposites shall be cut using an approved cutting method and approved equipment only. Where geomembranes are in place care shall be taken to protect this material from any damage that could be caused by the cutting of the geocomposites. During placement, care shall be taken not to entrap soil, stones, excessive dust, or moisture that could damage the geocomposites or the geomembrane, or hamper subsequent seaming or joining.

If there are any obstructions while deploying the geocomposite, the geocomposite shall be cut to fit around the obstruction. Care should be taken to make sure there is no gap between the obstruction and the geocomposite, to prevent any soil particles from migrating into the geonet core.

The geocomposite shall be deployed by rolling out by hand, with no vehicular traffic permitted over the underlying geomembrane.

The joining of geocomposites shall be in accordance with the manufacturer's specification. Adjacent edges of the geonet along the roll length of the geocomposites shall be overlapped a minimum of 50 mm and tied by plastic ties with a maximum of 1,500 mm intervals. Adjoining geocomposite rolls (end to end) along the roll width shall have the geonet overlapped a minimum of 300 mm across the roll width. Geonet shall be tied by plastic ties in 300 mm intervals across the roll width. The bottom layer of geotextile shall be overlapped.

The upper layer of geotextile shall be seamed by stitching or hot-air thermal sealing. Stitching shall be carried out using a hand held stitching machine with thread of similar material to the geocomposite. The contractor shall implement a needle management system, to the satisfaction of the Superintendent, to ensure no parts of needles remain in the stitched geocomposite joints or on Site.

The installation of the geocomposite shall be carried out under the supervision of the geomembrane contractor to ensure no damage occurs to the geomembrane.

The Contractor shall submit documentation related to the delivered and installed rolls of geocomposite to demonstrate that only approved geocomposite material was installed in the Works.

3.3.12.4 Ballast System for Geocomposite

The geocomposite shall be held in place to prevent uplift by wind by a ballast system, such as sand bags that shall remain in place until the overlying layer covers the geocomposite. Ballast shall be gently lowered onto the geocomposite, with a maximum drop height of 500 mm. Vehicle traffic is not permitted on the geosynthetics, so the ballast shall be placed as each roll of material is deployed.

3.3.13 Geogrid

3.3.13.1 Description

Once delivered to the Site the Contractor shall recover samples from the rolls of geogrid, as indicated by the Superintendent. Samples from on site rolls shall be recovered at a frequency of one sample per 4000 m^2, or as varied by the Superintendent. The Contractor shall arrange for the testing of the samples in accordance with the testing requirements outlined in Section 2.2.18 of this Specification to compare to both the design specifications and to the list of typical values of the properties provided by the manufacturer.

3.3.13.2 Storage and Handling of Geogrid

During shipment and storage, the geogrid shall be protected from ultraviolet light exposure, precipitation or other inundation, spills of hydrocarbons, mud, dirt, dust, cutting or other damaging deleterious conditions. The Contractor shall be responsible for the storage of the geogrid on the Site.

The geogrid shall be handled in such a manner as to ensure it is not damaged in any way.

3.3.13.3 Installation of Geogrid

The geogrid shall be sandwiched in Unit 6 – Base Material (refer Section 3.3.4).

The geogrid shall be secured and then rolled down the slope in such a manner as to continually keep the geosynthetic tension to preclude folds and wrinkles. All geogrid shall be weighted with sandbags or the equivalent. Such sandbags shall be installed during placement and shall remain until replaced with cover material. Geogrid shall be cut using an approved cutting method and approved equipment only. No vehicular traffic permitted over the installed geogrid.

Adjacent edges of the geogrid along the roll length (side by side) shall be overlapped a minimum of 300 mm and tied by plastic ties at a maximum of 1,500 mm intervals. The Contractor is to note that although a smaller side by side overlap is used in many geogrid applications, a 300 mm side by side overlap is a specific requirement for the project. Adjoining geogrid rolls (end to end) along the roll width shall be overlapped similarly and tied at maximum 1,000 m intervals.

The Contractor shall submit documentation related to the delivered and installed rolls of geogrid to demonstrate that only approved materials are installed in the Works.

3.3.13.4 Ballast System for Geogrid

The geogrid shall be held in place to prevent uplift by wind by a ballast system, such as sand bags that shall remain in place until the overlying layer covers the geogrid. Ballast shall be gently lowered onto the geogrid,

with a maximum drop height of 500 mm. Traffic is not permitted on the geogrid, so the ballast shall be placed as each roll of material is deployed.

3.3.14 Leachate Collection System for Cell Base Lining in Cells 1 to 4

The Contractor shall construct the leachate collection system and leachate sumps in accordance with the Design Drawings and as given below. As the leachate collection system will likely be constructed in two or three sub-stages within each stage (to be confirmed during detailed design), the Contractor shall appropriately cap all temporary leachate pipe terminations to allow future connection.

The leachate collection system for the cell base lining in the Cells 1 to 4 area includes the following materials (bottom to top):

- Unit 12 – Cushion Geotextile;
- 300 mm thick layer of Unit 7 – Drainage Aggregate;
- Unit 23 – Leachate Collection Pipe; and
- Unit 11 – Filter Geotextile.

3.3.14.1 Leachate Collection Pipe

Unit 23 - Leachate Collection Pipe shall be placed by hand or machinery on top of Unit 12 – Cushion Geotextile. The pipes shall be installed with the perforations at 45 degrees off the vertical and horizontal axes of the pipe. Minor adjustments to the alignment of the pipes are permitted to facilitate the use of standard angled bends and junctions. The ends of all pipes shall be capped during construction activities to prevent ingress of foreign materials.

Initial placement of leachate collection pipes, or the subsequent connection of a new portion of the piping system to a previously placed portion, constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

Following placement of each portion of leachate collection piping, the Contractor shall survey all pipe alignments and inverts, including leachate outlet pipes (Section 3.3.14.3) and leachate clean out access pipes (Section 3.3.14.4), and submit works-as-executed (WAE) drawings demonstrating compliance with the design within 7 days of completion of each portion of the system. It is noted the a Hold Point has not been established at this point because it would likely preclude the Contractor from covering all areas of the liner with Unit 7 – Drainage Aggregate quickly enough to comply with the 24-hour time window requirements for GCL, geomembrane, and cover placement given in Section 3.3.9.4 .

3.3.14.2 Leachate Drainage Layer

The Contractor shall place the Unit 7 – Drainage Aggregate over Unit 12 - Cushion geotextile using appropriate methods and equipment to prevent damage to the geotextile cushion, underlying geomembrane, and leachate collection pipes.

The Contractor shall provide a work method statement presenting the proposed method of placement of the Unit 7 – Drainage Aggregate. The work method statement must include, but not necessarily be limited to, the minimum requirements listed below.

- The minimum thickness of the layer shall be 300 mm as measured perpendicular to the surface of the underlying layer. The entire thickness shall be placed as one lift.
- The drainage aggregate covering the leachate collection pipe shall be in accordance with the Design Drawings with a minimum thickness of 300 mm above the top of the leachate collection pipe and a minimum width of 400 mm along the pipe alignment. Care shall be taken to ensure the granular

material extends all around the pipe to support the pipe. No vehicle traffic shall be permitted over the installed pipes unless the Contractor can demonstrate to the satisfaction of the Superintendent that sufficient cover material is in place to protect the pipe from traffic loads. Placement of Unit 7- Drainage Aggregate around the leachate collection pipes constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

- The maximum permitted machinery weight for drainage layer placement shall be 13T. At no point shall the placement equipment operate on a working platform of less than 300 mm thickness of material above the cushion geotextile. A field trial is required to confirm that the planned plant for use in hauling, spreading, and compacting the drainage aggregate can operate without damaging the geotextile cushion, underlying geomembrane, or leachate collection pipes and to establish minimum equipment setbacks from the leading edge of drainage aggregate placement.
- The Contractor shall compact the drainage layer using a suitable self propelled smooth drum roller, operated with the vibration turned off, and having a maximum combined static weight of no greater than 13T. Compaction equipment shall be operated such that passes are carried out in long parallel traverses. Turning or hard braking of the compaction equipment shall only be carried out off the drainage system.
- The drainage layer shall be compacted using 4 passes of the roller specified above.

The work method statement shall demonstrate to the satisfaction of the Superintendent that the proposed methods will be protective of the cushion geotextile, geomembrane, and leachate collection pipes. The work method shall include “Level 1” supervision and reporting by the GTA. Submission of the work method statement constitutes a HOLD POINT. Placement of the Unit 7- drainage aggregate shall not commence until the Hold Point is released.

Notwithstanding the above should any damage occur to the geotextile cushion, the leachate collection pipes or the geomembrane the Contractor shall make a full repair at his own cost to the satisfaction of the Superintendent.

After drainage layer placement, Unit 11 – Filter Geotextile shall be placed and secured over the drainage layer. Filter geotextile shall be installed in the same manner as outlined in Sections 3.3.11 of this Specification. Placement of Unit 11 – Filter geotextile constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

Following drainage layer placement and filter geotextile placement, the Contractor shall survey the finished surface level to provide works-as-executed (WAE) drawings and to demonstrate that the drainage layer design thickness has been achieved and that the constructed sump geometry is in accordance with the design. The survey shall be conducted on an approximate 10m grid with detailed survey of the sump. The Contractor shall submit the WAE drawings and an accompanying analysis demonstrating compliance with design thickness and sump geometry. Submission of the WAE drawings and accompanying analysis constitutes a HOLD POINT. Placement of any material above the drainage layer shall not commence until the Hold Point has been released, and all other contractual requirements have been fulfilled.

3.3.14.3 Leachate Sump and Outlet Pipe

The leachate sump and outlet pipe shall be constructed in accordance with the Design Drawings.

The Contractor shall provide a Work Method Statement for the installation of the leachate sump to the Superintendent for approval. This constitutes a HOLD POINT. No construction of the sump shall be carried out until the HOLD POINT has been released by the Superintendent.

The work method statement must include, but not necessarily be limited to, the minimum requirements as given in the remainder of this section.

Base and Lining Construction

The base surface on which the sump liner will be constructed shall be prepared to form a firm foundation. The surface shall be trimmed of all softened, loose and foreign materials, and formed to a uniform graded surface. Any depressions shall be filled with compacted Unit 4 – Clay Rich Material or Unit 2 – General Fill. No contaminated material shall be used for surface preparation.

Prior to liner placement, the Contractor shall survey the finished base surface level. This information shall be included in the works-as-executed (WAE) drawings of the leachate drainage layer (refer Section 3.3.14.2) and to demonstrate that the design levels have been achieved.

The sump liner shall comprise the following components:

- A 500 mm thick of Unit 5 – Clay Material which have minimum permeability of 10^{-9} m/sec;
- Double layer of Unit 17 - GCL;
- Unit 16 – HDPE Geomembrane; and
- Unit 12 – Cushion Geotextile.

Installation of Clay Material

The Contractor shall proposed method of moisture conditioning, placement and compaction, and maintenance of the leachate sump compacted clay liner to comply but not limit to the following requirements.

- The compacted clay liner layer shall be constructed in at least 3 layers. The clay liner shall be placed in layers of a nominal thickness of 170 mm. The clay liner layer shall have a minimum total thickness of 500 mm.
- The clay liner layer shall be compacted with a vibrating padfoot type roller, to achieve a minimum Dry Density Ratio (DDR) of at least of 98% standard (in accordance with AS1289.5.1.1 and 5.4.1) or a minimum HILF density ratio of 98% standard (in accordance with AS1289.5.7.1) at a moisture content within the range of 0% to +3% (wet) of the Standard Optimum Moisture Content (SOMC). The field density tests during placement of the material shall be minimum a test on each side of the base on each layer of as directed by Superintendent.
- If the required density and moisture is not achieved, the compacted material shall be reworked in-situ to meet the density and moisture content requirements. If the density and moisture content requirements again cannot be achieved after reworking, the failed layer shall be removed for moisture conditioning at the clay borrow area or at an approved designated area, or be discarded.
- Prior to the placement of each lift of the clay liner layer, the top of the previous lift shall be thoroughly scarified and moisture conditioned if necessary to bond each layer together and prevent laminations at the layer interfaces. Any areas where laminations occur, either between or within layers, shall be reworked such that all laminations and defects in the integrity of the clay liner layer are removed.
- Upon completion of the clay liner layer, the Contractor shall maintain the integrity of the layer by limiting the traffic movement over the clay surface and maintaining the surface of the clay in a moist condition, wet of SOMC, until covered by the geomembrane.
- Should the surface of a previously placed and compacted layer have dried or wetted up excessively, as determined by the Superintendent, the affected materials shall be excavated to expose material that has a moisture content within the specified tolerance. The excavated materials shall be returned to a designated area for moisture conditioning or be discarded.
- Trafficked areas are to be ripped, moisture conditioned and recompacted if in the opinion of the Superintendent the quality of these areas has deteriorated. Furthermore, any cracked clay that has formed due to desiccation shall be removed.

The placement of the leachate sump clay liner layer constitutes an INSPECTION POINT and the Contractor is required to provide 48 hours notice before commencing or recommencing this activity.

Following clay liner layer placement, the Contractor shall survey the finished surface level to include in the works-as-executed (WAE) drawings of the leachate sump and to demonstrate that the clay liner layer design thickness has been achieved and that design surface grades for geosynthetic placement have been achieved. The Contractor shall submit the WAE drawings and an accompanying analysis demonstrating compliance with design thickness and surface grades. This submission constitutes a HOLD POINT and geosynthetics installation for the sump shall not proceed until the Hold Point is released.

Geosynthetics Installation

The Contractor shall provide a rounded edge of the clay liner at the toe and crest of the side slope. The rounded edge shall be constructed to support the geomembrane so as to prevent stressing or creasing of the geomembrane under loads. In general, rounding shall be prepared over a length of approximately 300 mm.

The leachate sump shall be lined with the following layers:

- Two layers of Unit 17 - GCL overlying the prepared Unit 5 – Clay Material;
- A layer of Unit 16 – HDPE Geomembrane above the GCL; and
- A layer of Unit 12 – Cushion Geotextile.

The installation of the geosynthetic layers shall be as per Sections 3.3.9 to 3.3.11 of this Specification. This installation work constitutes an INSPECTION POINT and the Contractor is required to provide 48 hours notice before commencing or recommencing this activity.

Installation of Unit 24 – Leachate Sump Outlet Pipe and Sump Backfill

Unit 24 – Leachate Sump Outlet Pipe shall be connected to the leachate sump at the concrete outlet structure as shown in the Design Drawings. It is recommended that the outlet structure to be constructed prior to the installation of the liner system so that it will be ready to be connected with the geomembrane in the lining system.

Installation of Unit 24 – Leachate Sump Outlet Pipe constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

The backfilling of Unit 7 – Drainage Aggregate shall be by an excavator. The material shall be placed in a manner to minimise any impact on the geosynthetic layers underlain. Any damages shall be to be repaired to the satisfaction of the Superintendent at the Contractor's cost.

Backfilling shall occur within 24 hours of placement of the first GCL layer in the sump base in order to minimise potential GCL hydration swelling.

Installation of Unit 25 – Leachate Drainage Pipe and Unit 27 – Leachate Sump Riser

Unit 27 – Leachate Sump Riser shall be constructed outside of the perimeter bund and connected to the leachate sump outlet pipe. The Leachate Sump Riser adjacent to the Eastern Gully Landfill shall be connected with the existing leachate collection pipes and groundwater pipe from the existing Western and Eastern Gully Landfills as shown in the Design Drawings.

Requirements for bedding , sealing, pipe entrances (Unit 24 and Unit 25), and floor design for the Unit 27 – Leachate Sump Riser Pipes will be developed during detailed design.

Requirements for trenching, bedding and connection details for the Unit 25 – Leachate Drainage Pipe located: (i) within the Cell 1 footprint; and (ii) outside the southern boundary of Cells 1 to 4 will be developed during detailed design.

The Contractor will be required to prepare and Work Method Statement for for Unit 25 – Leachate Drainage Pipe and Unit 27 – Leachate Sump Riser installation and construction.

Installation of Unit 25 – Leachate Drainage Pipe and/or Unit 27 – Leachate Sump Riser constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing either activity.

3.3.14.4 Leachate Clean Out Access Point

Leachate Clean Out Access Points are the locations where the scouring equipment can be inserted into the leachate pipe to mechanically clean out the pipes to remove sediment and potential build-up of precipitates in the pipes.

The leachate clean out access point shall be constructed in accordance with the Design Drawings. In addition to these separate points, the leachate pipes which are connected in the leachate sump shall also have clean out access points where the pipes are extended into the riser pipe through the leachate sump outlet pipe.

Each leachate clean out access point shall comprise pipes extending to precast concrete boxes at the surface of the site. The end of the pipes includes removable caps that allow access to inside the pipes. The pipes shall have sweeping bends to maintain a minimum radius of curvature suitable for insertion/removal of scouring equipment.

The precast concrete boxes at the access points shall include lockable heavy duty concrete slabs with lifting points. Should the ground surface need to be raised, the collection pipes shall be extended in a straight line, and the concrete boxes re-located. The boxes shall have no floor to prevent collection of seepage in the boxes. The ends of the collection pipes shall be capped with airtight and watertight caps.

The Contractor shall submit the proposed materials required for the access point for approval prior to the construction. This constitutes a HOLD POINT and access point construction shall not commence until the Hold Point is released by the Superintendent.

Installation of leachate clean out access points constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

3.3.15 Leachate Collection System for Piggy Back Lining

The Contractor shall construct the leachate collection system for the piggy back lining areas in accordance with the Design Drawings and as given below. As the leachate collection system will likely be constructed in two or three sub-stages within each stage (to be confirmed during detailed design), the Contractor shall appropriately cap all temporary leachate pipe terminations to allow future connection.

The leachate collection system for the piggy back lining includes the following materials (bottom to top):

- Unit 14 – Geocomposite Drainage Net (Leachate); and
- Unit 23 – Leachate Collection Pipe covered with Unit 7 – Drainage Aggregate and wrapped with Unit 11 – Filter Geotextile.

It is noted that this leachate collection system will also used in the cell base lining in the natural ridge areas (i.e., Cells 2A, 2B and 4A).

3.3.15.1 Leachate Drainage Layer

The Contractor shall place the Unit 14 – Geocomposite Drainage Net (Leachate) over the LLDPE geomembrane (HDPE geomembrane in the natural ridge areas) using appropriate methods and equipment to prevent damage to the underlying geomembrane and GCL, in accordance with Section 3.3.12 of this Specification.

Should any damage occur to the geomembrane or the GCL the Contractor shall make a full repair at his own cost to the satisfaction of the Superintendent.

The geocomposite net layer is discontinuous at leachate collection pipe locations (eg. at cross-slope leachate collection pipes), as shown on the Design Drawings, to encourage flow into the pipes. The upper geotextile layer of the geocomposite net underlying drainage aggregate shall be removed, as shown on the Design Drawings.

Placement of Unit 14 – Geocomposite Drainage Net (Leachate) constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

3.3.15.2 Leachate Collection Pipe

Unit 23 - Leachate Collection Pipe shall be placed by hand or machinery on top of Unit 14 – Geocomposite Drainage Net (Leachate). The pipes shall be installed with the perforations at 45 degrees off the vertical and horizontal axes of the pipe. Minor adjustments to the alignment of the pipes are permitted to facilitate the use of standard angled bends and junctions. The ends of all pipes shall be capped during construction activities to prevent ingress of foreign materials.

Initial placement of leachate collection pipes, or the subsequent connection of a new portion of the piping system to a previously placed portion, constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

Following placement of each portion of leachate collection piping, the Contractor shall survey all pipe alignments and inverts, including leachate outlet pipes (Section 3.3.14.3) and leachate clean out access pipes (Section 3.3.14.4), and submit works-as-executed (WAE) drawings demonstrating compliance with the design within 7 days of completion of each portion of the system. It is noted the a Hold Point has not been established at this point because it would likely preclude the Contractor from covering all areas of the liner with Unit 9 – Protection Material quickly enough to comply with the 24-hour time window requirements for GCL, geomembrane, and cover placement given in Section 3.3.9.4 .

Prior to the placement of surrounds (Unit 7 – Drainage Aggregate) around the leachate collection pipes, the upper geotextile layer of Unit 14 – Geocomposite Drainage Net (Leachate) shall be removed within the zone which will be overlaid with the drainage aggregate.

Unit 7 – Drainage Aggregate shall then be placed around the pipes. Care shall be taken to ensure the granular material extends all around the pipe to support the pipe. No vehicle traffic shall be permitted over the installed pipes unless the Contractor can demonstrate to the satisfaction of the Superintendent that sufficient cover material is in place to protect the pipe from traffic loads. Placement of Unit 7 – Drainage Aggregate around the leachate collection pipes constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

Unit 11 – Filter Geotextile shall surround the drainage aggregate placed around the perforated leachate collection pipes. Filter geotextile shall be installed in the same manner as outlined in Sections 3.3.11.2 and 3.3.11.3 of this Specification and shall be placed concurrently with Unit 7.

Placement of Unit 11 – Filter geotextile constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

3.3.15.3 Unit 9 – Protection Material

The Contractor shall place the Unit 9 – Protection Material over Unit 14 - Geocomposite Drainage Net (Leachate) using appropriate methods and equipment to prevent damage to the geocomposite drain, underlying geomembrane, and leachate collection pipes.

The Contractor shall provide a work method statement presenting the proposed method of placement of the Unit 9 – Protection Material. The work method statement must include, but not necessarily be limited to, the minimum requirements listed below.

- The minimum thickness of the layer shall be 300 mm as measured perpendicular to the surface of the underlying layer. The entire thickness shall be placed as one lift.

- The maximum permitted machinery weight for protection layer placement shall be 13T. At no point shall the placement equipment operate on a working platform of less than 300 mm thickness of material above the geocomposite drain. A field trial is required to confirm that the planned plant for use in hauling and spreading the protection material can operate without damaging the geocomposite drain, underlying geomembrane, or leachate collection pipes and to establish minimum equipment setbacks from the leading edge of protection material placement.
- Compaction shall be only by trafficking with the spreading plant.

The work method statement shall demonstrate to the satisfaction of the Superintendent that the proposed methods will be protective of the geocomposite drain, geomembrane, and leachate collection pipes. The work method shall include "Level 1" supervision and reporting by the GTA. Submission of the work method statement constitutes a HOLD POINT. Placement of the Unit 7- drainage aggregate shall not commence until the Hold Point is released.

Notwithstanding the above should any damage occur to the geocomposite drain, the leachate collection pipes or the geomembrane the Contractor shall make a full repair at his own cost to the satisfaction of the Superintendent.

Following protection layer placement, the Contractor shall survey the finished surface level to provide works-as-executed (WAE) drawings and to demonstrate that the protection layer design thickness has been achieved. The survey shall be conducted on an approximate 10m grid. The Contractor shall submit the WAE drawings and an accompanying analysis demonstrating compliance with design thickness. Submission of the WAE drawings and accompanying analysis constitutes a HOLD POINT. Placement of any material above the protection layer shall not commence until the Hold Point has been released, and all other contractual requirements have been fulfilled.

3.3.16 Cap Components

3.3.16.1 Bearing Layer for Cap

The Contractor shall construct the bearing layer to provide a firm and smooth surface to support the Unit 15 – LLDPE geomembrane.

The bearing layer shall be constructed with Unit 4 – Clay Rich Material with a minimum as-compacted thickness of 200 mm.

The material shall be compacted to a minimum of 95 % SMDD (in accordance with AS1289.5.1.1 and 5.4.1) or a minimum HILF density ratio of 95 % standard (in accordance with AS1289.5.7.1) at a moisture content within the range of 0% to +3% of the Standard Optimum Moisture Content (SOMC) or as otherwise approved by the Superintendent.

The GITA shall provide "Level 1" supervision for material placement and moisture density testing. The frequency of field density and moisture testing during placement of the material shall as a minimum conform the following, whichever requires the most tests:

- 1 test per 2,500 m^2 per layer of material type; or
- 1 test per 500 m^3 per material type; or
- 3 tests per batch of work.

If the required density and moisture is not achieved, the compacted material shall be reworked in-situ to meet the density and moisture content requirements. If the density and moisture content requirements again cannot be achieved after reworking, the failed material shall be removed for moisture conditioning at the material borrow area or at an approved designated area, or be discarded.

Placement of Unit 4 material constitutes an INSPECTION POINT and the Contractor is required to provide 48 hours notice before commencing or recommencing this activity.

The Contractor shall maintain the bearing layer in a moist condition until Unit 15 –LLDPE geomembrane is installed. Should the bearing layer surface have dried excessively (e.g. desiccation cracking>20mm depth) or wetted up excessively, as determined by the Superintendent, the affected materials shall be excavated to expose material that has moisture content within the specified tolerance. The excavated materials shall be returned to a designated area for moisture conditioning or be discarded, and the excavated bearing layer material replaced. Note that the surface of the bearing layer is designed to shed water and its shape should be maintained during formation in order to avoid temporary water ponding during construction. Consideration may be given to use of micro-mist sprayers to limit loss of moisture from the completed surface during hot weather.

Trafficked areas of the bearing layer surface are to be ripped, moisture conditioned and recompacted if, in the opinion of the Superintendent, the quality of these areas has deteriorated.

The finished surface shall be smooth and well-drained. Coarse materials shall not protrude from the surface of the bearing layer by more than 5 mm. No areas of ponding shall be accepted on the surface. Additional surface requirements are given in Section 3.3.10.2.

The Contractor shall survey the final levels to provide works-as-executed (WAE) drawings and to demonstrate that the design levels and layer thickness have been achieved. The survey shall be conducted on an approximate 10 m grid. The Contractor shall submit the WAE drawings, an accompanying analysis demonstrating compliance with design levels, and a GITA certification statement. Submission of the WAE drawings and accompanying analysis constitutes a HOLD POINT. Placement of LLDPE geomembrane shall not commence in an area until the Hold Point has been released for that area, and all other contractual requirements have been fulfilled.

3.3.16.2 LLDPE Geomembrane

The LLDPE geomembrane will be installed as per Section 3.3.10 . This installation work constitutes an INSPECTION POINT and the Contractor is required to provide 48 hours notice before commencing or recommencing this activity.

3.3.16.3 Subsoil Drainage Layer

The subsoil drainage layer for the capping system comprises a layer of Unit 13 – Geocomposite Drainage Net (surface water) and Unit 26 – Subsoil Drainage Pipes, including cross-slope collection pipes and outlet pipes. The system arrangement is shown in the Design Drawings.

Unit 13 - Geocomposite Drainage Net (Surface Water) shall be placed on top of Unit 15 – LLDPE Geomembrane for the capping system as outlined in Section 3.3.12 of this Technical Specification.

Unit 26 - Subsoil Drainage Pipe shall be joined and placed on top of Unit 13 – Geocomposite Drainage Net. Minor adjustments to the alignment of the pipes are permitted to facilitate the use of standard angled bends and junctions. The ends of all pipes shall be capped to prevent ingress of drainage layer or topsoil materials. The cross-slope collection pipes shall be perforated or slotted and connected to the outlet pipes which shall be solid wall.

The cross-slope collection pipes will be covered by Unit 7 – Drainage Aggregate and wrapped with a Unit 15 –LLDPE Geomembrane flap. Details of joining Unit 15 itself or Unit 15 and Unit 13 together are shown in the Design Drawings. Unit 15 shall be installed in the same manner as outlined in Sections 3.3.10 of this Specification and shall be placed concurrently with Unit 7.

Installation of geomembrane and placement of Unit 7 – Drainage Aggregate around the perimeter pipes constitute an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

No vehicle traffic shall be permitted over the installed pipes unless the Contractor can demonstrate to the satisfaction of the Superintendent that sufficient cover material is in place to protect the pipe from traffic loads.

Notwithstanding the above should any damage occur to the pipes the Contractor shall make a full repair at his own cost to the satisfaction of the Superintendent.

The Contractor shall survey the subsoil drainage pipe alignment to provide works-as-executed (WAE) drawings. The Contractor shall submit the WAE drawings and an accompanying analysis demonstrating compliance with design. Submission of the WAE drawings and accompanying analysis constitutes a HOLD POINT. Placement of Unit 1 - Topsoil above the Geocomposite Drainage Net shall not commence in an area until the Hold Point has been released for that area.

3.3.16.4 Unit 1 - Topsoil

The Contractor shall provide a Work Method Statement presenting the proposed method of moisture conditioning, placement and compaction of Unit 1 – Topsoil. The work method statement shall demonstrate to the satisfaction of the Superintendent that the proposed methods will achieve stable placement of these soils and maintain favourable conditions for the sewing of grass seed. Submission of the work method statement constitutes a HOLD POINT. Placement of Unit 1 soil shall not commence until the Hold Point is released.

The work method statement must address the following requirements:

- Unit 1 – Topsoil shall be placed in two sub-layers of minimum total 500 mm thick and shall be placed by controlled pushing out of the material from the base of the batter slope toward the crest of the batter slope. Pushing up from the base of the batter is required to promote stability.
- The lower portion of Unit 1 – Topsoil shall be minimum 350 mm thick and shall be placed without damaging or disturbing the underlying geocomposites and the drainage collection pipes. If the Contractor is aware of any such damage or disturbance he shall immediately take measures to repair the damage and prevent further damage, and immediately inform the Superintendent.
- The lower portion of the Unit 1 – Topsoil shall be compacted as indicated subsequently while the upper portion shall remain uncompacted, except as occurs incidentally.
- The lower portion of Unit 1 – Topsoil shall be nominally compacted with a sheep's foot or similar roller to a minimum SMDD of 90% standard (in accordance with AS1289.5.1.1 and 5.4.1) or a minimum HILF density ratio of 90% standard (in accordance with AS1289.5.7.1) at a moisture content within the range of -5% to +3% of the Standard Optimum Moisture Content (SOMC). No direct compaction shall occur over the crown of the pipes.
- The upper portion Unit 1 - Topsoil shall be installed over the lower portion by tipping and retreating from the filled edge. An excavator or low bearing pressure bulldozer must be used to pull the stockpile towards itself and spread the 150 mm thick layer upper Unit 1 layer. The intention is that the upper soil horizon is not compacted and will provide favourable seeding conditions.
- As the lower portion of the topsoil layer is required to remain a low density, the Contractor shall arrange suitable plants and equipment for hauling, tipping and spreading material so that the layer shall not be over compacted. In case of any over compacted areas identified by GITA or Superintendent, the Contractor shall have to rework on the layer to the satisfaction of the Specification with his own cost. The Contractor may decide to assign specific hauling routes and working platforms for the upper portion of the topsoil placement. Those areas then shall be reworked to the satisfaction of the Specification prior to the placement of the upper portion of the topsoil on them.

Placement of each portion of Unit 1 – Topsoil constitutes an INSPECTION POINT and the Contractor is required to provide 48 hours notice before commencing or recommencing this activity.

The GITA shall provide "Level 1" supervision for material placement and moisture density testing. The frequency of field density and moisture testing during placement of the material shall as a minimum conform the following, whichever requires the most tests:

- 1 test per 2,500 m^2 per layer of material type; or
- 1 test per 750 m^3 per material type; or
- 3 tests per batch of work.

If the required density and moisture is not achieved, the compacted material shall be reworked in-situ to meet the density and moisture content requirements. If the density and moisture content requirements again cannot be achieved after reworking, the failed material shall be removed for moisture conditioning at the material borrow area or at an approved designated area, or be discarded.

Following placement of the topsoil layer, the Contractor shall survey the final landform levels to provide works-as-executed (WAE) drawings and to demonstrate that the design thickness has been achieved and that final landform levels comply with design levels. The survey shall be conducted on an approximate 10 m grid. The Contractor shall submit the WAE drawings, an accompanying analysis demonstrating compliance with design thickness and design levels. The WAE drawings and accompanying analysis shall be submitted within 5 working days of completing topsoil placement.

3.3.16.5 Revegetation

The required procedures and activities for revegetation of the landform will be provided in a revegetation specification that will be prepared during detailed design. A general description of the goals and purpose of revegetation is provided in the Whytes Gully Resource Recovery Park – Landscape Strategy (Corkery Consultant, January 2012).

The revegetation specification will address issues including, but not limited to, the following:

- Surface and soil preparation;
- Soil conditioning and amelioration;
- Plant species, direct seeding rates, and target plant numbers;
- Seed sowing, germination, and watering;
- Pest control (rabbits/hares and birds);
- Temporary erosion protection requirements; and
- Requirements for ongoing monitoring and maintenance.

The revegetation specification will include a requirement for the Contractor to prepare a detailed revegetation plan, prior to revegetation works, that will satisfy specification requirements. Any differences between the approach in the revegetation plan and that in this specification shall be justified with appropriate technical documentation and discussion. The submittal of the revegetation plan shall comprise a HOLD POINT. Revegetation shall not commence in an area until the revegetation plan has been accepted and the Hold Point has been released for that area by the Superintendent.

3.3.16.6 Drop Structures

Drop structures shall be constructed as shown on the Design Drawings and comprise shaping of the cap, supply and installation of Reno Mattresses, supply, and installation of the HDPE geomembrane and cushion geotextile, supply and installation of the erosion protection gravel and construction of soil mounds.

The Reno Mattress shall be 170 mm thick and shall comprise hexagonal double twisted wire mesh, as per British Standards EN 10223-3 "Steel wire and wire products for fences. Hexagonal steel wire netting for

engineering purposes" and shall be filled with stones or crushed rock. The crushed rock shall have a minimum particle size of 75 mm and a maximum particle size of 113 mm or two thirds of the thickness of the Reno Mattress and shall be VENM.

The steel wire used to manufacture the mattress shall be coated with Galfan, a Zn-5%Al-MM (mischmetal) alloy or approved similar. In order to reinforce the structure, all mesh panel edges shall be selvedged with a wire having a greater diameter.

All tests on wire must be performed prior to manufacturing the mesh. The wire used for the Reno Mattresses shall have the following properties:

- Tensile strength: the wire used for the manufacture of Reno mattresses and the lacing wire, shall have a tensile strength between 350-500 N/mm^2.
- Elongation: Elongation shall not be less than 10%. Test must be carried out on a sample at least 250 mm long.

3.3.17 Other Requirements

3.3.17.1 Surveying

All references in this Specification to required survey or survey to be performed by the Contractor means survey performed and reported by a registered surveyor.

3.3.17.2 Tolerances

The Contractor shall construct the cell to the construction dimension tolerances and minimum layer thicknesses provided for specific items in individual sections of this Specification.

For other items, the Contractor shall construct the cell to the general construction dimension tolerances provided below.

Levels and grades for material surfaces:

1) Surfaces shall be within +/- 100 mm of design levels;

2) Grades shall be in the design direction at all locations; and

3) Thickness of material layers shall be equal or greater than the design thickness.

Pipes and open drains:

1) Invert levels shall be within +/- 50 mm of design levels; and

2) Grades shall be maintained in the design direction at all locations.

RH/GRS:JMc/rh

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APPENDIX C

Interpretative Geotechnical Investigation Report for 50% Design

April 2012

WHYTES GULLY RESOURCE RECOVERY PARK

Interpretative Geotechnical Investigation Report for 50% Design

Submitted to:
Wollongong City Council

REPORT

Report Number. 117625003_059_R_Rev1

Distribution:

1 Copy - Wollongong City Council
1 Copy - Golder Associates Pty Ltd

Golder Associates

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1.0 INTRODUCTION

1.1 Project Description

The Whytes Gully Resource Recovery Park (WGRRP) is owned and operated by Wollongong City Council (Council) under Environment Protection Licence 5862. Existing landfill airspace at the WGRRP is projected to expire in late 2013. As part of a coordinated delivery of resource recovery and waste services in the Wollongong Local Government Area (LGA), Council are proposing to increase landfill capacity at the site by constructing a new landfill cell within the existing WGRRP, to the south of the existing landfill footprint and piggy-backing waste over the existing western and eastern gully landfills. This is estimated to provide more than 5 million cubic metres of additional airspace, projected to extend the life of the landfill by up to 50 years.

1.2 Previous Investigations

A number of investigations have been carried out across the site prior to this current phase of work. Information from these previous investigations has been reviewed during the preparation of this study and is included in the Geotechnical Investigation Report for Whytes Gully New Landfill Cell prepared by Golder Associates Pty Ltd, reference 117625003_077_R_Rev1 dated March 2012.

A geotechnical investigation was undertaken at the WGRRP in July and August 2011 by Golder Associates (Golder) on behalf of the Council. The objectives of this geotechnical investigation were to inform planning and design development of the proposed new landfill cell. The geotechnical investigation was targeted to provide subsurface information for the foundation conditions for the proposed new landfill cell footprint.

1.3 Scope of Report

The interpretation and analysis detailed in this report has been prepared for the 50% concept design submission of the Whytes Gully New Landfill Cell.

The report documents the geotechnical design approach, material properties, loads, load factors, standards adopted for design, and the results of geotechnical analysis.

2.0 SCOPE OF WORK

The scope of work for the geotechnical investigation (refer to Golder Associates report 117625003_077_R_Rev1 dated March 2012) included the following:

- Review of available literature on the local and regional geological and geotechnical setting of the Site;
- Borehole drilling using solid augers fitted to a truck mounted drill rig, including soil sample collection and Standard Penetration Tests (SPTs);
- Rock coring, core photography and point load testing;
- Installation of monitoring wells and water level measurement;
- Test pit excavation and collection of soil samples;
- Geological observation and mapping of existing cuttings and other rock exposures;
- Laboratory testing of soil and rock samples for geotechnical purposes;
- Survey of test locations.

This interpretive report provides interpretation and recommendations on:

- Geotechnical site model and geotechnical cross-sections;
- Interpreted geotechnical design parameters;
- Settlement analyses;
- Slope stability analyses; and
- Excavation stability and excavatability of natural materials.

3.0 PHYSICAL SETTING & BACKGROUND INFORMATION

3.1 Site Location

The WGRRP is located approximately 10 km to the south west of the Wollongong Central Business District (CBD) and is approximately 50 ha in size. Figure 1 presents the site locality and identifies the WGRRP regional context.

The WGRRP is located on Reddalls Road, Kembla Grange NSW. The site is generally bounded by Reddalls Road to the south and west, rural residential lands to the north, north-east and north-west, and a water treatment plant to the south east. An industrial area lies to the south of Reddalls Road and Dapto Creek lies to the west.

The residential suburb of Farmborough Heights is located approximately 360 m to the north east over a ridgeline.

3.2 Existing Site

WGRRP includes historical and existing landfills (Western and Eastern Gully), a transfer station, private roads, stormwater ponds, a leachate management system (including treatment plant and ponds), a materials recovery facility, a recycling area, weighbridge and administration and amenities buildings, as shown on Figure 2. The site also includes buildings previously housing a solid waste to energy facility.

3.3 Topography

The northwest and eastern extents of the landfill are bounded by ridgelines, with a small central north-south trending ridgeline separating the two historical gullies, the upslope portion of which remains clearly visible today. The site rises from RL 15 m at the south west to RL 100 m at the north east.

3.4 Hydrology

The general surface water drainage direction on the site is from the north east towards the south west. The catchment area of the site is approximately 50 ha and extends from a ridge to the north of the site to Reddalls Road to the south. Runoff from this catchment is directed to the stormwater ponds at the south west corner of the site before discharge to Dapto Creek.

Currently (2011), stormwater runoff from the landfill is generally directed along the eastern and western edges of both the Eastern Gully landfill and the Western Gully landfill through a series of swales and benches and a drain along the central ridge. There is currently a pond system on site to capture and treat the sediment runoff generated from the landfill activities. Run-on to the site is minimal due to the site being bounded by ridgelines.

3.5 Hydrogeology

3.5.1 Regional Hydrogeological Setting

Regionally the site is located within the southern portion of the Sydney Basin, a geological basin stretching from the Illawarra Plateau in the south to the Lower Hunter Valley region in the north, and incorporating the topographically low Cumberland Basin in the centre. Generally, the dip of the geological formations within the Sydney Basin is from the topographically higher ground in the north and south towards the topographic low ground in the centre of the basin, although this varies locally based on structural features.

The regional hydrogeological setting of the site includes groundwater resources associated principally with the sandstone formations of the Hawkesbury Sandstone, Narrabeen Group, Illawarra Coal Measures and the Shoalhaven Group. Each of these geological groups generally comprises varying proportions of sandstone, siltstone, claystone, shale and coal. Groundwater resources are generally described as occurring as stacked aquifer systems associated with the sandstone formations, separated by lower permeability strata acting as aquitards. Structural contours presented on the 1:100,000 geological map 'Wollongong-Port Hacking' (Department of Primary Industries, 1985) indicate a local geological dip direction approximately

towards the north to northwest in the vicinity of the site, which would be expected to influence the regional groundwater flow direction.

3.5.2 Local Hydrogeological Setting

On the site scale, groundwater occurrence is generally associated with two shallow systems: groundwater present in the upper weathered and fractured profile of the local bedrock geology, and groundwater present in the unconsolidated deposits that infill the two gullies at the site at the toe of the sloping topography. Water levels measured in wells installed within the shallow weathered bedrock in the sloping northern portion of the site generally range from 5 to 10 metres below ground level (mbgl), whereas water levels in wells installed in both the shallow bedrock and unconsolidated material in the flatter southern portion of the site are shallower, generally on the order of 1 to 3 mbgl. The water level associated with borehole GABH03 is approximately 0.4 m above ground level, indicating local artesian conditions within the shallow bedrock at this location.

Shallow groundwater flow associated with the weathered bedrock horizon is inferred to be sympathetic to the sloping topography of the northern portion of the site, with a south to southwest flow direction. Anecdotal information indicates that a number of springs were present in the two former gullies in which the existing landfill cells were developed. Groundwater within the unconsolidated deposits on the southern portion of the site also exhibits a south-southwest flow direction. Where nested wells were installed, an upward vertical hydraulic gradient was evident between the shallow weathered bedrock and the overlying unconsolidated deposits, which is likely attributable to the significant hydraulic gradient from the sloping terrain on the northern portion of the site. On the basis of the lithological logs and water level observations, it is considered that the weathered bedrock groundwater system is semi-confined beneath the unconsolidated deposits, but there is likely to be a degree of hydraulic connectivity between the systems.

Hydraulic testing of wells completed within both the shallow weathered bedrock and in the unconsolidated deposits indicated hydraulic conductivity values on the order of 10^{-5} to 10^{-6} m/s, which is consistent with the range of published values for the lithologies encountered.

3.6 Geology and Soil

Based on the 1:100,000 geological map ‘Wollongong-Port Hacking’, the WGRRP is on the boundary of two major geological formations. The southern part of the site is underlain by alluvial sands, silts and clays associated with Dapto Creek, and sandstone of the Budgong Sandstone formation underlies these alluvial soils. The central part of the site is underlain by red, brown and grey lithic sandstone that forms part of the Budgong Sandstone formation. The northern portion of the site is underlain by interbedded lithic sandstone, coal, carbonaceous claystone, siltstone and claystone of the Pheasants Nest Formation. It appears that the Pheasants Nest formation is mainly encountered on the ridgelines.

The environmental impact statement (EIS) (1982) indicates that prior to land-filling, volcanic sandstone covered most of the site with a transition to andesitic sandstone with coal seams, carbonaceous shale and mudstone in the higher section (above approximately RL 100 mAHD) and a zone of alluvium, gravels and sands in the lower sections (below approximately RL 30 mAHD). Bedrock is reported to appear at the surface in the upper sections of the site. The EIS (1992) for the Eastern Gully also notes that a relatively thick layer of colluvium was found along the base of the Eastern Gully.

The “Geology and Natural Slope Stability Zones in the City of Greater Wollongong, Figure 19, Sheets 1 and 2” (Rec. Geol. Surv. NSW, 14(2): Bowman) characterise the upper natural slopes as “moderately unstable, generally topographically high-relief land underlain by potentially unstable material requiring thorough investigation before development” and the site area at the toe of the natural slopes as “stable land with no landslip problems.”

Historical photographs taken from ground-level in the eastern gully at a time before landfill development have been provided to Golder by Council. The appearance of the surface topography and conditions in these photographs is generally consistent with the presence of colluvium and potentially perched groundwater levels within the gully slopes. We understand that colluvium was to be stripped from natural slopes prior to construction of the old landfill, but note that some materials could remain close to the toe of the natural slopes in the central and northern portions of the site.

4.0 GEOTECHNICAL CHARACTERISATION & DESIGN INPUTS

4.1 Geological Model

Golder Associates Geotechnical Investigation Report (Golder ref. 117625003_R_077_Rev0, issued January 2012) provides details of the subsurface conditions at the site.

We have inferred that subsurface conditions generally consist of fill, colluvial / alluvial soils, residual soil and sandstone and siltstone rock. The thickness of the different units varies throughout the site. A generalised description of the profile is provided in Table 1 below. Geological Sections indicating inferred Unit thickness and depths are provided in Figures 5 to 8.

Table 1: Summary of Generalised Subsurface Conditions

Unit	Description
Unit 41a: Old landfill waste Unit 41b: New landfill waste Unit 41c: Soil fill	Fill was encountered in zones of the proposed new cell floor (up to about 1.2 m deep) and generally comprised clayey soils with some sands. Fill in the existing landfill cap is mixed soils (clays and sands) with pockets of gravels, slag and coal-wash. Landfill Waste including plastic and rubble is present beneath the capping material.
Unit 42a: Alluvial soils Unit 42b: Colluvial soils	Mostly silty clay and clay with zones of sands and gravels and traces of cobbles. Soils in the upper 2 m to 3 m are soft to firm in parts, and strength improves with depth. Distinction between the Colluvial soils on the lower slopes and the Alluvial soils at the very bottom of the slopes is often difficult.
Unit 43: Residual soil and Extremely weathered rock	Mostly clay with varying quantities of gravel, silt and sand. Clay has medium plasticity and is generally stiff to very stiff with zones of medium dense to dense sand. Extremely weathered rock has extremely low to very low strength, typically sandstone with some siltstone and can be remoulded into a soil by hand.
Unit 44: Weathered SANDSTONE	Fine to medium grained, brown, low to medium strength, highly weathered to moderately weathered, with some iron stained jointing, jointing frequency typically 100 mm to 300 mm.
Unit 45: Fresh SANDSTONE	Fine to medium grained, grey, medium to high strength, generally slightly weathered to fresh, fracture spacing typically between 300 mm to 1 m.
Unit 46: Weathered SILTSTONE	Light brown, very low strength to low strength, highly weathered to moderately weathered, some zones interbedded with sandstone
Unit 47: Fresh SILTSTONE	Grey, low to medium strength, slightly weathered to fresh, encountered sparsely throughout the site

4.2 Hydrological Conditions

In conjunction with the geotechnical investigation, separate investigations were undertaken to investigate hydrogeological conditions at the site. These investigations are reported in the Hydrogeological Investigation Report 117625003-R_070_Rev0.

4.2.1 Leachate levels

Leachate is produced when water percolates through deposited waste. As it passes through the waste, the water becomes contaminated as it 'leaches' compounds from the waste. Leachate composition varies with the age of the waste from which it is generated; it also varies depending on the nature of the waste and the volume of water.

Water may enter the waste from several sources including: (i) rainfall; (ii) liquid as a result of breakdown of the landfill waste; (iii) surface water inflow (as run-off); and (iv) groundwater inflow. Liquid wastes and entrained water may also have been present in the waste when deposited.

For the Eastern and Western Gully Landfill, leachate levels have been assumed to be 5 m above the base of the existing old waste, based on preliminary information of water levels in abandoned landfill gas wells in the Western Gully landfill.

4.2.2 Groundwater levels

In conjunction with Variation #4, dated 4 November 2011, additional geotechnical investigations were undertaken in the area of the proposed new cell floor. The additional geotechnical investigations included installation of three standpipe piezometers within the Colluvial / Allluvial soils.

The groundwater levels measured to date, since December 2011, confirm a groundwater level in the new cell floor area of approximately 1 m to 3 m below existing ground level.

Details of the additional standpipe piezometers will be presented in a future addendum to the Hydrogeological Investigation Report 117625003-R_070_Rev0.

4.3 Seismicity

In accordance with Australian Standard AS1170.4-2007 Structural design action Part 4: Earthquake actions in Australia, to determine the Peak Ground Acceleration (PGA) the probability factor and hazard factor are required from AS1170.4 2007 Section 3, as follows:

- The design earthquake adopted for WGRRP is equivalent to an event with an annual probability of occurrence of 1 in 475;
- The Probability Factor (*kp*) associated with a 1/475 event is 1.0. Refer to Table 3.1 AS1170.4 2007 for values; and
- The earthquake hazard factor (*z*) is equivalent to an acceleration coefficient with an annual probability of exceedence in 1/475, and in Wollongong is equal to 0.09. Refer to Table 3.2 AS1170.4 2007 for values.

The proposed design PGA for WGRRP is therefore 0.09 g (α) assuming a 1 in 475 year event.

4.4 Geotechnical Design Parameters

4.4.1 Natural Materials, Fill & Waste

The soil properties for analysis were derived from typical values, based on classification of the soils encountered during borehole excavation. These values have then been compared with available laboratory test results from recent and historical investigations. Engineering judgement and published values were used to guide the geotechnical design parameters used for the analyses based on the soil and rock profiles encountered and on the expected materials within the containment cell, as described in Table 2 and Table 3 below.

We note that assigning geotechnical properties to waste is inherently uncertain due to the heterogeneous nature of the material and the varying amounts of cover soil incorporated into the waste mass. Typical values for municipal solid waste have been adopted as per Qian et al (2002)[1] comprising friction angle, Φ = 30º, cohesion, c = 0 kPa, and unit weight, γ = 11 kN/m^3.

The adopted unit weight for the municipal solid waste is likely be considered further for 90 % design using site records of waste placement and appropriate sensitivity analysis for stability and settlement.

As indicated in Section 4.2.1 , for the purposes of this preliminary assessment, a standing leachate head of 5 m has been assumed within existing waste in the existing Eastern and Western Landfill Gully cells. Leachate within the proposed cells has been generally assumed to be free-draining into the continuous blanket leachate collection drain above the proposed Piggy Back and Cell Liner Systems so that no pore pressures are present within the new waste mass.

Although the slope stability analysis results presented subsequently in this report were found to be relatively insensitive to leachate levels within the existing waste, the assumption of a 5 m head should be further assessed during detailed design considering implications for slope stability as well as leachate migration.

It is noted that the materials forming the landfill cap have not been included in the slope stability analyses because their effect on the stability of the overall waste mass is considered negligible.

[1] Qian, X, Koerner, R.M & Gray, D.H., (2002), *Geotechnical Aspects of Landfill Design and Construction.* Prentice-Hall, Inc., Upper Saddle River, New Jersey.

Table 2: Geotechnical Design Parameters - Compressibility Analysis

Geotechnical Unit	Drained Modulus E' (MPa)	Constrained Modulus E_s (MPa)	Poisson's Ratio v'	OCR	Pre consolidation Pressure P_C (kPa)	Void Ratio e_o	Compression Index C_c	Modified Compression Index $C_{c\varepsilon}$	Recompression Index C_r	Modified Recompression Index	Creep Coefficient C_α (%)
Unit 41a – New Landfill[2]	-	-	0.3	1	-	2	0.6[5]	0.2[5]	-	0.02	0.06
Unit 41b – Old Landfill[3]	-	-	0.3	1	-	2	0.6[5]	0.2[5]	-	0.02	0.06
Unit 41bb – Old Landfill *soft zone* [3]	-	-	0.3	1	-	2	1.0	-	0.1	-	0.2
Unit 41c – Soil Fill	-	-	0.3	1	-	2	0.2	-	0.02	-	0.06
Unit 42a – Alluvium 0-4m depth	-	-	0.3	NA	75	1	0.27[6]	-	0.06[7]	-	0.01[8]
Unit 42a – Alluvium >4m depth	-	-	0.3	1.2	-	1	0.27[6]	-	0.06[7]	-	0.01[8]
Unit 42b – Colluvium	-	-	0.3	3	-	1.5	0.15	-	0.025	-	0.006
Unit 43 - Residual Soil / Extremely Weathered Rock[4]	60	72	0.25	-	-	-	-	-	-	-	-
Unit 44 - Weathered Sandstone [4]	300	360	0.25	-	-	-	-	-	-	-	-
Unit 45 - Fresh Sandstone [4]	300	360	0.25	-	-	-	-	-	-	-	-
Unit 46 - Weathered Siltstone [4]	300	360	0.25	-	-	-	-	-	-	-	-
Unit 47 - Fresh Siltstone [4]	300	360	0.25	-	-	-	-	-	-	-	-

Notes:-

1. The above geotechnical compressibility design values are proposed for use as *design values* of soil and rock.
2. Unit 41a – New Landfill refers to compacted waste that will be placed as part of the proposed Whytes Gully New Landfill Cell (above Interface 1 – piggy back liner).
3. Unit 41b – Old Landfill refers to existing waste and waste that will be placed as part of the current filling plan (below Interface 1 – piggy back liner).
4. Assumed Rock Mass Parameters using Rocscience Roclab software.
5. Compression Index taken from published value in Gourc & Oliver (2005), and engineering judgment.
6. C_c derived from Liquid limit and C_c correlation, Terzaghi and Peck (1967).
7. Cr derived from Atterberg Limit laboratory testing correlation, Table 22, Lambe and Whitlam (1979).
8. C_α derived from $C_\alpha = 0.032C_c$, Mesri and Godlewski (1977).

Table 3: Geotechnical Design Parameters - Stability Analysis

Geotechnical Unit / Interface	Bulk Unit Weight (γ)[1]	Drained Friction Angle (φ')[1]	Drained Cohesion (c')[1]	Undrained Shear Strength (c_u)[1]
	(kN/m^3)	(°)	(kPa)	(kPa)
Unit 41a - New Solid Waste Landfill [2]	11	30	0	N/A
Unit 41b - Old Landfill [3]	11	30	0	N/A
Unit 41c - Soil Fill	17	26	2	N/A
Unit 42a - Alluvium	17	25	2	$0.25\sigma_v$ (min. 25) [4]
Unit 42b - Colluvium	18	27	5	100 + 10z [5]
Unit 43 - Residual Soil / Extremely Weathered Rock	20	30	5	130
Unit 44 - Weathered Sandstone [6]	24	38	40	1000
Unit 45 - Fresh Sandstone [7]	24	N/A	N/A	N/A
Unit 46 - Weathered Siltstone [6]	23	36	20	750
Unit 47 - Fresh Siltstone [7]	24	N/A	N/A	N/A
Interface 1 - Critical Interface within Proposed Piggy Back Liner [9]	19	Peak = 17 Residual = 7 (slopes) Residual = 11 to 14 (flat) [8]	0	N/A
Interface 2 - Critical Interface within Proposed Cell Liner [9]	19	Peak = 17 Residual = 7 (slopes) Residual = 11 to 14 (flat) [8]	0	N/A
Interface 3 - Critical Interface within Existing Eastern Gully Base Liner System (Slope steeper than 4H:1V) [9]	19	30	0	N/A
Interface 4 - Critical Interface within Existing Eastern Gully Base Liner System (Slope shallower than 4H:1V) [9]	19	18	0	N/A

Notes:

1. The above geotechnical strength design values are proposed for use as *design values* of soil and rock.
2. Unit 41a – New Solid Landfill refers to compacted landfill that will be placed as part of the proposed new cell (above Interface 1).
3. Unit 41b – Old Solid Landfill refers to existing landfill and landfill that will be placed as part of the current filling plan (below Interface 1).
4. Design value for undrained shear strength = 0.25 times the overburden stress (kPa), with a minimum shear strength of 25 kPa.
5. Design value for undrained shear strength = 100 kPa + 10z where z is the depth in metres below the top of Unit 2b.
6. Assumed Rock Mass Parameters
7. Assumed impenetrable for modeling purposes
8. Design value for drained friction angle = 14° for Eastern Gully Landfill, and 11° for Western Gully Landfill (refer Appendix A, Figure 1)
9. The shear strength of each liner system has been characterized by the minimum shear strength of each component or interface in each system. The shear strength parameters assigned to each component and interface is included in Appendix B1.

4.4.2 Proposed lining systems

Two lining systems are proposed for this 50% design:

1) The piggy back liner is proposed to be installed where the New Landfill will be located above the Old Landfill; and
2) The new cell liner is proposed to be installed in regions where the New Landfill will be located on natural material.

The proposed piggy back liner (from top to bottom) comprises:

- Unit 9: Protection Material (300 mm)
- Unit 14: Geocomposite Leachate Drainage Net
- Unit 15: Textured LLDPE Geomembrane
- Unit 17: GCL
- Unit 4: Compacted Clay Rich Bearing Material (200 mm)
- Unit 6: Base Material (min. 150 mm)
- Unit 18: Geogrid
- Unit 6: Base Material (min. 150 mm)
- Prepared Subgrade (existing cover soil)

The proposed new cell liner (from top to bottom) comprises:

- Selected waste (500 mm)
- Unit 11: Filter Geotextile
- Unit 7: Drainage Aggregate (300 mm)
- Unit 12: Cushion Geotextile
- Unit 16: Textured HDPE Geomembrane
- Unit 17: GCL
- Unit 4: Compacted Clay Rich Bearing Material (200 mm)
- Prepared Subgrade (existing cover soil)

Typical sections of the proposed arrangements are provided in the design drawings D022 and D031 (ref: 117625003_145_S_RevB). Note the proposed new cell liner is referred to as the base cell liner in the design drawings.

The proposed lining systems have been incorporated in the analysis using the parameters provided in Table 3 and Appendix B1.

4.4.3 Existing lining system

Based on the details of the existing Eastern Gully landfill base lining system provided to Golder by Council[2] and discussed with Council, the Eastern Gully landfill base lining is understood to comprise two systems; one on slopes steeper than 4H:1V, and one on slopes shallower than 4H:1V.

The existing Eastern Gully landfill base lining system (slope steeper than 4H:1V) is understood to comprise (from top to bottom):

- Leachate Drainage Layer (500 mm)
- Textured HDPE Geomembrane
- Groundwater Drainage Layer (500 mm)

The existing Eastern Gully landfill base lining system (slope shallower than 4H:1V) is understood to comprise (from top to bottom):

- Protective Layer (300 mm)
- Leachate Drainage Layer (300 mm)
- Smooth HDPE Geomembrane
- Groundwater Drainage Layer (500 mm)

The existing lining systems have been incorporated in the analysis using the parameters provided in Table 3 and Table B.1 in Appendix B1.

[2] Maunsell Drawing 14892-005 Rev02 “Whytes Gully Landfill, Construction Details”, dated 16 February 1993

5.0 METHODOLOGY

5.1 Relationships with Concept Design

This report provides baseline geotechnical information which is used in the New Landfill Cell 50% design, as follows:

Table 4: Relationships between geotechnical information and design components

Design Stage	Design Component	Relationships
50 % Design Comprising approximately 20 drawings and technical specifications	Excavation depths and foundation preparation	Geotechnical input is required to assess material suitability, treatment requirements and settlement performance of the new landfill cell floor.
	Geometry	Geotechnical input is required to assess the final landform geometry.
	Earthworks	Geotechnical input is required to assess material suitability, treatment requirements and settlement performance.
	Staging	Geotechnical input is required to assess temporary slope stability during waste placement. This aspect will be considered further at 90% Design, when the depth of temporary cuts and batters is better known.
	Cell floor liner design	Geotechnical input is required to assess material suitability, soil/liner interaction, stability, settlement and strains at the interface with existing natural soil profile.
	Piggy back liner design	Geotechnical input is required to assess material suitability, soil/liner interaction, stability, settlement and strains at the interface with existing solid waste.
	Surface water design	Geotechnical data is required for analysis of final landform drainage bench design
	Landfill gas (piggy back liner interface only)	None, except as consequence of piggy back liner design
	Leachate collection	None, except as consequence of geometry
	Leachate storage sizing	None
	Leachate treatment plant augmentation	None

5.2 Slope Stability

5.2.1 Analytical Method

Stability of the proposed landform has been assessed using the limit-equilibrium program *SLOPE/W*[3] for Spencer circular and non-circular failure mechanisms for both static and earthquake stability. Global stability analysis checks are conducted at the serviceability limit state. Consequently overall Factors of Safety (FoS) are applied in the global stability analysis, as follows:

- Target FoS for the overall slope of 1.5 or greater to provide acceptable long term stability under static loading, where the landfill liner is at peak strength;
- Target FoS for the overall slope of 1.2 or greater to provide acceptable long term stability under static loading where the landfill liner is at residual strength (such as post earthquake conditions). Considered a conservative test of stability, as residual strengths are unlikely to develop simultaneously across the whole area of the liner;
- Target FoS for the overall slope of 1.1 or greater to provide acceptable stability under earthquake loading, where the landfill liner is at peak strength; and
- Target FoS for the overall slope of 1.0 or greater to provide acceptable stability under earthquake loading, where the landfill liner is at residual strength.

Long term (effective) material parameters were used as these govern design, but a check of the undrained condition under earthquake loading was also carried out, using the undrained shear strength parameters (where applicable, such as for cohesive materials) as described in Section 4.4.

Additional notes regarding the slope stability analysis methods are:

- Analysis has been performed for the selected cross-section geometries, thus providing a two-dimensional (2-D) representation of the actual (3-D) conditions. Although this is consistent with standard geotechnical practice, it is known that 2-D analysis of valley landfills, such as the eastern gully landfill, when performed for critical cross sections, is generally a conservative approach because it does not account for beneficial 3-D geometry effects. Slope stability analyses that fully account for 3-D effects can be performed but are significantly more costly and complex than 2-D analyses.
- The critical surface search algorithms in Slope/W can converge on insignificant shallow veneer failures. To prevent this, a minimum slip surface depth within the waste mass was selected as required for the condition analysed.
- Where required for ease of slope stability modelling, the base liner layers are collectively represented by the properties of the “weakest material or interface in liner system” as indicated in Appendix B1.
- Results are based on the optimised Spencer limit equilibrium search methods as implemented in Slope/W.

5.2.2 Seismicity

To simulate potential seismic forces, a pseudo-static slope stability approach has been adopted wherein potential seismic effects are modelled as additional (destabilising) horizontal forces. Although this approach simplifies complex, dynamic seismic loading as static forces, it is commonly applied for slope stability analysis of landfill embankments, with more complex analysis generally justified only in cases where the simplified analysis indicates stability concerns.

As per Table 3.2 in AS1170.4 (2007), a peak horizontal acceleration of 0.09g (the peak horizontal acceleration for Wollongong) has been identified; and subsequently modified to 50% (i.e. 0.045g) in the horizontal direction

[3] SLOPE/W, “Slope Stability Analysis”, GeoStudio 2007, Geo-Slope International, 2007

for application to landfill embankment analysis. This represents an earthquake event with an approximate 475-year recurrence interval, a recurrence interval generally considered very conservative for landfill slope stability analysis.

As indicated in Table I2 in AS4678 (2002), a site amplification factor of 1.0 (for less than 30 m of medium dense coarse sands and gravels, firm to stiff clays or controlled fill under the landfill mass) has been applied to the horizontal acceleration of 0.045g. A horizontal acceleration coefficient of 0.045g has therefore been adopted for the pseudo-static slope stability analysis.

5.2.3 Slope Geometry

Slope stability analyses were carried out on four cross-sections that were considered to present the highest relative risk of slope instability, based on geometry and subsurface conditions. The location of these sections is shown in Appendix A, Figure A1. The sections are described as follows:

- Section E-E': This section extends north to south along the proposed 4.5H:1V slope of Western portion of the final landform.
- Section F-F': This section extends north-east to south-west along the centre of the natural Western Gully alignment.
- Section G-G': This section extends north-east to south-west through the Central Ridge between the two gullies and along the proposed 4.5H:1V slope of Eastern portion of the final landform.
- Section H-H': This section extends north-east to south-west along the centre of the natural Eastern Gully alignment.

These four sections are provided in Appendix A, Figures A2 to A5.

5.3 Settlement

Settlement analysis was carried out for design of liner and drainage systems, to assess the risk of grade reversal and settlement-related tensile strains. The analysis was broken down into four components, as follows:

- Settlement of natural soil profile at selected locations where there is appreciable thickness of natural soils likely to undergo settlement (equivalent to the position of parts of the cell floor liner). As these soils will form the landfill foundation for the new cell floor it is important to understand soil behaviour under the proposed new load and how this will affect the cell floor liner and final landform levels. The method of analysis used one-dimensional consolidation and elastic theory by proprietary software *Settle3D* (refer to section 5.3.1).
- Settlement of the piggy back liner system at selected locations. Analysis considered consolidation and degradation of the old waste, which were added to the settlements of the natural soil profile. Analysis was conducted using a Microsoft Office Excel spreadsheet to calculate the short and long term settlement equations referred to in section 5.3.2.
- Settlement of the final landform surface at selected locations. Analysis considered consolidation and degradation of the new waste, which were added to the settlements of the piggy back liner. Analysis used the same method described above, as referred to in section 5.3.2.
- Overall deformations and strains in the liners. To assess overall deformations and strains of the liner and to cross check the methods described above, finite element analysis was conducted using proprietary software PLAXIS (refer to section 5.3.3).

The cross sections adopted for slope stability assessment (refer to Section 5.2.3) were also considered appropriate for the settlement assessment. The four cross sections, Section E-E', Section F-F', Section G-G' and Section H-H', are provided in Appendix A, Figures A2 to A5.

The stratigraphy for the settlement analyses were taken from Golder factual geotechnical report, ref 117625003_077_R_Rev1.

5.3.1 Settlement of Natural Soil Profile

To assist in the settlement modeling of the natural soil profile, proprietary software program *Settle3D* (Roc Science) was used. *Settle3D* analysis includes the following assumptions:

- Applied loads are flexible, the stress at the surface is uniformly distributed but the displacement is not;
- Soil layers within Settle 3D are horizontal and continuous;
- The initial ground surface is horizontal; and
- Groundwater levels can be altered over the time stages to simulate drop in ground water Settle 3D modeling approach.

Settle3D analysis uses the following methods:

- Three dimensional stresses are calculated within a soil mass using elastic analysis;
- Consolidation analysis is performed for all Units in the soil profile; and
- Settlements and pore pressures are calculated in one dimension, assuming that only vertical displacements can occur.

The location where the settlement of natural soils is considered critical is defined by Section F-F' in the Western Gully Landfill between Ch425 m and Ch650 m, where the cell floor liner extends over natural soils. At this location the conceptual site model for the cell floor indicates that it is underlain by variable thicknesses of fill at shallow depths and increasing thicknesses of Colluvium to approximately Ch 525 m and Alluvium from Ch 500 m. At other sections, the natural soils were of limited thickness and unlikely to undergo significant settlement. Settlement analysis of these sections was therefore not considered necessary.

A summary of the five locations in Section F-F' selected for Settle3D analysis are shown in Table 5.

Table 5: Summary of Settle3D critical analysis locations

Analysis	Proposed thickness of new waste (m)	Comment
Section F-F' Ch 425 m	32.43	Toe of old solid waste placement (Western Gully Landfill)
Section F-F' Ch 475 m	25.30	Thickest profile Unit 41c Soil Fill and 42b Colluvium (3 & 12 m respectively)
Section F-F' Ch 570 m	11.15	Thickest profile Unit 42a Alluvium (16 m)
Section F-F' Ch 600 m	7.84	Mid point between Ch 570 m & 630 m
Section F-F' Ch 630 m	4.21	Near toe of new solid waste placement

The total settlements at each location were calculated from 1D consolidation analysis using the parameters described in Table 2. Where the thickness of Unit 42a exceeded 4 m it was divided into two layers for modeling purposes. The upper 4 m of Alluvium is assumed to be controlled by pre-consolidation pressure, whereas the Alluvium behavior below the upper 4 m is governed by the over-consolidation ratio.

The groundwater table for each model was assumed to be 2 m below existing ground level, dropping 1 m by 40 years post completion of filling. This drop is related to the controlling influence of the proposed concept design on the hydrological and hydrogeological conditions.

The placement of the new solid waste material was simulated by placing of time sequenced loads as a layer in an embankment. The embankment was modeled to have sufficient size as to minimise edge effects on the calculated 1D settlement.

Once the total soil settlements (primary and secondary settlements) had been calculated they were used in the liner-strain and grade change calculations for Section F-F' for the cell floor liner.

5.3.2 Settlement of Piggy Back Liner

The settlement of landfill waste was considered in the 'short term' and 'long term'. In the context of landfill waste settlement, short-term refers to settlement occurring in response to loading and generally within a few months of load application. The generally attributed mechanisms in the technical literature for short-term waste settlement are physical, primarily particle breakage and/or rearrangement into a denser structure.

The short term settlement of old solid waste was modelled using the following equation (Eq 12.9, Qian et al (2002)).

$$s = H \times C_{c\varepsilon} \times \log \frac{\sigma_0 + \Delta\sigma}{\sigma_0}$$

Where:

H Initial thickness of the waste later of the existing landfill (m)

$C_{c\varepsilon}$ Modified primary compression index

σ_0 Existing overburden pressure acting at the mid level of the waste layer, calculated using material parameters from Table 3.

$\Delta\sigma$ Increment of overburden pressure due to vertical expansion or other extra load calculated from new design levels provided in Sections in Appendix A.

In the context of landfill settlement, long-term refers to settlement that generally occurs over a period of decades, at a diminishing rate, and is not directly associated with any load application. The generally attributed mechanisms in the technical literature for long-term waste settlement are chemical/biological rather than physical, being primarily decomposition of organic materials resulting in loss of solid mass.

The long term settlement of new and old solid waste was modelled using the following equation (Eq 12.11, Qian et al (2002)).

$$s = H \times C_{\alpha\varepsilon} \times \log \frac{t_{final}}{t_{initial}}$$

Where:

H Initial thickness of the waste later of the existing landfill (m).

$C_{\alpha\varepsilon}$ Modified secondary compression index.

$t_{initial}$ The starting time of secondary settlement (years). It is assumed to be equal to the age of the existing landfill for vertical settlement.

t_{final} The time for the end of secondary settlement (years).

These equations were modelled using a Microsoft Office Excel spreadsheet to calculate the short and long term settlement, using the input parameters described in Section 4.4.

Settlement-induced strains for the liner systems were calculated directly as the average strain (tension or compression). Adjacent points along Section F-F' and Section H-H' were used in the calculation, and the distance between the points in their initial positions and post settlement positions were calculated. This method provided an estimate of the approximate strain along the profile provided in Section F-F' and H-H' to be compared with the components of the liner system.

For the Eastern and Western Gully landfill construction records indicate that most soils were stripped prior to commencement of filling thus there would be no compression of natural soil and rock materials underlying Unit 41b Old Solid Waste. The piggy back liner will therefore only be subjected to settlement from compression and decomposition of the existing waste (Unit 41b) underlying the piggy back liner.

Section F-F' (Western Gully Landfill) and Section H-H' (Eastern Gully Landfill) were selected for analyses of the piggy back liner settlement.

The proposed filling programme for the Whytes Gully Landfill Cell used to calculate initial and final ages for new solid waste placement was taken from the staging plans and programme revision 3, dated 11 January 2012. Staging plan drawings are presented in the 50% concept design report. A summary of the adopted filling programme used for settlement analysis is provided in Table 6.

Table 6: Filling programme adopted for settlement analysis

Stage	Proposed Liner Construction Period	Proposed Capping Construction Period (*)	Operation Period (Waste Filling)	
			(from year to year)	Length (years)
Stage 1	end 2012 - 2015 (3 years)	end 2015 - 2019	2013 - 2017	4.1
Stage 2A	end 2016 - 2017 (1 year)	end 2019 - 2021	2017 - 2020	2.4
Stage 2B	end 2019 - 2022 (3 years)	end 2022 - 2037	2020 - 2035	15.2
Stage 3	end 2034 - 2037 (3 years)	end 2037 - 2048	2035 - 2046	11.3
Stage 4	end 2045 - 2048 (3 years)	end 2048 - 2055	2046 - 2053	7.2

The historical filling programme for the existing Eastern and Western Gully landfills are provided as cross sections in Figures C.7 and C.9 in Appendix C.

For settlement predictions the proposed design life for the "extension" assessed for settlement analysis was forty years after completion of the final date of filling at the analysis section.

5.3.3 Settlement of Final Landform Surface

Settlement of the final landform surface has been assessed at three locations, which included long term settlement on old and new solid waste only. Settlement of the existing soil profile was not considered, as construction records for the Western and Eastern Gully Landfill showed this material to have been stripped during construction at the nominated chainages.

The three points were selected from cross sections F-F`, G-G` and H-H` as being representative of the thickness of new waste to be placed and at highest elevation proposed for the final landform. For Section G-G', the new solid waste will form part of a newly constructed cell, and we have assumed that unsuitable materials will be stripped from foundation level prior to waste filling.

The methods of analysis and assumptions for settlement of the final landform surface are described above in Section 5.3.2.

5.3.4 Comparative Finite Element Analysis

PLAXIS finite element analysis was carried out to assess forces and strains within the liner systems resulting from differential settlement of the existing landfill and natural materials under the overburden load of the proposed new landfill materials, and for the case of hypothetical soft spots below the liner.

The performance of the piggy back liner and the new landfill cell base liner was modelled during the various stages of construction and operation shown in Table 6 above.

Two PLAXIS models were developed, as follows:

- A two dimensional (2D) “global” model along the centerline of the western gully at cross-section F-F’ to quantify overall time–displacement behavior, simplified single liner stresses and strains, total and differential settlements, operational surface slope gradients and potential failure mechanisms; and
- A “local” axisymmetric model examining more closely the interaction between the existing and proposed landfill at a critical liner location identified in the 2D analysis. This incorporates two geosythentic layers (Unit 18 geogrid and Unit 15/16 geomembrane) and a nominally sized buried soft spot to assess liner behaviour in response to localised deformations.

A full discussion of the modelling approach is provided in Appendix D of this report.

6.0 RESULTS AND DISCUSSION

6.1 Slope Stability

A summary of stability analysis results is provided in Table 7 below, which indicate that all sections analysed meet the target factors of safety. A full list of analysis results is contained in Appendix B2. The output figures referenced below are included in Appendix B3.

Table 7: Summary of Stability Analysis Results

Failure Mechanism	Conditions	Target FoS	Calculated FoS	Analysed Sections	Output Figures
Circular through New Landfill	Long-term	1.50	2.66 – 2.99	E, G	B3.1, B3.17
	Earthquake	1.10	2.14 - 2.41	E, G	B3.2, B3.18
Non-circular (sliding) along proposed piggy back and new cell liners at **peak** strength	Long-term	1.50	1.51 – 2.06	E, F, G, H	B3.3, B3.9, B3.19, B3.25
	Earthquake	1.10	1.24 – 1.47	E, F, G, H	B3.4, B3.10, B3.20, B3.26
Non-circular (sliding) along proposed piggy back and new cell liners at **residual** strength	Long-term	1.20	1.24 – 1.49	E, F, G, H	B3.5, B3.11, B3.21, B3.27
	Earthquake	1.00	1.01 - 1.09	E, F, G, H	B3.6, B3.12, B3.22, B3.28
Circular through Old Landfill	Long-term	1.50	2.87 – 3.10	F, H	B3.13, B3.29
	Earthquake	1.10	2.23 – 2.50	F, H	B3.14, B3.30
Non-circular (sliding) along existing base liner in eastern landfill gully	Long-term	1.50	1.99	H	B3.31
	Earthquake	1.10	1.63	H	B3.32
Circular below Old Landfill (through natural soil)	Long-term	1.50	2.09 – 2.29	E, F	B3.7, B3.15
	Earthquake	1.10	1.25 - 1.67	E, F	B3.8, B3.16
Non-circular (sliding) below Old Landfill (through natural soil)	Long-term	1.50	1.66	G	B3.23
	Earthquake	1.10	1.31	G	B3.24

Based on the analysis results, the concept design meets the target factors of safety assigned to the design of global slope stability.

For all of the four cross-sections analysed, the critical failure mode for global stability of the final landform is non-circular (sliding) failure along the proposed piggy back and new cell liners, predominantly on the new cell floor. This is the case for both long-term static conditions and under earthquake loading. Consequently, the stability of the final landform is dependent on the shear strength of the critical interface or component within the proposed liner systems. The concept design overcomes this stability constraint by specifying minimum liner shear strengths near the toe of the landfill, in order to buttress the middle and upper slopes.

The minimum liner shear strengths required to support the design for global slope stability are presented in Appendix B1 and summarised in Table 8 as follows:

Table 8: Shear Strength Requirements for Piggy Back Liner and New Cell Liner

Zone[1]	Minimum Shear Strength			
	Peak		Residual	
	Drained Friction Angle (φ') (°)	Drained Cohesion (c') (kPa)	Drained Friction Angle (φ') (°)	Drained Cohesion (c') (kPa)
Slopes of old and new landfill	17	0	7	0
Flat areas of new cell floor	17	0	11	0
Eastern Gully (lower portion only)	17	0	14	0

1. Refer to Appendix A, Figure A1.

It should be noted that laboratory testing (interface shear and internal shear strength testing of each liner component) will be required to confirm the above shear strength parameters are satisfied as part of the selection process of the liner components.

In addition to the above global stability assessment, the following stability assessments are recommended to be undertaken as part of the final design:

- Stability assessment of interim construction slopes including consideration of surface loads, construction plant on batter slopes, liner uplift and potential for landfill gas pressure below the piggy back liner;
- Rock slope stability assessment of excavations in borrow pit areas;
- Stability assessment of 4H:1V northern final landform slope; and
- Stability assessment of the capping system (veneer stability).

6.2 Settlement

6.2.1 Settlement of Natural Soil Profile

As described in Section 5.3.1, the cell floor liner extends onto natural soils in the Eastern and Western Gully Landfill. Section F-F' was assessed as the most critical location for the proposed cell floor liner, where there is approximately 100m of new liner to be placed on the natural soil profile.

The results of settlement analysis for the natural soil profile are provided in Appendix C.1 to C.6, and summarised in the table below.

Table 9: Summary of calculated natural soil profile settlement at base of Western Gully Landfill

Section Chainage	Filling Stages	Total Settlement at 40yrs post completion of filling (m)
Ch425	Stage 2B	0.58
Ch475	Stage 2B	0.48
Ch 570	Stage 2B & Stage 3	0.77
Ch600	Stage 2B & Stage 3	0.42
Ch625	Stage 2B & Stage 3	0.18

The predicted total settlements were used to calculate settlement-induced strain in the cell floor liner in Section F-F' due to the underlying natural soils. Results are provided in Appendix C.8, and summarised in the table below.

Table 10: Summary of calculated tensile strains for the cell floor liner on natural ground

Section	Landfill	Settlement-induced strain (%)	
		Minimum	Maximum
Section F-F'	Western Gully Landfill	-1.3 (compression)	0.2 (tension)

6.2.2 Piggy back Liner

As described in Section 5.3.2, Section F-F' (Western Gully Landfill) and Section H-H' (Eastern Gully Landfill) were analysed for settlement of Unit 41b Old solid waste. There was no inclusion of settlement due to a natural soil profile, which had been stripped during landfill construction prior to waste placement.

Detailed settlement results are provided in Appendix C.8 and C.10. A summary of the settlement analysis results in for the piggy back liner are provided in the table below.

Table 11: Summary of calculated total settlements for the piggy back liner

Section	Location	Total Settlement at 40yrs post completion of filling (m)	
		Minimum	Maximum
Section F-F'	Western Gully Landfill	0.00	3.98
Section H-H'	Eastern Gully Landfill	0.07	4.98

The predicted total settlements were used to calculate settlement-induced strain in the piggy back liner system. Results are provided in Appendix C.8 and C.10, and summarised in the table below.

Table 12: Summary of calculated tensile strains for the piggy back liner (using MS Excel)

Section	Landfill	Settlement-induced strain (%)	
		Minimum	Maximum
Section F-F'	Western Gully Landfill	-0.60 (compression)	0.50 (tension)
Section H-H'	Eastern Gully Landfill	-0.87 (compression)	0.15 (tension)

The calculated liner system strains were compressive (from 0% to -0.6%) along most points in the cross section. However, maximum tensile strains of approximately 0% to 0.5% tension were also calculated.

Tensile strains are the primary concern with respect to maintaining liner system integrity. The calculation also indicates settlement-induced changes in liner system grades, however, there were no grade reversals suggested by the analysis results.

A limitation of using MS Excel to assess strain and grade reversal is that we cannot assess lateral deformation. These strains provide an indication of strain related to vertical movement only. Refer to Appendix C8 and C10 for MS Excel analysis results.

The results of the PLAXIS models and discussions will be presented in Revision 0 of this report.

6.2.3 Final Landform Surface

As described in Section 5.3.3, settlement of the final landform surface was assessed at three locations on selected from cross sections F-F', G-G' and H-H' as being representative of the thickness of new waste to be placed at the highest elevation proposed for the top deck and final landform.

The results of analysis are present in
Table 13, with detailed calculations presented in Appendix C.11 to C.13.

Table 13: Summary of calculated total settlements at the final landform surface

Section	Notes	Total Long Term Settlement (m)	Distance between points	Change in grade (%)
Section F-F' Ch 175 Design RL 110.22 m	Western Gully Landfill – Top Deck	3.0m	130m	1.0
Section G-G' Ch 200 Design RL 110.12 m	New Solid Waste Only – Top Deck	1.7m		
Section H-H' Ch 200 Design RL 101 m	Eastern Gully Landfill	1.5m	150m	0.1

The calculation indicates settlement-induced changes in final landform grades, with a predicted grade reversal across the proposed top deck final landform (Section F-F' and Section G-G'). There is a minor change in grade between Section G-G' and H-H' but not a grade reversal.

The predicted grade reversal is a product of the concept design staging programme, which sees waste placement and settlement at H-H' occurring before placement and settlement of waste at Section G-G' and Section F-F'. The presence of incompressible founding material at the new cell floor also contributes to a lower long term settlement prediction at Section G-G' compared to Section F-F'.

The grade reversal will need to be considered for final landform geometry and surface water design but is expected to be manageable with relatively small revision in final cap design grades.

6.3 Forces and Strains in the liner system

The results of the PLAXIS analyse indicate the following key findings:

- Landfill settlements do not result in excessive concentrated relative movements within the liner systems.
- Resulting forces and strains in the components of the proposed piggy back liner and new cell base liner systems are within acceptable limits.
- The geogrid (Unit 18) component within the piggy back liner provides necessary reinforcement required to maintain peak strains in the geomembrane component (Unit 15) to below 4 %.

General agreement was achieved between the PLAXIS, Slope/W and 1D settlement analyses.

A full discussion of the results of the analyses (including basic sensitivity cases) is provided in Appendix D.

6.4 Liquefaction

Based on the available geological information from the site, the natural soils below the landfill are generally clayey in nature. The fines content of soils affects liquefaction potential, with materials with higher fines contents generally having lower susceptibility to liquefaction.

The geological deposition of soils can give an indication of their susceptibility to liquefaction. Loose soils with uniform primarily sand grain sizes tend to have increased liquefaction susceptibility, compared to denser, well-graded soils. Saturated sandy soils formed by fluvial, colluvial and aeolian deposition processes generally have higher liquefaction susceptibility than alluvial-fan, alluvial-plain, beach, terrace, playa or estuarine deposits (Kramer (1996)). The subject site contains a range of soils from both depositional types, although the majority are clayey and therefore less susceptible to liquefaction. For the purposes of this assessment we consider it reasonable to assume that landfill waste (predominantly unsaturated) is not susceptible to liquefaction.

A layer of loose alluvial sand was identified in borehole GABH05 at 1.2m to 2.0m depth and other loose clayey sand layers were noted in the same borehole from 3m to 4m depth and in GMW107 from 0.5m to 1.2m depth.

Due to the variable depositional nature of the alluvium there is potential that there may be other discrete loose sandy layers near the toe of the proposed landfill that have not been encountered in boreholes.

As these loose sand soils may be susceptible to liquefaction we have completed an initial assessment of whether liquefaction may be triggered during the adopted design earthquake event. For this assessment we have adopted a horizontal ground motion for the site for a 1 in 475 year Annual Exceedence Probability (AEP) earthquake event for Wollongong (assuming z=0.09 and k_p=1.0) of 0.09g, based on AS1170.4, Tables 3.1 and 3.2. A magnitude 6.5 earthquake has been assumed.

Liquefaction potential of the loose sand layer from borehole GABH05 at 1.2m depth was assessed using the method of Robertson (2004). For this assessment we assumed that the layer has a density index (Dr) of 30% and used a cone penetration test (CPT) correlation (Baldi et al (1986)) to estimate an equivalent q_c value for use in the calculation.

We have assumed a friction ratio of 1 % x q_c which correlates to clean sand with typically ≤ 5 % fines. The results of the initial liquefaction assessment calculations are shown in Appendix C, Figure C15. The range of Factor of Safety (FoS) values calculated indicate acceptable performance against liquefaction (i.e. FoS is greater than 1.1).

In summary, the initial assessment of liquefaction susceptibility indicates that there may be localised layers of loose sand at the base of the landfill, which have a liquefiable particle size distribution. An initial assessment of whether liquefaction is triggered in these layers indicates that performance against liquefaction is acceptable.

There may also be other similar layers that were not encountered in the exploratory locations that have been completed, given the expected lateral variability in these deposits. However, we consider based on the available information and inferred geotechnical model, that there is a low likelihood of extensive, persistent liquefiable layers. We consider that the overall risk associated with liquefaction instability is low.

6.5 Excavations

The concept design will require that some areas are excavated to provide appropriate grades for the new cell floors, for example Section G-G` Ch100 to Ch575 m, and Section F-F' Ch400 to 650 m.

In addition, to facilitate unrestricted movement of construction equipment during the new cell floor construction, areas underlain by soft to firm and loose soils may require subgrade treatment. This could include excavation of these poor soils to a depth of at least 500 mm below final levels and replacement with suitable fill. Alternatively, a working platform could be constructed by filling over the areas of poor subgrade soils with crushed granular materials, subject to the materials left in place meeting the requirements defined by slope stability considerations. The actual depth of granular fill that might be required (possibly also using geosynthetic separation or reinforcing layers) would depend on the condition of the subgrade at the time, and should be considered on a case-by-case basis during construction.

Groundwater levels encountered during the site investigation indicate that at some locations the fill may need to be removed from below groundwater level. Contractors should consider methods for excavation and backfilling the excavations below groundwater level, or alternatively pumping groundwater from sumps to holding ponds while excavation, validation and backfill takes place. Wet fill will likely need to be moisture conditioned (dried or mixed with drier soil) prior to incorporation in the containment cell to improve handling and compaction.

Excavation of the fill, natural soils and extremely weathered rock horizons could be carried out by a medium sized (or larger) excavator. Excavation of very low and low strength rock (particularly carbonaceous lenses and siltstone) may be possible using large excavators at low production rates. Where medium and high strength rock is encountered rock breakers would likely be required. Alternatively it may be feasible to use a medium to large dozer with ripping tyne, subject to the capabilities of the equipment.

For unsupported excavations, the batters indicated in Table 14: Maximum Temporary and Permanent Batter Slopes are recommended for temporary and permanent applications. Some shallow excavations in the stiff or better clays will stand unsupported vertically in temporary applications, provided the weather and soil at the

time of excavation are relatively dry. NSW Workcover requirements for maximum allowable depth of unsupported excavations should be adhered to at all times.

Table 14: Maximum Temporary and Permanent Batter Slopes

Unit	Material	Temporary Batter Slope (H:V)	Permanent Batter Slope (H:V)
Unit 41c	Soil FILL – variable silty clay, gravely sand or sandy gravel.	2 : 1	3 : 1
Unit 42a	Alluvium – loose sand or firm clay (and mixtures thereof)	2 : 1	3 : 1
Unit 42b	Colluvium – stiff to hard clay soil with varying portions of silt, sand and gravel	1.5 : 1	2 : 1
Unit 43	Residual soil and extremely weathered rock	1 : 1	2 : 1
Unit 44 / 46	Extremely to highly weathered carbonaceous siltstone, siltstone, sandstone, conglomerate	1 : 1	2 : 1
Unit 45/47	Slightly weathered to fresh siltstone, sandstone, conglomerate	0.5 : 1*	1 : 1*

* vertical slopes with localised rock bolting may be feasible in materials not susceptible to erosion, and subject to geological inspection during construction.

Drainage and vegetation will be required to reduce erosion and the risk of local instability in permanent batter slopes.

7.0 CLOSURE

Your attention is drawn to the document “Limitations”, which is attachment in Appendix E. The statements presented in this document are intended to advise you of what your realistic expectations of this report should be. The document is not intended to reduce the level of responsibility accepted by Golder Associates, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in so doing.

8.0 REFERENCES

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Report Signature Page

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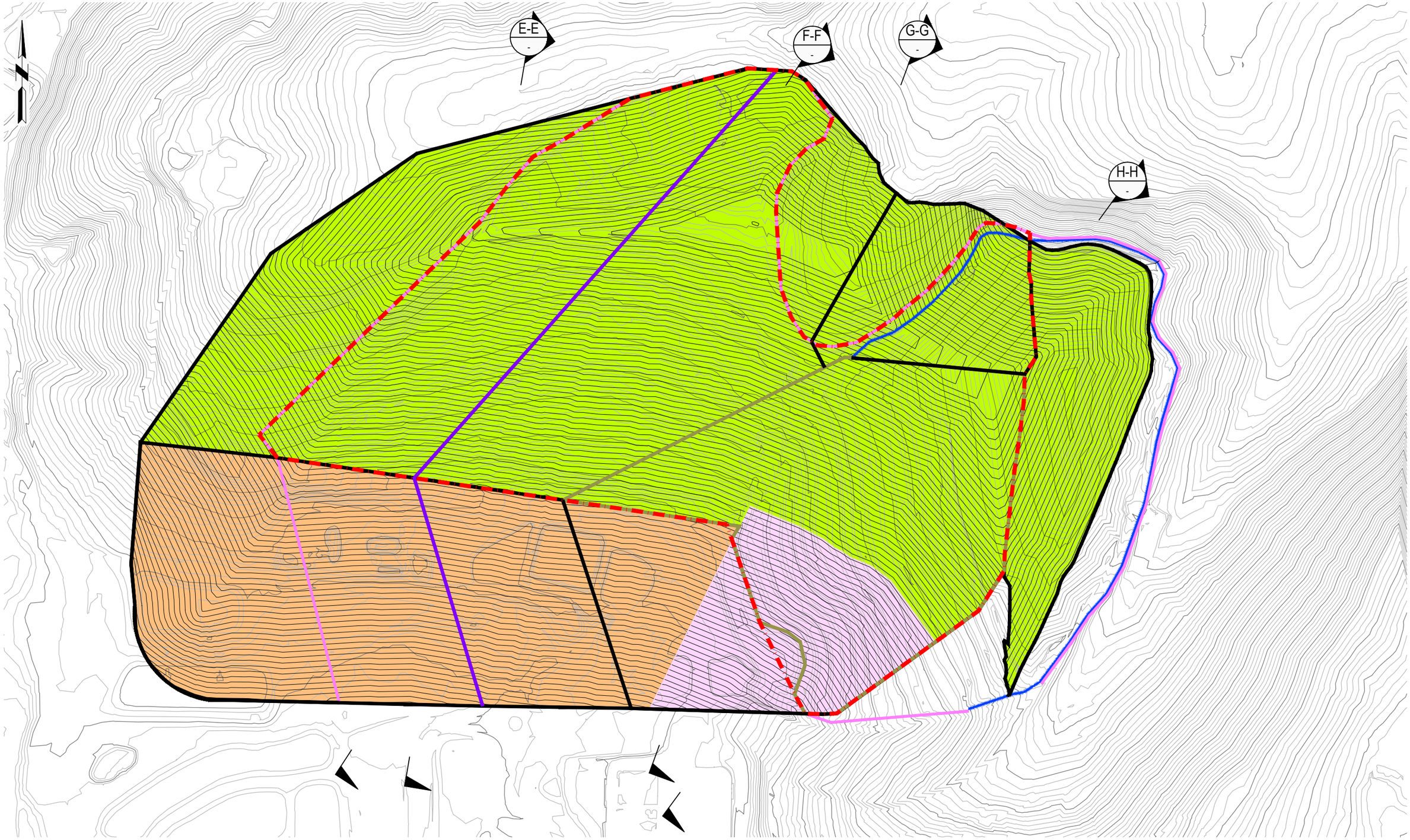
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APPENDIX A

Cross Sections

- Cross Section E-E'
- Cross Section F-F'
- Cross Section G-G'
- Cross Section H-H'

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LEGEND

- Φ'_R (SLOPES) ≥ 7°
- Φ'_R (FLAT) ≥ 11°
- Φ'_R (EASTERN GULLY) ≥ 14°
- APPROXIMATE EXTENT OF PROPOSED PIGGY BACK LINER
- MINIMUM RESIDUAL EFFECTIVE INTERFACE FRICTION ANGLE (Φ'_R) FOR PROPOSED PIGGY BACK AND CELL LINERS

1:3,000

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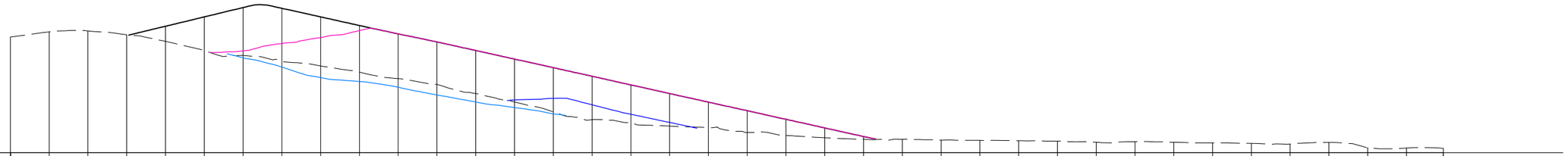
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DRAWN BY: E JEET	DATE: 17.01.2012	DRAWING TITLE: LOCATIONS OF CROSS SECTIONS	
CHECKED BY: CSC	DATE: 17.01.2012		
SCALE: 1:3000	SHEET SIZE: A3	PROJECT No: 117625003	DOC No: 059 / DOC TYPE: R / FIGURE No: F00A1 / REVISION: 0 / FIGURE A1

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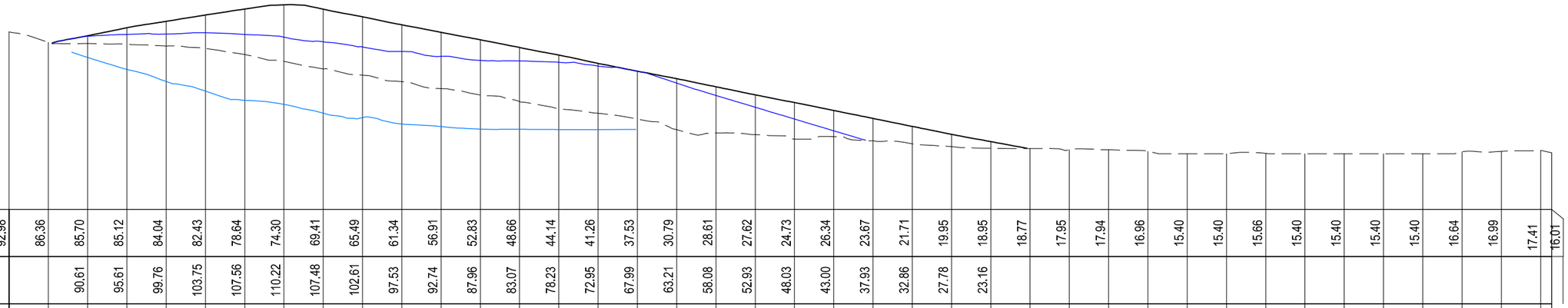
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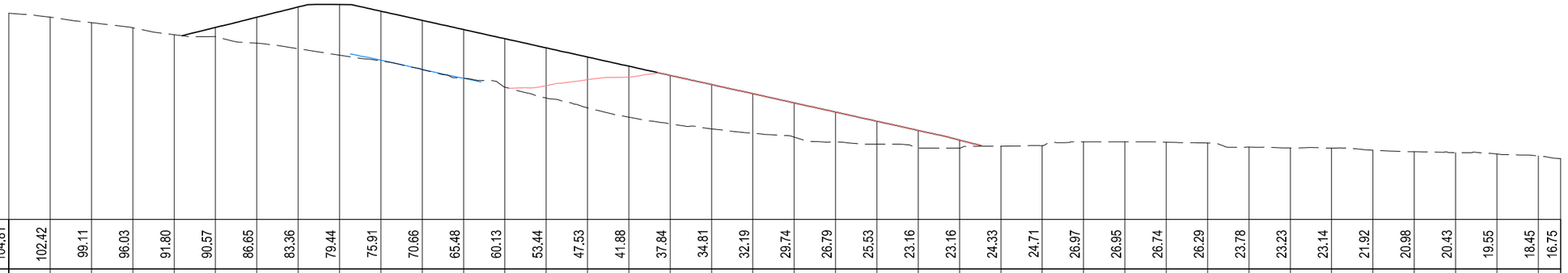
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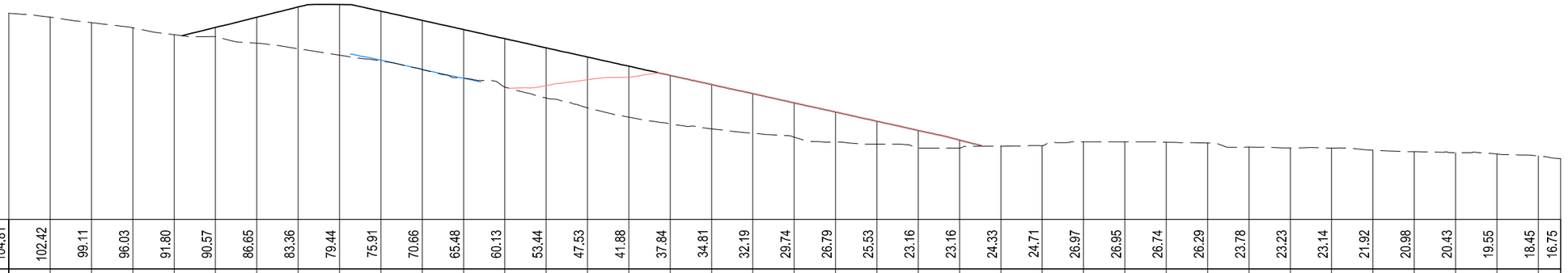
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APPENDIX B

Stability Analysis Results

APPENDIX B1
Geotechnical Design Parameters - Stability Analysis - Liner Components and Interfaces

Liner System	Component/ Interface	Bulk Unit Weight (γ) (kN/m^3)	Drained Friction Angle (φ') (°)	Drained Cohesion (c') (kPa)	Undrained Shear Strength (Cu) (kPa)	Comment
Proposed Piggy Back Liner System	Unit 9: Protection Materials (300 mm)	19	30	0	N/A	Typical value for track rolled sandy soil
	Interface between Unit 9 and Unit 14	N/A	27	0	N/A	Reduction Factor of 0.9 applied to Unit 9 friction angle (φ‘ = tan^{-1}(0.9 tan 30°))
	Unit 14: Geocomposite Leachate Drainage Net	10	Peak = 25 Residual = 8	Peak = 21 Residual = 32	N/A	Typical values
	Interface between Unit 14 and Unit 15	N/A	Peak = 24 Residual = 15	0	N/A	Typical values for textured geomembrane-geotextile interface
	Unit 15: Textured LLDPE Geomembrane	10	N/A	N/A	N/A	Assumed not to shear internally
	Interface between Unit 15 and Unit 17 or Internal Shearing of Unit 17: GCL	19	Peak = 17 Residual = 7 (slope) – 11 (flat) [1]	0	N/A	Typical range of values based on Zornberg et al (2005)[2], McCartney et al (2009)[3] and Koerner and Narejo (2005)[4]
	Interface between Unit 17 and Unit 4	N/A	23	0	N/A	Reduction Factor of 0.8 applied to Unit 4 friction angle (φ' = tan^{-1}(0.8 tan 28°))
	Unit 4: Compacted Clay Rich Bearing Material (200 mm)	19	28	0	0.25γv[5]	Typical values for clay-rich compacted soil
	Unit 6: Base Material (150 mm) (well, graded, compacted soil)	18	32	0	N/A	Qian et al (2002)[6]
	Interface between Unit 6 and Unit 18	N/A	29	0	N/A	Reduction Factor of 0.9 applied to Unit 6 friction angle (φ' = tan^{-1}(0.9 tan 32°))
	Unit 18: Geogrid	10	N/A	N/A	N/A	Assumed not to shear internally
	Interface between Unit 18 and Unit 6	N/A	29	N/A	N/A	Reduction Factor of 0.9 applied to Unit 6 friction angle (φ' = tan^{-1}(0.9 tan 32°))

[1] Design value for drained friction angle = 14° for particular zone in the Eastern Gully (refer Appendix A, Figure 1)

[2] Zornberg, J.G., McCartney, J.S. & Swan, R.H.(Jr), (March 2005), “Analysis of a Large Database of GCL Internal Shear Strength Results” In *Journal of Geotechnical and Geoenvironmental Engineering*, pp367-380.

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[4] Koerner, G.R. & Narejo, D., (June 2005), “Direct Shear Database of Geosynthetic-to-Geosynthetic and Geosynthetic-to-Soil Interfaces” In Geosynthetic Research Institute Report #30.

[5] Design value for undrained shear strength = 0.25γv where γ = unit weight of overburden (kN/m^3) and v = depth of overburden (m)

[6] Qian, X, Koerner, R.M & Gray, D.H., (2002), *Geotechnical Aspects of Landfill Design and Construction.* Prentice-Hall, Inc., Upper Saddle River, New Jersey.

Liner System	Component/ Interface	Bulk Unit Weight (γ) (kN/m^3)	Drained Friction Angle (φ') (°)	Drained Cohesion (c') (kPa)	Undrained Shear Strength (Cu) (kPa)	Comment
	Unit 6: Base Material (150 mm) (coarse soil)	18	32	0	-	Qian et al (2002)[6]
	Existing cover soil (reshaped, proof - rolled soil)	19	30	0	0.25γv[5]	Typical values
	Interface 1 - Critical Interface within Proposed Piggy Back Liner System [9]	**19**	**Peak = 17 Residual = 7 (slope) – 11 (flat) [1]**	**0**	**N/A**	
Proposed New Cell Liner System	Unit 11: Filter Geotextile	10	N/A	N/A	N/A	Assumed not to shear internally
	Interface between Unit 11 and Unit 7	N/A	25	0	N/A	Assumed typical value
	Unit 7: Drainage Aggregate (300 mm)	18	38	0	N/A	Qian et al (2002)[6]
	Interface between Unit 7 and Unit 12	N/A	25	0	N/A	Assumed typical value
	Unit 12: Cushion Geotextile	10	N/A	N/A	N/A	Assumed not to shear internally
	Interface between Unit 12 and Unit 16	N/A	Peak = 24 Residual = 15	0	N/A	Typical values for textured geomembrane-geotextile interface
	Unit 16: Textured HDPE Geomembrane	10	N/A	N/A	N/A	Assumed not to shear internally
	Interface between Unit 15 and Unit 17 or Internal Shearing of Unit 17: GCL	19	Peak = 17 Residual = 7 - 11[1]	0	N/A	Typical range of values based on Zornberg et al (2005)[2], McCartney et al (2009)[3] and Koerner and Narejo (2005)[4]
	Interface between Unit 17 and Unit 4	N/A	23	N/A	N/A	Reduction Factor of 0.8 applied to Unit 4 friction angle (φ' = tan^{-1}(0.8 tan 28°))
	Unit 4: Compacted Clay Rich Bearing Material (200 mm)	18	28	0	0.25γv[5]	Typical values for clay-rich compacted soil
	Interface 2 - Critical Interface within Proposed Cell Liner System [9]	**19**	**Peak = 17 Residual = 7 (slope) – 11 (flat) [1]**	**0**	**N/A**	
Existing Eastern Gully Landfill Base Liner System (Slope steeper than 4H:1V)	A. Leachate Drainage layer 500mm thick (assume clean sand)	18	38	0	N/A	Qian et al (2002)[6]
	B. Interface between materials A. and C.	N/A	30	0	N/A	Assumed typical published interface shear strength values (eg. Dixon &
	C. Textured HDPE Geomembrane	10	N/A	N/A	N/A	

Liner System	Component/ Interface	Bulk Unit Weight (γ) (kN/m^3)	Drained Friction Angle (φ') (°)	Drained Cohesion (c') (kPa)	Undrained Shear Strength (Cu) (kPa)	Comment
	D. Interface between materials C. and E.	N/A	30	0	N/A	Jones (2003)[7])
	E. Groundwater Drainage layer 500mm thick (assume gravel)	18	38	0	N/A	Qian et al (2002)[6]
	Interface 3 - Critical Interface within Existing Eastern Gully Base Liner System (Slope steeper than 4H:1V) [9]	**19**	**30**	**0**	**N/A**	
Existing Eastern Gully Landfill Base Liner System (Slope shallower than 4H:1V)	A. Protective layer 300mm thick (assume coarse soil)	19	32	0	N/A	Qian et al (2002)[6]
	B. Leachate Drainage layer 300mm thick (assume clean sand)	18	38	0	N/A	Qian et al (2002)[6]
	C. Interface between materials B. and D.	N/A	18	0	N/A	Assumed typical published interface shear strength values (eg. Dixon & Jones (2003)[7])
	D. Smooth HDPE Geomembrane	10	N/A	N/A	N/A	
	E. Interface between materials D. and F.	N/A	18	0	N/A	
	F. Groundwater Drainage layer 500mm thick (assume gravel)	18	38	0	N/A	Qian et al (2002)[6]
	Interface 4 - Critical Interface within Existing Eastern Gully Base Liner System (Slope shallower than 4H:1V) [9]	**19**	**18**	**0**	**N/A**	

[7] Dixon, N. & Jones, D.R.V. (Golder Associates (UK) Ltd and Loughborough University Consultants Ltd.), (2003). *Stability of Landfill Lining Systems: Report No. 2 Guidance* (R&D Technical Report P1-385/TR2). Environmental Agency, Bristol.

APPENDIX B2 - SLOPE STABILITY ANALYSIS REGISTER

Client: Wollongong City Council
Project No: 117625003
Project: Whytes Gully Landfill - New Landfill Cell
Reference: 117625003_059_R_Rev0-Interpretive Geotechnical Report

Analysed Cross-Section	Analysis	Target FoS	Calculated FoS	Checked By	Figure Number	Comments
Section E-E'	CR through New Landfill DR (P)	1.5	2.99	CSC	B3.1	CR through New LF (Entry & Exit method selected to focus on failure through waste & confirmed by a selection of fully specified failure paths)
	CR through New Landfill UD & EQ (P)	1.1	2.41	CSC	B3.2	CR through New LF (selection of fully specified failure paths to focus on failure through waste)
	NC along Proposed Liner DR (P)	1.5	1.80	CSC	B3.3	Block failure along proposed liner at toe
	NC along Proposed Liner UD & EQ (P)	1.1	1.47	CSC	B3.4	Block failure along proposed liner at toe
	NC along Proposed Liner DR (R)	1.2^	1.35	CSC	B3.5	Block failure along proposed liner at toe
	NC along Proposed Liner UD & EQ (R)	1.0	1.10	CSC	B3.6	Block failure along proposed liner at toe
	CR below Old Landfill DR*	1.5	2.29	CSC	B3.7	CR through natural soil below LF (selection of fully specified failure paths to focus on failure below waste)
	CR below Old Landfill UD & EQ	1.1	1.67	CSC	B3.8	CR through natural soil below LF (selection of fully specified failure paths to focus on failure below waste)
Section F-F'	NC along Proposed Liner DR (P)	1.5	2.06	CSC	B3.9	Block failure at toe along proposed liner
	NC along Proposed Liner UD & EQ (P)	1.1	1.45	CSC	B3.10	Block failure at toe along proposed liner
	NC along Proposed Liner DR (R)	1.2^	1.49	CSC	B3.11	Block failure at toe along proposed liner
	NC along Proposed Liner UD & EQ (R)	1.0	1.06	CSC	B3.12	Block failure at toe along proposed liner
	CR through Old Landfill DR	1.5	2.87	CSC	B3.13	CR through New LF (Entry & Exit method selected to focus on failure through waste & confirmed by a selection of fully specified failure paths)
	CR through Old Landfill UD & EQ	1.1	2.23	CSC	B3.14	CR through New LF (selection of fully specified failure paths to focus on failure through waste - still optimises along liner)
	CR below Old Landfill DR*	1.5	2.09	CSC	B3.15	CR through natural soil under toe of new LF
	CR below Old Landfill UD & EQ	1.1	1.25	CSC	B3.16	CR through natural soil under toe of new LF
Section G-G'	CR through New Landfill DR (P)	1.5	2.66	CSC	B3.17	CR through New LF (Entry & Exit method selected to focus on failure through waste & confirmed by a selection of fully specified failure paths)
	CR through New Landfill UD & EQ (P)	1.1	2.14	CSC	B3.18	CR through New LF (Entry & Exit method selected to focus on failure through waste)
	NC along Proposed Liner DR (P)	1.5	1.96	CSC	B3.19	Block failure at toe along proposed liner
	NC along Proposed Liner UD & EQ (P)	1.1	1.60	CSC	B3.20	Block failure at toe along proposed liner
	NC along Proposed Liner DR (R)	1.2^	1.24	CSC	B3.21	Block failure at toe along proposed liner
	NC along Proposed Liner UD & EQ (R)	1.0	1.18	CSC	B3.22	Block failure at toe along proposed liner
	NC below Old Landfill DR (P)	1.5	1.66	CSC	B3.23	Block failure along natural soil under proposed liner (selection of block & fully specified analyses)
	NC below Old Landfill UD & EQ (P)	1.1	1.31	CSC	B3.24	Large scale block failure along natural soil under proposed liner (selection of block & fully specified analyses)
Section H-H'	NC along Proposed Liner DR (P)	1.5	1.51	CSC	B3.25	Block failure at toe along proposed liner
	NC along Proposed Liner UD & EQ (P)	1.1	1.24	CSC	B3.26	Block failure at toe along proposed liner
	NC along Proposed Liner DR (R)	1.2^	1.24	CSC	B3.27	Block failure at toe along proposed liner
	NC along Proposed Liner UD & EQ (R)	1.0	1.01	CSC	B3.28	Block failure at toe along proposed liner
	CR through Old Landfill DR	1.5	3.10	CSC	B3.29	CR through Old LF (Entry & Exit method selected to focus on failure through waste & confirmed by a selection of fully specified failure paths)
	CR through Old Landfill UD & EQ	1.1	2.50	CSC	B3.30	CR through Old LF (Entry & Exit method selected to focus on
	NC along Existing Liner DR	1.5	1.99	CSC	B3.31	Large block failure at toe along existing liner
	NC along Existing Liner UD & EQ	1.1	1.63	CSC	B3.32	Large block failure at toe along existing liner

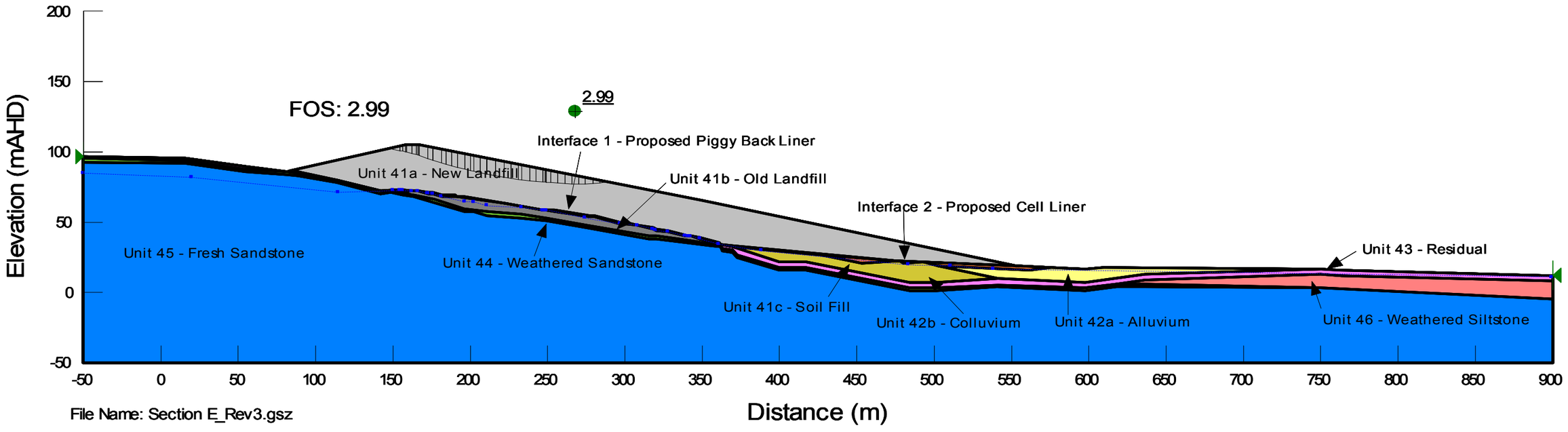
Notes:
CR: Circular
NC: Non-Circular
DR: Drained (Long-term)
UN: Undrained
EQ: Earthquake
P: Peak interface shear strength (liner)
R: Residual interface shear strength (liner)
^ Factor of Saftey of 1.2 adopted for long-term (drained) scenarios where failure occurs along the proposed liner at residual shear strength conditions. Note that residual conditions are unlikely to develop across all areas of the liner simultaneously.
Results based on optimised Spencer limit equilibrium analyses, unless optimised slip appeared kinematically inadmissable (*).
For ease of modelling, all liner layers are characterised by the shear strength properties of the critical interface.
Earthquake loading assumes a horizontal acceleration of 0.045g (refer Section 5.2.2 of main report).
A 5 m limit of slip surface depth was added to the Landfill mass to prevent SlopeW converging on shallow veneer failures as required.

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Whytes Gully SlopeW - Section E-E'

Name: CR through New Landfill_DR

Name: Unit 41a - New Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Unit 41c - Soil Fill Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 26 °
Name: Unit 42a - Alluvium Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 25 °
Name: Unit 42b - Colluvium Model: Mohr-Coulomb Unit Weight: 18 kN/m³ Cohesion: 5 kPa Phi: 27 °
Name: Unit 43 - Residual Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 5 kPa Phi: 30 °
Name: Unit 44 - Weathered Sandstone Model: Mohr-Coulomb Unit Weight: 24 kN/m³ Cohesion: 40 kPa Phi: 38 °
Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable)
Name: Unit 46 - Weathered Siltstone Model: Mohr-Coulomb Unit Weight: 23 kN/m³ Cohesion: 20 kPa Phi: 36 °
Name: Interface 1 - Proposed Piggy Back Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 °
Name: Interface 2 - Proposed Cell Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 °



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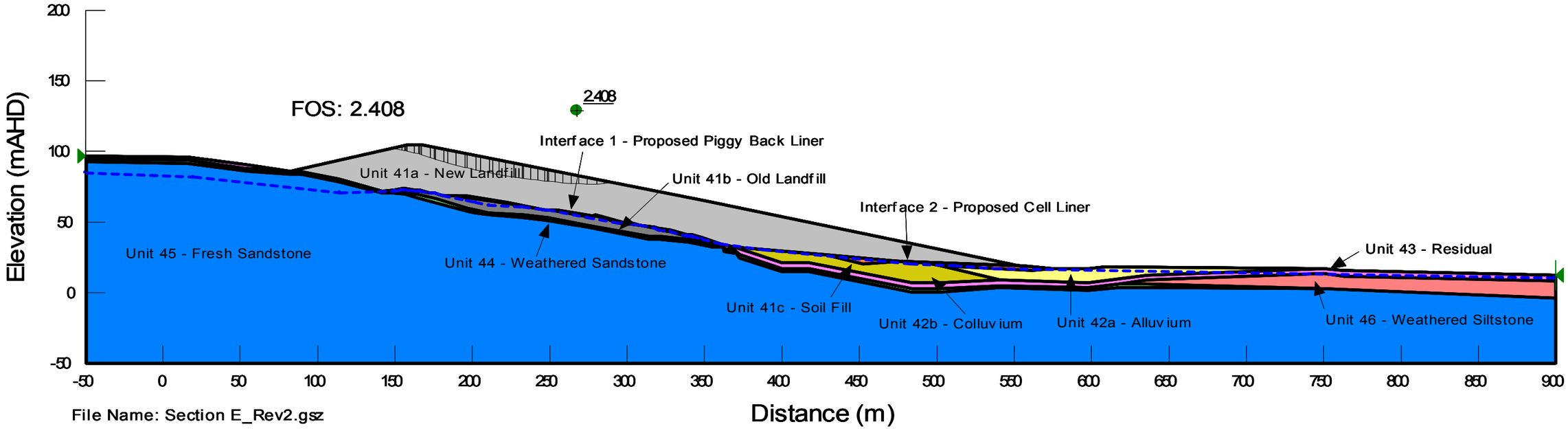
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	DRAWN: PR	DATE: 29/02/12	TITLE: Section E-E'		
	CHECKED: CSC	DATE: 1/03/12	Circular through New Landfill - Long-term		
	SCALE: As shown		PROJECT No. 117625003	FIGURE No. **B3.1**	A3

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Whytes Gully SlopeW - Section E-E'

Name: CR through New Landfill_UD & EQ

Name: Unit 41a - New Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Unit 41c - Soil Fill Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 0 kPa Phi: 26 °
Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable)
Name: Interface 1 - Proposed Piggy Back Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 °
Name: Interface 2 - Proposed Cell Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 °
Name: Unit 42a - Alluvium (UD) Model: S=f(overburden) Unit Weight: 17 kN/m³ Tau/Sigma Ratio: 0.25 Minimum Strength: 25
Name: Unit 42b - Colluvium (UD) Model: S=f(depth) Unit Weight: 18 kN/m³ C-Top of Layer: 100 kPa C-Rate of Change: 10 kPa/m Limiting C: 1000 kPa
Name: Unit 43 - Residual (UD) Model: Undrained (Phi=0) Unit Weight: 20 kN/m³ Cohesion: 130 kPa
Name: Unit 44 - Weathered Sandstone (UD) Model: Undrained (Phi=0) Unit Weight: 24 kN/m³ Cohesion: 1000 kPa
Name: Unit 46 - Weathered Siltstone (UD) Model: Undrained (Phi=0) Unit Weight: 23 kN/m³ Cohesion: 750 kPa



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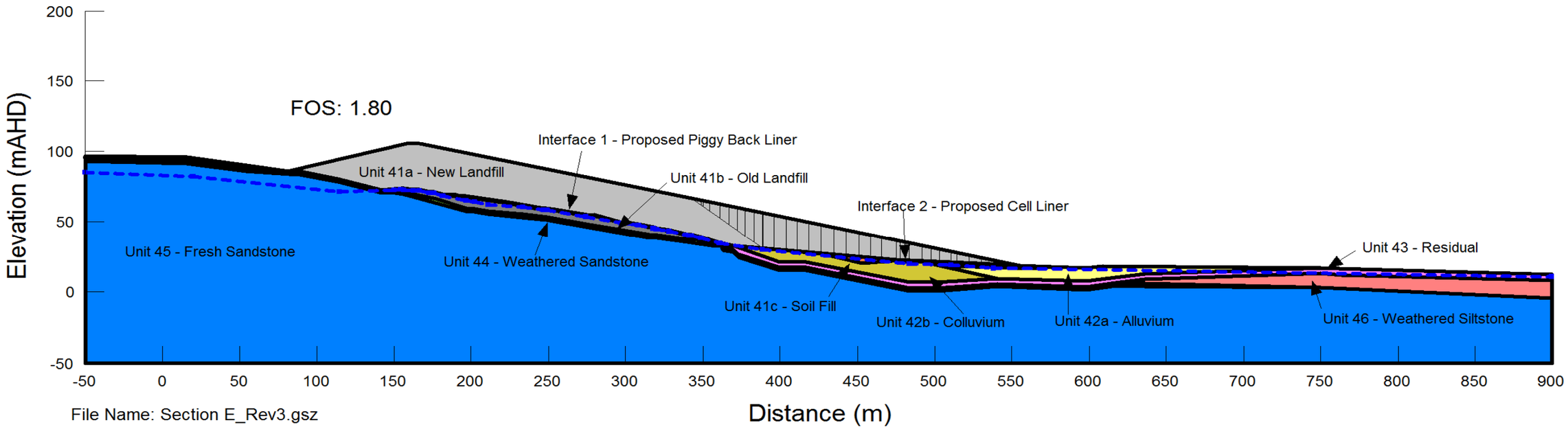
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	DRAWN: PR	DATE: 17/01/12	TITLE: Section E-E'	
	CHECKED: CSC	DATE: 17/01/12	Circular through New Landfill - Earthquake	
	SCALE: As shown		PROJECT No. 117625003	FIGURE No. **B3.2** A3

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Whytes Gully SlopeW - Section E-E'

Name: NC along Proposed Liner_DR (P)

Name: Unit 41a - New Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Unit 41c - Soil Fill Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 26 °
Name: Unit 42a - Alluvium Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 25 °
Name: Unit 42b - Colluvium Model: Mohr-Coulomb Unit Weight: 18 kN/m³ Cohesion: 5 kPa Phi: 27 °
Name: Unit 43 - Residual Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 5 kPa Phi: 30 °
Name: Unit 44 - Weathered Sandstone Model: Mohr-Coulomb Unit Weight: 24 kN/m³ Cohesion: 40 kPa Phi: 38 °
Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable)
Name: Unit 46 - Weathered Siltstone Model: Mohr-Coulomb Unit Weight: 23 kN/m³ Cohesion: 20 kPa Phi: 36 °
Name: Interface 1 - Proposed Piggy Back Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 °
Name: Interface 2 - Proposed Cell Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 °



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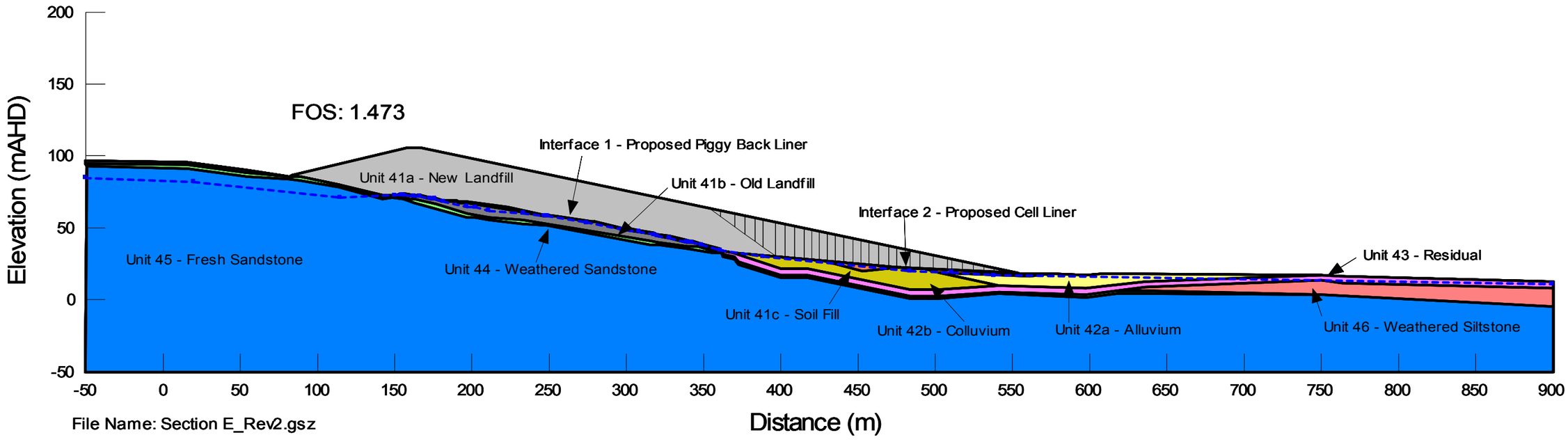
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	DRAWN: PR	DATE: 17/01/12	TITLE: Section E-E'		
	CHECKED: CSC	DATE: 17/01/12	Non-circular along Proposed Liner (Peak) - Long-term		
	SCALE: As shown		PROJECT No. 117625003	FIGURE No. **B3.3**	A3

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Whytes Gully SlopeW - Section E-E'

Name: NC along Proposed Liner_UD & EQ (P)

Name: Unit 41a - New Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Unit 41c - Soil Fill Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 0 kPa Phi: 26 °
Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable)
Name: Interface 1 - Proposed Piggy Back Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 °
Name: Interface 2 - Proposed Cell Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 °
Name: Unit 42a - Alluvium (UD) Model: S=f(overburden) Unit Weight: 17 kN/m³ Tau/Sigma Ratio: 0.25 Minimum Strength: 25
Name: Unit 42b - Colluvium (UD) Model: S=f(depth) Unit Weight: 18 kN/m³ C-Top of Layer: 100 kPa C-Rate of Change: 10 kPa/m Limiting C: 1000 kPa
Name: Unit 43 - Residual (UD) Model: Undrained (Phi=0) Unit Weight: 20 kN/m³ Cohesion: 130 kPa
Name: Unit 44 - Weathered Sandstone (UD) Model: Undrained (Phi=0) Unit Weight: 24 kN/m³ Cohesion: 1000 kPa
Name: Unit 46 - Weathered Siltstone (UD) Model: Undrained (Phi=0) Unit Weight: 23 kN/m³ Cohesion: 750 kPa



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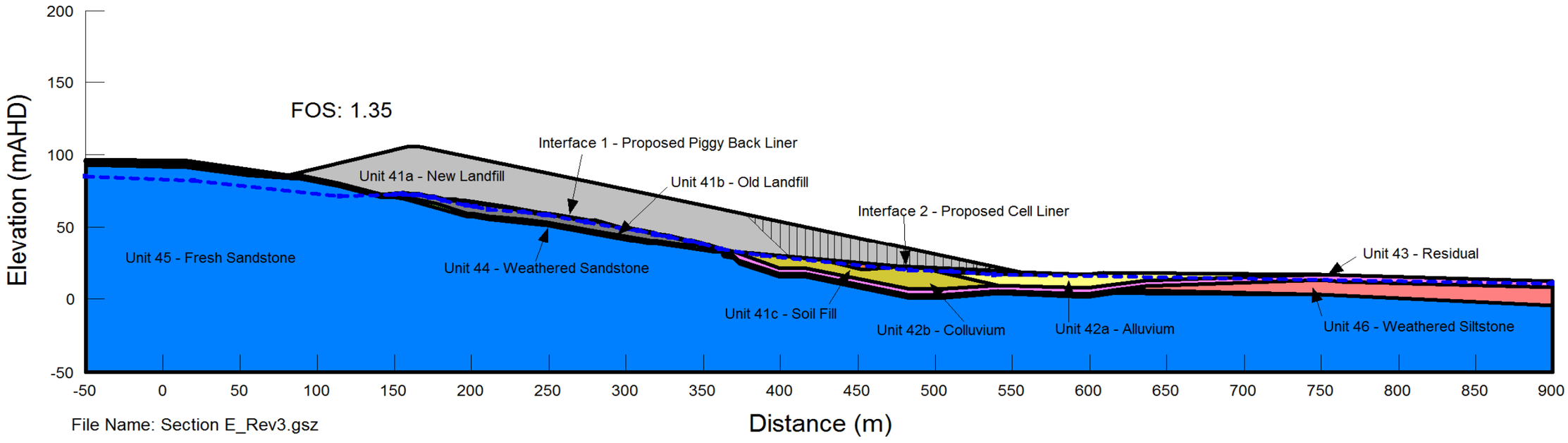
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	CHECKED: CSC	DATE: 17/01/12	Non-circular along Proposed Liner (Peak) - Earthquake	
	SCALE: As shown		PROJECT No. 117625003	FIGURE No. **B3.4** A3

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Whytes Gully SlopeW - Section E-E'

Name: NC along Proposed Liner_DR (R)

Name: Unit 41a - New Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Unit 41c - Soil Fill Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 26 °
Name: Unit 42a - Alluvium Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 25 °
Name: Unit 42b - Colluvium Model: Mohr-Coulomb Unit Weight: 18 kN/m³ Cohesion: 5 kPa Phi: 27 °
Name: Unit 43 - Residual Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 5 kPa Phi: 30 °
Name: Unit 44 - Weathered Sandstone Model: Mohr-Coulomb Unit Weight: 24 kN/m³ Cohesion: 40 kPa Phi: 38 °
Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable)
Name: Unit 46 - Weathered Siltstone Model: Mohr-Coulomb Unit Weight: 23 kN/m³ Cohesion: 20 kPa Phi: 36 °
Name: Interface 1 - Proposed Piggy Back Liner System (Residual - Slopes) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 7 °
Name: Interface 2 - Proposed Cell Liner System (Residual - Slopes) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 7 °
Name: Interface 2 - Proposed Cell Liner System (Residual - Flat) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 11 °



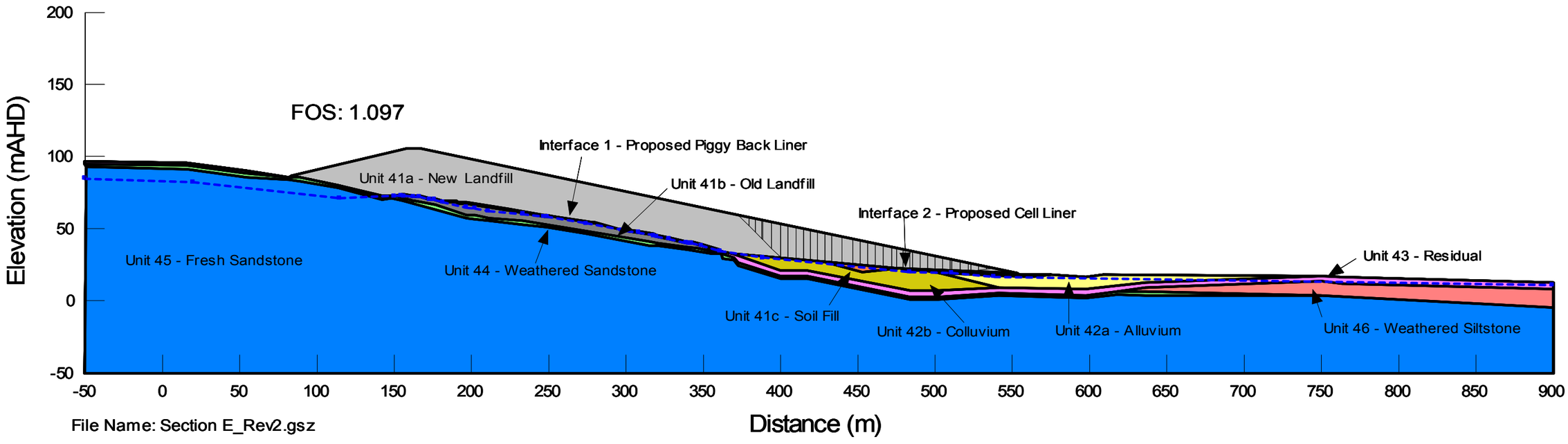
Golder Associates	CLIENT: Wollongong City Council		PROJECT: **Whytes Gully RRP - Interpretative Geotechnical Report for 50% Design**	
	DRAWN: PR	DATE: 17/01/12	TITLE: Section E-E'	
	CHECKED: CSC	DATE: 17/01/12	Non-circular along Proposed Liner (Residual) - Long-term	
	SCALE: As shown		PROJECT No. 117625003	FIGURE No. **B3.5** A3

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Whytes Gully SlopeW - Section E-E'

Name: NC along Proposed Liner_UD & EQ (R)

Name: Unit 41a - New Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Unit 41c - Soil Fill Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 0 kPa Phi: 26 °
Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable)
Name: Interface 1 - Proposed Piggy Back Liner System (Residual - Slopes) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 7 °
Name: Interface 2 - Proposed Cell Liner System (Residual - Slopes) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 7 °
Name: Unit 42a - Alluvium (UD) Model: S=f(overburden) Unit Weight: 17 kN/m³ Tau/Sigma Ratio: 0.25 Minimum Strength: 25
Name: Unit 42b - Colluvium (UD) Model: S=f(depth) Unit Weight: 18 kN/m³ C-Top of Layer: 100 kPa C-Rate of Change: 10 kPa/m Limiting C: 1000 kPa
Name: Unit 43 - Residual (UD) Model: Undrained (Phi=0) Unit Weight: 20 kN/m³ Cohesion: 130 kPa
Name: Unit 44 - Weathered Sandstone (UD) Model: Undrained (Phi=0) Unit Weight: 24 kN/m³ Cohesion: 1000 kPa
Name: Unit 46 - Weathered Siltstone (UD) Model: Undrained (Phi=0) Unit Weight: 23 kN/m³ Cohesion: 750 kPa
Name: Interface 2 - Proposed Cell Liner System (Residual - Flat) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 11 °



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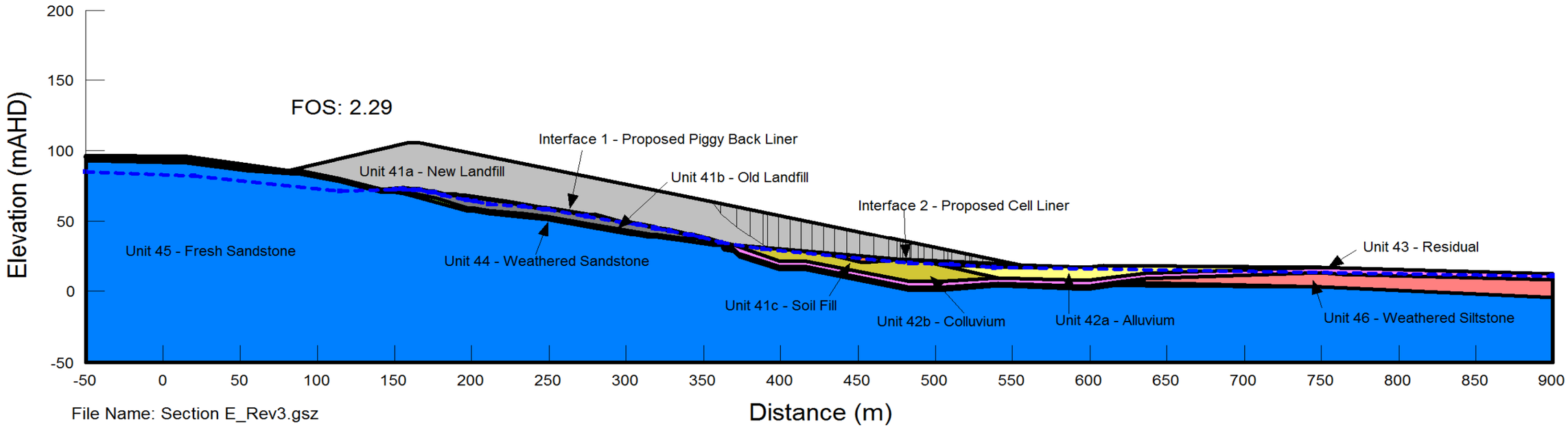
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	CHECKED: CSC	DATE: 17/01/12			
	SCALE: As shown		PROJECT No. 117625003	FIGURE No. **B3.6**	A3

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Whytes Gully SlopeW - Section E-E'

Name: Below Old Landfill_DR

Name: Unit 41a - New Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Unit 41c - Soil Fill Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 26 °
Name: Unit 42a - Alluvium Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 25 °
Name: Unit 42b - Colluvium Model: Mohr-Coulomb Unit Weight: 18 kN/m³ Cohesion: 5 kPa Phi: 27 °
Name: Unit 43 - Residual Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 5 kPa Phi: 30 °
Name: Unit 44 - Weathered Sandstone Model: Mohr-Coulomb Unit Weight: 24 kN/m³ Cohesion: 40 kPa Phi: 38 °
Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable)
Name: Unit 46 - Weathered Siltstone Model: Mohr-Coulomb Unit Weight: 23 kN/m³ Cohesion: 20 kPa Phi: 36 °
Name: Interface 1 - Proposed Piggy Back Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 °
Name: Interface 2 - Proposed Cell Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 °



File Name: Section E_Rev3.gsz

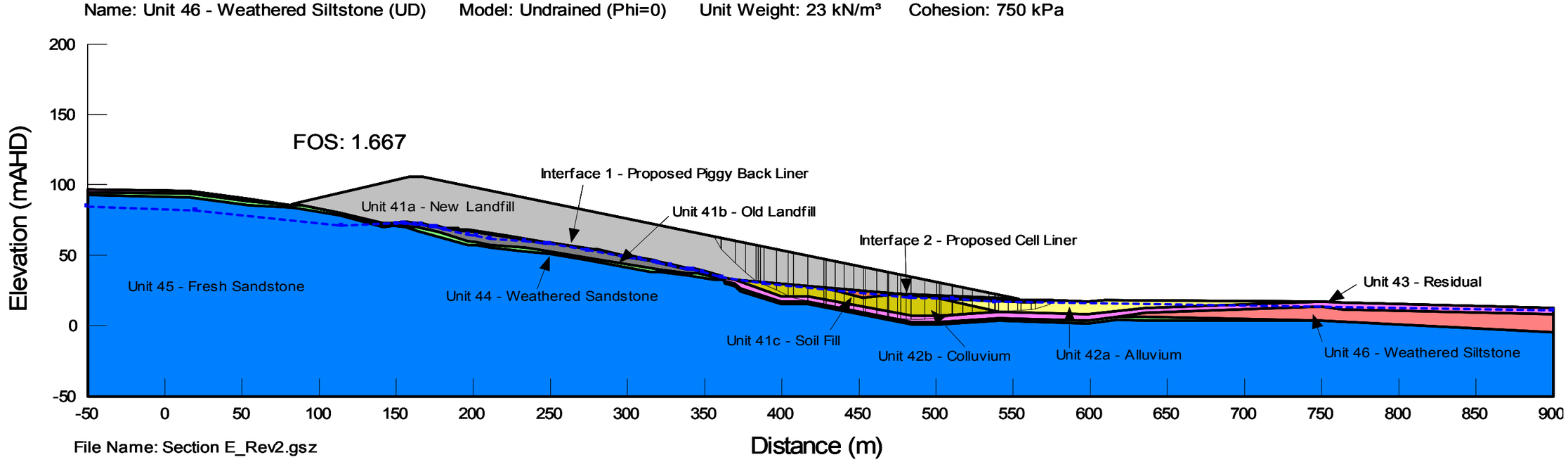
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	DRAWN: PR	DATE: 17/01/12	TITLE: Section E-E'	
	CHECKED: CSC	DATE: 17/01/12	Circular below Old Landfill - Long-term	
	SCALE: As shown		PROJECT No. 117625003	FIGURE No. **B3.7** A3

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Whytes Gully SlopeW - Section E-E'

Name: Below Old Landfill_UD & EQ

Name: Unit 41a - New Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Unit 41c - Soil Fill Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 0 kPa Phi: 26 °
Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable)
Name: Interface 1 - Proposed Piggy Back Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 °
Name: Interface 2 - Proposed Cell Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 °
Name: Unit 42a - Alluvium (UD) Model: S=f(overburden) Unit Weight: 17 kN/m³ Tau/Sigma Ratio: 0.25 Minimum Strength: 25
Name: Unit 42b - Colluvium (UD) Model: S=f(depth) Unit Weight: 18 kN/m³ C-Top of Layer: 100 kPa C-Rate of Change: 10 kPa/m Limiting C: 1000 kPa
Name: Unit 43 - Residual (UD) Model: Undrained (Phi=0) Unit Weight: 20 kN/m³ Cohesion: 130 kPa
Name: Unit 44 - Weathered Sandstone (UD) Model: Undrained (Phi=0) Unit Weight: 24 kN/m³ Cohesion: 1000 kPa
Name: Unit 46 - Weathered Siltstone (UD) Model: Undrained (Phi=0) Unit Weight: 23 kN/m³ Cohesion: 750 kPa



File Name: Section E_Rev2.gsz

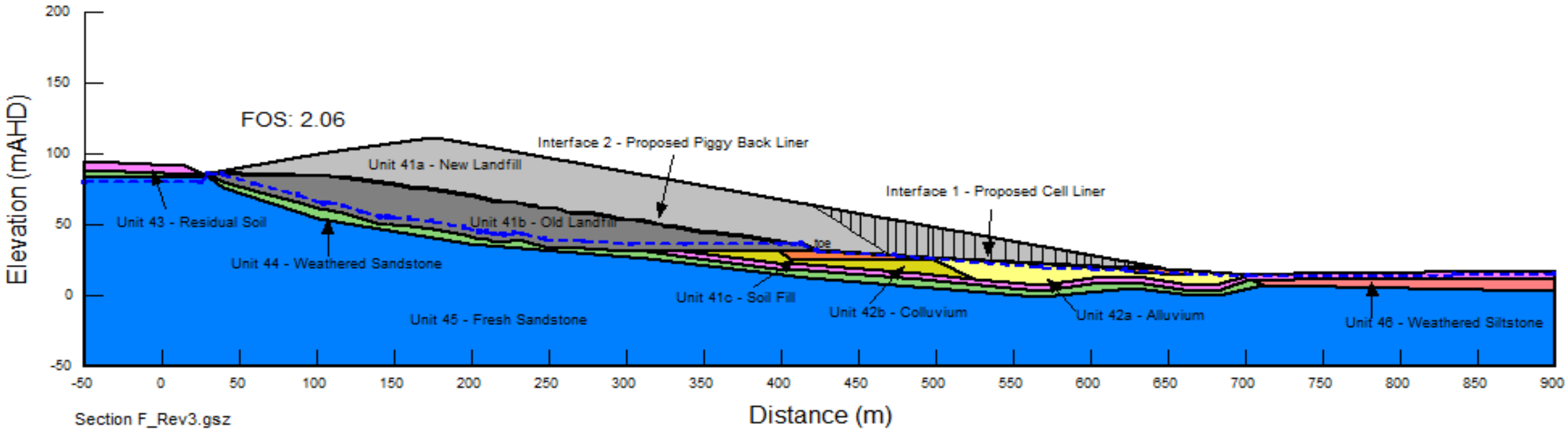
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	DRAWN: PR	DATE: 17/01/12	TITLE: Section E-E'	
	CHECKED: CSC	DATE: 17/01/12	Circular below Old Landfill - Earthquake	
	SCALE: As shown		PROJECT No. 117625003	FIGURE No. **B3.8** A3

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Whytes Gully SlopeW - Section F-F'

Name: NC along Proposed Liner_DR (P)

Name: Unit 41a - New Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Unit 41c - Soil Fill Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 26 °
Name: Unit 42a - Alluvium Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 25 °
Name: Unit 42b - Colluvium Model: Mohr-Coulomb Unit Weight: 18 kN/m³ Cohesion: 5 kPa Phi: 27 °
Name: Unit 43 - Residual Soil Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 5 kPa Phi: 30 °
Name: Unit 44 - Weathered Sandstone Model: Mohr-Coulomb Unit Weight: 24 kN/m³ Cohesion: 40 kPa Phi: 38 °
Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable)
Name: Unit 46 - Weathered Siltstone Model: Mohr-Coulomb Unit Weight: 23 kN/m³ Cohesion: 20 kPa Phi: 36 °
Name: Interface 2 - Proposed Cell Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 °
Name: Interface 1 - Proposed Piggy Back Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 °



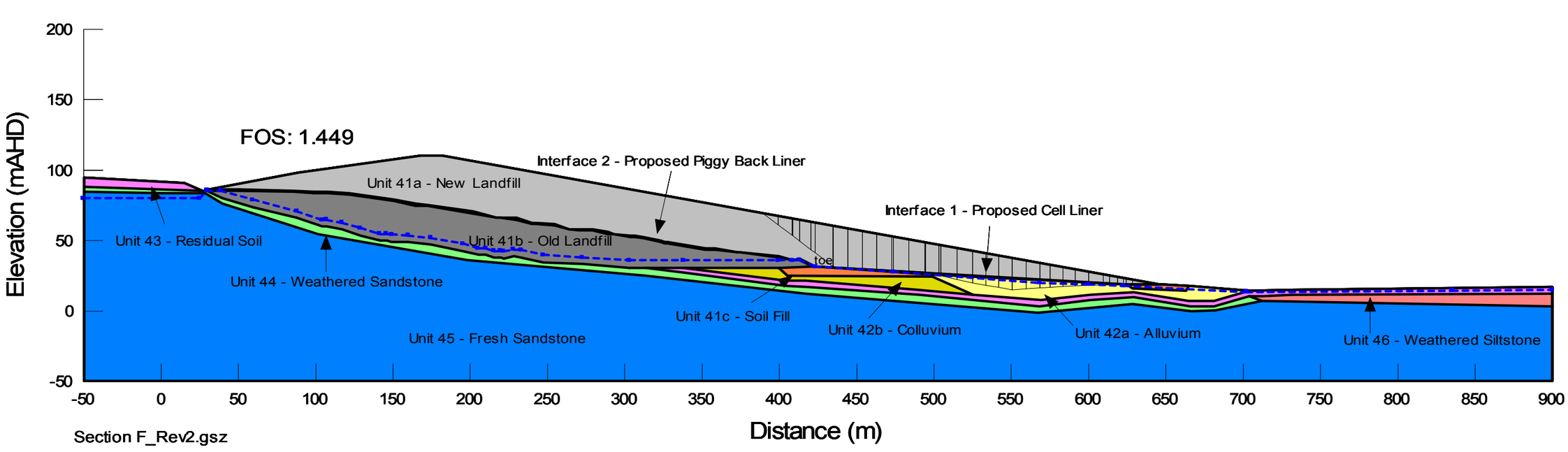
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	DRAWN: PR	DATE: 17/01/12	TITLE: Section F-F'	
	CHECKED: CSC	DATE: 17/01/12	Non-circular along Proposed Liner (Peak) - Long-term	
	SCALE: As shown		PROJECT No. 117625003	FIGURE No. **B3.9** A3

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Whytes Gully SlopeW - Section F-F'

Name: NC along Proposed Liner_UD & EQ (P)

Name: Unit 41a - New Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Unit 41c - Soil Fill Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 0 kPa Phi: 26 °
Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable)
Name: Interface 2 - Proposed Cell Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 °
Name: Interface 1 - Proposed Piggy Back Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 °
Name: Unit 42b - Colluvium (UD) Model: S=f(depth) Unit Weight: 18 kN/m³ C-Top of Layer: 100 kPa C-Rate of Change: 10 kPa/m Limiting C: 1000 kPa
Name: Unit 43 - Residual Soil (UD) Model: Undrained (Phi=0) Unit Weight: 20 kN/m³ Cohesion: 130 kPa
Name: Unit 44 - Weathered Sandstone (UD) Model: Undrained (Phi=0) Unit Weight: 24 kN/m³ Cohesion: 1000 kPa
Name: Unit 46 - Weathered Siltstone (UD) Model: Undrained (Phi=0) Unit Weight: 23 kN/m³ Cohesion: 750 kPa
Name: Unit 42a - Alluvium (UD) Model: S=f(overburden) Unit Weight: 17 kN/m³ Tau/Sigma Ratio: 0.25 Minimum Strength: 25



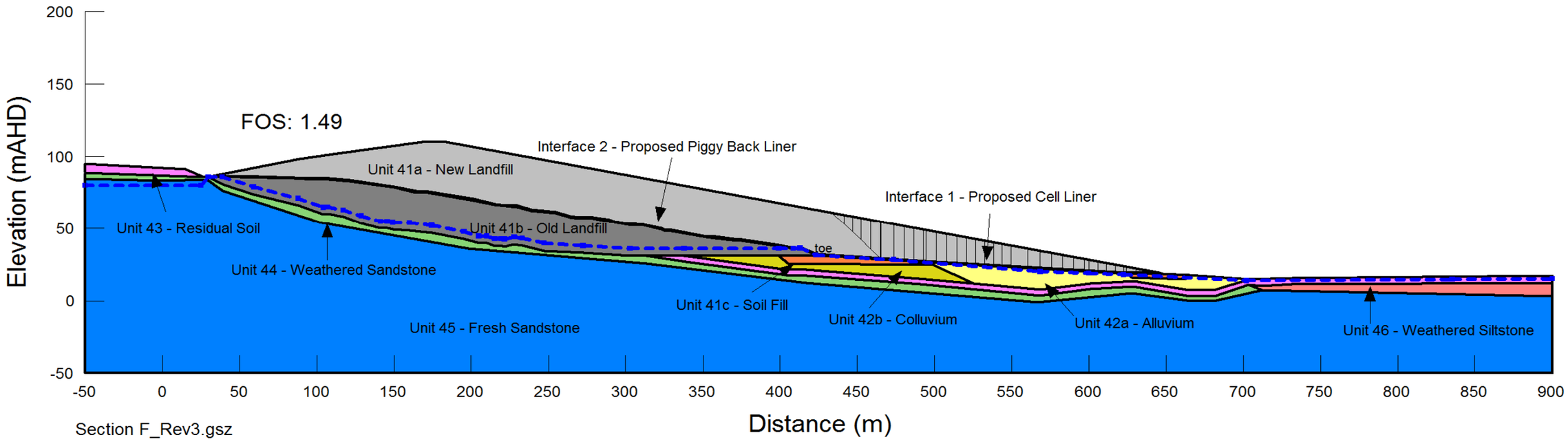
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DRAWN: PR	DATE: 17/01/12	TITLE: Section F-F'	
CHECKED: CSC	DATE: 17/01/12	Non-circular along Proposed Liner (Peak) - Earthquake	
SCALE: As shown		PROJECT No. 117625003	FIGURE No. B3.10 A3

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Whytes Gully SlopeW - Section F-F'

Name: NC along Proposed Liner_DR (R)

Name: Unit 41a - New Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Unit 41c - Soil Fill Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 26 °
Name: Unit 42a - Alluvium Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 25 °
Name: Unit 42b - Colluvium Model: Mohr-Coulomb Unit Weight: 18 kN/m³ Cohesion: 5 kPa Phi: 27 °
Name: Unit 43 - Residual Soil Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 5 kPa Phi: 30 °
Name: Unit 44 - Weathered Sandstone Model: Mohr-Coulomb Unit Weight: 24 kN/m³ Cohesion: 40 kPa Phi: 38 °
Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable)
Name: Unit 46 - Weathered Siltstone Model: Mohr-Coulomb Unit Weight: 23 kN/m³ Cohesion: 20 kPa Phi: 36 °
Name: Interface 1 - Proposed Piggy Back Liner System (Residual - Slopes) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 7 °
Name: Interface 2 - Proposed Cell Liner System (Residual - Flat) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 11 °



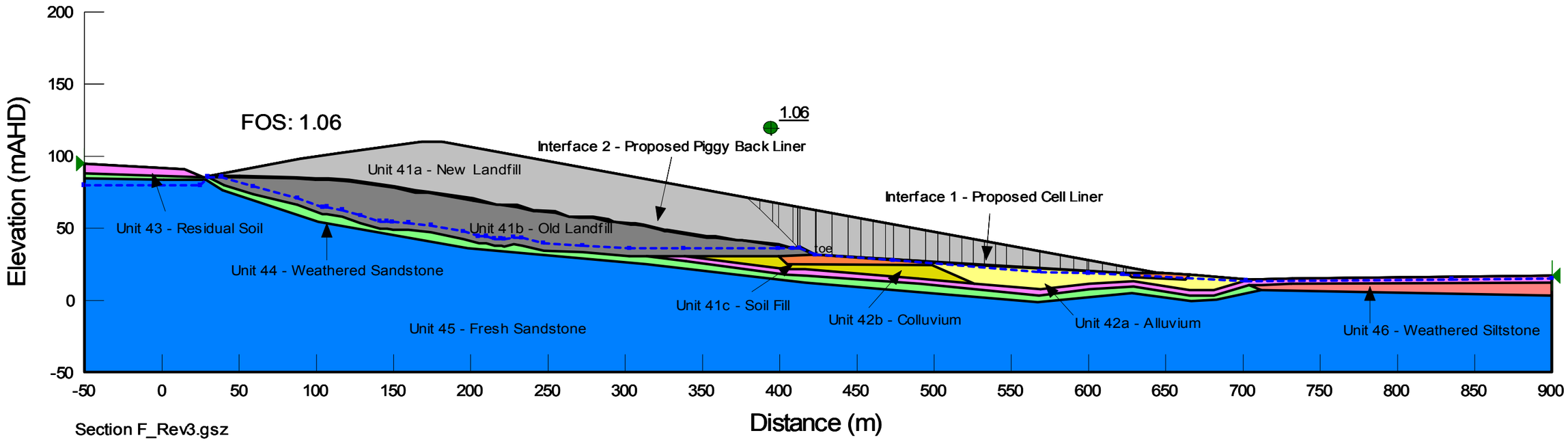
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	DRAWN: PR	DATE: 17/01/12	TITLE: Section F-F'		
	CHECKED: CSC	DATE: 17/01/12	Non-circular along Proposed Liner (Residual) - Earthquake		
	SCALE: As shown		PROJECT No. 117625003	FIGURE No. **B3.11**	A3

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Whytes Gully SlopeW - Section F-F'

Name: NC along Proposed Liner_UD & EQ (R) (CSC)

Name: Unit 41a - New Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Unit 41c - Soil Fill Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 26 °
Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable)
Name: Interface 1 - Proposed Piggy Back Liner System (Residual - Slopes) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 7 °
Name: Unit 42b - Colluvium (UD) Model: S=f(depth) Unit Weight: 18 kN/m³ C-Top of Layer: 100 kPa C-Rate of Change: 10 kPa/m Limiting C: 1000 kPa
Name: Unit 43 - Residual Soil (UD) Model: Undrained (Phi=0) Unit Weight: 20 kN/m³ Cohesion: 130 kPa
Name: Unit 44 - Weathered Sandstone (UD) Model: Undrained (Phi=0) Unit Weight: 24 kN/m³ Cohesion: 1000 kPa
Name: Unit 46 - Weathered Siltstone (UD) Model: Undrained (Phi=0) Unit Weight: 23 kN/m³ Cohesion: 750 kPa
Name: Unit 42a - Alluvium (UD) Model: S=f(overburden) Unit Weight: 17 kN/m³ Tau/Sigma Ratio: 0.25 Minimum Strength: 25
Name: Interface 2 - Proposed Cell Liner System (Residual - Flat) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 11 °



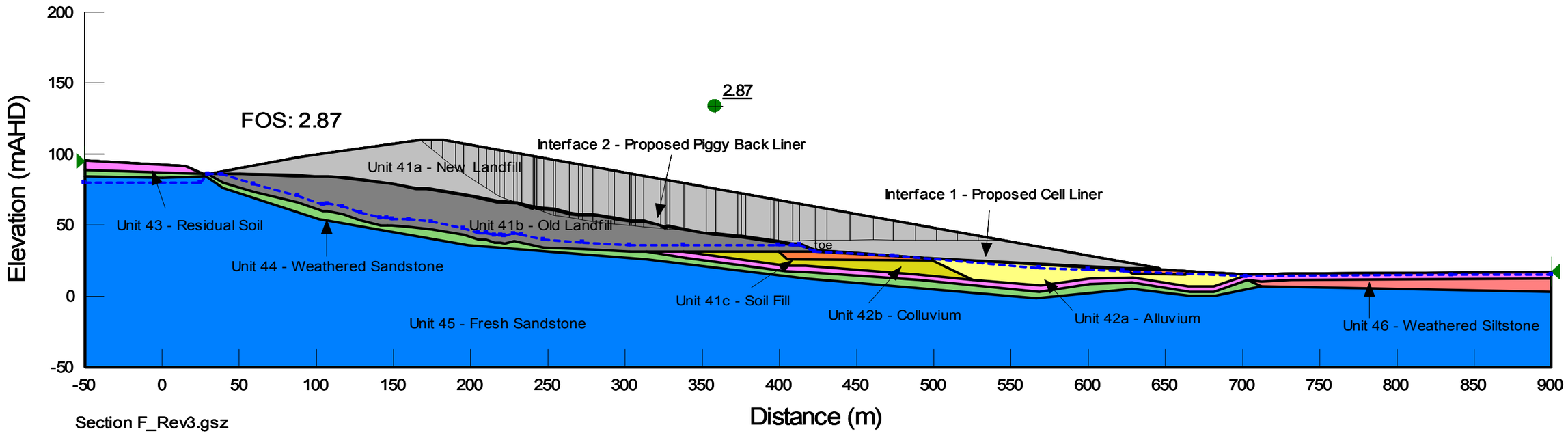
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	CHECKED: CSC	DATE: 1/03/12	Non-circular along Proposed Liner (Residual) - Earthquake		
	SCALE: As shown		PROJECT No. 117625003	FIGURE No. **B3.12**	A3

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Whytes Gully SlopeW - Section F-F'

Name: CR through Old Landfill_DR

Name: Unit 41a - New Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Unit 41c - Soil Fill Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 26 °
Name: Unit 42a - Alluvium Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 25 °
Name: Unit 42b - Colluvium Model: Mohr-Coulomb Unit Weight: 18 kN/m³ Cohesion: 5 kPa Phi: 27 °
Name: Unit 43 - Residual Soil Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 5 kPa Phi: 30 °
Name: Unit 44 - Weathered Sandstone Model: Mohr-Coulomb Unit Weight: 24 kN/m³ Cohesion: 40 kPa Phi: 38 °
Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable)
Name: Unit 46 - Weathered Siltstone Model: Mohr-Coulomb Unit Weight: 23 kN/m³ Cohesion: 20 kPa Phi: 36 °
Name: Interface 2 - Proposed Cell Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 °
Name: Interface 1 - Proposed Piggy Back Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 °



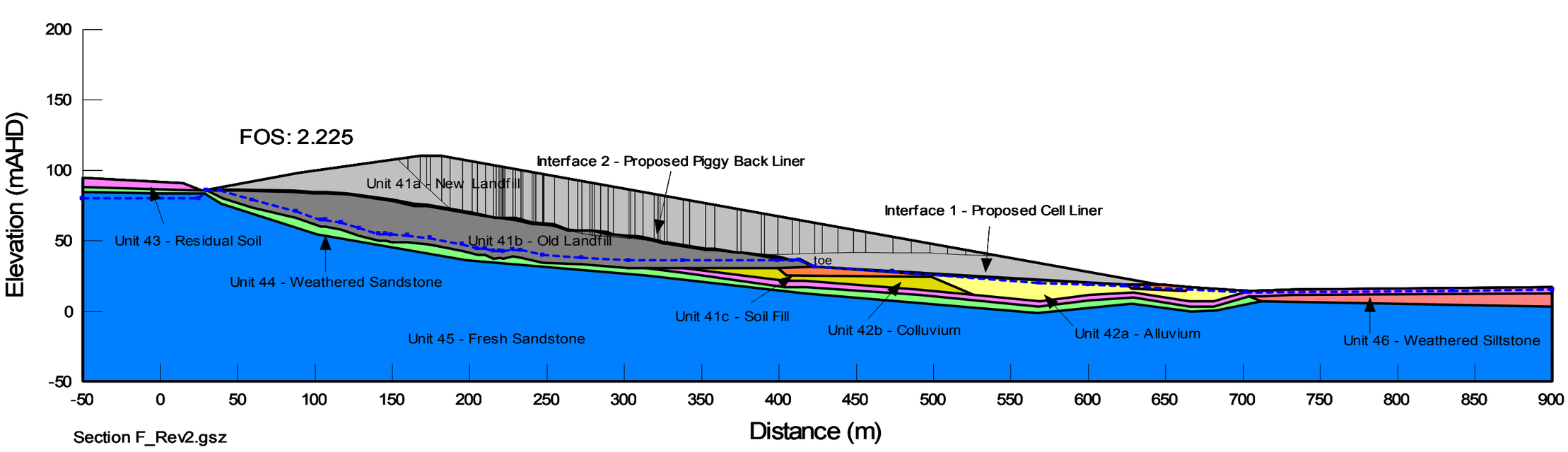
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	DRAWN: PR / DATE: 29/02/12	TITLE: Section F-F'	
	CHECKED: CSC / DATE: 1/03/12	Circular through Old Landfill - Long-term	
	SCALE: As shown	PROJECT No. 117625003	FIGURE No. **B3.13** A3

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Whytes Gully SlopeW - Section F-F'

Name: CR through Old Landfill_UD & EQ

Name: Unit 41a - New Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Unit 41c - Soil Fill Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 0 kPa Phi: 26 °
Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable)
Name: Interface 2 - Proposed Cell Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 °
Name: Interface 1 - Proposed Piggy Back Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 °
Name: Unit 42b - Colluvium (UD) Model: S=f(depth) Unit Weight: 18 kN/m³ C-Top of Layer: 100 kPa C-Rate of Change: 10 kPa/m Limiting C: 1000 kPa
Name: Unit 43 - Residual Soil (UD) Model: Undrained (Phi=0) Unit Weight: 20 kN/m³ Cohesion: 130 kPa
Name: Unit 44 - Weathered Sandstone (UD) Model: Undrained (Phi=0) Unit Weight: 24 kN/m³ Cohesion: 1000 kPa
Name: Unit 46 - Weathered Siltstone (UD) Model: Undrained (Phi=0) Unit Weight: 23 kN/m³ Cohesion: 750 kPa
Name: Unit 42a - Alluvium (UD) Model: S=f(overburden) Unit Weight: 17 kN/m³ Tau/Sigma Ratio: 0.25 Minimum Strength: 25



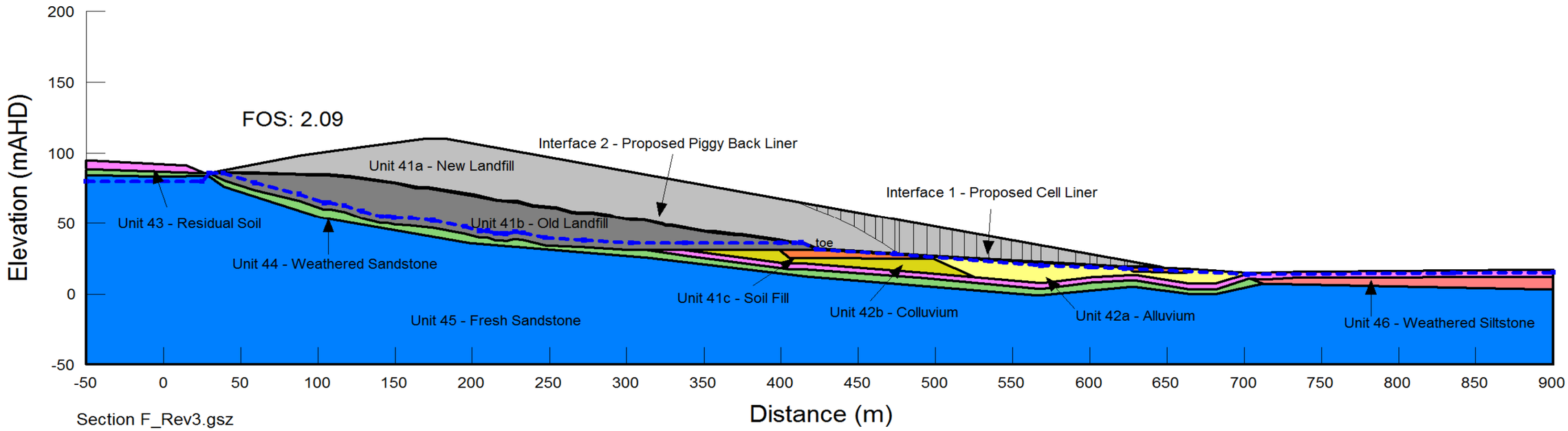
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	CHECKED: CSC	DATE: 17/01/12	Circular through Old Landfill - Earthquake	
	SCALE: As shown		PROJECT No. 117625003	FIGURE No. B3.14 A3

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Whytes Gully SlopeW - Section F-F'

Name: Below Old Landfill_DR

Name: Unit 41a - New Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Unit 41c - Soil Fill Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 26 °
Name: Unit 42a - Alluvium Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 25 °
Name: Unit 42b - Colluvium Model: Mohr-Coulomb Unit Weight: 18 kN/m³ Cohesion: 5 kPa Phi: 27 °
Name: Unit 43 - Residual Soil Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 5 kPa Phi: 30 °
Name: Unit 44 - Weathered Sandstone Model: Mohr-Coulomb Unit Weight: 24 kN/m³ Cohesion: 40 kPa Phi: 38 °
Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable)
Name: Unit 46 - Weathered Siltstone Model: Mohr-Coulomb Unit Weight: 23 kN/m³ Cohesion: 20 kPa Phi: 36 °
Name: Interface 2 - Proposed Cell Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 °
Name: Interface 1 - Proposed Piggy Back Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 °



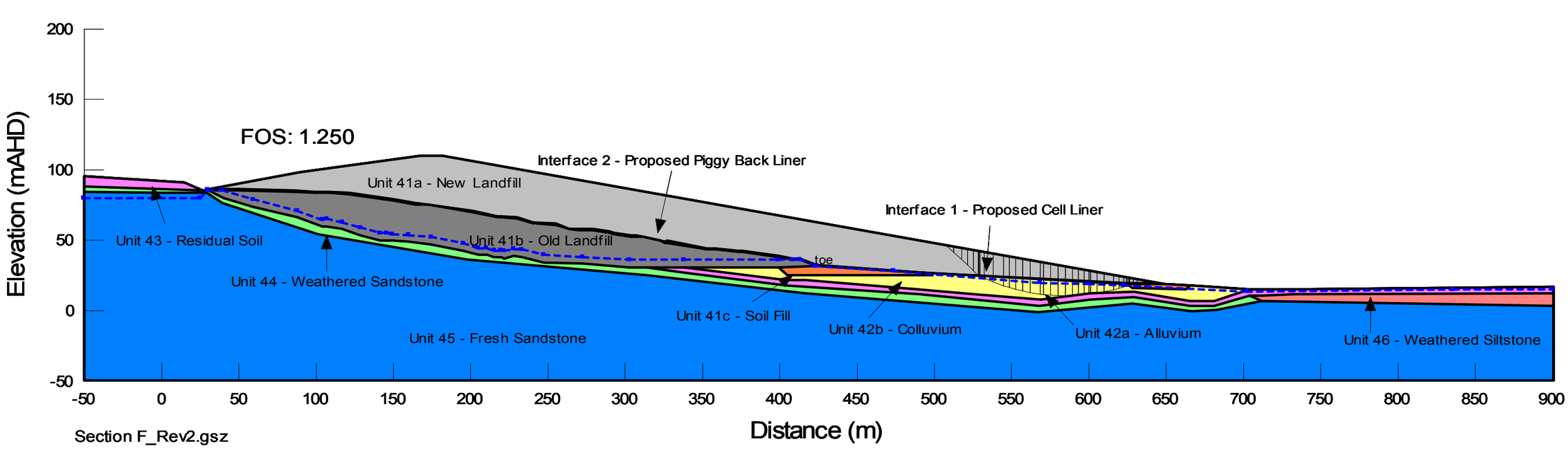
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	DRAWN: PR	DATE: 17/01/12	TITLE: Section F-F'		
	CHECKED: CSC	DATE: 17/01/12	Circular below Old Landfill - Long-term		
	SCALE: As shown		PROJECT No. 117625003	FIGURE No. **B3.15**	A3

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Whytes Gully SlopeW - Section F-F'

Name: Below Old Landfill_UD & EQ

Name: Unit 41a - New Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Unit 41c - Soil Fill Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 0 kPa Phi: 26 °
Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable)
Name: Interface 2 - Proposed Cell Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 °
Name: Interface 1 - Proposed Piggy Back Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 °
Name: Unit 43 - Residual Soil (UD) Model: Undrained (Phi=0) Unit Weight: 20 kN/m³ Cohesion: 130 kPa
Name: Unit 44 - Weathered Sandstone (UD) Model: Undrained (Phi=0) Unit Weight: 24 kN/m³ Cohesion: 1000 kPa
Name: Unit 46 - Weathered Siltstone (UD) Model: Undrained (Phi=0) Unit Weight: 23 kN/m³ Cohesion: 750 kPa
Name: Unit 42a - Alluvium (UD) Model: S=f(overburden) Unit Weight: 17 kN/m³ Tau/Sigma Ratio: 0.25 Minimum Strength: 25



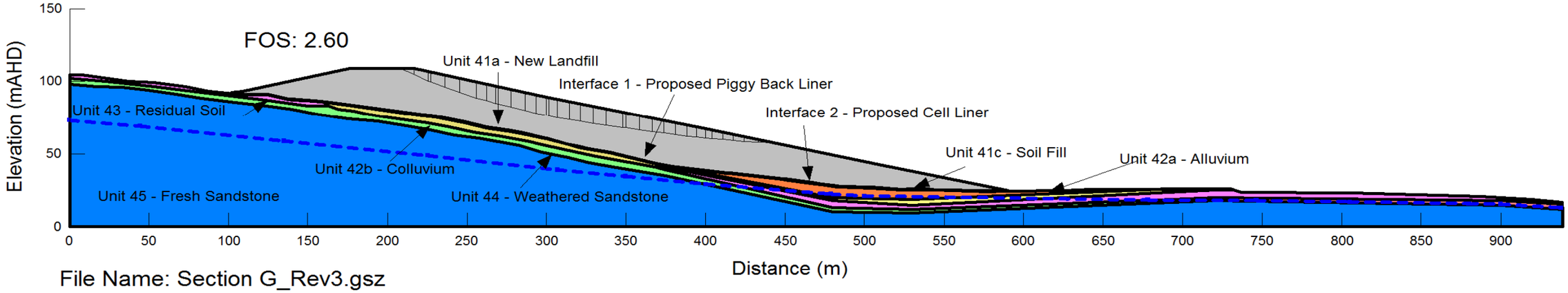
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	DRAWN: PR	DATE: 17/01/12	TITLE: Section F-F'	
	CHECKED: CSC	DATE: 17/01/12	Circular below Old Landfill - Earthquake	
	SCALE: As shown		PROJECT No. 117625003	FIGURE No. **B3.16** A3

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Whytes Gully SlopeW - Section G-G'

Name: CR through New Landfill_DR

Name: Unit 41c - Soil Fill Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 26 ° Phi-B: 0 ° Piezometric Line: 1
Name: Unit 43 - Residual Soil Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 5 kPa Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Unit 42a - Alluvium Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 25 ° Phi-B: 0 ° Piezometric Line: 1
Name: Unit 44 - Weathered Sandstone Model: Mohr-Coulomb Unit Weight: 24 kN/m³ Cohesion: 40 kPa Phi: 38 ° Phi-B: 0 ° Piezometric Line: 1
Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Unit 41a - New Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Unit 46 - Weathered Siltstone Model: Mohr-Coulomb Unit Weight: 23 kN/m³ Cohesion: 20 kPa Phi: 36 ° Phi-B: 0 ° Piezometric Line: 1
Name: Interface 1 - Proposed Piggy Back Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 ° Phi-B: 0 ° Piezometric Line: 1
Name: Interface 2 - Proposed Cell Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 ° Phi-B: 0 ° Piezometric Line: 1
Name: Unit 42b - Colluvium Model: Mohr-Coulomb Unit Weight: 18 kN/m³ Cohesion: 5 kPa Phi: 27 ° Phi-B: 0 ° Piezometric Line: 1



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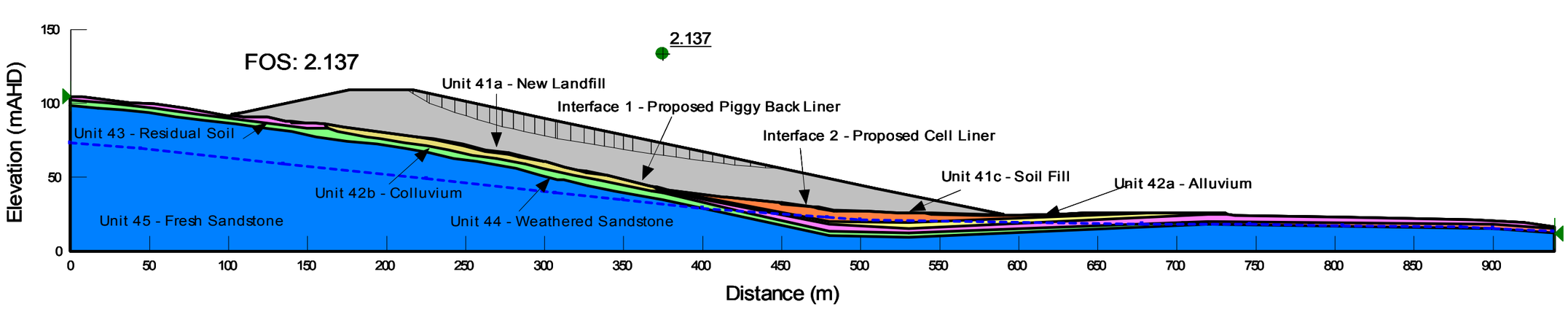
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	DRAWN: PR	DATE: 17/01/12	TITLE: Section G-G'	
	CHECKED: CSC	DATE: 17/01/12	Circular through New Landfill - Long-term	
	SCALE: As shown		PROJECT No. 117625003	FIGURE No. **B3.17** A3

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Whytes Gully SlopeW - Section G-G'

Name: CR through New Landfill_UD & EQ

Name: Unit 41c - Soil Fill Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 0 kPa Phi: 26 ° Phi-B: 0 ° Piezometric Line: 1
Name: Unit 43 - Residual Soil Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 5 kPa Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Unit 42a - Alluvium Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 0 kPa Phi: 25 ° Phi-B: 0 ° Piezometric Line: 1
Name: Unit 44 - Weathered Sandstone Model: Mohr-Coulomb Unit Weight: 24 kN/m³ Cohesion: 0 kPa Phi: 38 ° Phi-B: 0 ° Piezometric Line: 1
Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Unit 41a - New Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Unit 46 - Weathered Siltstone Model: Mohr-Coulomb Unit Weight: 23 kN/m³ Cohesion: 0 kPa Phi: 36 ° Phi-B: 0 ° Piezometric Line: 1
Name: Interface 1 - Proposed Piggy Back Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 ° Phi-B: 0 ° Piezometric Line: 1
Name: Interface 2 - Proposed Cell Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 ° Phi-B: 0 ° Piezometric Line: 1
Name: Unit 42b - Colluvium Model: Mohr-Coulomb Unit Weight: 18 kN/m³ Cohesion: 0 kPa Phi: 27 ° Phi-B: 0 ° Piezometric Line: 1



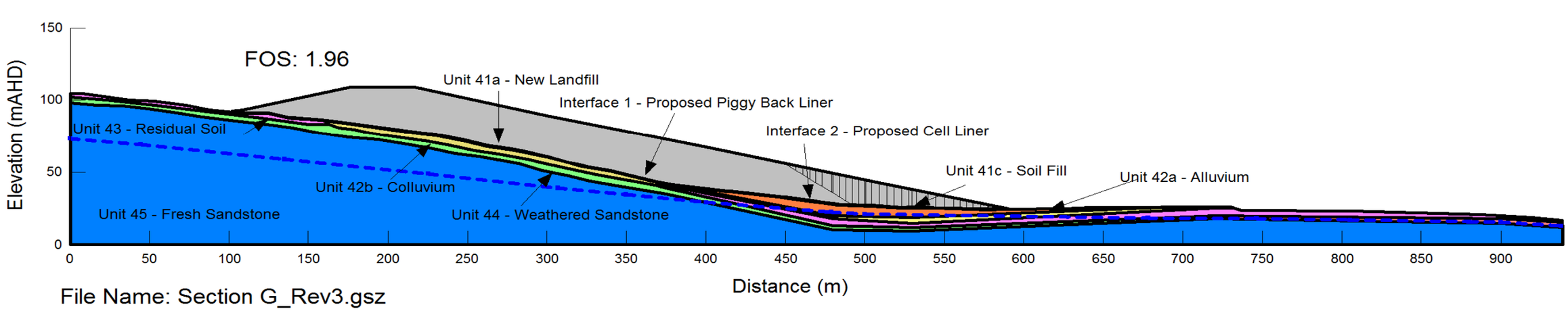
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DRAWN: PR	DATE: 17/01/12	TITLE: Section G-G'	
CHECKED: CSC	DATE: 17/01/12	Circular through New Landfill - Earthquake	
SCALE: As shown		PROJECT No. 117625003	FIGURE No. B3.18 A3

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Whytes Gully SlopeW - Section G-G'

Name: NC along Proposed Liner_DR (P)

Name: Unit 41c - Soil Fill Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 26 ° Phi-B: 0 ° Piezometric Line: 1
Name: Unit 43 - Residual Soil Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 5 kPa Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Unit 42a - Alluvium Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 25 ° Phi-B: 0 ° Piezometric Line: 1
Name: Unit 44 - Weathered Sandstone Model: Mohr-Coulomb Unit Weight: 24 kN/m³ Cohesion: 40 kPa Phi: 38 ° Phi-B: 0 ° Piezometric Line: 1
Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Unit 41a - New Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Unit 46 - Weathered Siltstone Model: Mohr-Coulomb Unit Weight: 23 kN/m³ Cohesion: 20 kPa Phi: 36 ° Phi-B: 0 ° Piezometric Line: 1
Name: Interface 1 - Proposed Piggy Back Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 ° Phi-B: 0 ° Piezometric Line: 1
Name: Interface 2 - Proposed Cell Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 ° Phi-B: 0 ° Piezometric Line: 1
Name: Unit 42b - Colluvium Model: Mohr-Coulomb Unit Weight: 18 kN/m³ Cohesion: 5 kPa Phi: 27 ° Phi-B: 0 ° Piezometric Line: 1



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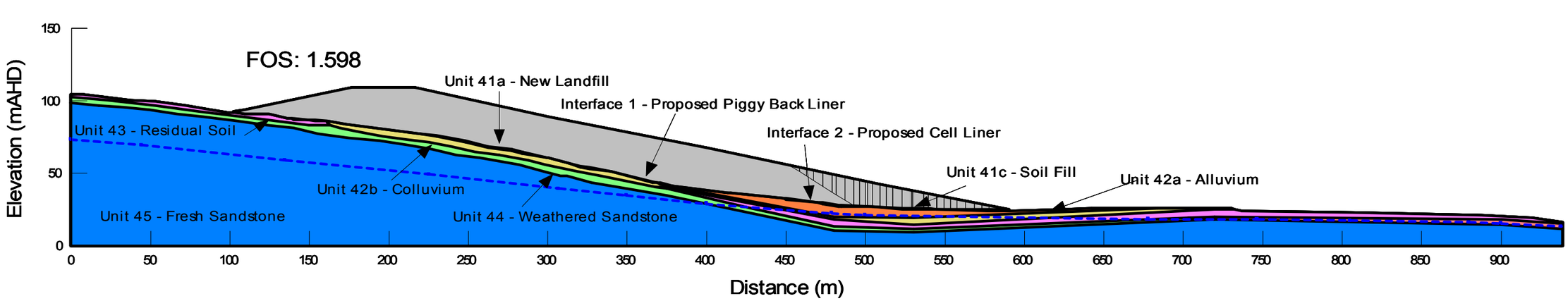
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	CHECKED: CSC	DATE: 17/01/12		
	SCALE: As shown		PROJECT No. 117625003	FIGURE No. **B3.19** A3

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Whytes Gully SlopeW - Section G-G'

Name: NC along Proposed Liner_UD & EQ (P)

Name: Unit 41c - Soil Fill Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 0 kPa Phi: 26 ° Phi-B: 0 ° Piezometric Line: 1
Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Unit 41a - New Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Interface 1 - Proposed Piggy Back Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 ° Phi-B: 0 ° Piezometric Line: 1
Name: Interface 2 - Proposed Cell Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 ° Phi-B: 0 ° Piezometric Line: 1
Name: Unit 42b - Colluvium (UD) Model: S=f(depth) Unit Weight: 18 kN/m³ C-Top of Layer: 100 kPa C-Rate of Change: 10 kPa/m Limiting C: 1000 kPa Piezometric Line: 1
Name: Unit 43 - Residual Soil (UD) Model: Undrained (Phi=0) Unit Weight: 20 kN/m³ Cohesion: 130 kPa Piezometric Line: 1
Name: Unit 44 - Weathered Sandstone (UD) Model: Undrained (Phi=0) Unit Weight: 24 kN/m³ Cohesion: 1000 kPa Piezometric Line: 1
Name: Unit 46 - Weathered Siltstone (UD) Model: Undrained (Phi=0) Unit Weight: 23 kN/m³ Cohesion: 750 kPa Piezometric Line: 1



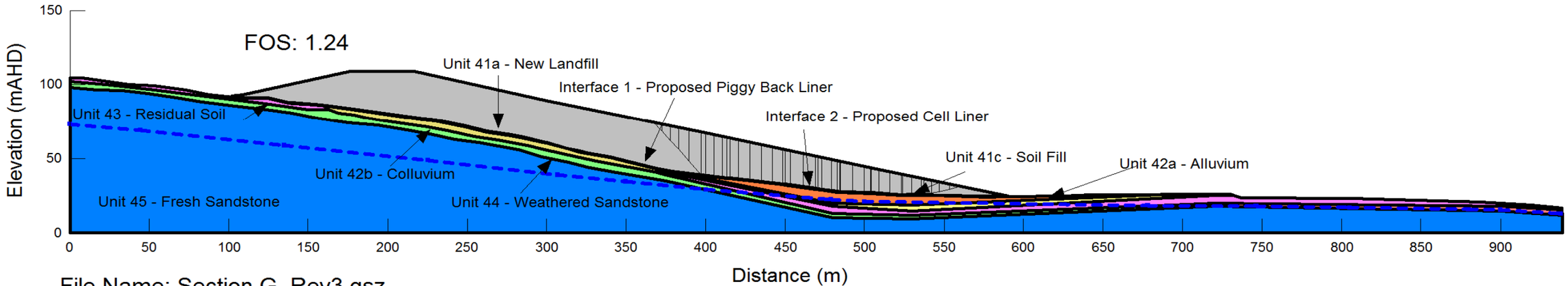
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	DRAWN: PR	DATE: 17/01/12	TITLE: Section G-G'	
	CHECKED: CSC	DATE: 17/01/12	Non-circular along Proposed Liner (Peak) - Earthquake	
	SCALE: As shown		PROJECT No. 117625003	FIGURE No. **B3.20** A3

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Whytes Gully SlopeW - Section G-G'

Name: NC along Proposed Liner_DR (R)

Name: Unit 41c - Soil Fill Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 26 ° Phi-B: 0 ° Piezometric Line: 1
Name: Unit 43 - Residual Soil Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 5 kPa Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Unit 42a - Alluvium Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 25 ° Phi-B: 0 ° Piezometric Line: 1
Name: Unit 44 - Weathered Sandstone Model: Mohr-Coulomb Unit Weight: 24 kN/m³ Cohesion: 40 kPa Phi: 38 ° Phi-B: 0 ° Piezometric Line: 1
Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Unit 41a - New Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Unit 46 - Weathered Siltstone Model: Mohr-Coulomb Unit Weight: 23 kN/m³ Cohesion: 20 kPa Phi: 36 ° Phi-B: 0 ° Piezometric Line: 1
Name: Unit 42b - Colluvium Model: Mohr-Coulomb Unit Weight: 18 kN/m³ Cohesion: 5 kPa Phi: 27 ° Phi-B: 0 ° Piezometric Line: 1
Name: Interface 1 - Proposed Piggy Back Liner System (Residual - Slopes) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 7 ° Phi-B: 0 ° Piezometric Line: 1
Name: Interface 2 - Proposed Cell Liner System (Residual - Slopes) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 7 ° Phi-B: 0 ° Piezometric Line: 1
Name: Interface 2 - Proposed Cell Liner System (Residual - Flat) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 11 ° Phi-B: 0 ° Piezometric Line: 1



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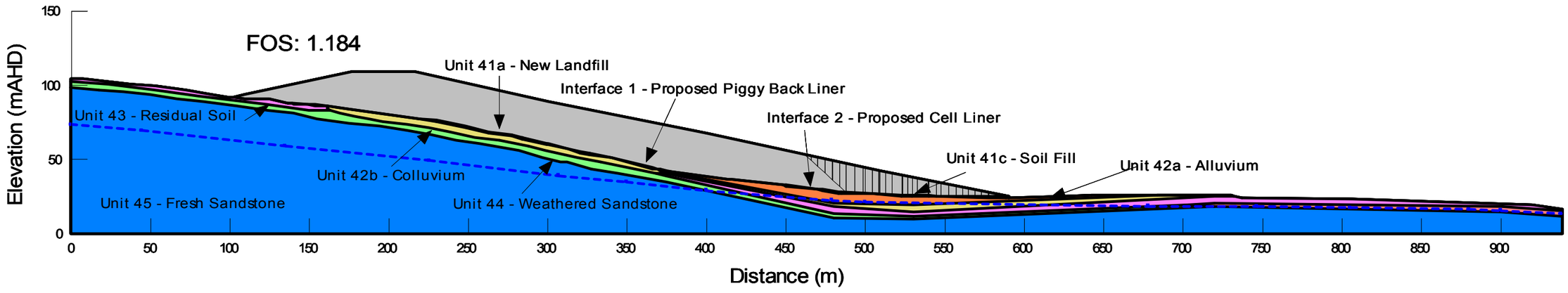
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	CHECKED: CSC	DATE: 17/01/12	Non-circular along Proposed Liner (Residual) - Long-term	
	SCALE: As shown		PROJECT No. 117625003	FIGURE No. **B3.21** A3

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Whytes Gully SlopeW - Section G-G'

Name: NC along Proposed Liner_UD & EQ (R)

Name: Unit 41c - Soil Fill Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 0 kPa Phi: 26 ° Phi-B: 0 ° Piezometric Line: 1
Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Unit 41a - New Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Unit 42b - Colluvium (UD) Model: S=f(depth) Unit Weight: 18 kN/m³ C-Top of Layer: 100 kPa C-Rate of Change: 10 kPa/m Limiting C: 1000 kPa Piezometric Line: 1
Name: Unit 43 - Residual Soil (UD) Model: Undrained (Phi=0) Unit Weight: 20 kN/m³ Cohesion: 130 kPa Piezometric Line: 1
Name: Unit 44 - Weathered Sandstone (UD) Model: Undrained (Phi=0) Unit Weight: 24 kN/m³ Cohesion: 1000 kPa Piezometric Line: 1
Name: Unit 46 - Weathered Siltstone (UD) Model: Undrained (Phi=0) Unit Weight: 23 kN/m³ Cohesion: 750 kPa Piezometric Line: 1
Name: Interface 1 - Proposed Piggy Back Liner System (Residual - Slopes) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 7 ° Phi-B: 0 ° Piezometric Line: 1
Name: Interface 2 - Proposed Cell Liner System (Residual - Slopes) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 7 ° Phi-B: 0 ° Piezometric Line: 1
Name: Interface 2 - Proposed Cell Liner System (Residual - Flat) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 11 ° Phi-B: 0 ° Piezometric Line: 1



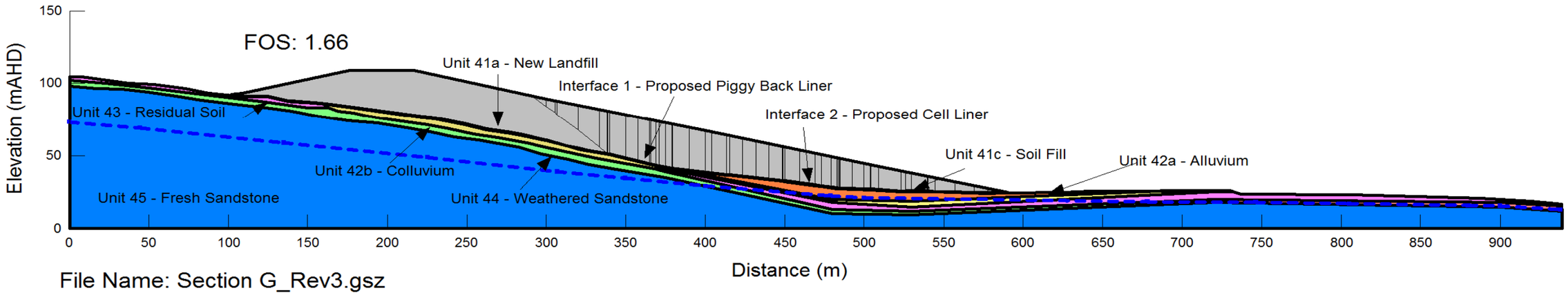
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	DRAWN: PR	DATE: 17/01/12	TITLE: Section G-G'		
	CHECKED: CSC	DATE: 17/01/12	Non-circular along Proposed Liner (Residual) - Long-term		
	SCALE: As shown		PROJECT No. 117625003	FIGURE No. **B3.22**	A3

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Whytes Gully SlopeW - Section G-G'

Name: Below Old Landfill_DR (Block)

Name: Unit 41c - Soil Fill Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 26 ° Phi-B: 0 ° Piezometric Line: 1
Name: Unit 43 - Residual Soil Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 5 kPa Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Unit 42a - Alluvium Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 25 ° Phi-B: 0 ° Piezometric Line: 1
Name: Unit 44 - Weathered Sandstone Model: Mohr-Coulomb Unit Weight: 24 kN/m³ Cohesion: 40 kPa Phi: 38 ° Phi-B: 0 ° Piezometric Line: 1
Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Unit 41a - New Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Unit 46 - Weathered Siltstone Model: Mohr-Coulomb Unit Weight: 23 kN/m³ Cohesion: 20 kPa Phi: 36 ° Phi-B: 0 ° Piezometric Line: 1
Name: Interface 1 - Proposed Piggy Back Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 ° Phi-B: 0 ° Piezometric Line: 1
Name: Interface 2 - Proposed Cell Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 ° Phi-B: 0 ° Piezometric Line: 1
Name: Unit 42b - Colluvium Model: Mohr-Coulomb Unit Weight: 18 kN/m³ Cohesion: 5 kPa Phi: 27 ° Phi-B: 0 ° Piezometric Line: 1



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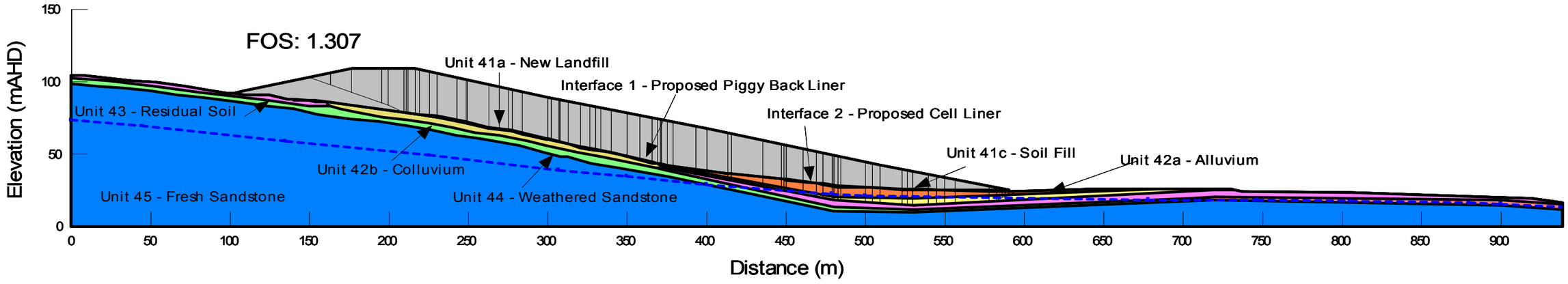
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	CHECKED: CSC	DATE: 17/01/12			
	SCALE: As shown		PROJECT No. 117625003	FIGURE No. **B3.23**	A3

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Whytes Gully SlopeW - Section G-G'

Name: Below Old Landfill_UD & EQ

Name: Unit 41c - Soil Fill Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 0 kPa Phi: 26 ° Phi-B: 0 ° Piezometric Line: 1
Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Unit 41a - New Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Interface 1 - Proposed Piggy Back Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 ° Phi-B: 0 ° Piezometric Line: 1
Name: Interface 2 - Proposed Cell Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 ° Phi-B: 0 ° Piezometric Line: 1
Name: Unit 42a - Alluvium (UD) Model: S=f(overburden) Unit Weight: 17 kN/m³ Tau/Sigma Ratio: 0.25 Minimum Strength: 25 Piezometric Line: 1
Name: Unit 42b - Colluvium (UD) Model: S=f(depth) Unit Weight: 18 kN/m³ C-Top of Layer: 100 kPa C-Rate of Change: 10 kPa/m Limiting C: 1000 kPa Piezometric Line: 1
Name: Unit 43 - Residual Soil (UD) Model: Undrained (Phi=0) Unit Weight: 20 kN/m³ Cohesion: 130 kPa Piezometric Line: 1
Name: Unit 44 - Weathered Sandstone (UD) Model: Undrained (Phi=0) Unit Weight: 24 kN/m³ Cohesion: 1000 kPa Piezometric Line: 1
Name: Unit 46 - Weathered Siltstone (UD) Model: Undrained (Phi=0) Unit Weight: 23 kN/m³ Cohesion: 750 kPa Piezometric Line: 1



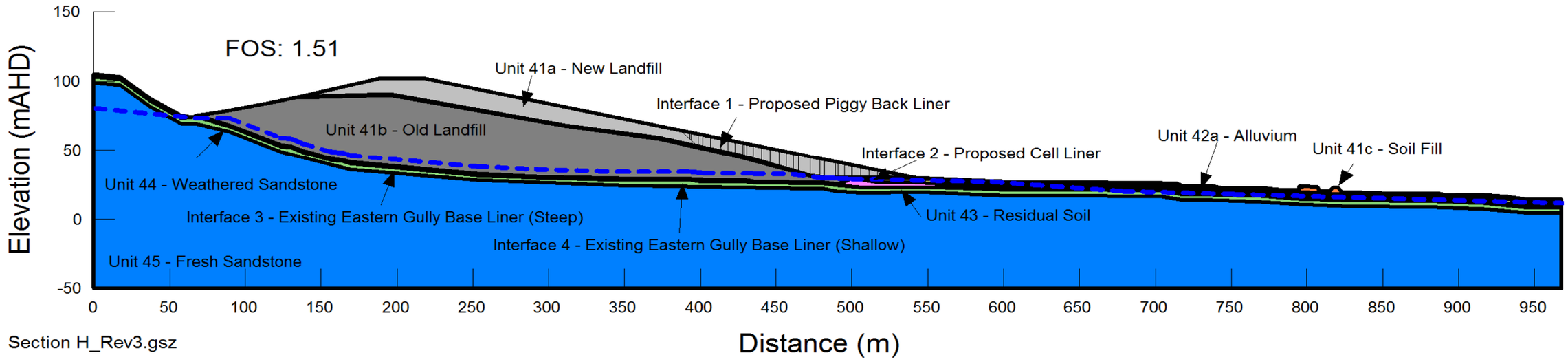
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	SCALE: As shown		PROJECT No. 117625003	FIGURE No. **B3.24**	A3

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Whytes Gully SlopeW - Section H-H'

Name: NC along Proposed Liner_DR (P)

Name: Unit 41a - New Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Unit 41c - Soil Fill Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 26 °
Name: Unit 42a - Alluvium Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 25 °
Name: Unit 43 - Residual Soil Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 5 kPa Phi: 30 °
Name: Unit 44 - Weathered Sandstone Model: Mohr-Coulomb Unit Weight: 24 kN/m³ Cohesion: 40 kPa Phi: 38 °
Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable)
Name: Interface 2 - Proposed Cell Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 °
Name: Interface 1 - Proposed Piggy Back Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 °
Name: Interface 3 - Eastern Gully Base Liner System (Steep) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Interface 4 - Eastern Gully Base Liner System (Shallow) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 18 °



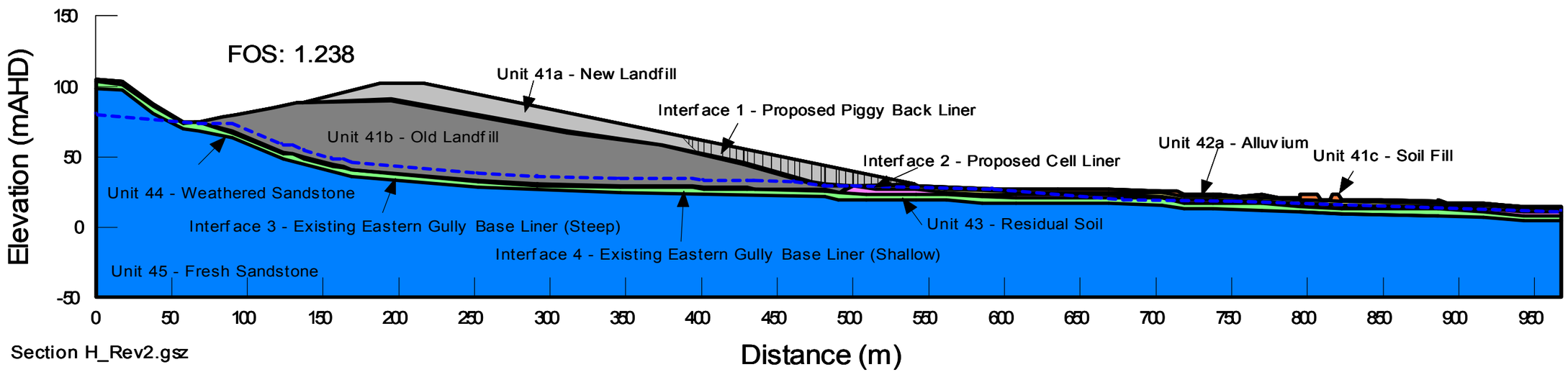
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	CHECKED: CSC	DATE: 17/01/12	Non-circular along Proposed Liner (Peak) - Long-term		
	SCALE: As shown		PROJECT No. 117625003	FIGURE No. **B3.25**	A3

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Whytes Gully SlopeW - Section H-H'

Name: NC along Proposed Liner_UD & EQ (P)

Name: Unit 41a - New Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Unit 41c - Soil Fill Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 0 kPa Phi: 26 °
Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable)
Name: Interface 2 - Proposed Cell Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 °
Name: Interface 1 - Proposed Piggy Back Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 °
Name: Interface 3 - Eastern Gully Base Liner System (Steep) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Interface 4 - Eastern Gully Base Liner System (Shallow) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 18 °
Name: Unit 42a - Alluvium (UD) Model: S=f(overburden) Unit Weight: 17 kN/m³ Tau/Sigma Ratio: 0.25 Minimum Strength: 25
Name: Unit 43 - Residual Soil (UD) Model: Undrained (Phi=0) Unit Weight: 20 kN/m³ Cohesion: 130 kPa
Name: Unit 44 - Weathered Sandstone (UD) Model: Undrained (Phi=0) Unit Weight: 24 kN/m³ Cohesion: 1000 kPa



Section H_Rev2.gsz

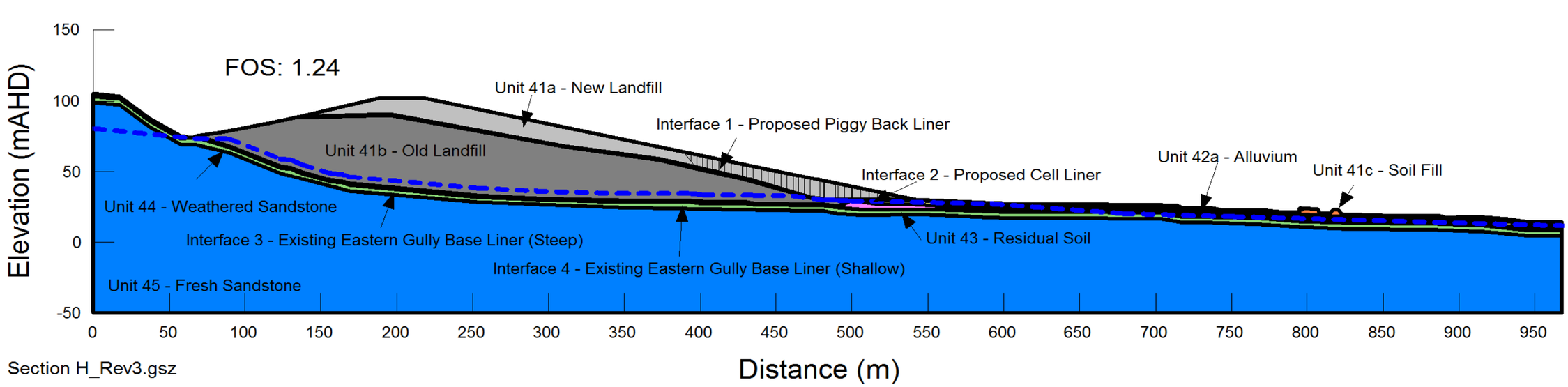
Golder Associates	CLIENT: Wollongong City Council		PROJECT: **Whytes Gully RRP - Interpretative Geotechnical Report for 50% Design**		
	DRAWN: PR	DATE: 17/01/12	TITLE: Section H-H'		
	CHECKED: CSC	DATE: 17/01/12	Non-circular along Proposed Liner (Peak) - Earthquake		
	SCALE: As shown		PROJECT No. 117625003	FIGURE No. **B3.26**	A3

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Whytes Gully SlopeW - Section H-H'

Name: NC along Proposed Liner_DR (R)

Name: Unit 41a - New Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Unit 41c - Soil Fill Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 26 °
Name: Unit 42a - Alluvium Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 25 °
Name: Unit 43 - Residual Soil Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 5 kPa Phi: 30 °
Name: Unit 44 - Weathered Sandstone Model: Mohr-Coulomb Unit Weight: 24 kN/m³ Cohesion: 40 kPa Phi: 38 °
Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable)
Name: Interface 1 - Proposed Piggy Back Liner System (Residual - Slopes) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 7 °
Name: Interface 3 - Eastern Gully Base Liner System (Steep) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Interface 4 - Eastern Gully Base Liner System (Shallow) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 18 °
Name: Interface 2 - Proposed Cell Liner System (Residual - Eastern Gully) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 14 °
Name: Interface 1 - Proposed Piggy Back Liner System (Residual - Eastern Gully) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 14 °



Section H_Rev3.gsz

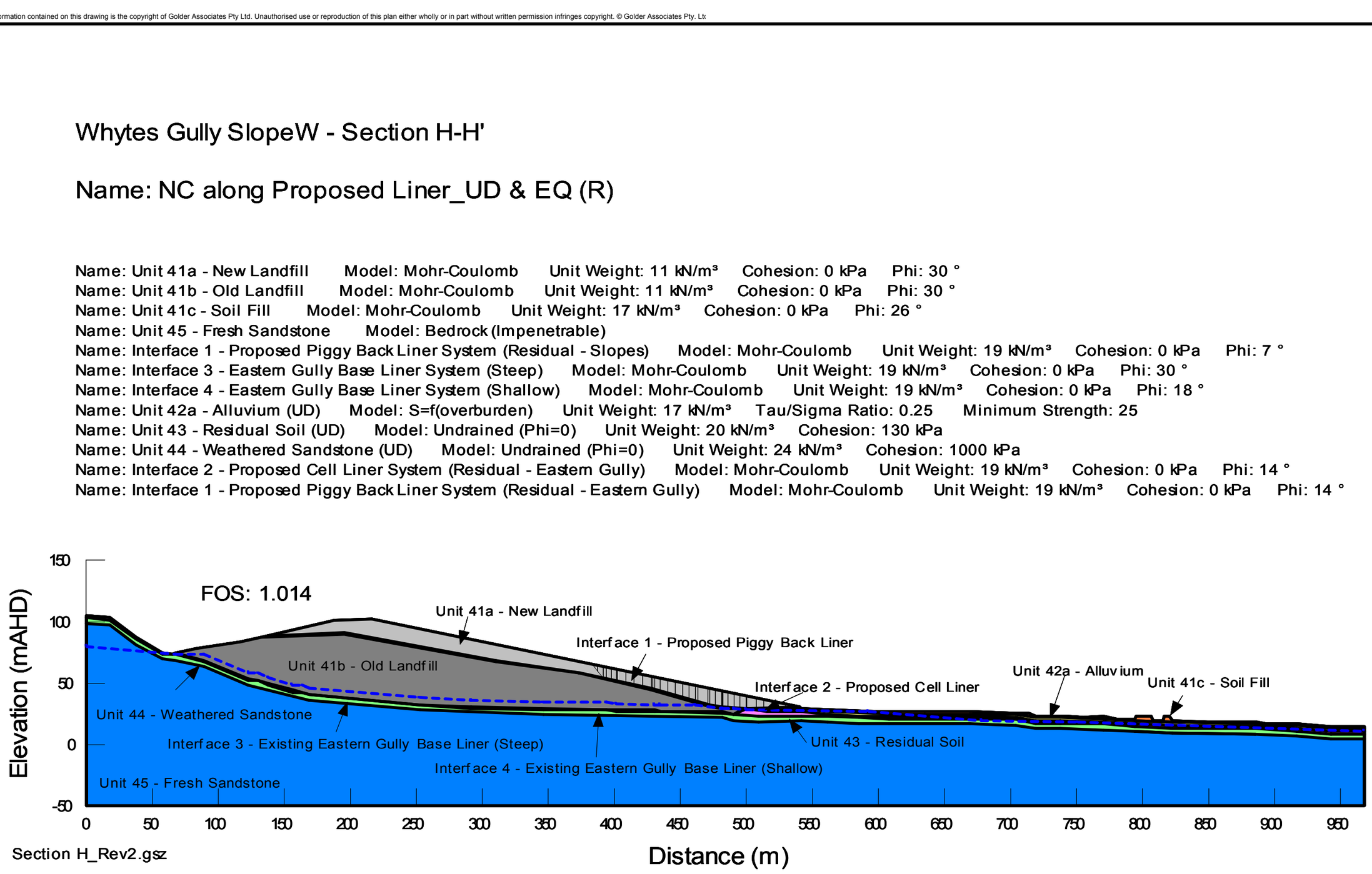
Golder Associates	CLIENT: Wollongong City Council		PROJECT: **Whytes Gully RRP - Interpretative Geotechnical Report for 50% Design**		
	DRAWN: PR	DATE: 17/01/12	TITLE: Section H-H'		
	CHECKED: CSC	DATE: 17/01/12	Non-circular along Proposed Liner (Residual) - Long-term		
	SCALE: As shown		PROJECT No. 117625003	FIGURE No. **B3.27**	A3

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Whytes Gully SlopeW - Section H-H'

Name: NC along Proposed Liner_UD & EQ (R)

Name: Unit 41a - New Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Unit 41c - Soil Fill Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 0 kPa Phi: 26 °
Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable)
Name: Interface 1 - Proposed Piggy Back Liner System (Residual - Slopes) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 7 °
Name: Interface 3 - Eastern Gully Base Liner System (Steep) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Interface 4 - Eastern Gully Base Liner System (Shallow) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 18 °
Name: Unit 42a - Alluvium (UD) Model: S=f(overburden) Unit Weight: 17 kN/m³ Tau/Sigma Ratio: 0.25 Minimum Strength: 25
Name: Unit 43 - Residual Soil (UD) Model: Undrained (Phi=0) Unit Weight: 20 kN/m³ Cohesion: 130 kPa
Name: Unit 44 - Weathered Sandstone (UD) Model: Undrained (Phi=0) Unit Weight: 24 kN/m³ Cohesion: 1000 kPa
Name: Interface 2 - Proposed Cell Liner System (Residual - Eastern Gully) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 14 °
Name: Interface 1 - Proposed Piggy Back Liner System (Residual - Eastern Gully) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 14 °



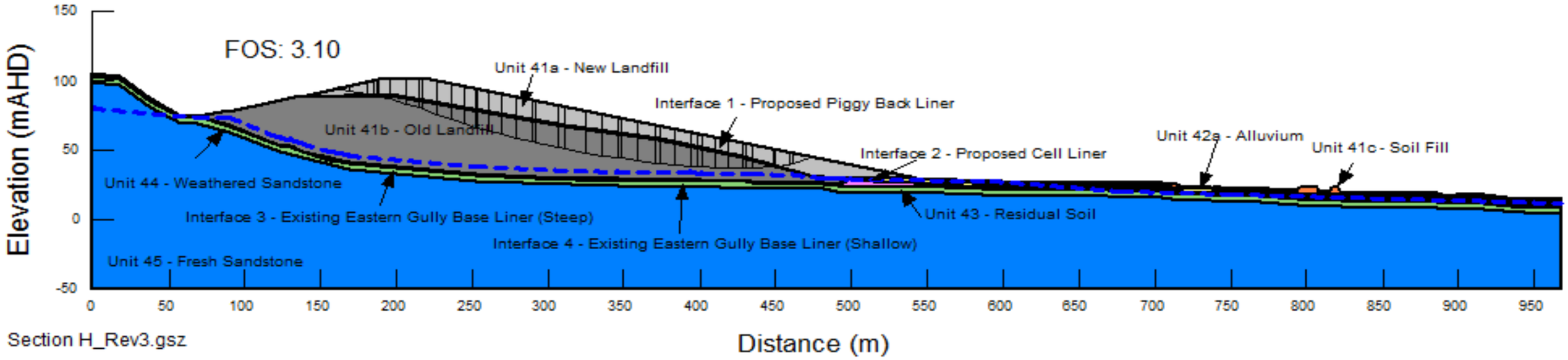
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	DRAWN: PR	DATE: 17/01/12	TITLE: Section H-H'		
	CHECKED: CSC	DATE: 17/01/12	Non-circular along Proposed Liner (Residual) - Earthquake		
	SCALE: As shown		PROJECT No. 117625003	FIGURE No. **B3.28**	A3

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Whytes Gully SlopeW - Section H-H'

Name: CR through Old Landfill_DR

Name: Unit 41a - New Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Unit 41c - Soil Fill Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 26 °
Name: Unit 42a - Alluvium Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 25 °
Name: Unit 43 - Residual Soil Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 5 kPa Phi: 30 °
Name: Unit 44 - Weathered Sandstone Model: Mohr-Coulomb Unit Weight: 24 kN/m³ Cohesion: 40 kPa Phi: 38 °
Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable)
Name: Interface 2 - Proposed Cell Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 °
Name: Interface 1 - Proposed Piggy Back Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 °
Name: Interface 3 - Eastern Gully Base Liner System (Steep) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Interface 4 - Eastern Gully Base Liner System (Shallow) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 18 °



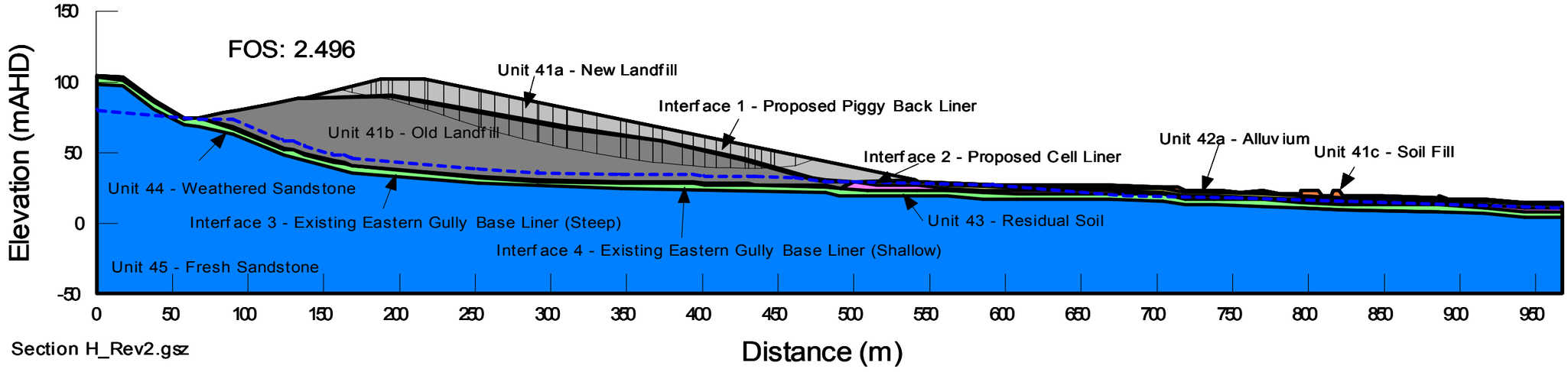
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	DRAWN: PR	DATE: 17/01/12	TITLE: Section H-H'	
	CHECKED: CSC	DATE: 17/01/12	Circular through Old Landfill - Long-term	
	SCALE: As shown		PROJECT No. 117625003	FIGURE No. **B3.29** A3

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Whytes Gully SlopeW - Section H-H'

Name: CR through Old Landfill_UD & EQ

Name: Unit 41a - New Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Unit 41c - Soil Fill Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 0 kPa Phi: 26 °
Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable)
Name: Interface 2 - Proposed Cell Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 °
Name: Interface 1 - Proposed Piggy Back Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 °
Name: Interface 3 - Eastern Gully Base Liner System (Steep) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Interface 4 - Eastern Gully Base Liner System (Shallow) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 18 °
Name: Unit 42a - Alluvium (UD) Model: S=f(overburden) Unit Weight: 17 kN/m³ Tau/Sigma Ratio: 0.25 Minimum Strength: 25
Name: Unit 43 - Residual Soil (UD) Model: Undrained (Phi=0) Unit Weight: 20 kN/m³ Cohesion: 130 kPa
Name: Unit 44 - Weathered Sandstone (UD) Model: Undrained (Phi=0) Unit Weight: 24 kN/m³ Cohesion: 1000 kPa



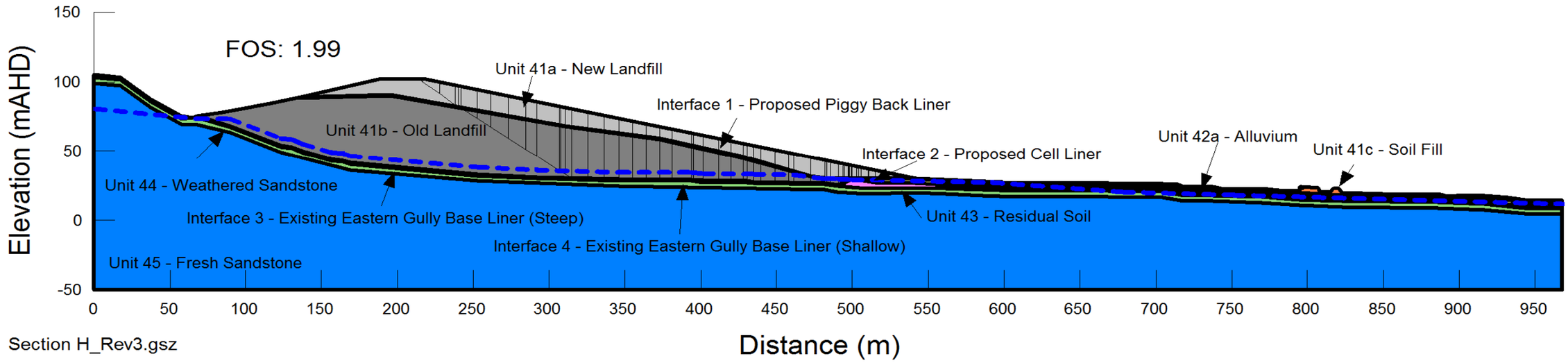
Golder Associates	CLIENT: Wollongong City Council		PROJECT: Whytes Gully RRP - Interpretative Geotechnical Report for 50% Design	
	DRAWN: PR	DATE: 17/01/12	TITLE: Section H-H'	
	CHECKED: CSC	DATE: 17/01/12	Circular through Old Landfill - Earthquake	
	SCALE: As shown		PROJECT No. 117625003	FIGURE No. B3.30 A3

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Whytes Gully SlopeW - Section H-H'

Name: NC along Existing Liner_DR

Name: Unit 41a - New Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Unit 41c - Soil Fill Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 26 °
Name: Unit 42a - Alluvium Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 25 °
Name: Unit 43 - Residual Soil Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 5 kPa Phi: 30 °
Name: Unit 44 - Weathered Sandstone Model: Mohr-Coulomb Unit Weight: 24 kN/m³ Cohesion: 40 kPa Phi: 38 °
Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable)
Name: Interface 2 - Proposed Cell Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 °
Name: Interface 1 - Proposed Piggy Back Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 °
Name: Interface 3 - Eastern Gully Base Liner System (Steep) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Interface 4 - Eastern Gully Base Liner System (Shallow) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 18 °



Section H_Rev3.gsz

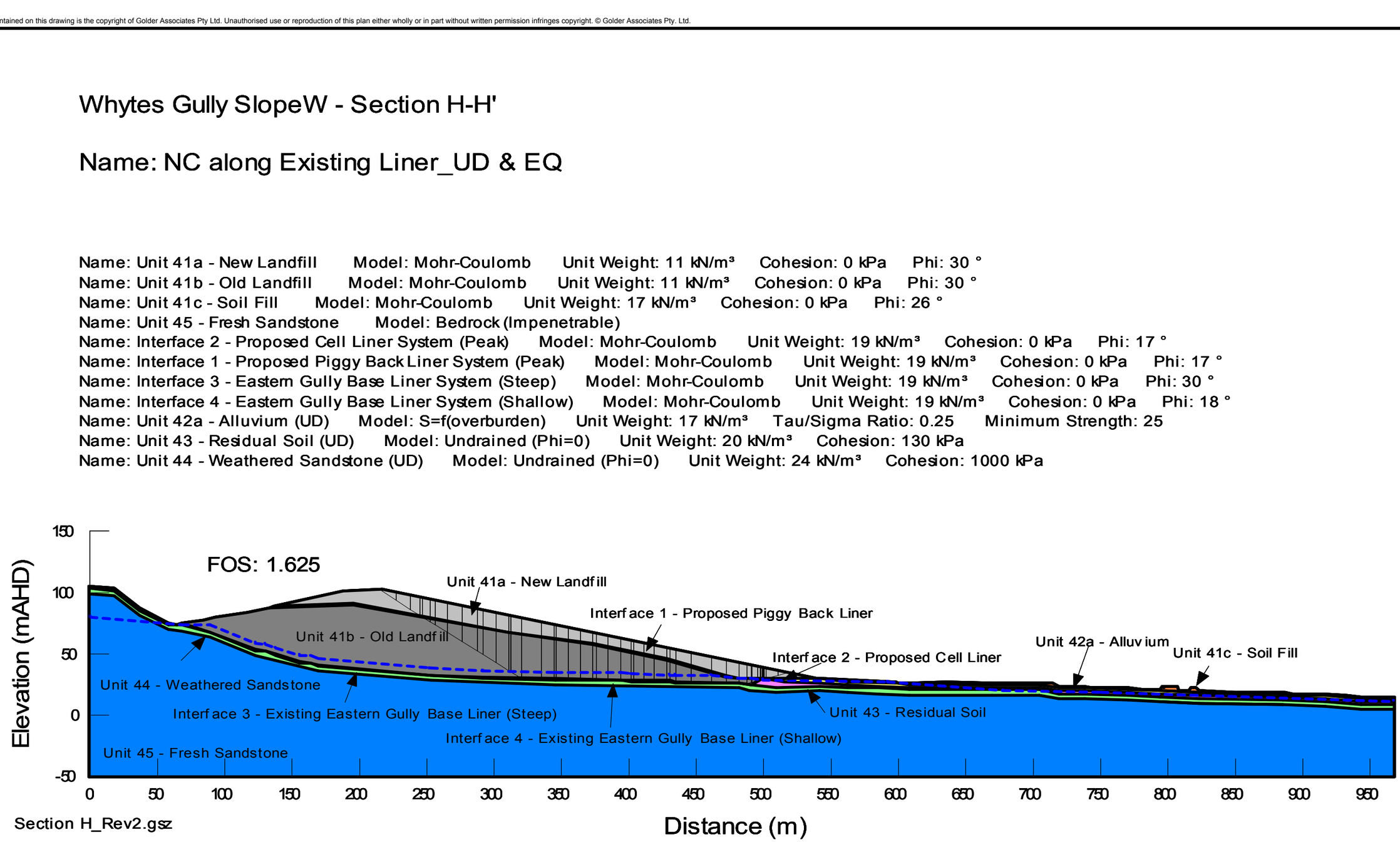
Golder Associates	CLIENT: Wollongong City Council		PROJECT: **Whytes Gully RRP - Interpretative Geotechnical Report for 50% Design**		
	DRAWN: PR	DATE: 17/01/12	TITLE: Section H-H'		
	CHECKED: CSC	DATE: 17/01/12	Non-circular along Existing Liner - Long-term		
	SCALE: As shown		PROJECT No. 117625003	FIGURE No. **B3.30**	A3

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Whytes Gully SlopeW - Section H-H'

Name: NC along Existing Liner_UD & EQ

Name: Unit 41a - New Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Unit 41c - Soil Fill Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 0 kPa Phi: 26 °
Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable)
Name: Interface 2 - Proposed Cell Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 °
Name: Interface 1 - Proposed Piggy Back Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 °
Name: Interface 3 - Eastern Gully Base Liner System (Steep) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Interface 4 - Eastern Gully Base Liner System (Shallow) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 18 °
Name: Unit 42a - Alluvium (UD) Model: S=f(overburden) Unit Weight: 17 kN/m³ Tau/Sigma Ratio: 0.25 Minimum Strength: 25
Name: Unit 43 - Residual Soil (UD) Model: Undrained (Phi=0) Unit Weight: 20 kN/m³ Cohesion: 130 kPa
Name: Unit 44 - Weathered Sandstone (UD) Model: Undrained (Phi=0) Unit Weight: 24 kN/m³ Cohesion: 1000 kPa



Golder Associates	CLIENT: Wollongong City Council		PROJECT: Whytes Gully RRP - Interpretative Geotechnical Report for 50% Design		
	DRAWN: PR	DATE: 17/01/12	TITLE: Section H-H'		
	CHECKED: CSC	DATE: 17/01/12	Non-circular along Existing Liner - Earthquake		
	SCALE: As shown		PROJECT No. 117625003	FIGURE No. B3.32	A3

APPENDIX C

Settlement Analysis Results

Appendix C Figure No.	Description
C.1	Settle3D Model Inputs
C.2	Settle 3D Result - Section F-F' - CH425 m Existing Soil Profile - Total Settlement
C.3	Settle 3D Result - Section F-F' - CH475 m Existing Soil Profile - Total Settlement
C.4	Settle 3D Result - Section F-F' - CH570 m Existing Soil Profile - Total Settlement
C.5	Settle 3D Result - Section F-F' - CH600 m Existing Soil Profile - Total Settlement
C.6	Settle 3D Result - Section F-F' - CH630 m Existing Soil Profile - Total Settlement
C.7	Western Gully Landfill – Historical Filling Stages
C.8a	Long Term Waste Settlement Results - Section F-F' - Western Gully Landfill Geometry data
C.8b	Long Term Waste Settlement Results - Section F-F' -Western Gully Landfill Geometry of waste filling stages (graph)
C.8c	Long Term Waste Settlement Results - Section F-F' – Western Gully Landfill Existing waste settlement calculations
C.8d	Long Term Waste Settlement Results - Section F-F' – Western Gully Landfill Settlement induced liner strains & liner grade change calculations
C.8e	Long Term Waste Settlement Results - Section F-F' – Western Gully Landfill Old landfill waste compression after new landfill waste placement (graph).
C.9	Eastern Gully Landfill – Historical Filling Stages
C.10a	Long Term Waste Settlement Results - Section H-H' - Western Gully Landfill Geometry data
C.10b	Long Term Waste Settlement Results - Section H-H' -Western Gully Landfill Geometry of waste filling stages (graph)
C.10c	Long Term Waste Settlement Results - Section H-H' – Western Gully Landfill Existing waste settlement calculations
C.10d	Long Term Waste Settlement Results - Section H-H' – Western Gully Landfill Settlement induced liner strains & liner grade change calculations
C.10e	Long Term Waste Settlement Results - Section H-H' – Western Gully Landfill Old landfill waste compression after new landfill waste placement (graph).
C.11	Long Term New Waste Settlement Results – Section F-F’ – Ch 175 m
C.12	Long Term New Waste Settlement Results – Section G-G’ – Ch 200 m
C.13	Long Term New Waste Settlement Results – Section H-H’ – Ch 220 m
C.14	Long Term New Waste Settlement Results – Cross Final Landform Settlement induced strains & grade change calculations
C.15	Liquefaction Assessment Calculations

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SUBJECT	SETTLE 3D MODEL INPUTS	
Job No.: 117625003/200/2031	Made by RMP	Date 10/01/2012
Ref.	Checked by	Sheet 1 of 1

SECTION F-F'

New Landfill Cell – New waste onto soil profile

SOIL PROFILES

	Chainage (m)				
	Ch 425	Ch 475	Ch 570	Ch 600	Ch 630
UNIT 41(c)	32.43m	25.30m	11.15m	7.84m	4.21m
UNIT 41(c)	5.5m	3.0m	0m	0m	2.5m
UNIT 42(a)	/	/	16m	9m	2.5m
UNIT 42(b)	4.5m	9m	/	/	/
UNIT 43	4m	4m	4m	4m	4m

Assumptions

Start of model:

$t = 0 = 2013$

Start of filling:

Stage 3	2035 – 2046	(11.8yrs)	New waste to be placed in Stage 3
Stage 2b	2020 – 2035	(15.2yrs)	$t = 22$ for start of operations.

- Assume that 6m of waste will be placed in 1 year of operation. Model load as embankment layers.
- Assume that @ $t = 0$ groundwater level is at 2m bgl.
- Assume that @ $t = 40$ groundwater level is at 3m bgl.

Loading sequence:

Ch 425

	Embankment (H)
$t = 0 = 2013$	Layer = 0m
$t = 15$ (+0yrs)	Layer = 0m
2b. $t = 16$ (+1yr)	Layer = 6m
$t = 17$ (+2yrs)	Layer = 6m
$t = 20$ (+5yrs)	Layer = 18m
3. $t = 40$ (+40yrs) (Stage 2b)	Layer no change

$\Delta H = 30m$

$\gamma = 11 kN/m^3$

Total Load = 330kPa

Ch 475

	Embankment (H)
$t = 0 = 2013$	Layer = 0m
2b. $t = 15 =$ Start 3	Layer = 0m
$t = 16$ (+1yr)	Layer = 6m
$t = 17$ (+2yrs)	Layer = 6m
3. $t = 18$ (+3yrs)	Layer = 6.3m
$t = 26$ (+11yrs)	Layer = 7.3m

$\Delta H = 25.3m$

$\gamma = 11 kN/m^3$

Total Load = 278.3kPa

Ch 570

	Embankment (H)
$t = 0 = 2013$	no change
$t = 22 =$ Start 3	no change
$t = 23$ (+1yr)	Layer 6m
$t = 24$ (+2yrs)	Layer 5.5m
$t = 27$ (+5yrs)	No change
$t = 40$ (+40yrs)	No change.

$\Delta H = 11.15m$

$\gamma = 11 kN/m^3$

Total Load = 122.65kPa

Ch 600

	Embankment (H)
$t = 0 = 2013$	Layer = 0m
$t = 22$ (0) =	Layer = 0m
$t = 23$ (+1yr)	Layer = 7.84m
$t = 27$ (+5yrs)	no change.
$t = 40$ (+40yrs)	no change.

$\Delta H = 7.84$ $\gamma = 11 kN/m^3$

Total Load = 86.24kPa

Ch 630

	Embankment (H)
$t = 0 = 2013$	Layer = 0m
$t = 22$ (0yrs)	Layer = 0m
$t = 22.5$ (+0.5yrs)	Layer = 4.21m
$t = 27$ (+5yrs)	no change
$t = 40$ (+40yrs)	no change

$\Delta H = 4.21m$ $\gamma = 11 kN/m^3$

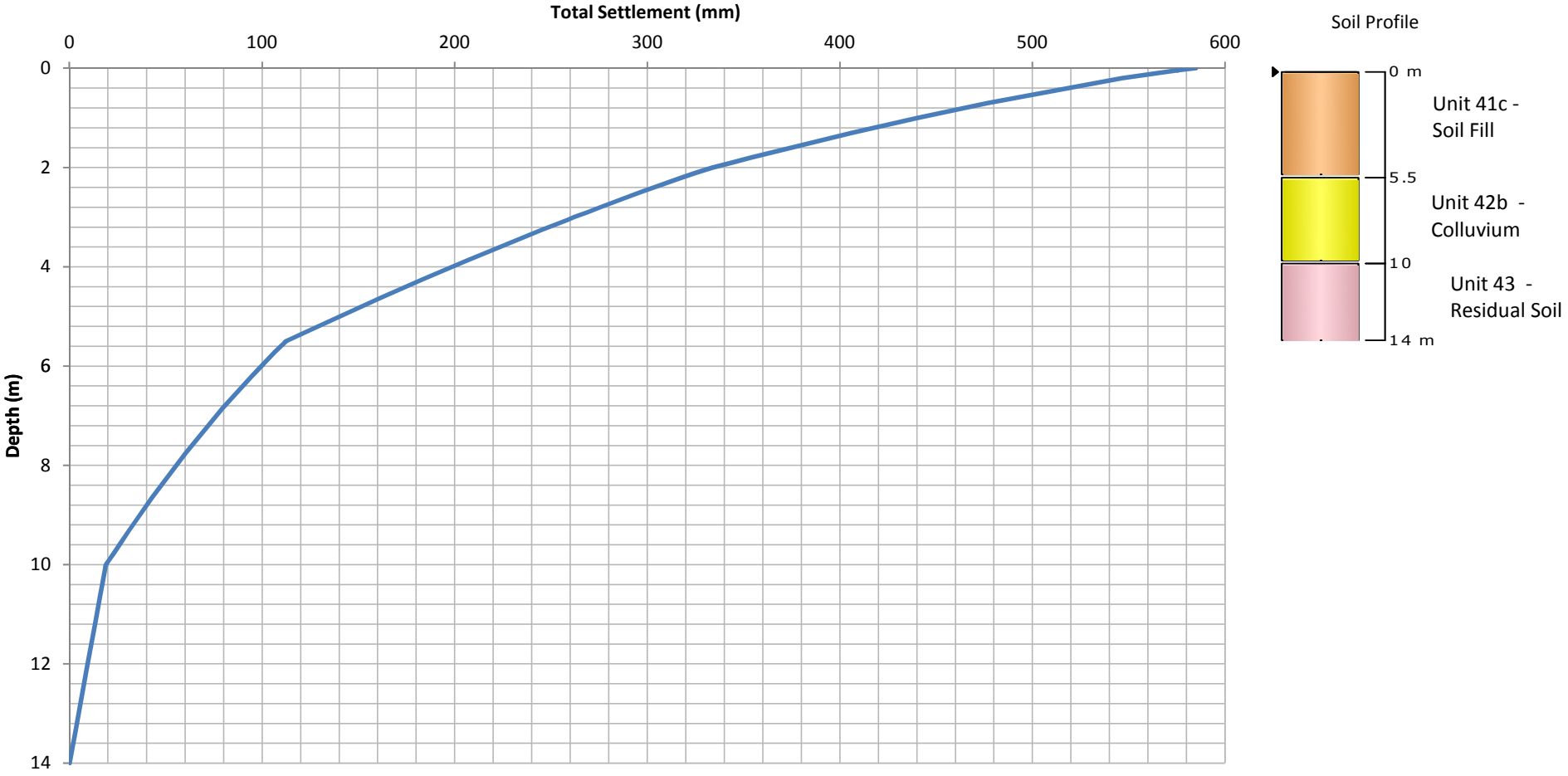
Total Load = 46.31kPa.

CLIENT	Wollongong City Council		PROJECT	Whytes Gully New Landfill Cell	
DRAWN	GS/RMP	DATE: 16/01/11	TITLE:	Western Gully Landfill	
CHECKED	CSC	DATE: 16/01/11		Settle3D Model Inputs	
SCALE:	N/A		PROJECT No.	117625003	FIGURE No. C.1 A3

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Section F-F' Ch 425m - 40yrs post end of filling
Total Settlement vs. Depth

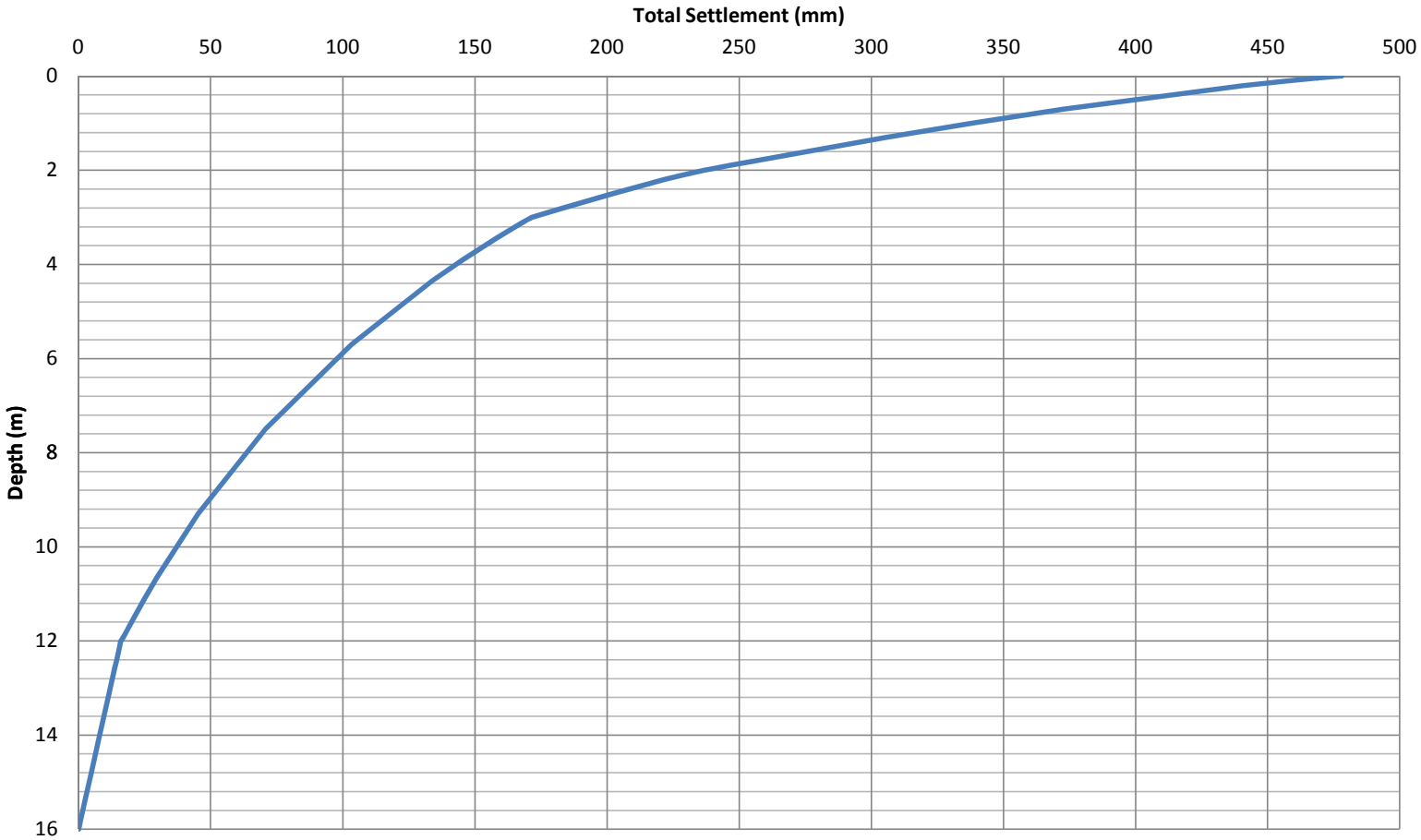


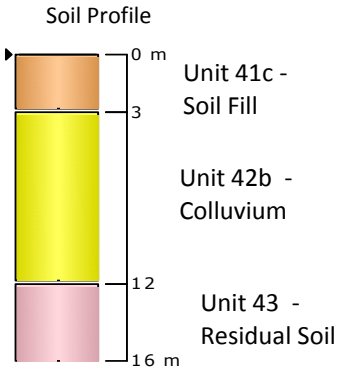
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	DRAWN	RMP	DATE: 16/01/2011	Section F-F' - CH425 m	
	CHECKED	CSC	DATE: 16/01/2011	Existing Soil Profile - Total Settlement	
	SCALE:	As Shown	PROJECT No. 117625003	FIGURE No. C.2	A4

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Section F-F' Ch 475m - 40yrs post end of filling
Total Settlement vs. Depth



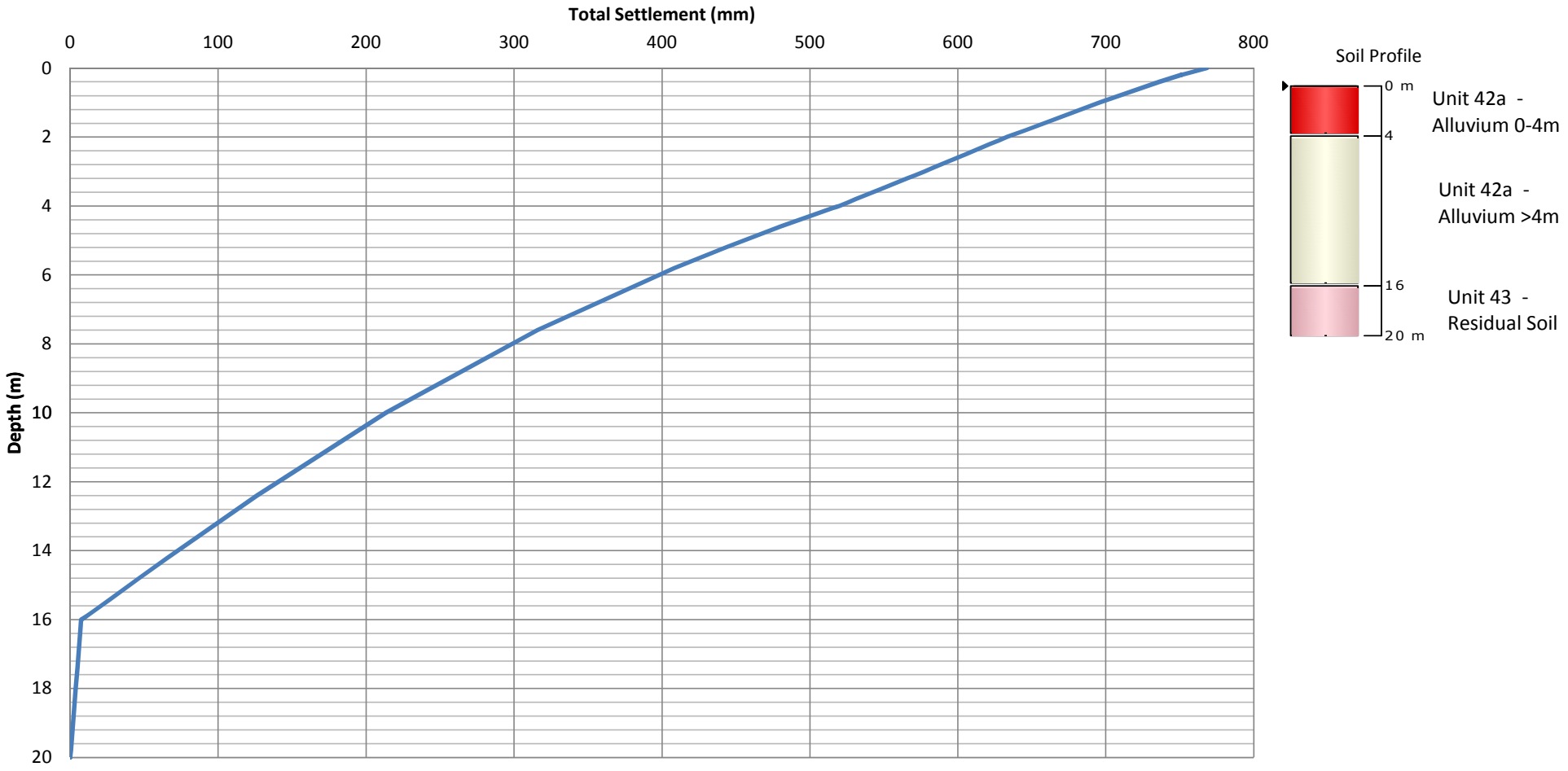


CLIENT: Wollongong City Council		PROJECT: Whytes Gully New Landfill Cell	
DRAWN: RMP	DATE: 16/01/2011	Section F-F' - CH475 m Existing Soil Profile - Total Settlement	
CHECKED: CSC	DATE: 16/01/2011		
SCALE: As Shown		PROJECT No.: 117625003	FIGURE No.: C.3 A4

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Section F-F' Ch 570m - 40yrs post end of filling
Total Settlement vs. Depth

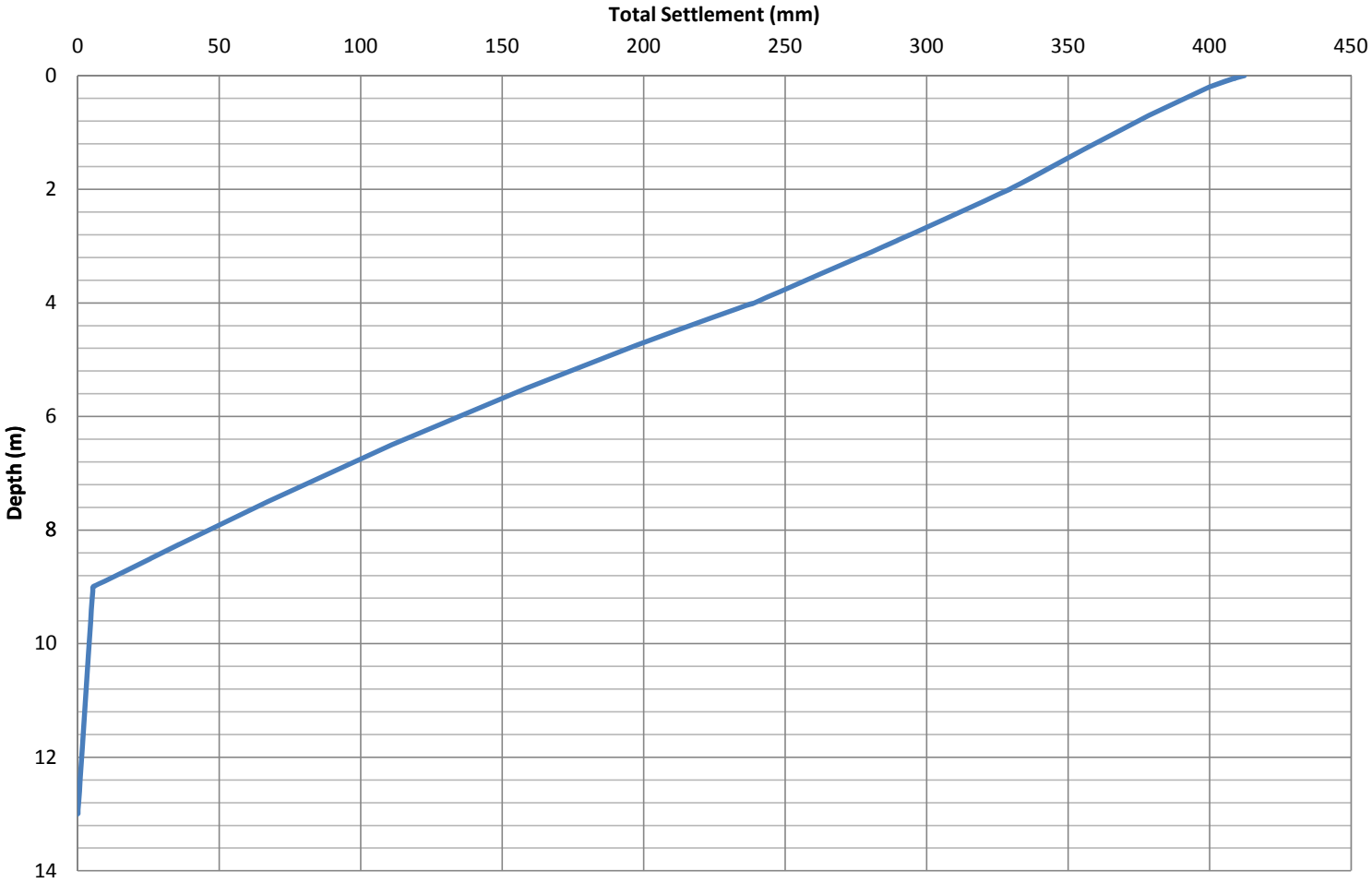


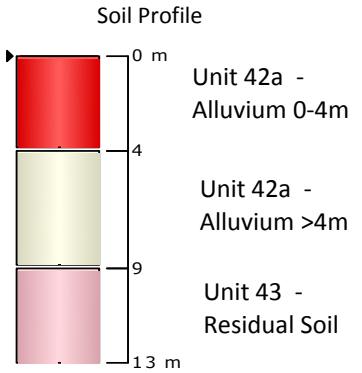
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DRAWN	RMP DATE: 16/01/2011		Section F-F' - CH570 m
CHECKED	CSC DATE: 16/01/2011		Existing Soil Profile - Total Settlement
SCALE:	As Shown	PROJECT No. 117625003	FIGURE No. C.4 A4

C:\Users\rprosser\Desktop\[Figs C1 and C2.xlsx]Fig C.1

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Section F-F' Ch 600m - 40yrs post end of filling
Total Settlement vs. Depth



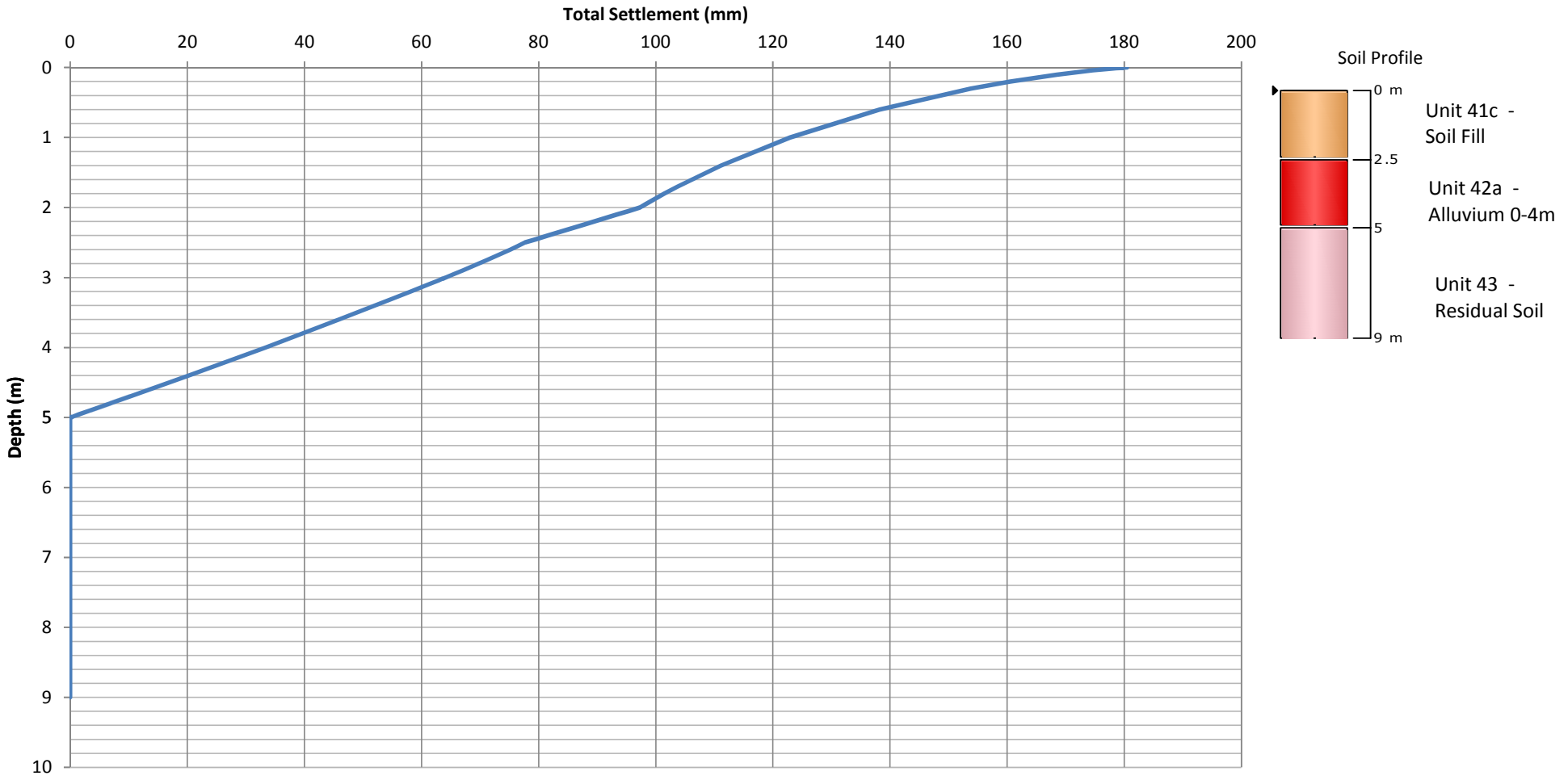


CLIENT: Wollongong City Council		PROJECT: Whytes Gully New Landfill Cell	
DRAWN: RMP	DATE: 16/01/2011	Section F-F' - CH600 m	
CHECKED: CSC	DATE: 16/01/2011	Existing Soil Profile - Total Settlement	
SCALE: As Shown		PROJECT No.: 117625003	FIGURE No.: C.5 A4

C:\Users\rprosser\Desktop\[Figs C1 and C2.xlsx]Fig C.1

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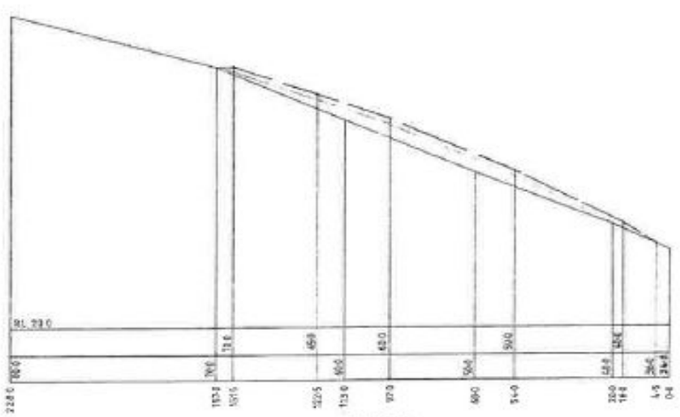
Section F-F' Ch 630m - 40yrs post end of filling
Total Settlement vs. Depth

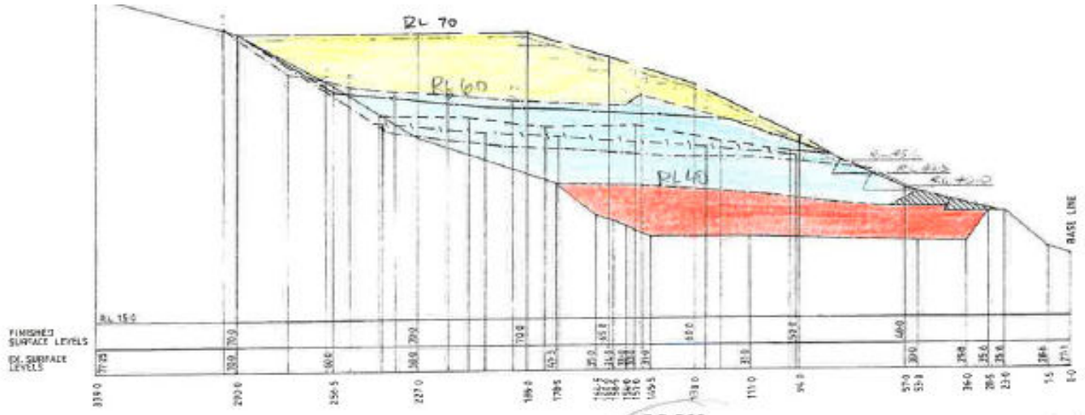


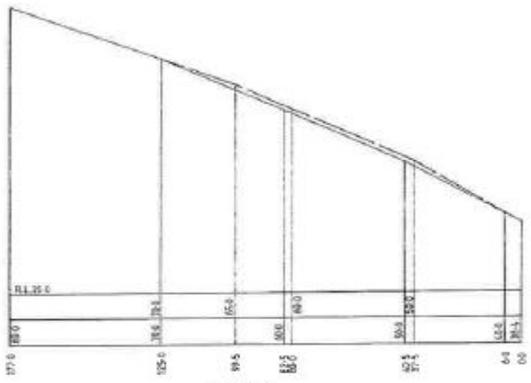
CLIENT: Wollongong City Council		PROJECT: Whytes Gully New Landfill Cell	
DRAWN: RMP	DATE: 16/01/2011	Section F-F' - CH630 m	
CHECKED: CSC	DATE: 16/01/2011	Existing Soil Profile - Total Settlement	
SCALE: As Shown		PROJECT No.: 117625003	FIGURE No.: C.6 A4

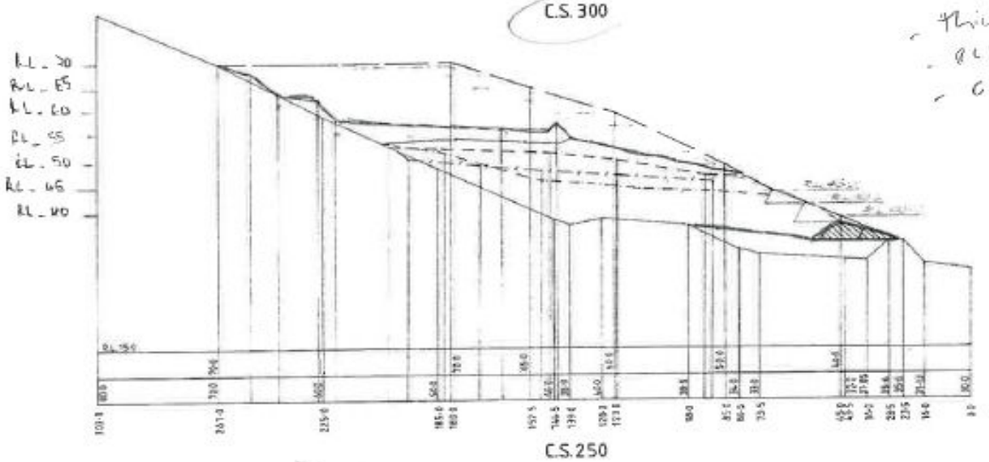
C:\Users\rprosser\Desktop\[Figs C1 and C2.xlsx]Fig C.1

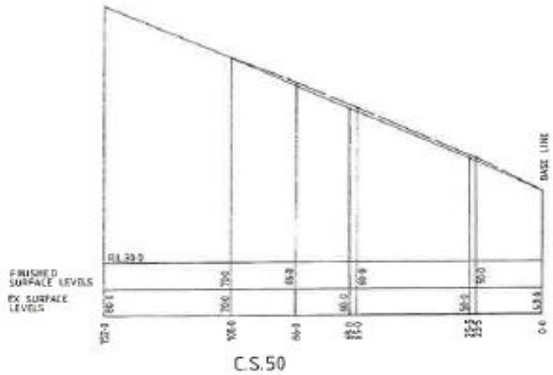
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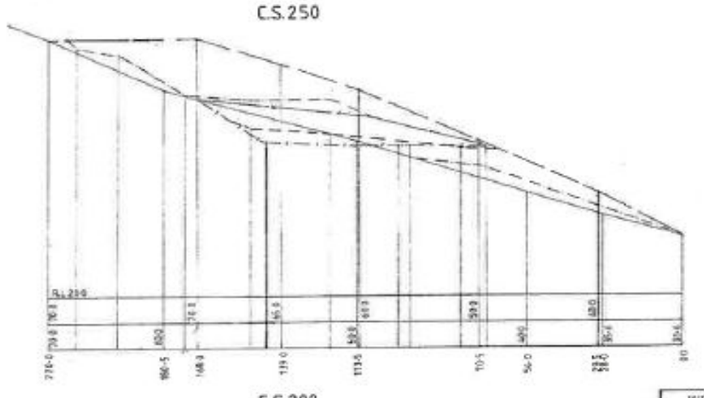












26 yrs old

21-26 yrs old

< 21 yrs old.

SCALES
HORIZ. 1:1000
VERT. 1:500

SURVEYED 10/1/91
SURVEYED 24/4/90
SURVEYED 30/5/89
SURVEYED 4/11/88
SURVEYED 3/3/88
SURVEYED 27/8/86.

LEGEND:
BUND WALL AS CONSTRUCTED.
FUTURE BUND WALL.

DRAWN: K.IRVINE 9/86

INDEX BASE No.

CITY OF WOLLONGONG

WHYTES GULLY WASTE DISPOSAL DEPOT
CROSS SECTIONS THROUGH TIPPING AREA

No OF SHEETS 3 | SHEET No 2

DRAWING No. P331/12

Golder Associates

CLIENT	Wollongong City Council	PROJECT	Whytes Gully New Landfill Cell
DRAWN	GS/RMP	DATE: 16/01/11	TITLE: Western Gully Landfill
CHECKED	CSC	DATE: 16/01/11	Filling Stages
SCALE:	N/A	PROJECT No. 117625003	FIGURE No. **C.7** A3

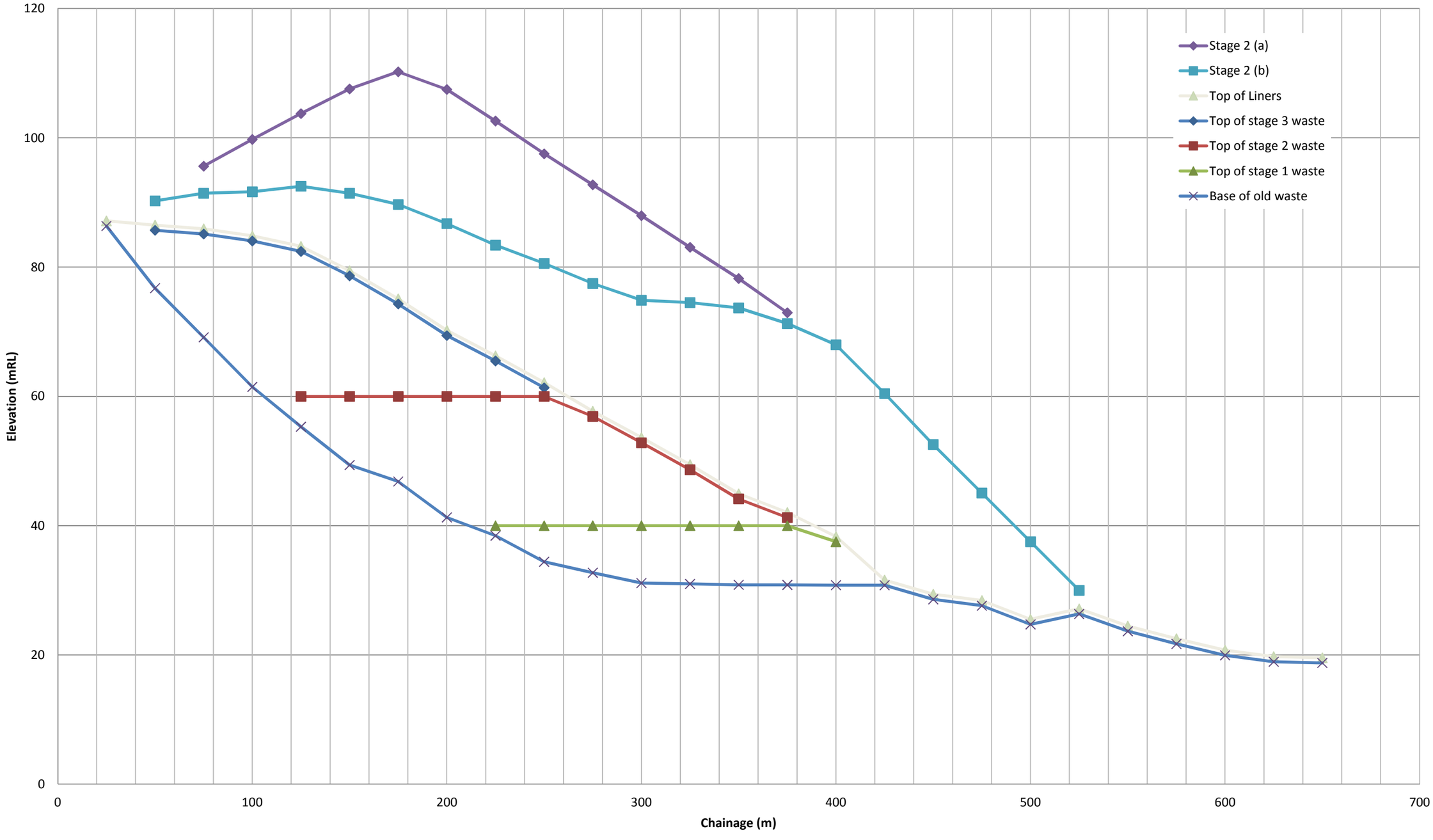
C:\Users\rprossen\Desktop\[Figs C1 and C2.xlsx]Fig C.7

117625003 Whytes Gully New Landfill Cell
Western Gully Landfill - Section F-F'
Geometry data (cross section elevations) for existing waste settlement

Proposed Liner Thickness 0.8 m

Point	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Chainage	25	50	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500	525	550	575	600	625	650
Elevation (mRL) - New Waste																										
Stage 1 (a)																										
Stage 1 (b)																										
Stage 1 (c)																										
Stage 1 (d)																										
Stage 2 (a)			**95.61**	**99.76**	**103.75**	**107.56**	**110.22**	**107.48**	**102.61**	**97.53**	**92.74**	**87.96**	**83.07**	**78.23**	**72.95**											
Stage 2 (b)		**90.25**	**91.42**	**91.65**	**92.51**	**91.43**	**89.69**	**86.73**	**83.4**	**80.58**	**77.47**	**74.87**	**74.51**	**73.69**	**71.27**	**67.99**	**60.44**	**52.56**	**45.05**	**37.53**	**30**					
Stage 2 (c)																										
Stage 2 (d)																										
Stage 2 (e)																										
Stage 3 (a)																	**63.21**	**58.08**	**52.93**	**48.03**	**43**	**37.93**	**32.86**	**27.78**	**23.16**	18.77
Stage 3 (b)																										
Stage 3 (c)																										
Stage 4 (a)																										
Stage 4 (b)																										
Stage 4 (c)																										
Top of Liners	87.16	86.5	85.92	84.84	83.23	79.44	75.1	70.21	66.29	62.14	57.71	53.63	49.46	44.94	42.06	38.33	31.59	29.41	28.42	25.53	27.14	24.47	22.51	20.75	19.75	19.57
Top of stage 3 waste		85.7	85.12	84.04	82.43	78.64	74.3	69.41	65.49	61.34																
Top of stage 2 waste					60	60	60	60	60	60	56.91	52.83	48.66	44.14	41.26											
Top of stage 1 waste									40	40	40	40	40	40	40	37.53										
Base of old waste	86.36	76.75	69.14	61.47	55.31	49.38	46.84	41.28	38.45	34.42	32.72	31.13	30.99	30.85	30.84	30.8	30.79	28.61	27.62	24.73	26.34	23.67	21.71	19.95	18.95	18.77
Calculated Thickness (m)																										
Stage 1 (a)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 1 (b)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 1 (c)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 1 (d)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 2 (a)	0	0	4.19	8.11	11.24	16.13	20.53	20.75	19.21	16.95	15.27	13.09	8.56	4.54	1.68	0	0	0	0	0	0	0	0	0	0	0
Stage 2 (b)	0	3.75	5.5	6.81	9.28	11.99	14.59	16.52	17.11	18.44	19.76	21.24	25.05	28.75	29.21	29.66	28.85	23.15	16.63	12	2.86	0	0	0	0	0
Stage 2 (c)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 2 (d)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 2 (e)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 3 (a)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.77	5.52	7.88	10.5	13	37.93	32.86	27.78	23.16	18.77
Stage 3 (b)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 3 (c)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 4 (a)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 4 (b)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 4 (c)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Piggyback liner	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
stage 3	0	8.95	15.98	22.57	22.43	18.64	14.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
stage 2	0	0	0	0	4.69	10.62	13.16	18.72	20	20	16.91	12.83	8.66	4.14	1.26	0	0	0	0	0	0	0	0	0	0	0
stage 1	0	0	0	0	0	0	0	0	1.55	5.58	7.28	8.87	9.01	9.15	9.16	6.73	0	0	0	0	0	0	0	0	0	0

117625003 - Section F-F' - Western Gully Landfill
Geometry of waste filling stages



117625003 Whytes Gully New Landfill Cell

2. EXISTING WASTE SETTLEMENT CALCULATION

Western Gully Landfill - Section F-F'

Waste Materials	Old waste				New Waste	**Basis of adopted value**
Material	stage 1	stage 2	stage 3			
waste type	MSW	MSW	MSW		New	from available site information
Unit Weight (kN/m3)	11	11	11		11	assumed based on waste type
C-ce (mod primary)	0.2	0.2	0.2		NA	range from Gourc & Olivier (2005) is 0.12 to >0.24
C-c alph (mod secondary)	0.06	0.06	0.06		NA	range from Gourc & Olivier (2005) is 0.02 to >0.14
average age in 2017(yr)	33	29.5	26		-	from available site information

2.1 SHORT-TERM "PRIMARY CONSOLIDATION"

Section 12.4.2 Settlement of existing solid waste: Eq 12.9, Ref Xuede, Koerner and Gray P.451

$$s = H \times C_{c\varepsilon} \times \log \frac{\sigma_0 + \Delta\sigma}{\sigma_0}$$

$C_{c\varepsilon}$ - Modified primary compression index

Assumptions

use Sigma-0 = current vertical stress at layer midpoint
use delta-sigma = vertical stress increase from new waste placement

2.2 LONG-TERM "SECONDARY CONSOLIDATION"

Section 12.4.2 Settlement of existing solid waste: Eq 12.11, Ref Xuede, Koerner and Gray P.451

$$s = H \times C_{\alpha\varepsilon} \times \log \frac{t_{final}}{t_{initial}}$$

$C_{\alpha\varepsilon}$ - Modified secondary compression index

Assumptions

use t-initial= average age in 2017 at start of Stage 2
use t-final= t-initial plus 40 years

t initial starting time of the secondary settlement. Assumed to be equal to the age of the existing landfill for vertical expansion.
t final ending time of the secondary settlement

2.1 Short-Term "Primary" Settlement of Liner

Point	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Chainage (m)	25	50	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500	525	550	575	600	625	650
Thickness of New Landfill Waste Filling Stages (m)																										
Stage 1 (a)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 1 (b)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 1 (c)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 1 (d)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 2 (a)	0	0	4.19	8.11	11.24	16.13	20.53	20.75	19.21	16.95	15.27	13.09	8.56	4.54	1.68	0	0	0	0	0	0	0	0	0	0	0
Stage 2 (b)	0	3.75	5.5	6.81	9.28	11.99	14.59	16.52	17.11	18.44	19.76	21.24	25.05	28.75	29.21	29.66	28.85	23.15	16.63	12	2.86	0	0	0	0	0
Stage 2 (c)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 2 (d)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 2 (e)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 3 (a)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.77	5.52	7.88	10.5	13	37.93	32.86	27.78	23.16	18.77
Stage 3 (b)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 3 (c)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 4 (a)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 4 (b)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 4 (c)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total thickness of new waste	0	3.75	9.69	14.92	20.52	28.12	35.12	37.27	36.32	35.39	35.03	34.33	33.61	33.29	30.89	29.66	31.62	28.67	24.51	22.5	15.86	37.93	32.86	27.78	23.16	18.77
Thickness Western Gully FIlling Stage3	0.00	8.95	15.98	22.57	22.43	18.64	14.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.77	5.52	7.88	10.50	13.00	37.93	32.86	27.78	23.16	18.77
Sigma-0 (kN/m2)	NA	49.23	87.89	124.14	123.37	102.52	78.65	NA	NA	NA	NA	NA	NA	NA	NA	NA	15.24	30.36	43.34	57.75	71.50	208.62	180.73	152.79	127.38	103.24
Delta-sigma (kN/m2)	NA	41.25	106.59	164.12	225.72	309.32	386.32	NA	NA	NA	NA	NA	NA	NA	NA	NA	347.82	315.37	269.61	247.50	174.46	417.23	361.46	305.58	254.76	206.47
Calc settlement of layer (m)	0.00	0.47	1.10	1.65	2.03	2.25	2.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.76	1.17	1.35	1.52	1.40	3.62	3.14	2.65	2.21	1.79
Thickness Western Gully FIlling Stage2	0.00	0.00	0.00	0.00	4.69	10.62	13.16	18.72	20.00	20.00	16.91	12.83	8.66	4.14	1.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sigma-0 (kN/m2)	NA	NA	NA	NA	272.53	263.45	229.68	102.96	110.00	110.00	93.01	70.57	47.63	22.77	6.93	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Delta-sigma (kN/m2)	NA	NA	NA	NA	225.72	309.32	386.32	409.97	399.52	389.29	385.33	377.63	369.71	366.19	339.79	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.25	0.72	1.13	2.61	2.66	2.63	2.41	2.06	1.63	1.02	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thickness Western Gully FIlling Stage1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.55	5.58	7.28	8.87	9.01	9.15	9.16	6.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sigma-0 (kN/m2)	NA	NA	NA	NA	NA	NA	NA	NA	228.53	250.69	226.05	189.92	144.82	95.87	64.24	37.02	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Delta-sigma (kN/m2)	NA	NA	NA	NA	NA	NA	NA	NA	399.52	389.29	385.33	377.63	369.71	366.19	339.79	326.26	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.45	0.63	0.84	0.99	1.25	1.46	1.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total "Primary" settlement (m)	0.00	0.47	1.10	1.65	2.27	2.97	3.33	2.61	2.80	3.08	3.03	2.90	2.62	2.27	1.89	1.34	0.76	1.17	1.35	1.52	1.40	3.62	3.14	2.65	2.21	1.79

2.2 Long-Term "Secondary" Settlement of Liner

Note: for the purpose of this secondary settlement calculation, all piggy back liner and overlying new waste is assumed to be placed at the same time. This is choes to corrspond of the start

Point	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
New Waste																										
Total Thickness	0.00	3.75	9.69	14.92	20.52	28.12	35.12	37.27	36.32	35.39	35.03	34.33	33.61	33.29	30.89	29.66	31.62	28.67	24.51	22.50	15.86	37.93	32.86	27.78	23.16	18.77
Old Waste																										
Thickness Western Gully FIlling Stage3	0.00	8.95	15.98	22.57	22.43	18.64	14.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.77	5.52	7.88	10.50	13.00	37.93	32.86	27.78	23.16	18.77
T-initial (yr)	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00
T-final (yr)	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00
Calc settlement of layer (m)	0.00	0.22	0.39	0.55	0.54	0.45	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.13	0.19	0.25	0.32	0.92	0.80	0.67	0.56	0.46
Thickness Western Gully FIlling Stage2	0.00	0.00	0.00	0.00	4.69	10.62	13.16	18.72	20.00	20.00	16.91	12.83	8.66	4.14	1.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T-initial (yr)	29.50	29.50	29.50	29.50	29.50	29.50	29.50	29.50	29.50	29.50	29.50	29.50	29.50	29.50	29.50	29.50	29.50	29.50	29.50	29.50	29.50	29.50	29.50	29.50	29.50	29.50
T-final (yr)	69.50	69.50	69.50	69.50	69.50	69.50	69.50	69.50	69.50	69.50	69.50	69.50	69.50	69.50	69.50	69.50	69.50	69.50	69.50	69.50	69.50	69.50	69.50	69.50	69.50	69.50
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.10	0.24	0.29	0.42	0.45	0.45	0.38	0.29	0.19	0.09	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thickness Western Gully FIlling Stage1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.55	5.58	7.28	8.87	9.01	9.15	9.16	6.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T-initial (yr)	33.00	33.00	33.00	33.00	33.00	33.00	33.00	33.00	33.00	33.00	33.00	33.00	33.00	33.00	33.00	33.00	33.00	33.00	33.00	33.00	33.00	33.00	33.00	33.00	33.00	33.00
T-final (yr)	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.12	0.15	0.18	0.19	0.19	0.19	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total "Secondary" settlement(m)	**0.00**	**0.22**	**0.39**	**0.55**	**0.65**	**0.69**	**0.64**	**0.42**	**0.48**	**0.56**	**0.53**	**0.47**	**0.38**	**0.28**	**0.22**	**0.14**	**0.07**	**0.13**	**0.19**	**0.25**	**0.32**	**0.92**	**0.80**	**0.67**	**0.56**	**0.46**

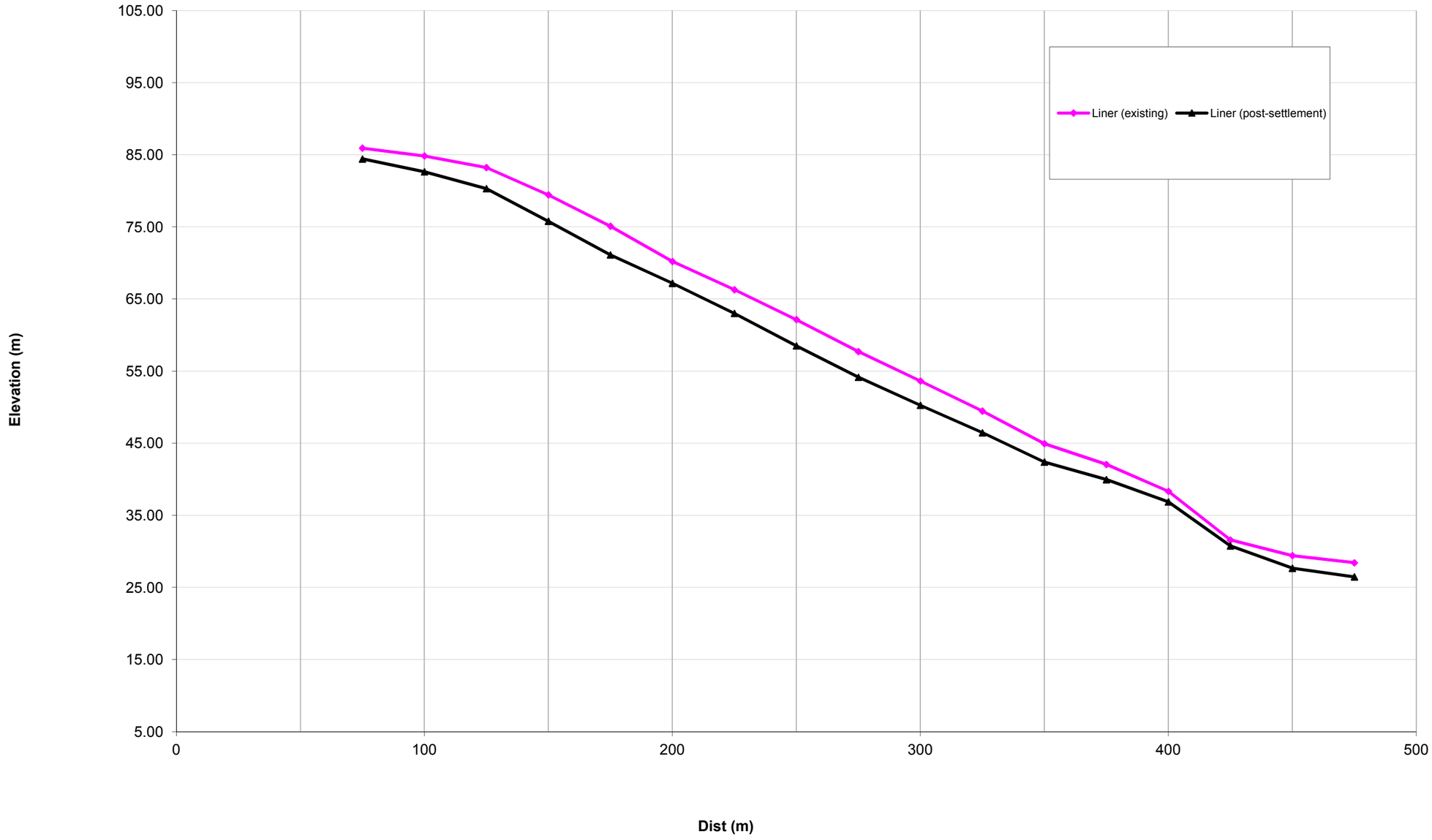
Natural Soil Profile Total Settlement (m) (Settle3D outputs)	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.53**	**0.45**	**0.41**	**0.50**	**0.55**	**0.65**	**0.67**	**0.39**	**0.17**	**0.15**

Sum of calculated "Primary" and "Secondary" settlement (m)	0.00	0.69	1.49	2.20	2.92	3.66	3.98	3.03	3.28	3.64	3.56	3.37	3.00	2.55	2.11	1.47	0.83	1.75	1.96	2.27	2.26	5.19	4.60	3.71	2.94	2.40

117625003 Whytes Gully New Landfill Cell
Western Gully Landfill - Section F-F'
3. CALCULATE SETTLEMENT-INDUCED LINER STRAINS & LINER GRADE CHANGES

Point	1		2		3		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18		19		20		21		22		23		24		25		26
Interval		**1-2**		**2-3**		**3-4**		**4-5**		**5-6**		**6-7**		**7-8**		**8-9**		**9-10**		**10-11**		**11-12**		**12-13**		**13-14**		**14-15**		**15-16**		**16-17**		**17-18**		**18-19**		**19-20**		**20-21**		**21-22**		**22-23**		**23-24**		**24-25**		**25-26**	
Distance (m)	25		50		75		100		125		150		175		200		225		250		275		300		325		350		375		400		425		450		475		500		525		550		575		600		625		650
Existing Elevation (m)	86.36		86.50		85.92		84.84		83.23		79.44		75.10		70.21		66.29		62.14		57.71		53.63		49.46		44.94		42.06		38.33		31.59		29.41		28.42		25.53		27.14		24.47		22.01		20.75		19.75		19.57
Existing interval surface length (m)		25.000		25.007		25.023		25.052		25.286		25.374		25.474		25.305		25.342		25.389		25.331		25.345		25.405		25.165		25.277		25.893		25.095		25.020		25.166		25.052		25.142		25.077		25.062		25.020		25.001	
Existing interval grade (%)		0.6		-2.3		-4.3		-6.4		-15.2		-17.4		-19.6		-15.7		-16.6		-17.7		-16.3		-16.7		-18.1		-11.5		-14.9		-27.0		-8.7		-4.0		-11.6		6.4		-10.7		-7.8		-7.0		-4.0		-0.7	
Total calculated primary and secondary settlement (m)		0.7		1.5		2.2		2.9		3.7		4.0		3.0		3.3		3.6		3.6		3.4		3.0		2.6		2.1		1.5		0.8		1.8		2.0		2.3		2.3		5.2		4.6		3.7		2.9		2.4	
Elevation after primary and secondary settlement (m)	86.360		85.810		84.430		82.641		80.309		75.783		71.124		67.181		63.012		58.496		54.147		50.256		46.455		42.388		39.951		36.856		30.760		27.660		26.464		23.257		24.879		19.280		17.910		17.040		16.811		17.173
Post-settlement surface length of interval (m)		25.006		25.038		25.064		25.109		25.406		25.430		25.309		25.345		25.405		25.375		25.301		25.287		25.329		25.118		25.191		25.732		25.191		25.029		25.205		25.053		25.619		25.038		25.015		25.001		25.003	
Settlement-induced strain (%), [positive=tension]		**0.0**		**0.1**		**0.2**		**0.2**		**0.5**		**0.2**		**-0.6**		**0.2**		**0.2**		**-0.1**		**-0.1**		**-0.2**		**-0.30**		**-0.19**		**-0.34**		**-0.62**		**0.38**		**0.04**		**0.15**		**0.00**		**1.90**		**-0.16**		**-0.19**		**-0.08**		**0.01**	
Post-settlement interval grade (%)		-2.2		-5.5		-7.2		-9.3		-18.1		-18.6		-15.8		-16.7		-18.1		-17.4		-15.6		-15.2		-16.3		-9.7		-12.4		-24.4		-12.4		-4.8		-12.8		6.5		-22.4		-5.5		-3.5		-0.9		1.4	
Settlement-induced grade change (%)		**-2.8**		**-3.2**		**-2.8**		**-2.9**		**-2.9**		**-1.3**		**3.8**		**-1.0**		**-1.5**		**0.3**		**0.8**		**1.48**		**1.81**		**1.77**		**2.54**		**2.68**		**-3.68**		**-0.82**		**-1.27**		**0.05**		**-11.72**		**2.36**		**3.56**		**3.08**		**2.17**	
Grade Change?		**Grade Reversal**		**No Grade Reversal**		**No Grade Reversal**		**No Grade Reversal**		**No Grade Reversal**		**No Grade Reversal**		**No Grade Reversal**		**No Grade Reversal**		**No Grade Reversal**		**No Grade Reversal**		**No Grade Reversal**		**No Grade Reversal**		**No Grade Reversal**		**No Grade Reversal**		**No Grade Reversal**		**No Grade Reversal**		**No Grade Reversal**		**No Grade Reversal**		**No Grade Reversal**		**No Grade Reversal**		**No Grade Reversal**		**No Grade Reversal**		**No Grade Reversal**		**No Grade Reversal**		**Grade Reversal**	

Cross Section F-F' Western Gully Landfill
Old Landfill Waste Compression after New Landfill Waste Placement
(excludes new landfill waste on proposed new cell floor)



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NOTE: EXTRACT FROM COUNCIL DRAWING # 1475

Reference survey drawings

Dec. 2000 # 2982

Dec 2001 # 3156

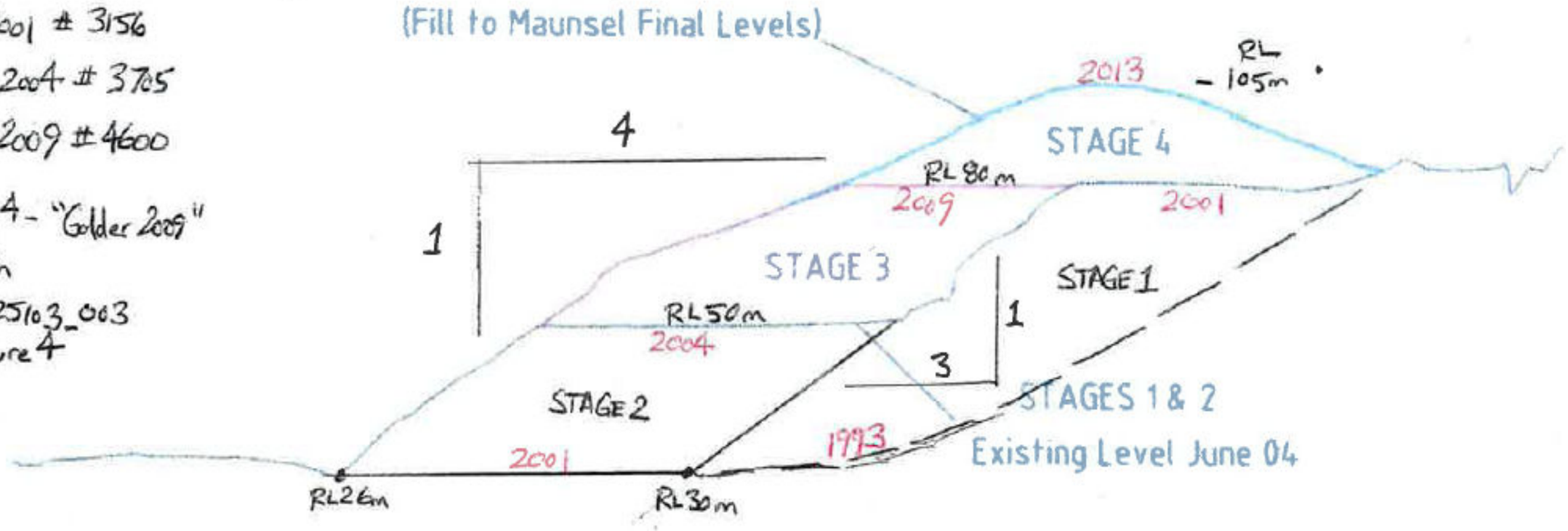
June 2004 # 3705

Dec 2009 # 4600

Stage 4 - "Golder 2009" design

097625103_003

Figure 4



Golder Associates	CLIENT	Wollongong City Council		PROJECT	Whytes Gully New Landfill Cell
	DRAWN	GS/RMP	DATE: 16/01/11	TITLE:	Eastern Gully Landfill Filling Stages
	CHECKED	CSC	DATE: 16/01/11		
	SCALE:	N/A		PROJECT No. 117625003	FIGURE No. **C.9** A3

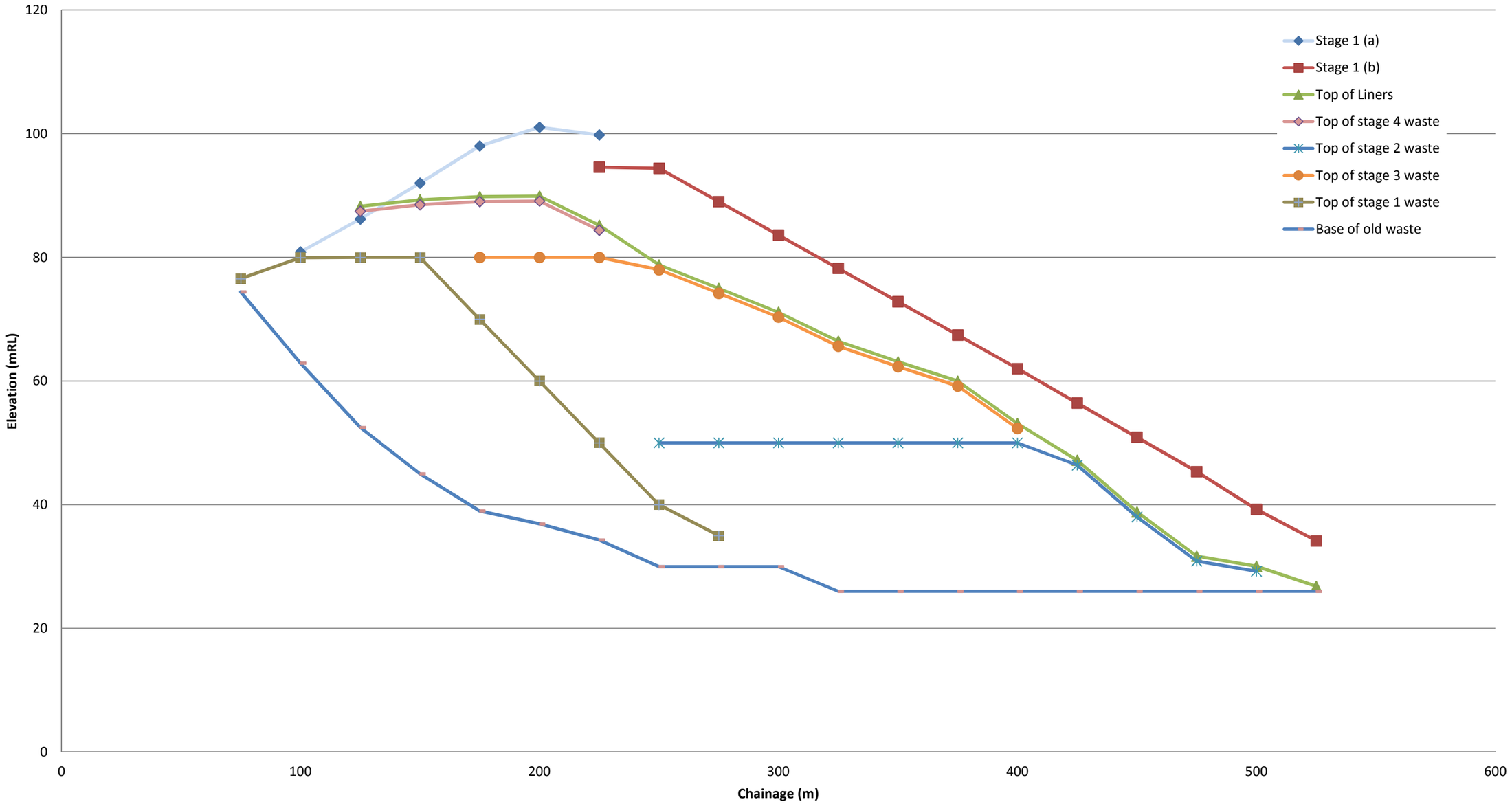
C:\Users\rprosser\Desktop\[Figs C1 and C2.xlsx]Fig C.7

117625003 Whytes Gully New Landfill Cell
Eastern Gully Landfill - Section H-H'
Geometry data (cross section elevations) for existing waste settlement

Proposed Design Thickness of Piggyback Liner: 0.8 m

Point	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Chainage	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500	525
Elevation (mRL) - New Waste																			
Stage 1 (a)		80.87	86.21	92.01	98.02	101.05	99.8												
Stage 1 (b)							94.59	94.41	89.02	83.62	78.23	72.84	67.45	62.01	56.46	50.91	45.36	39.25	34.16
Stage 1 (c)																			
Stage 1 (d)																			
Stage 2 (a)																			
Stage 2 (b)																			
Stage 2 (c)																			
Stage 2 (d)																			
Stage 2 (e)																			
Stage 3 (a)																			
Stage 3 (b)																			
Stage 3 (c)																			
Stage 4 (a)																			
Stage 4 (b)																			
Stage 4 (c)																			
Top of Liners			88.26	89.31	89.82	89.91	85.2	78.8	74.99	71.13	66.44	63.12	59.99	53.13	47.2	38.84	31.68	30.05	26.8
Top of stage 4 waste			87.46	88.51	89.02	89.11	84.4												
Top of stage 3 waste					80	80	80	78	74.19	70.33	65.64	62.32	59.19	52.33					
Top of stage 2 waste								50	50	50	50	50	50	50	46.4	38.04	30.88	29.25	
Top of stage 1 waste	76.54	79.96	80	80	70	60	50	40	35										
Base of old waste	74.41	62.9	52.5	45	39	36.9	34.3	30	30	30	26	26	26	26	26	26	26	26	26
Calculated Thickness (m)																			
Stage 1 (a)	0	0.91	-2.05	2.7	8.2	11.14	5.21	0	0	0	0	0	0	0	0	0	0	0	0
Stage 1 (b)	0	0	0	0	0	0	9.39	15.61	14.03	12.49	11.79	9.72	7.46	8.88	9.26	12.07	13.68	9.2	7.36
Stage 1 (c)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 1 (d)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 2 (a)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 2 (b)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 2 (c)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 2 (d)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 2 (e)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 3 (a)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 3 (b)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 3 (c)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 4 (a)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 4 (b)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 4 (c)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Piggyback liner			0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
stage 4	0	0	7.46	8.51	9.02	9.11	4.4	0	0	0	0	0	0	0	0	0	0	0	0
stage 3	0	0	0	0	10	20	30	28	24.19	20.33	15.64	12.32	9.19	2.33	0	0	0	0	0
stage 2	0	0	0	0	0	0	0	10	15	20	24	24	24	24	20.4	12.04	4.88	3.25	0
stage 1	2.13	17.06	27.5	31	31	23.1	15.7	10	5	0	0	0	0	0	0	0	0	0	0

117625003 - Section H-H' - Eastern Gully Landfill
Geometry of waste filling stages



117625003 Whytes Gully New Landfill Cell
Eastern Gully Landfill - Section H-H'
2. EXISTING WASTE SETTLEMENT CALCULATION

Waste Materials	Old waste				New Waste	**basis of adopted value**
Material	stage 1	stage 2	stage 3	stage 4	-	
waste type	MSW	MSW	MSW	MSW	MSW	from available site information
Unit Weight (kN/m3)	11	11	11	11	11	assumed based on waste type
C-ce (mod primary)	0.2	0.2	0.2	0.2	NA	range from Gourc & Olivier (2005) is 0.12 to >0.24
C-c alph (mod secondary)	0.06	0.06	0.06	0.06	NA	range from Gourc & Olivier (2005) is 0.02 to >0.14
average age in 2013(yr)	16	10.5	7.5	1.5	-	from available site information

2.1 SHORT-TERM "PRIMARY CONSOLIDATION"

Section 12.4.2 Settlement of existing solid waste: Eq 12.9, Ref Xuede, Koerner and Gray P.451

$$s = H \times C_{c\varepsilon} \times \log \frac{\sigma_0 + \Delta\sigma}{\sigma_0}$$

$C_{c\varepsilon}$ - Modified primary compression index
C'c = 0.17 ~0.36

Assumptions
use Sigma-0 = current vertical stress at layer midpoint
use delta-sigma = vertical stress increase from new waste placement

2.2 LONG-TERM "SECONDARY CONSOLIDATION"

Section 12.4.2 Settlement of existing solid waste: Eq 12.11, Ref Xuede, Koerner and Gray P.451

$$s = H \times C_{a\varepsilon} \times \log \frac{t_{final}}{t_{initial}}$$

$C_{a\varepsilon}$ - Modified secondary compression index

Assumptions
use t-initial= average age in 2013
use t-final= t-initial plus 40 years

t initial starting time of the secondary settlement. Assumed to be equal to the age of the existing landfill for vertical expansion.
t final ending time of the secondary settlement

2.1 Short-Term "Primary" Settlement of Liner

Point	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Chainage (m)	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500	525
Proposed Staged Filling Programme Elevations (m)																			
Stage 1 (a)	0	0.91	-2.05	2.7	8.2	11.14	5.21	0	0	0	0	0	0	0	0	0	0	0	0
Stage 1 (b)	0	0	0	0	0	0	9.39	15.61	14.03	12.49	11.79	9.72	7.46	8.88	9.26	12.07	13.68	9.2	7.36
Stage 1 (c)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 1 (d)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 2 (a)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 2 (b)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 2 (c)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 2 (d)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 2 (e)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 3 (a)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 3 (b)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 3 (c)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 4 (a)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 4 (b)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 4 (c)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total thickness of new waste	0	0.91	-2.05	2.7	8.2	11.14	14.6	15.61	14.03	12.49	11.79	9.72	7.46	8.88	9.26	12.07	13.68	9.2	7.36
Thickness Old Waste Stage4	0.00	0.00	7.46	8.51	9.02	9.11	4.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sigma-0 (kN/m2)	NA	NA	41.03	46.81	49.61	50.11	24.20	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Delta-sigma (kN/m2)	NA	NA	-22.55	29.70	90.20	122.54	160.60	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calc settlement of layer (m)	0.00	0.00	-0.52	0.36	0.81	0.98	0.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thickness Old Waste Stage3	0.00	0.00	0.00	0.00	10.00	20.00	30.00	28.00	24.19	20.33	15.64	12.32	9.19	2.33	0.00	0.00	0.00	0.00	0.00
Sigma-0 (kN/m2)	NA	NA	NA	NA	154.22	210.21	213.40	154.00	133.05	111.82	86.02	67.76	50.55	12.82	NA	NA	NA	NA	NA
Delta-sigma (kN/m2)	NA	NA	NA	NA	90.20	122.54	160.60	171.71	154.33	137.39	129.69	106.92	82.06	97.68	NA	NA	NA	NA	NA
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.40	0.80	1.46	1.82	1.62	1.42	1.25	1.01	0.77	0.44	0.00	0.00	0.00	0.00	0.00
Thickness Old Waste Stage2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	15.00	20.00	24.00	24.00	24.00	24.00	20.40	12.04	4.88	3.25	0.00
Sigma-0 (kN/m2)	NA	NA	NA	NA	NA	NA	NA	363.00	348.59	333.63	304.04	267.52	233.09	157.63	112.20	66.22	26.84	17.88	NA
Delta-sigma (kN/m2)	NA	NA	NA	NA	NA	NA	NA	171.71	154.33	137.39	129.69	106.92	82.06	97.68	101.86	132.77	150.48	101.20	NA
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34	0.48	0.60	0.74	0.70	0.63	1.01	1.14	1.15	0.80	0.54	0.00
Thickness Old Waste Stage1	2.13	17.06	27.50	31.00	31.00	23.10	15.70	10.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sigma-0 (kN/m2)	11.72	93.83	233.31	264.11	379.72	447.26	464.75	363.00	293.59	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Delta-sigma (kN/m2)	0.00	10.01	-22.55	29.70	90.20	122.54	160.60	171.71	154.33	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calc settlement of layer (m)	0.00	0.15	-0.24	0.29	0.57	0.49	0.40	0.34	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total "Primary" settlement (m)	0.00	0.15	0.00	0.65	1.79	2.26	2.64	2.49	2.28	2.01	1.99	1.71	1.40	1.44	1.14	1.15	0.80	0.54	0.00

2.2 Long-Term "Secondary" Settlement of Liner

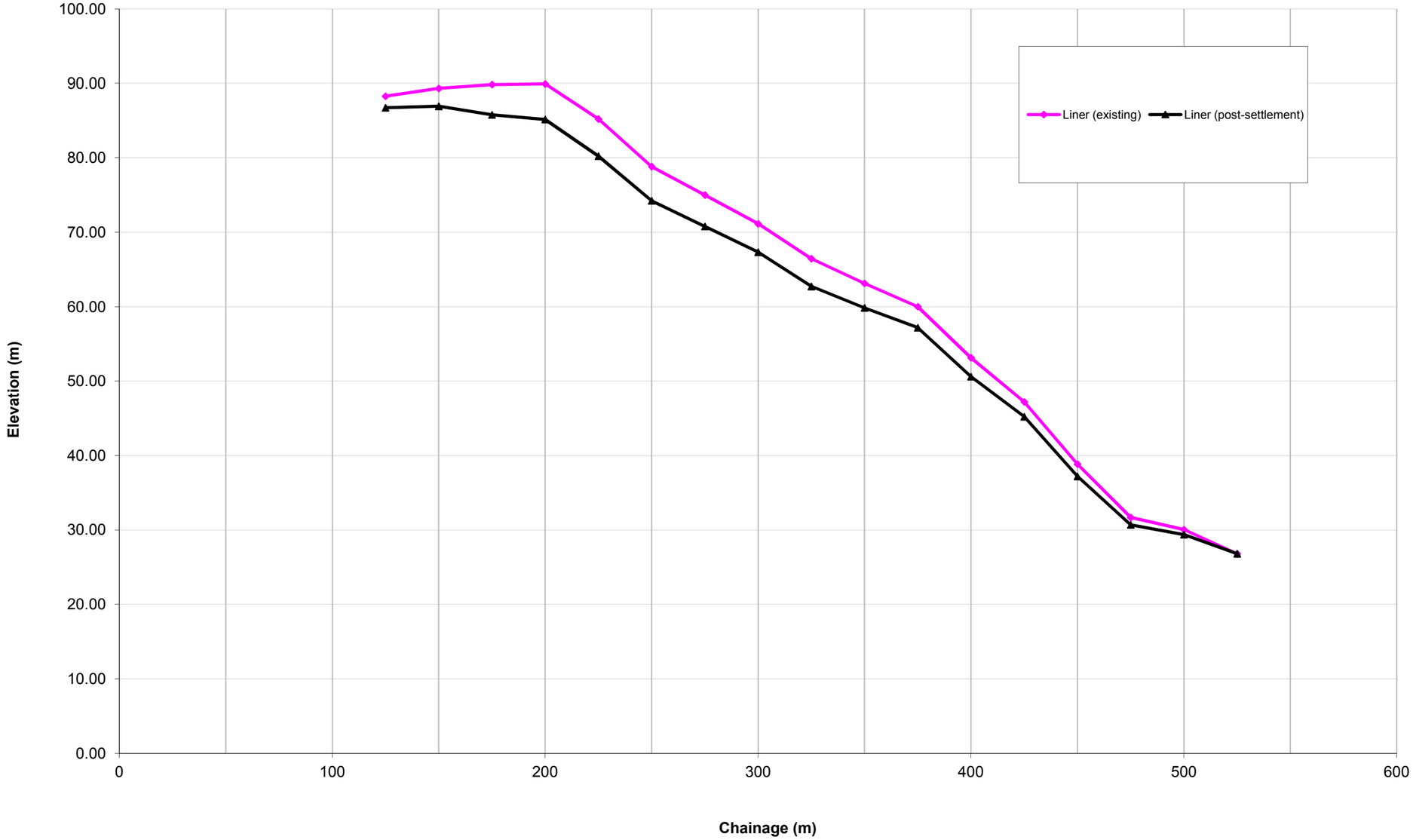
Point	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
New Waste																			
Total Thickness	0.00	0.91	-2.05	2.70	8.20	11.14	14.60	15.61	14.03	12.49	11.79	9.72	7.46	8.88	9.26	12.07	13.68	9.20	7.36
Old Waste																			
Thickness Old Waste Stage4	0.00	0.00	7.46	8.51	9.02	9.11	4.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T-initial (yr)	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
T-final (yr)	41.50	41.50	41.50	41.50	41.50	41.50	41.50	41.50	41.50	41.50	41.50	41.50	41.50	41.50	41.50	41.50	41.50	41.50	41.50
Calc settlement of layer (m)	0.00	0.00	0.65	0.74	0.78	0.79	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thickness Old Waste Stage3	0.00	0.00	0.00	0.00	10.00	20.00	30.00	28.00	24.19	20.33	15.64	12.32	9.19	2.33	0.00	0.00	0.00	0.00	0.00
T-initial (yr)	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50
T-final (yr)	47.50	47.50	47.50	47.50	47.50	47.50	47.50	47.50	47.50	47.50	47.50	47.50	47.50	47.50	47.50	47.50	47.50	47.50	47.50
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.48	0.96	1.44	1.35	1.16	0.98	0.75	0.59	0.44	0.11	0.00	0.00	0.00	0.00	0.00
Thickness Old Waste Stage2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	15.00	20.00	24.00	24.00	24.00	24.00	20.40	12.04	4.88	3.25	0.00
T-initial (yr)	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50
T-final (yr)	50.50	50.50	50.50	50.50	50.50	50.50	50.50	50.50	50.50	50.50	50.50	50.50	50.50	50.50	50.50	50.50	50.50	50.50	50.50
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.41	0.61	0.82	0.98	0.98	0.98	0.98	0.83	0.49	0.20	0.13	0.00
Thickness Old Waste Stage1	2.13	17.06	27.50	31.00	31.00	23.10	15.70	10.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T-initial (yr)	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00
T-final (yr)	56.00	56.00	56.00	56.00	56.00	56.00	56.00	56.00	56.00	56.00	56.00	56.00	56.00	56.00	56.00	56.00	56.00	56.00	56.00
Calc settlement of layer (m)	0.07	0.56	0.90	1.01	1.01	0.75	0.51	0.33	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total "Secondary" settlement(m)	**0.07**	**0.56**	**1.54**	**1.75**	**2.27**	**2.50**	**2.34**	**2.08**	**1.94**	**1.80**	**1.73**	**1.57**	**1.42**	**1.09**	**0.83**	**0.49**	**0.20**	**0.13**	**0.00**

Sum of calculated "Primary" and "Secondary" settlement (m)	0.07	0.71	1.54	2.40	4.06	4.77	4.98	4.58	4.22	3.81	3.72	3.29	2.82	2.54	1.98	1.64	1.00	0.67	0.00

117625003 Whytes Gully New Landfill Cell
Eastern Gully Landfill - Section H-H'
3. CALCULATE SETTLEMENT-INDUCED PIGGY BACK LINER STRAINS & LINER GRADE CHANGES

Point	1		2		3		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18		19
interval		1-2		2-3		3-4		4-5		5-6		6-7		7-8		8-9		9-10		10-11		11-12														
Distance (m)	75		100		125		150		175		200		225		250		275		300		325		350		375		400		425		450		475		500		525
Existing Elevation (m)	0.00		0.00		88.26		89.31		89.82		89.91		85.20		78.80		74.99		71.13		66.44		63.12		59.99		53.13		47.20		38.84		31.68		30.05		26.80
Existing interval surface length (m)		25.000		91.732		25.022		25.005		25.000		25.440		25.806		25.289		25.296		25.436		25.219		25.195		25.924		25.694		26.361		26.005		25.053		25.210	
Existing interval grade (%)		0.0		353.0		4.2		2.0		0.4		-18.8		-25.6		-15.2		-15.4		-18.8		-13.3		-12.5		-27.4		-23.7		-33.4		-28.6		-6.5		-13.0	
Total calculated primary and secondary settlement (m)	0.1		0.7		1.5		2.4		4.1		4.8		5.0		4.6		4.2		3.8		3.7		3.3		2.8		2.5		2.0		1.6		1.0		0.7		0.0
Elevation after primary and secondary settlement (m)	-0.070		-0.707		86.717		86.912		85.761		85.143		80.220		74.223		70.770		67.319		62.716		59.831		57.167		50.594		45.220		37.197		30.680		29.382		26.800
Post-settlement surface length of interval (m)		25.008		90.928		25.001		25.026		25.008		25.480		25.709		25.237		25.237		25.420		25.166		25.142		25.850		25.571		26.256		25.835		25.034		25.133	
Settlement-induced strain (%), [positive=tension]		**0.0**		**-0.9**		**-0.1**		**0.1**		**0.0**		**0.2**		**-0.4**		**-0.2**		**-0.2**		**-0.1**		**-0.2**		**-0.2**		**-0.29**		**-0.48**		**-0.40**		**-0.65**		**-0.08**		**-0.31**	
Post-settlement interval grade (%)		-2.6		349.7		0.8		-4.6		-2.5		-19.7		-24.0		-13.8		-13.8		-18.4		-11.5		-10.7		-26.3		-21.5		-32.1		-26.1		-5.2		-10.3	
Settlement-induced grade change (%), [positive=steeper grade]		**-2.6**		**-3.3**		**-3.4**		**-6.6**		**-2.8**		**-0.9**		**1.6**		**1.4**		**1.6**		**0.3**		**1.7**		**1.86**		**1.15**		**2.22**		**1.34**		**2.57**		**1.33**		**2.67**	
Grade Change?		**Grade Reversal**		**No Grade Reversal**		**No Grade Reversal**		**Grade Reversal**		**Grade Reversal**		**No Grade Reversal**		**No Grade Reversal**		**No Grade Reversal**		**No Grade Reversal**		**No Grade Reversal**		**No Grade Reversal**		**No Grade Reversal**		**No Grade Reversal**		**No Grade Reversal**		**No Grade Reversal**		**No Grade Reversal**		**No Grade Reversal**		**No Grade Reversal**	

Cross Section H-H' Eastern Gully Landfill
Old Solid Waste Compression after New Solid Waste Placement



SUBJECT: SECTION F-F' - NEW WASTE LONG TERM SETTLEMENT		
Job No.: 117625003	Made by RNP	Date 13/01/2012
Ref. QIAN/KOERNER/GRAY	Checked by	Sheet 1 of 1

GEOMETRY TAKEN FROM Ch 17

RL	DATE	
110.22m ———	2046	
H_{o_1} = 20.53m	New Waste	av. age = 1yr @ 2046 Δt to 2046 = 0 t_1 = .1yr t_2 at 2086 = 41yrs
89.69m ———	2044 / 2034	
H_{o_2} = 15.19m	New Waste	av. age = 1.5yrs @ 2034 Δt to 2046 = 12yrs t_1 = 12 + 1.5yrs = 13.5yrs t_2 at 2086 = 53.5yrs
74.50 ———	2031 / 1993	
H_{o_3} = 14.5m	old waste	av. age = 1yr @ 1993 Δt to 2046 = 53yrs t_1 = 53 + 1 = 54yrs t_2 at 2086 = 94yrs
60m ———	1991	
H_{o_4} = 13.6m	old waste	av. age = 2.5yrs @ 1991 Δt to 2046 = 55yrs t_1 = 55 + 2.5 = 57.5yrs t_2 at 2086 = 97.5yrs
46.84m ———	1986	

LONGTERM SECONDARY SETTLEMENT

$$\Delta H_\alpha = C'_\alpha \cdot H_o \cdot \log \frac{t_2}{t_1}$$ (p. 450 eq. 12.7)

where:

t_2 = time at 2086 (+40yrs)
t_1 = ave. age of waste at 2046.
C'_α = 0.06
H_o = initial layer thickness.

$\therefore$

$0.06 \cdot 20.53 \cdot \log\left(\frac{41}{1}\right) = 2.0\text{m}$

$0.06 \cdot 15.19 \cdot \log\left(\frac{53.5}{13.5}\right) = 0.55\text{m}$

$0.06 \cdot 14.5 \cdot \log\left(\frac{94}{54}\right) = 0.21\text{m}$

$0.06 \cdot 13.6 \cdot \log\left(\frac{97.5}{57.5}\right) = 0.19\text{m}$

Sum of Settlement 2.95m

SUBJECT	SECTION G-G' – NEW WASTE LONG TERM SETTLEMENT		
Job No.: 11762503		Made by RMP	Date 13/01/12
Ref. OIAN/KOERNER/GRAY		Checked by	Sheet 1 of 1

SECTION G-G' CH200

110.12 ——— 2046
NEW WASTE
"Stage 3"

H_{03} = 15.34m

H_0 = 30.68m

94.68 - - - - - - - - 2020 / 2043.
Stage "2A"

H_{02} = 15.34m

79.44 ——— 2016.
ASSUMED INCOMPRESSIBLE MATERIAL.

ave. age @ 2046 = 2.5/2 = 1.25yrs t_1 = 1.25yrs
Δt to 2046 = 0yrs t_2 = 41.25yrs

av. age @ 2020 = 4/2 = 2yrs.] "Stage 2A"
Δt to 2046 = 26yrs

∴ t_1 = 28yrs
t_2 = 66yrs (t @ 2086)

LONG TERM SETTLEMENT (p.450 eq 12-7)

$$\Delta H_2 = C'_2 \cdot H_0 \cdot \log\left(\frac{t_2}{t_1}\right)$$

Where!

t_2 = age at 2060 (+40yrs)

t_1 = ave. age at 2020

C'_2 = 0.06 (Ref Golder report: 55_Rev0_Interp report)

H_0 = Initial layer thickness

∴ ΔH_2

Stage 3 = $0.06 \times 15.34 \times \log\left(\frac{41.25}{1.25}\right)$ = 1.40 m

Stage 2 = $0.06 \times 15.34 \times \log\left(\frac{66}{28}\right)$ = 0.34 m

Sum of settlement = 1.74m

ASSUMPTION

New waste has been modelled in two stages (2 and 3) as staging plan allows minor overlaping of filling along ridge line (division between two cells).

SUBJECT	SECTION H-H' - NEW WASTE LONG TERM SETTLEMENT	
Job No.: 117625003	Made by RNP	Date 13/01/2012
Ref. QUAN/KOERNER/GRAY	Checked by	Sheet 1 of 1

SECTION H-H' Ch220m

DL (m)		DATE			
101		2035			
H_0 = 10.15m	NEW WASTE "Stage 2(B)"		av. age = 15/2 = 7.5yrs Δt to 2035 = 0	∴	t_1 = 7.5yrs t_2 = 47.5yrs
90.85		2017 / 2020			
H_0 = 5.85	"Stage 1"		ave age = 5/2 = 2.5yrs Δt to 2035 = 18yrs	∴	t_1 = 20.5yrs t_2 = 60.5yrs
85m	OLD WASTE	2012			
H_0 = 5m	"Stage 4"		ave age = 8/2 = 1.5yrs Δt to 2035 = 23yrs	∴	t_1 = 24.5yrs t_2 = 64.5yrs
80m	"Stage 3"	2009			
H_0 = 19			ave age = 2/2 = 1yr Δt to 2035 = 26yrs	∴	t_1 = 27yrs t_2 = 67yrs
61m	"Stage 1"	1996 / 2007			
H_0 = 21.57m			ave. age = 3/2 = 1.5yrs Δt to 2035 = 39	∴	t_1 = 40.5yrs t_2 = 80.5yrs
39.43		1993			

LONG TERM SECONDARY SETTLEMENT: (p. 450 eq 12-7)

$$\Delta H_\alpha = C'_\alpha \cdot H_0 \cdot \log\left(\frac{t_2}{t_1}\right)$$

where: t_2 = time at 2075 (2035 + 40yrs)
t_1 = av. age of waste @ 2035
C'_α = 0.06
H_0 = Initial layer thickness

∴

Stage 2(B) = $0.06 \times 10.15 \times \log\left(\frac{47.5}{7.5}\right)$ = 0.49m

Stage 1 = $0.06 \times 5.85 \times \log\left(\frac{60.5}{20.5}\right)$ = 0.16m

"Stage 4" = $0.06 \times 5 \times \log\left(\frac{64.5}{24.5}\right)$ = 0.13m

"Stage 3" = $0.06 \times 19 \times \log\left(\frac{67}{27}\right)$ = 0.45m

"Stage 1" = $0.06 \times 21.57 \times \log\left(\frac{80.5}{40.5}\right)$ = 0.39m

Sum of settlement = 1.62 m

117625003 Whytes Gully New Landfill Cell
CROSS FINAL LANDFORM
NEW AND EXISTING WASTE SETTLEMENT -INDUCED CAPPING SYSTEM GRADE CHANGES

Point	**1**		**2**		**3**
Profile	**Section F-F'**		**Section G-G'**		**Section H-H'**
Section Chainge (m)	**CH175**		**Ch200**		**Ch200**
Interval		**1-2**		**2-3**	
Distance (m)	0		130		280
Existing Elevation (m)	110.22		110.12		101.15
Existing interval surface length (m)		130.000		150.268	
Existing interval grade (%)		-0.1		-6.0	
Total calculated primary and secondary settlement (m)	3.0		1.7		1.6
Elevation after primary and secondary settlement (m)	107.270		108.380		99.530
Post-settlement surface length of interval (m)		130.005		150.261	
Settlement-induced strain (%), [positive=tension]		**NA**		**NA**	
Post-settlement interval grade (%)		0.9		-5.9	
Settlement-induced grade change (%)		**0.9**		**0.1**	
Grade Change?		**Grade Reversal**		**No Grade Reversal**	

Golder Associates	**Whytes Gully**	Sheet	1	of 1
		Job No. :	117625003	Ref. Interpretative Report
		Made by :	JDM	Date : 17 January 2012
		Checked by:	PRED	Date : 17 January 2012

Liquefaction Assessment using CPT

Reference : Robertson P.K, 2004, Evaluating Soil Liquefaction and Post-Earthquake deformations using the CPT

Version : 01-08

Location : GABH05 - 1.2m

Input Data :					**Note**
Cone penetration resistance	**qc (kPa)**	2200.00			
CPT sleeve friction stress	**fs (kPa)**	22.00			
Depth of Reported qc values	**Depth (m)**	1.20			
Total vertical overburden stress	**σ_{vo} (kPa)**	21.60			
Effective vertical overburden stress	**σ'_{vo} (kPa)**	21.60			
Additional Surcharge on top	**q (kPa)**	0.00			
Maximum horizontal acceleration at ground surface	**a_{max}/g**	0.09			
Earthquake magnitue	**M**	6.50			
Stress reduction factor	**rd**	**0.99**			**Eq. 2**
Magnitude Scaling Factor	**MSF**	**1.44**			**Eq. 9**
Stress exponent	**n**	**1.00**	**0.50**	**0.75**	
Normalised cone penetration resistance (dimensionless)	**Q**	100.85	46.87	68.75	**Eq. 5**
Normalised friction ration in per cent	**F**	1.01			
Soil behavioiur type index	**I_c**	**1.91**	**2.18**	**2.04**	
Normalised cone penetration resistance (dimensionless)	**q_c1N**	**101.85**	**47.34**	**69.44**	***I_c iteration using q_c1N***
	I_c	***1.91***	***2.17***	***2.04***	
Correction factor	**k_c**	1.20	1.61	1.36	**Eq. 7 (if 2.6>Ic>1.64, kc=1 if Ic<1.64)**
Normalised cone penetration resistance (dimensionless)	**q_c1N**	***47.34***			**(k_c=1)**
Equivalent clean sand normalise cone penetration resistance	**(q_c1N)_cs**	***122.08***	***76.23***	***94.22***	**Eq. 4**
	(q_c1N)_cs	**76.23**			**If Ic>2.6 use n=1, Ic<2.6 use n=0.5, Ic ~2.6 use n=0.75**
Soil classification		**sand**			**IF Ic>2.6 possible Clayey SILT, evaluate using other criteria** **Unlikely to liquefy if F>1% as well**
Cyclic Stress Ratio for M = 7.5	**CSR_7.5**	**0.0404**			**Eq. 1 and Eq 9.**
Cyclic Resistance Ratio for M = 7.5	**CRR_7.5**	*0.1212*			**Eq. 3 for 50<(q_c1N)_cs<160**
		0.1135			**Eq. 3 for (q_c1N)_cs<50**
Factor of Safety	**FoS**	**3.00**			

J:\civ\2011\Whytes Gully - Amendments to Report\Technical\[Liquefaction-Robertson_Whytes Gully.xls]GABH05-Loose SAND 1.2m to 2m

APPENDIX D

Deformation Analysis Results

PLAXIS Analysis

To assist in quantifying landfill behaviour for liner design, finite element PLAXIS analyses were carried out to model the performance of the piggy back liner and the new landfill cell base liner during the various stages of construction and operation.

Specifically, the modelling was carried out to assess forces and strains within the liner systems resulting from differential settlement of the existing landfill and natural materials under the overburden load of the proposed new landfill materials, and for the case of hypothetical soft spots below the liner.

In addition, PLAXIS modelling was used to cross-check critical stability mechanisms against those obtained from limit equilibrium slope stability (Slope/W) models and to cross check global settlements against those obtained from one-dimensional settlement spreadsheet analyses.

1.1.1 Modelling approach

Two PLAXIS finite element models were developed, as follows:

- A two dimensional (2D) "global" model along the centerline of the western gully to quantify overall time–displacement behavior, simplified single liner stresses and strains, total and differential settlements, operational surface slope gradients and potential failure mechanisms; and
- A "local" axisymmetric model examining more closely the interaction between the existing and proposed landfill at a critical liner location identified in the 2D analysis. This incorporates two geosythentic layers (geogrid and geomembrane) and a nominally sized buried soft spot to assess liner behavior in response to localised deformations.

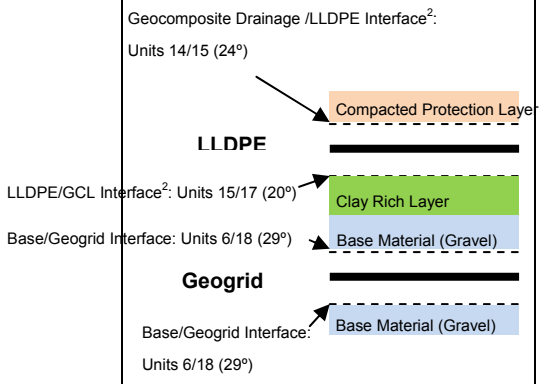
Generic liner properties were adopted for the PLAXIS analyses, with frictional interface properties that were adjusted according to the case being analysed, viz:

- 2D Geogrid assessment for liner forces: These are utilized in the 2D model at the new/old landfill interface where a default geogrid (Unit 18) was included with relatively high 'peak' geogrid/gravel friction interface values. We note that the geogrid is present in the piggy back liner but not the new cell base liner.
- 2D Geomembrane assessment for slope stability: Potential slip surfaces between liner components and the low interface friction geomembrane component (Unit 15-LLDPE where it occurs in the piggy back liner, or Unit 16-HDPE in the new cell base liner) were interrogated in the 2D model by substituting the geogrid properties (above) with geomembrane properties, and replacing gravel/geogrid interface values with appropriate liner/soil or liner/composite properties. Residual friction angles were adopted for interfaces to assess critical failure mechanisms.

A graphical summary of the geogrid, geomembrane and interface combinations used in the analyses are summarised in Table D1, overleaf.

Typical sections of the proposed new cell liner and piggy back liner are included in design drawings D022 and D031, respectively (ref: 117625003_001_D_RevA).

Table D1 – PLAXIS Cases 1 to 3

	Piggy back liner (placed on top of existing landfill)[1]	***New Landfill Cell base liner*** (placed below new landfill in the toe area) [1]
PLAXIS 2D Model for Global Behaviour using single, simplified liner (Settlement, Liner forces, Stability)		
Case 1 Simplified Liner Model (for 2D strain and axial force check)	Base/Geogrid Interface: Units 6/18 (29º) Geogrid Base/Geogrid Interface: Units 18/6 (29º)	Cushion/HDPE Interface[2]: Units 16/12 (24º) HDPE HDPE/GCL Interface[2]: Units 16/17 (15º)
Case 2 Simplified Liner Model (for 2D stability check)	Geocomposite Drainage/LLDPE Interface[3]: Units 14/15 (15º) LLDPE LLDPE/GCL Interface[3]: Units 15/17 (12º)	Cushion/HDPE Interface[3]: Units 16/12 (15º) HDPE HDPE/GCL Interface[3]: Units 16/17 (12º)
PLAXIS Axisymmetric Model for Local Piggy back Liner Design (Liner forces) – soft spot		
Case 3 (Combined Geogrid and Geomembrane)		N/A

Notes:

1. Refer to parameters in Table 2-4 (of main report) for detailed description of interface materials and friction values

2. Peak values used in Case 1 to provide increased friction (i.e. load transfer) for strength/strain checks

3. Residual type values used in Case 2 to use reduce friction for stability checks

1.1.2 Material properties

Material properties used in the analyses are summarised in Tables 2 and 3 (of main report), and in Appendix D1, attached. Compressibility parameters were selected based on the results of limited laboratory testing and experience at similar sites. The adopted set of input variables for the base case analyses are

considered to represent “moderately conservative” strength and stiffness properties for homogeneous landfill material.

The moderately conservative, homogeneous landfill compressibility values used in the PLAXIS model could be calibrated against field data from the proposed settlement pad trial. In lieu of this data, the sensitivity of key input design parameters (landfill stiffness, geogrid stiffness and geogrid on/off) have been assessed to a limited degree to quantify the impact on settlements, liner forces and strains. We anticipate that additional sensitivity analyses will be completed for key input parameters (including landfill compressibility, soft spot geometry and soft spot stiffness) in subsequent, detailed design stages.

As the landfill behaviour is expected to be dominated by global creep settlements resulting from ongoing decomposition of the landfill, the “soft soil creep” constitutive model in PLAXIS was adopted for the landfill materials (Unit 41) including the prepared cohesive subgrade overlying the existing landfill. This model was also adopted for the clayey (i.e. consolidating) materials including soil fill (Unit 41c), alluvium (Unit 42), and colluvium (Unit 42).

An elasto-plastic Mohr-Coulomb constitutive model was adopted for the residual soil (Unit 43), base material (Unit 6) within the liner system and compacted clay-rich bearing material (Unit 4). The rock was assumed to behave as a linear-elastic material.

The geogrid and geomembrane components were modelled using structural ‘Geogrid’ elements provided in PLAXIS. The stress-strain characteristics for these components were estimated from typical laboratory test data from manufacturers and published literature. In the PLAXIS model, stiffness is input as modulus x cross sectional area (EA) properties. Factored base case EA values of 500 kN/m and 80 KN/m have been adopted for the geogrid and LLDPE membrane layers, respectively, based on values used in previous projects. These factored design values correspond to equivalent stiffness material reduction factors (in the direction of the geogrid bars) of 1.6 on a medium-weight geogrid product such as Global Synthetics Secugrid 40/40 Q1, and a factor of approximately 8 for the 1.5mm thick LLDPE gemomembrane liner Permathene L200. We note that these factors are intended to reflect a stiffness reduction due to installation damage, creep and other factors, and are considered reasonable for the purpose of this modelling.

The soil/geotextile interfaces in PLAXIS are modelled as having zero thickness, along which sliding can occur, according to user-defined strength and stiffness properties. Interfaces were modelled using the appropriate interface element shear strength properties summarised in Table D1, above. The soil/geotextile interface stiffness properties which apply before yielding are equal to the adjacent host soil properties. The sensitivity of the design to interface stiffness was checked by doubling the interface stiffness, but this had an insignificant effect on mobilised liner forces.

1.1.3 PLAXIS 2D analysis for global behaviour

The profile for Cross-Section F through the Western Gully was adopted for the PLAXIS 2D analysis, as this section represents significant and variable thicknesses of both the existing landfill and new landfill materials. The schematic layout of the model is shown in Figure D1 below.

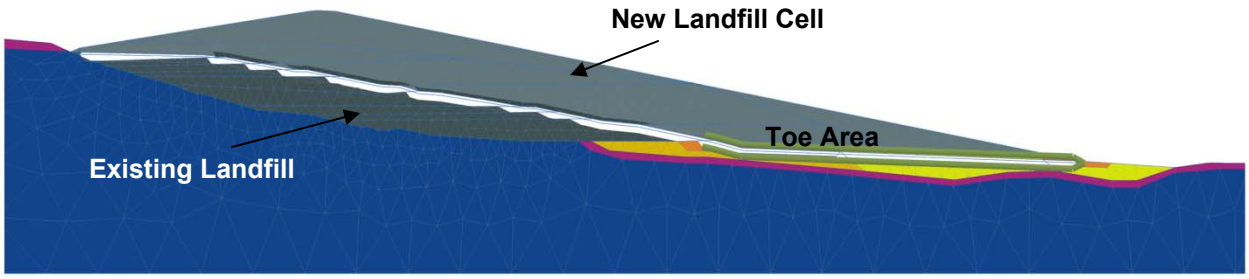


Figure D1: General layout of PLAXIS 2D analysis

The simplified construction sequence used in the model comprised: construction of the old landfill to existing levels (end 2011), installation of liner elements (end 2013), placement of landfill in the new landfill cell (end 2060), and ongoing consolidation to 40 years from end of filling. Displacements in the model were zeroed at the time of liner placement.

A sketch summarising the modelled construction sequence is summarised in Figure D2, below. The modelled sequence underestimates the age of the existing waste above RL 70, which was actually placed between 1991 and 1993, but this is considered to be conservative as the younger landfill in the as-modelled condition will experience larger post-construction creep settlements. We note also that an area at the base of the landfill has conservatively been modelled as Stage 4 filling but this would in fact be older Stage 4 filling. We consider this would have a minor effect on the modelled outcomes.

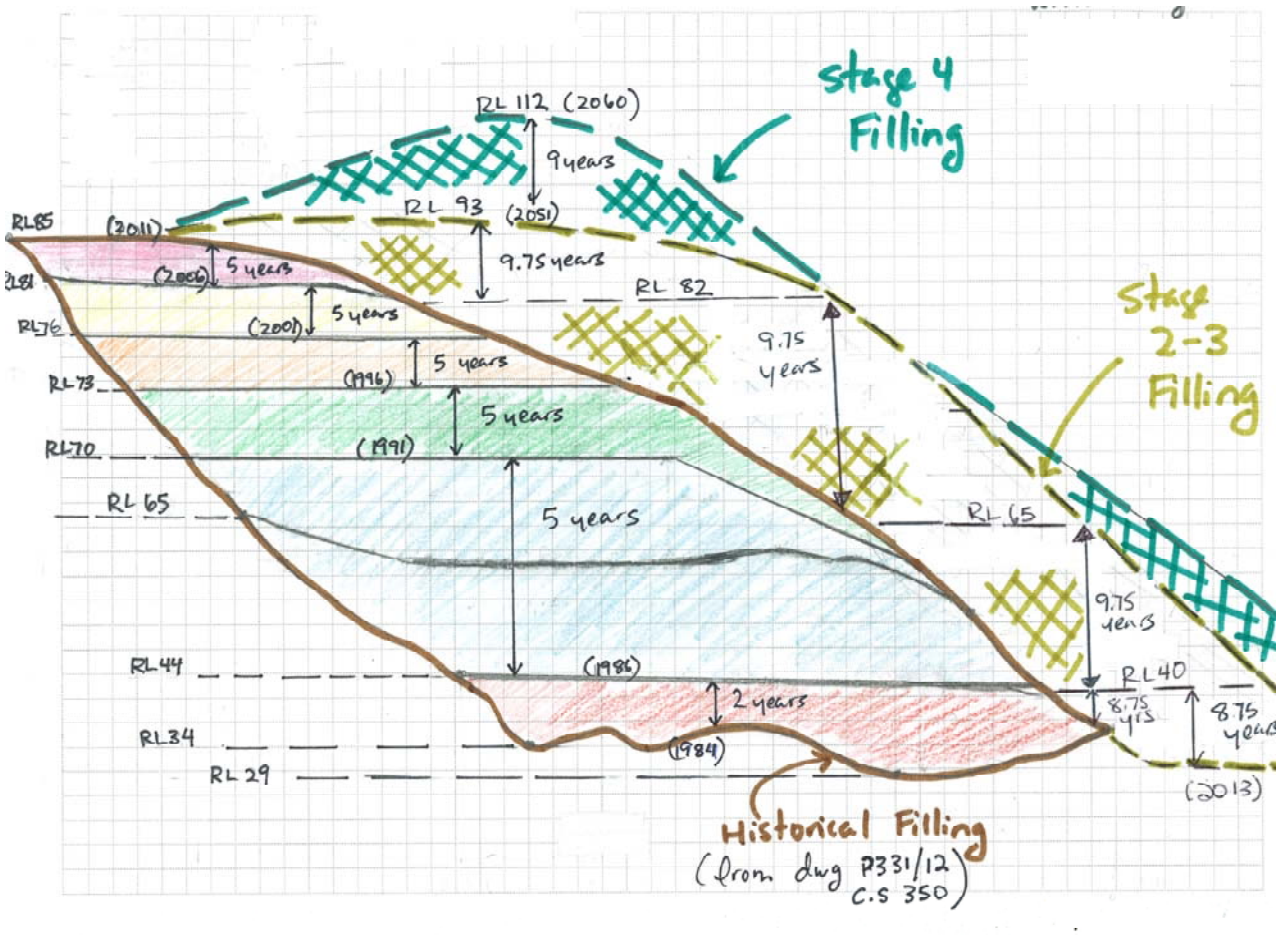


Figure D2: PLAXIS 2D Construction Sequence

The finite element mesh was re-constructed ("re-meshed") between calculation stages to account for the high displacements experienced in the landfill materials. Outputs from the PLAXIS model are presented at '40 years after filling', corresponding to a point in time 40 years after completion of new landfill to RL 112m AHD (year 2100). We note that this is 87 years following placement of initial geotextiles and commencement of new filling at the toe of the existing landfill. In the base case outputs provided below, no account of liner stiffness reduction over time is allowed for because a relatively low, factored stiffness is used from the outset. The effect of liner stiffness is assessed separately in the sensitivity section.

Leachate levels were modelled as approximately 2m above the base of the existing landfill, although we note that the modelling results are not expected to be highly sensitive to this assumption, as liner forces and displacements are governed principally by creep behaviour.

Geosynthetic stiffness properties for the liner and geogrid have been entered in the PLAXIS model as linear elastic values (kN/m). These factored values have been based on product data sheets for commonly available products and are representative of the material properties when operating within serviceability limits. Normal and frictional loads are transferred to the geosynthetic layers through interface elements which have user defined properties discussed in Section 1.1.2.

The resulting geogrid liner and geomembrane strains and forces are then obtained from the PLAXIS model in the following ways:

- **Liner/geogrid Forces**: These are output directly from the PLAXIS model at relevant time intervals without manipulation. A single liner/geogrid stress value is generated for each 'stress point' within the nominated liner/geogrid. Stress points are spaced at automatically generated finite element mesh intersections and at intermediate nodes.

- **Liner/geogrid Strains:** These are simply obtained by dividing the Liner/Geogrid Forces (above) by the user-defined (factored) stiffness (EA) value to obtain the strain at a given location. In places where lateral compression occurs, strains are non-zero (negative). For the purposes of this assessment, these compressive strains are ignored (assigned zero values on plots) and only tensile strains are shown on plots as positive values.

1.1.3.1 Results

The results of the 2D PLAXIS analyses indicate settlements at the liner interface of up to about 3m at 40 years from completion of filling with new landfill materials. Large-scale (i.e. non-soft-spot) differential settlements of up to 1 in 30 were identified at this end-of-life time step near the crest of the existing landfill, which is considered satisfactory because this is unlikely to result in surface grade reversals.

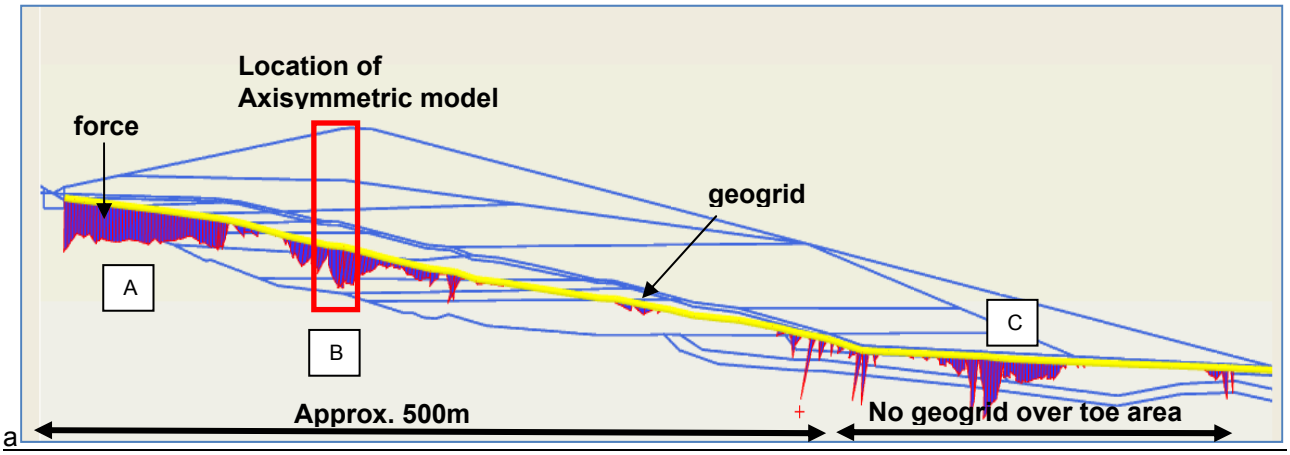
Using the methodology discussed above, zones of concentrated elevated liner stress and tensile strain were identified at the following locations along the liner, as shown in Figure D3 and as described below:

A. Near the crest of the existing landfill, where the liner is relatively restrained against downwards movement, and incremental strains accumulate towards upslope areas;

B. Near the proposed location of maximum height of new landfill materials; and

C. Near the new cell base liner, where consolidating natural materials (colluvium and alluvium) materials underlie the liner.

The distribution of axial forces and strains in the liner (modeled below as a single, continuous geogrid) at 40 years after completion of filling are shown in Figures D3 to D5 below.



a

Figure D3: Schematic distribution of axial force in the geogrid 40 years after filling

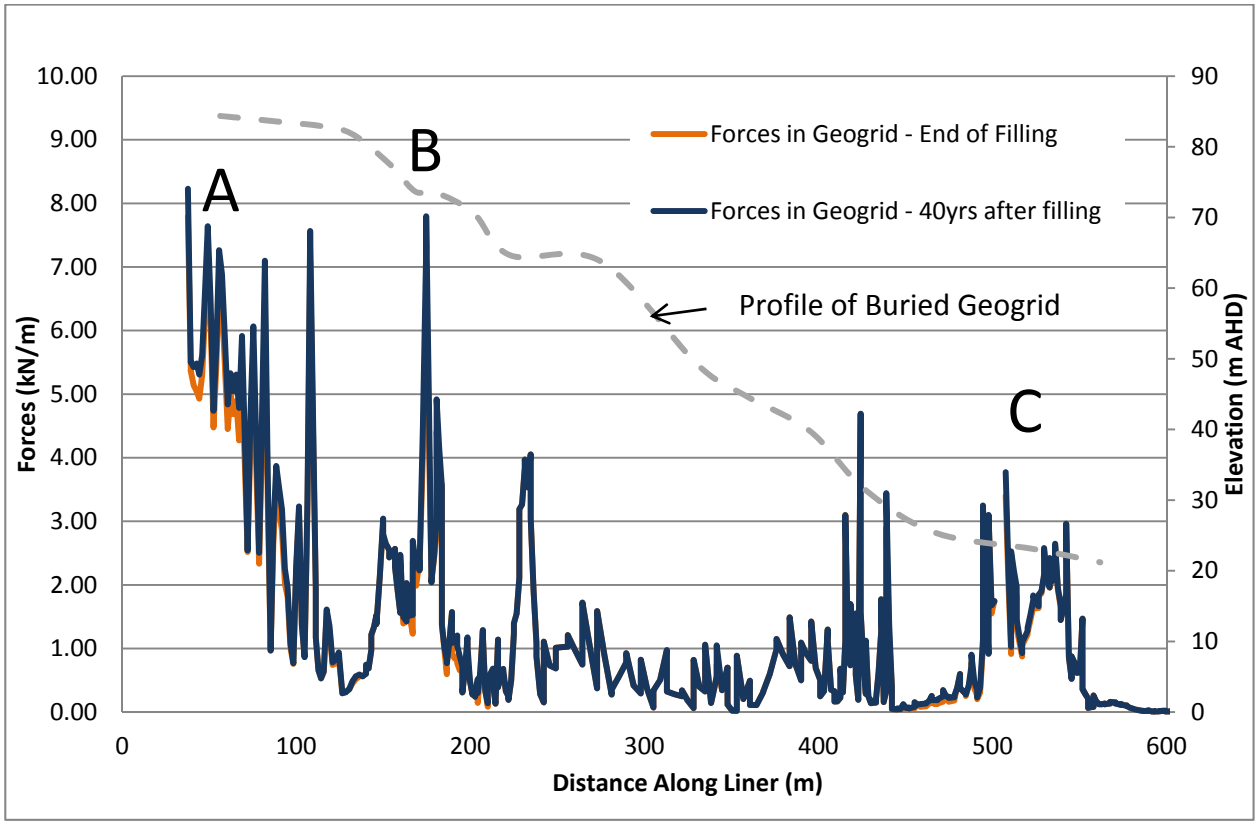


Figure D4: Distribution of axial force in the geogrid at 40 years after filling

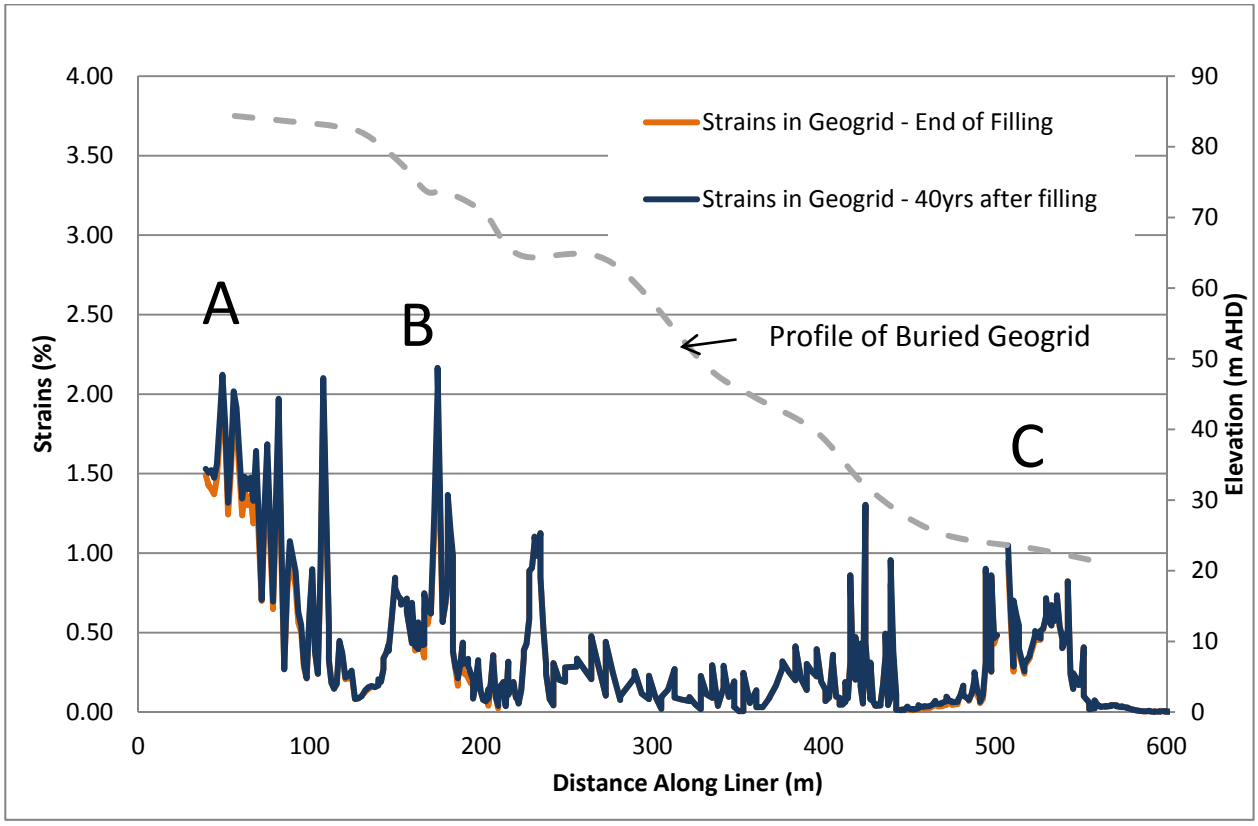


Figure D5: Distribution of strains in the geogrid at 40 years after filling

As shown in Figure D4 above, the maximum mobilised axial force near the upslope end of the geogrid is approximately 8 kN/m and the maximum tensile strains are in the order of 2 %. These strains are well within the typical operational range for geogrids, being in the order of up to 5 %. Excess pore pressures in the alluvium near the landfill toe are largely dissipated at the end of the design life (2100) and result in generally lower geogrid forces compared to upslope areas.

1.1.3.2 Comparison with 1D settlement analysis

A comparison was carried out between the results of the 2D PLAXIS model and the 1D spreadsheet settlement analysis, at 40 years after full height of filling. The results are summarised in Table D2 below, and generally indicate that results are within agreement to approximately 20 %. This is considered reasonable given the intrinsic differences in theoretical approach.

Table D2- Piggy back liner Settlements (m), 40 years after full height filling at that location

Model Chainage	Spreadsheet Prediction (m)	PLAXIS Prediction (m)	% Difference (PLAXIS Vs. XLS)	Year end
75	1.49	1.5	1	2053
Average at 60-90	1.46	1.54	5	
180	3.98	3.04	-24	2060
Average at 170-190	3.5	3.01	-14	
205	3.03	3.09	2	2066
Average at 145-260	3.5	2.94	-16	
320	3	2.38	-21	2073
Average at 230-410	2.65	2.13	-20	
435	0.83	0.30	-64*	2079

Note * 1-D 'blanket loading' approach is likely to significantly over-estimate settlement in this 'locally loaded' area.

1.1.3.3 PLAXIS Slope stability analysis

A slope stability analysis was carried out for the stage of final filling using the c-phi reduction feature in PLAXIS 2D. During the c-phi reduction analysis, the strength of the soil strata is incrementally reduced until a failure mechanism forms, as determined using nominated strain criteria. The calculated incremental displacement obtained from a c-phi reduction analysis in the model incorporating the geomembrane identifies a most probable slip mechanism, while the magnitude of the reduction indicates how much reserve capacity (or global Factor of Safety, FoS) is available. This is not directly comparable to a limited equilibrium FoS value, which is a measure of the ratio of disturbing force to available resistance, but the two FoS values should typically match to within about 10%.

The PLAXIS global Factor of Safety calculated for the stage of final filling is approximately 1.8. This is comparable to the limit equilibrium FoS results obtained from Slope/W analysis for Cross-Section F to within approximately 10 % (refer Section 6.1). The critical failure mechanism predicted by PLAXIS is shown in Figure D6 below and almost exactly matches the comparable SLOPE/W mechanism. The corresponding predicted relative movement along the liner (geomembrane) interface associated with the PLAXIS failure analysis is approximately 3m. In other words, the factor of safety against a 3m slip displacement developing is approximately 1.8.

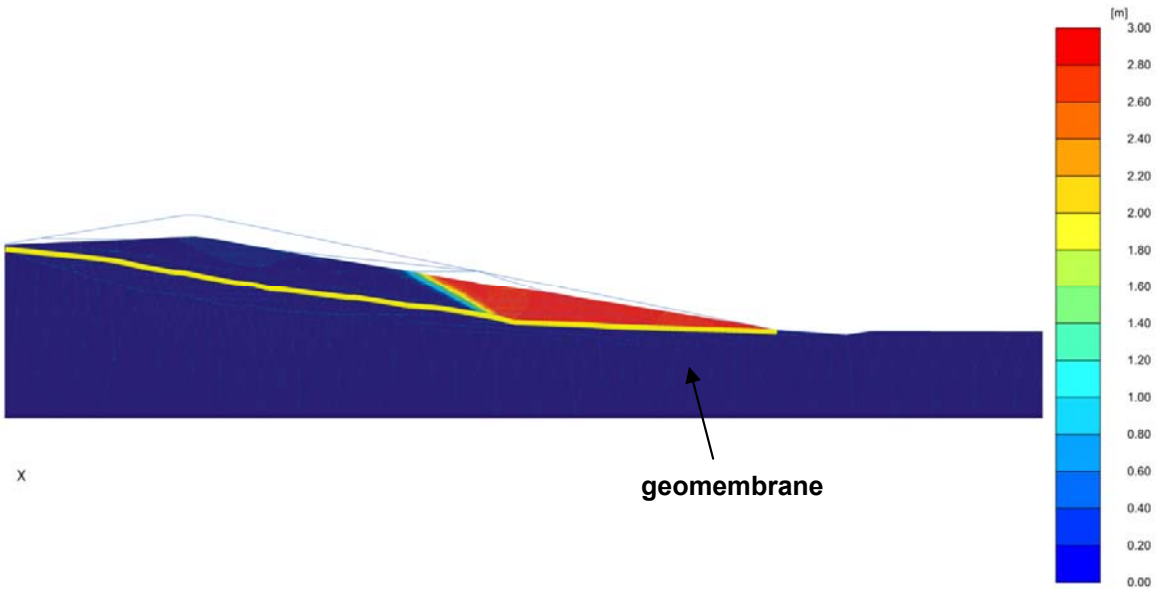


Figure D6: Displacement contours at induced failure from PLAXIS stability analysis

1.1.4 PLAXIS axisymmetric analysis for local behaviour

The results of the 2D analysis were interrogated to identify areas of high axial forces and strains within the geogrid. The axisymmetric model was then accordingly created at the location of maximum new landfill height, as shown in Figure D3 above, to explore geogrid and liner behaviour at a more localised level of detail. The main purpose of the axisymmetric model is to assess the impact of a potential softer area within the landfill, as opposed to the global liner behaviour from the 2D model.

To perform an upper bound assessment of variation in landfill compressibility over a short distance, a hypothetical zone of "soft landfill" was introduced into the model as a zone measuring 6m in diameter and 5m thick, buried 2m below the piggy back liner in an area of higher stiffness existing landfill. A study carried out for a similar landfill in Victoria[1] identified this soft spot geometry as reasonable in terms of differential settlements on the basis that excavation and compaction of existing landfill materials will be carried out to shallow depths below the liner (Manassero, 2006). Although such excavation and compaction of existing waste is likely to be minimal for the Whytes Gully project, we consider that this soft spot geometry provides a reasonable basis for analysing the effects of potential landfill variability on liner performance.

The construction sequence and timing used in the 2D analysis was also adopted for the axisymmetric analysis, with the exception that the new landfill was applied as a surcharge load. Stresses and strains within the liner were then obtained using the methodology developed for the 2D model, described in Section 1.1.3.

Given the shallow depths represented in the axisymmetric model, leachate levels did not apply. The axisymmetric model geometry is shown below in Figures D7 and D8.

Manassero, M. 2006. 'Geosynthetic Reinforced Composite Clay Liner Performace Evaluation Under Differential Settlements 07217-PPPXVVE06-MAR', Studio Geotecnico Italiano, Milan

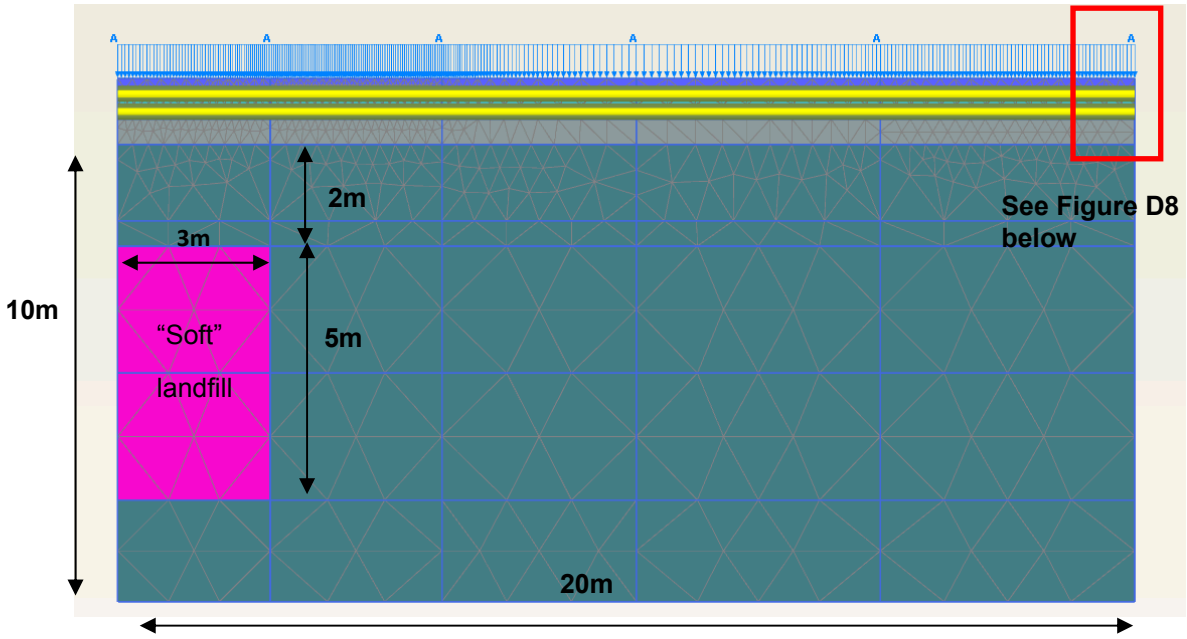


Figure D7: General layout of PLAXIS axisymmetric analysis

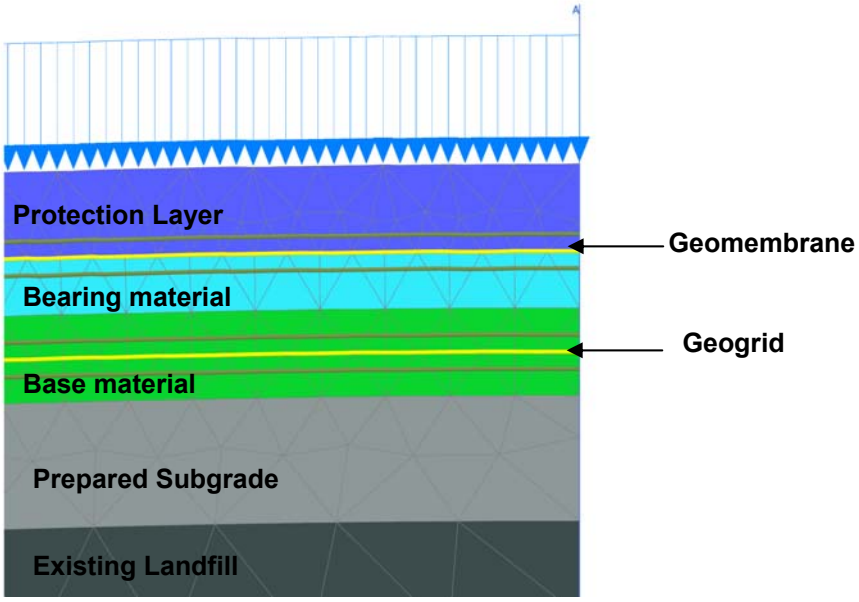


Figure D8: Detail View of Liner Components in PLAXIS axisymmetric analysis

1.1.4.1 Results

As shown in Figures D9 and D10 overleaf, maximum differential settlements across the piggy back liner are less than 1/15. The settlement profile reflects the presence of the soft landfill material, as expected. We note that as the gradient of the differential settlement is less than the proposed slope gradient, and so a surface depression resulting from this hypothetical soft spot settlement is not likely to result in ponding.

As shown in Figures D11 and D12, the localised maximum axial force in the geogrid due to the soft spot is approximately 6 kN/m, which is less than the peak global forces developed in the 2D model. The corresponding maximum tensile geogrid strain is approximately 1 %. The maximum strain in the geomembrane at 40 years is approximately 3 %.

Conservatively superimposing the peak global 2D strains of about 2 % with the peak hypothetical local soft spot strains at up to 1 % at the end of cell design life (40 years after completion of filling), the predicted

maximum geogrid liner strain is predicted to be less than 4 %. This is within the typical limiting value of 5% for geogrid products and, in practice, it is unlikely that these two conditions would occur at the same location on the landfill.

Similarly, the maximum geomembrane strains at the end of cell design life (40 years after completion of filling) in the base case soft-spot model, are predicted to be less than 3 %. This is within the typical limiting value of 8% to 10% for geosynthetic liner products.

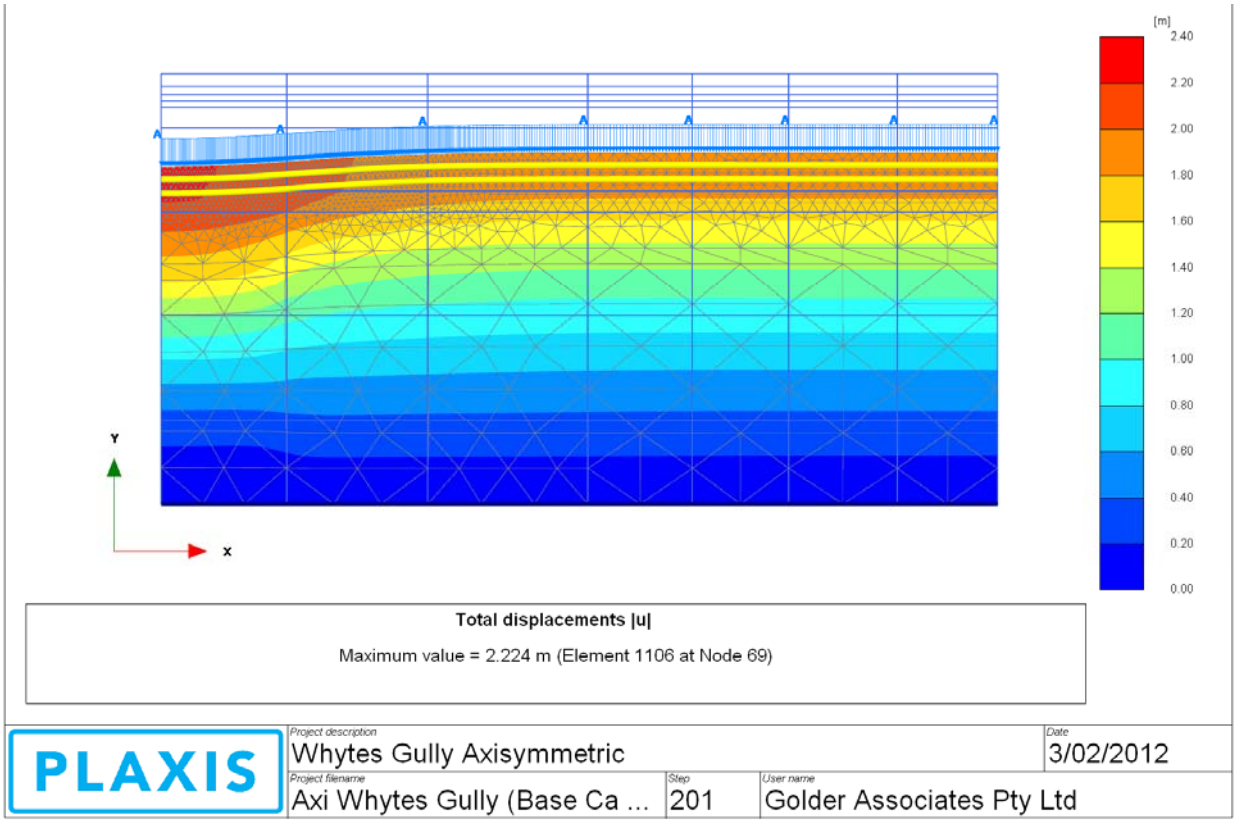


Figure D9: Displacement contours at 40 years from end of filling (from time of liner placement)

The computed shear stress levels along the soil/geogrid interface are highest near the edge of the soft spot, where tensile forces and strains are highest, and are within about 50% of the yield shear stress value (i.e. within the elastic range of deformation). Corresponding relative movements at the soil/geogrid interface are very small, being only fractions of a millimetre.

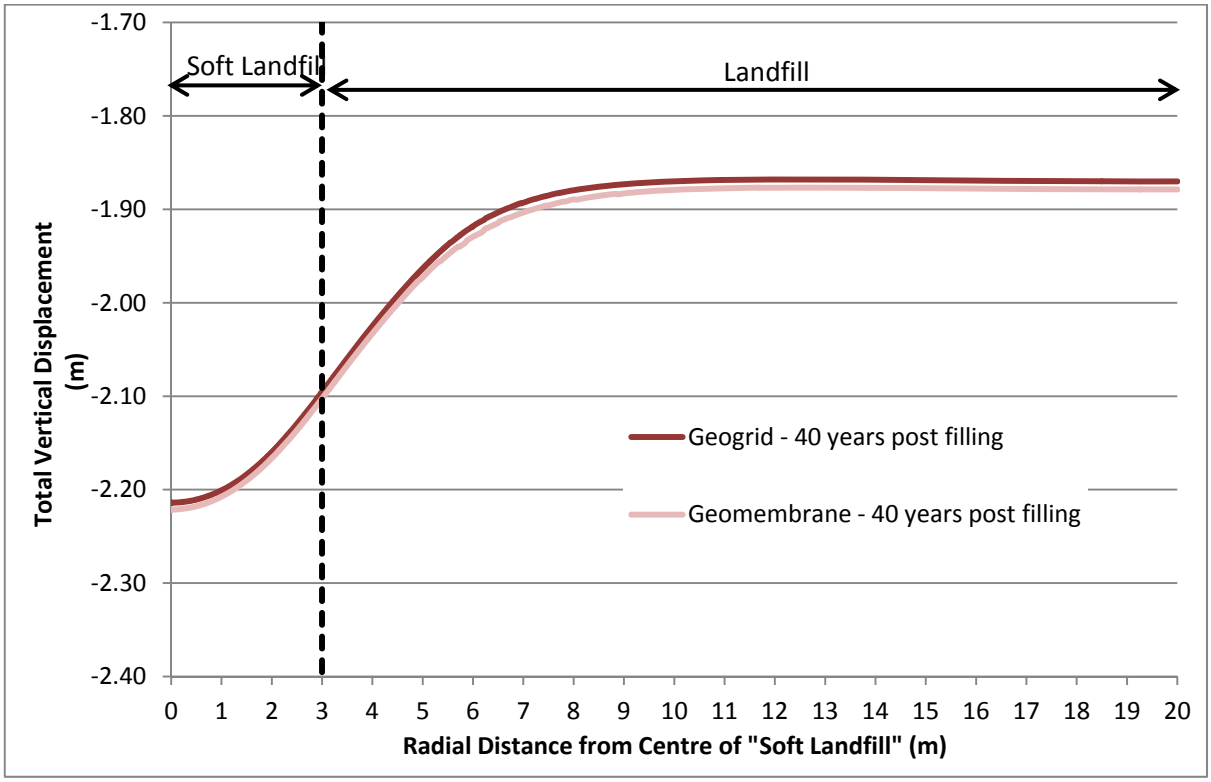


Figure D10: Base Case vertical displacement at 40 years from end of filling (Axisymmetric model)

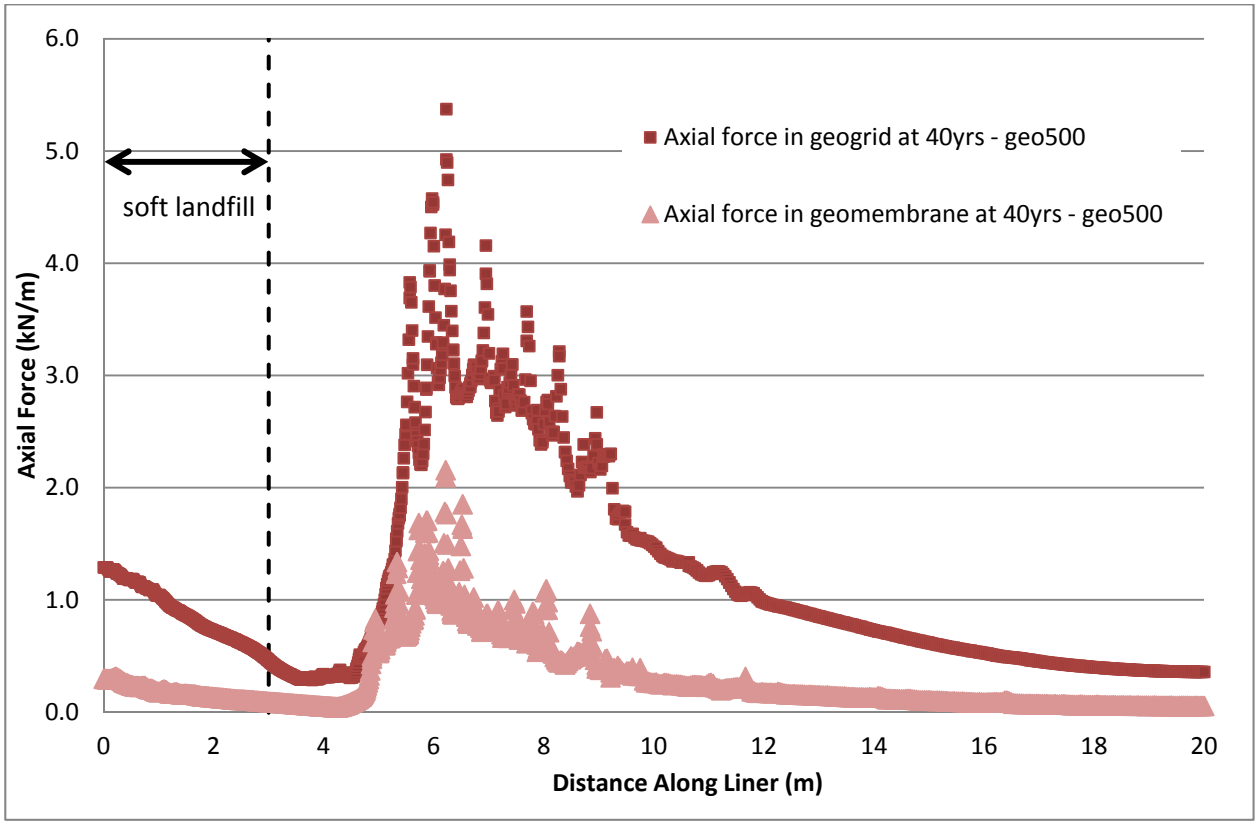


Figure D11: Base Case axial forces at 40 years from end of filling (Axisymmetric model)

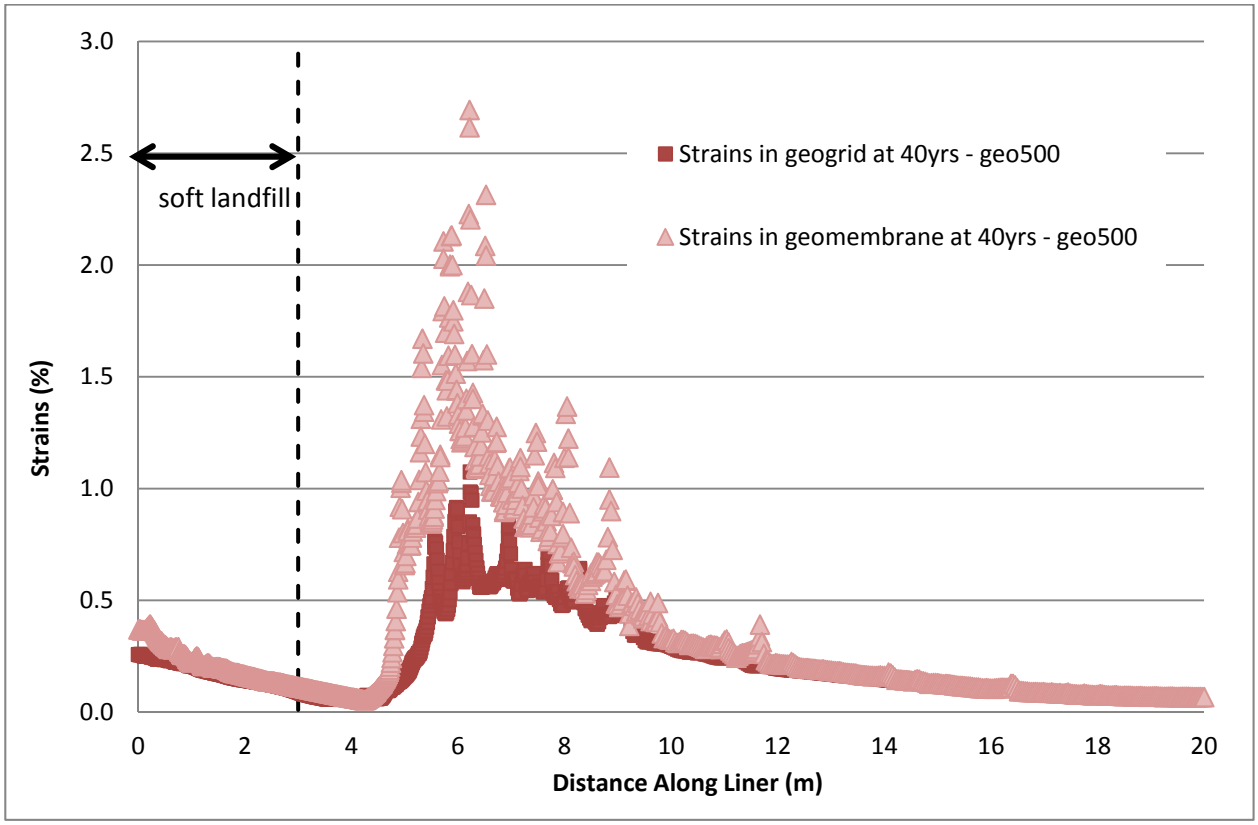


Figure D12: Base Case strains at 40 years from end of filling (Axisymmetric model)

1.1.5 Sensitivity analyses

Basic sensitivity analyses have been carried out to quantify the effect of varying landfill and liner stiffness, and removal of the geogrid. Sensitivity cases were undertaken as follows:

- **Softened landfill stiffness sensitivity**: Compressibility parameters in the axisymmetric model were increased from Cc=0.6, Ca=0.06 (representing "intermediate compressibility", Gourc 2005) to Cc =0.72, Ca =0.14 (representing "high to very high compressibility"). The compressibility of the soft spot was increased from Cc=1.0, Ca=0.2 (representing "high to very high" compressibility) to Cc=2, Ca=0.4 (representing "very high" compressibility). This change effectively made the soft spot relatively softer compared to the host material in the sensitivity case.
- **Softened geogrid stiffness sensitivity**: The reduced waste stiffness sensitivity case above was concurrently analysed with a range of geogrid stiffness values of 500 kN/m (base case), 360 kN/m (reduced stiffness) and for the case of no geogrid.

The results are shown in Figures D13 to D15, below.

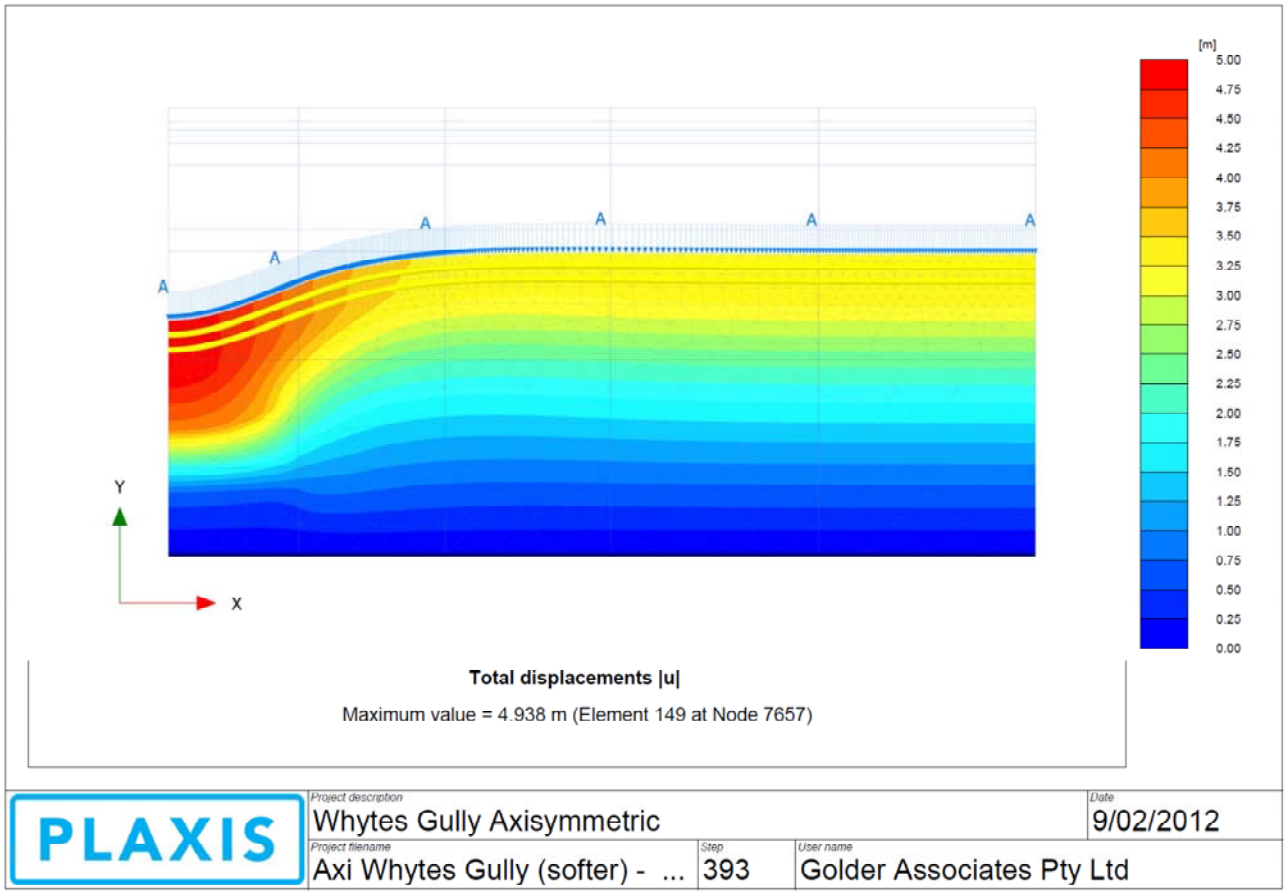


Figure D13: Displacements for softened landfill stiffness (includes settlement before liner placement)

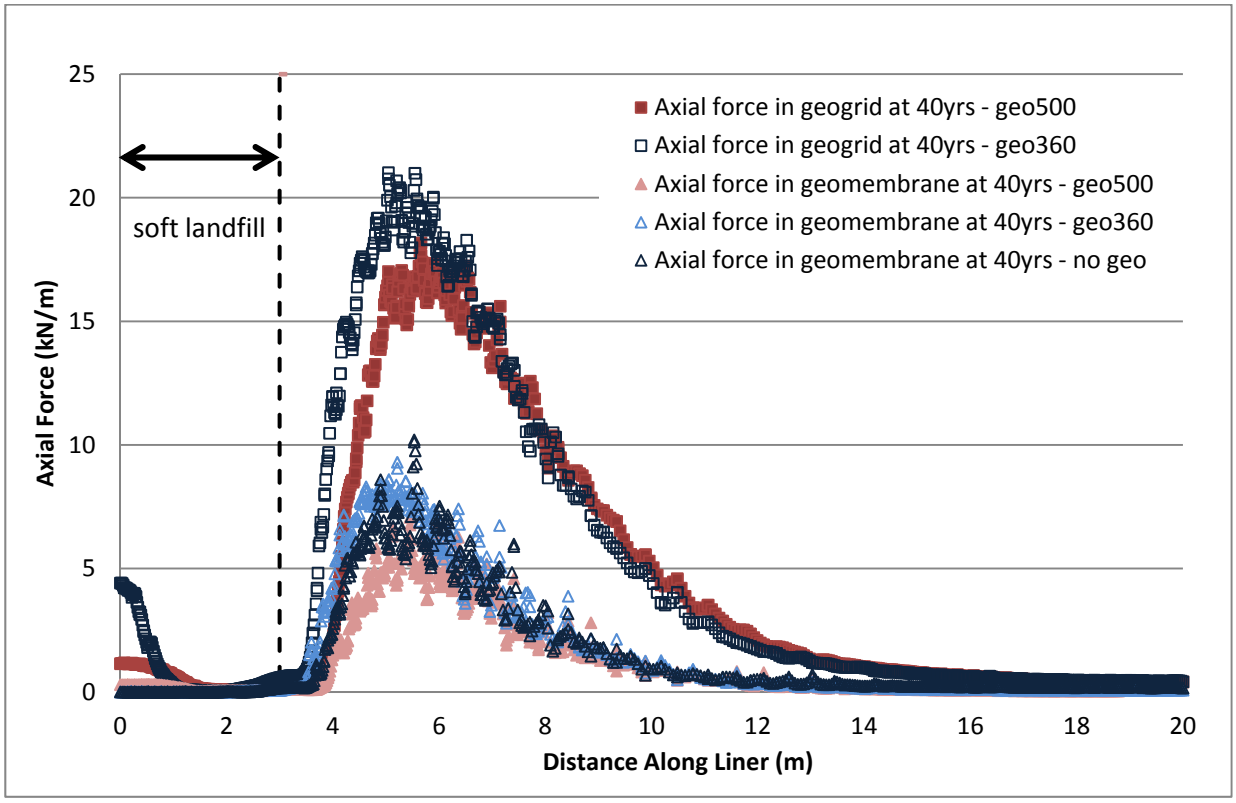


Figure D14: Sensitivity analyses for liner force with varying geogrid stiffness and softened landfill stiffness (Axisymmetric model)

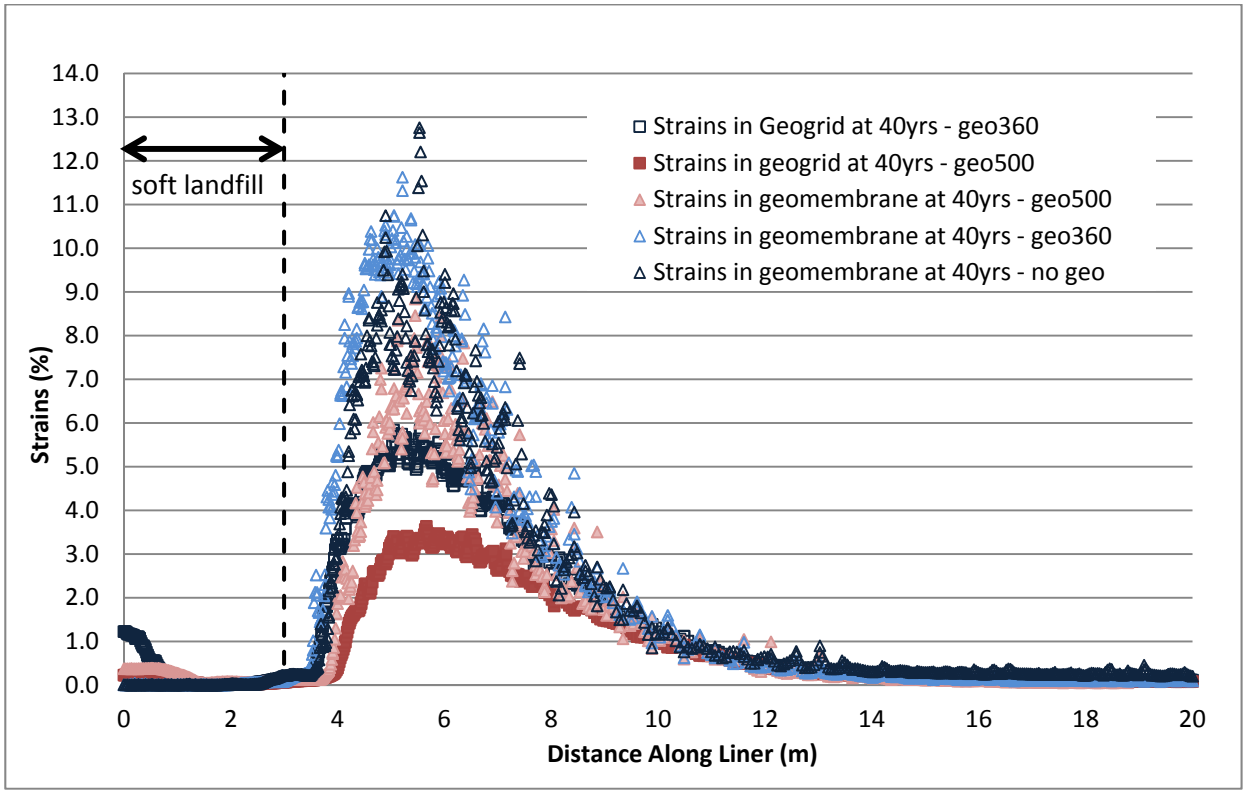


Figure D15: Sensitivity analyses for liner strain with varying geogrid stiffness and softened landfill stiffness (Axisymmetric model)

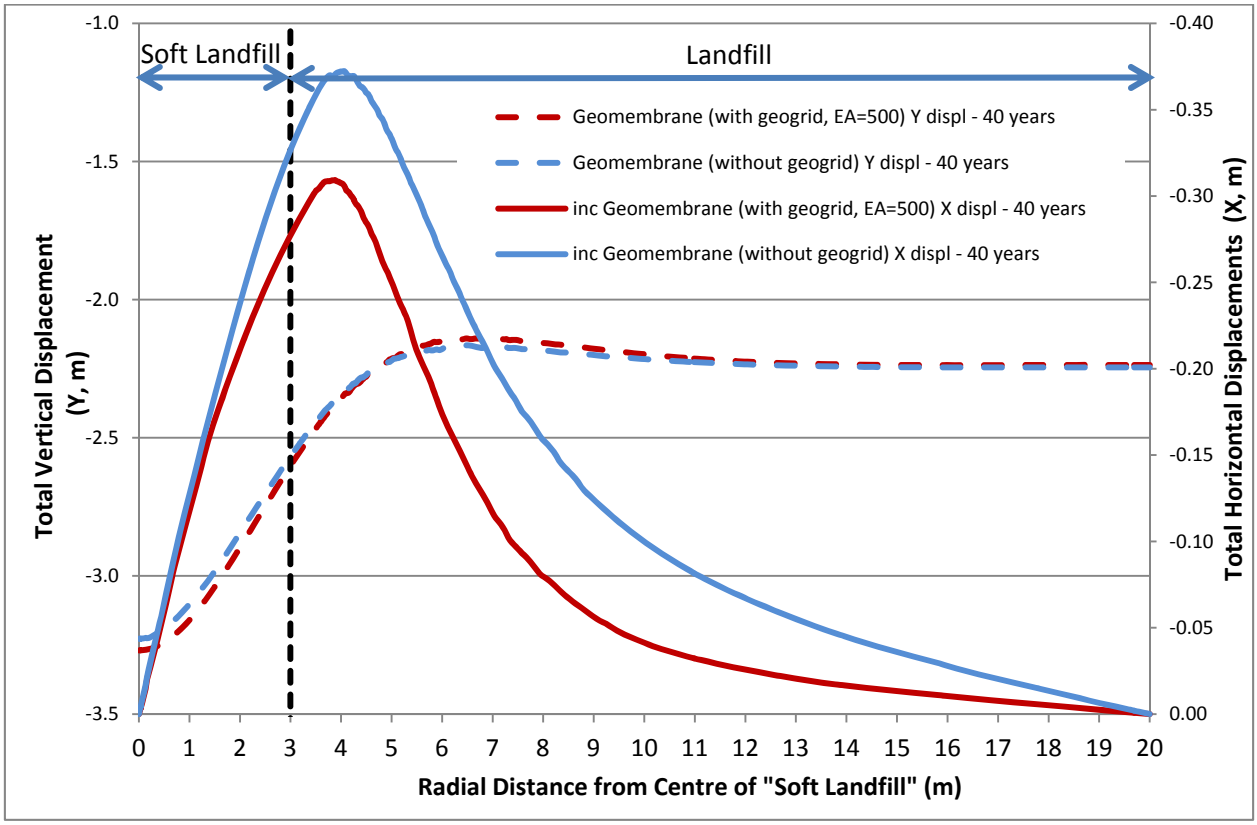


Figure D16: Total vertical and horizontal geomembrane displacements (after liner placement) with softened landfill stiffness (Axisymmetric model)

Key outcomes of the sensitivity analyses shown in Figures 14, 15 and 16, are summarised below:

- Increasing landfill compressibility in the softened sensitivity model nearly doubles the overall vertical settlements at the geomembrane centerline compared to the base case model. Tensile forces in the geogrid increase from the base case value of about 5 kN/m to 18 kN/m, and forces in the geomembrane liner increase from the base case value of about 2 kN/m to 7 kN/m. Corresponding strains increase proportionately in the geogrid and geomembrane from values of 1 % and 2.5% to approximately 3.5 % and 9 %, respectively. We consider that these liner strains are just within tolerable values for the softened landfill sensitivity case.

- Decreasing the geogrid stiffness in the axisymmetric model from 500 kN/m to 360 kN/m in the softened sensitivity model results in similar geogrid forces (within 15 %), but because the geogrid is softer, the geogrid strains increase significantly to a maximum of approximately 6 %. This suggests that a 360 kN/m geogrid may not be suitable for use in the case that softened sensitivity parameters apply.

- Removal of the geogrid completely from the softened sensitivity model increases the peak geomembrane forces to about 10 kN/m, compared to 9 kN/m for the case with 360 kN/m geogrid and 9 kN/m for the case with 500 kN/m geogrid. Corresponding geomembrane strains for the no-geogrid case increase to about 13 %, compared to 11 % for the case with 360 kN/m geogrid and 9% for the case with 500 kN/m geogrid. Adopting a limiting tensile strain 8 to 10 % for LLDPE geomembrane means that having no geogrid or 360 kN/m geogrid would likely not be tolerable in the case that softened sensitivity parameters apply.

- Vertical geomembrane displacements remain essentially unchanged in the softened landfill sensitivity model when comparing the cases with and without geogrid. However there is a difference in horizontal geomembrane displacements (Figure D16), which reflects the lateral extension and correspondingly higher strains of the case without geogrid.

The above results are consistent with overall expectations of liner behaviour, and demonstrate that the combination of 500 kN/m geogrid with the nominated geomembrane provides necessary reinforcement required to keep peak strains in the geogrid and geomembrane layers to below 5 % and 8 to 10 %, respectively – even for the sensitivity case of softened landfill stiffness.

1.1.6 Conclusions

The results of the PLAXIS analyses indicate that landfill settlements do not result in excessive concentrated relative movements within the liner system. The resulting forces and strains in the components of the proposed piggy back liner and new cell base liner systems are considered to be within acceptable limits.

General agreement was achieved between the PLAXIS, Slope/W and 1D settlement analyses.

1.1.7 For further assessment

We consider that further assessment is warranted at detailed design stage for the following:

- Material properties calibrated against field settlement trials; and
- Variations in liner stiffness over time.

Assessment of deformation effects for the landfill final capping system should also be carried out.

APPENDIX D1

Material Properties used in PLAXIS analysis

Geogrid																							
Identification number				1	2	3																	
Identification				Interface 1 - Geogrid (500)	Interface 2 - Geomembra	Interface 1 - Geomembrane																	
Material type				Elastic	Elastic	Elastic																	
Properties																							
EA	kN/m			500	80	80																	
Soil - Linear Elastic				**Soil - Mohr Coulomb**													**Soil - Soft Soil Creep**						
Identification		Unit 44 to 47 - Rock		Identification		Unit 43 - Residual Soil	Interface Unit 12-16P	Unit 6 - Base Material	Interface Unit 6-18	Interface Unit 15-17R	Unit 4 - Clay Rich bearing	Interface Unit 16-17R	Interface Unit 12-16R	Interface Unit 16-17P	Interface Unit 14-15		Identification		Unit 41a - New Landfill	Unit 41b - Old Landfill	Unit 41a - Soil Fill	Unit 42b - Alluvium	Unit 42b - Colluvium
Material model		Linear elastic		Material model		Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb		Material model		Soft soil creep	Soft soil creep	Soft soil creep	Soft soil creep	Soft soil creep
Drainage type		Drained		Drainage type		Drained	Drained	Drained	Drained	Drained	Drained	Drained	Drained	Drained	Drained		Drainage type		Drained	Drained	Drained	Drained	Drained
γ_unsat	kN/m^3	23		γ_unsat	kN/m^3	20	11	18	10	10	19	10	11	10	11		γ_unsat	kN/m^3	11	11	17	17	18
γ_sat	kN/m^3	23		γ_sat	kN/m^3	20	11	18	10	10	19	10	11	10	11		γ_sat	kN/m^3	11	11	17	17	18
Advanced				Advanced													Advanced						
Void ratio				Void ratio													Void ratio						
Dilatancy cut-off		No		Dilatancy cut-off		No	No	No	No	No	No	No	No	No	No		Dilatancy cut-off		No	No	No	No	No
e_init		0.5		e_init		0.5	2	0.5	0.5	0.5	0.5	0.5	2	0.5	2		e_init		2	2	2	1	1.5
e_min		0		e_min		0	0	0	0	0	0	0	0	0	0		e_min		0	0	0	0	0
e_max		999		e_max		999	999	999	999	999	999	999	999	999	999		e_max		999	999	999	999	999
Damping				Damping													Damping						
Rayleigh α		0		Rayleigh α		0	0	0	0	0	0	0	0	0	0		Rayleigh α		0	0	0	0	0
Rayleigh β		0		Rayleigh β		0	0	0	0	0	0	0	0	0	0		Rayleigh β		0	0	0	0	0
Parameters				Parameters													Parameters						
Material set				Material set													Material set						
Identification number		7		Identification number		1	8	9	10	11	12	13	14	15	16		Identification number		2	3	4	5	6
Identification		Unit 44 to 47 - Rock		Identification		Unit 43 - Residual Soil	Interface Unit 12-16P	Unit 6 - Base Material	Interface Unit 6-18	Interface Unit 15-17R	Unit 4 - Clay Rich bearing	Interface Unit 16-17R	Interface Unit 12-16R	Interface Unit 16-17P	Interface Unit 14-15		Identification		Unit 41a - New Landfill	Unit 41b - Old Landfill	Unit 41a - Soil Fill	Unit 42b - Alluvium	Unit 42b - Colluvium
Material model		Linear elastic		Material model		Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb		Material model		Soft soil creep	Soft soil creep	Soft soil creep	Soft soil creep	Soft soil creep
Drainage type		Drained		Drainage type		Drained	Drained	Drained	Drained	Drained	Drained	Drained	Drained	Drained	Drained		Drainage type		Drained	Drained	Drained	Drained	Drained
Stiffness				Stiffness													Stiffness						
E	kN/m^2	3.00E+05		E	kN/m^2	6.00E+04	1.50E+04	3.00E+04	3.00E+04	1.50E+04	1.00E+04	3.00E+04	1.50E+04	3.00E+04	1.50E+04		λ* (lambda*)		0.08696	0.08696	0.02899	0.0587	0.02609
ν (nu)		0.25		ν (nu)		0.25	0.3	0.3	0.3	0.3	0.3	0	0.3	0	0.3		κ* (kappa*)		0.01739	0.01739	5.80E-03	0.02609	8.70E-03
Alternatives				Alternatives													Alternatives						
G	kN/m^2	1.20E+05		G	kN/m^2	2.40E+04	5769	1.15E+04	1.15E+04	5769	3846	1.50E+04	5769	1.50E+04	5769		Use alternatives		No	No	No	No	No
E_oed	kN/m^2	3.60E+05		E_oed	kN/m^2	7.20E+04	2.02E+04	4.04E+04	4.04E+04	2.02E+04	1.35E+04	3.00E+04	2.02E+04	3.00E+04	2.02E+04		C_c		0.6	0.6	0.2	0.27	0.15
Velocities				Strength													C_s		0.06	0.06	0.02	0.06	0.025
V_s	m/s	226.1		c_ref	kN/m^2	5	0.01	0.01	1.00E-03	0.01	1.00E-03	1.00E-03	0.01	1.00E-03	0.01		e_init		2	2	2	1	1.5
V_p	m/s	391.7		ϕ (phi)	°	30	24	32	29	11	28	12	15	24	15		Strength						
Advanced				ψ (psi)	°	0	0	0	0	0	0	0	0	0	0		c_ref	kN/m^2	2	2	2	2	2
Set to default values		Yes		Velocities													ϕ (phi)	°	30	30	26	25	27
Stiffness				V_s	m/s	108.4	71.69	79.26	106.3	75.19	44.54	121.2	71.69	121.2	71.69		ψ (psi)	°	0	0	0	0	0
E_inc	kN/m^2/m	0		V_p	m/s	187.8	134.1	148.3	198.9	140.7	83.33	171.5	134.1	171.5	134.1		Advanced						
y_ref	m	0		Advanced													Set to default values		Yes	Yes	Yes	Yes	Yes
Interfaces				Set to default values		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		Stiffness						
Material set				Stiffness													v_ur		0.15	0.15	0.15	0.15	0.15
Identification number		7		E_inc	kN/m^2/m	0	0	0	0	0	0	0	0	0	0		K_0^nc		0.5	0.5	0.5616	0.5774	0.546
Identification		Unit 44 to 47 - Rock		y_ref	m	0	0	0	0	0	0	0	0	0	0		M		1.589	1.589	1.407	1.221	1.379
Material model		Linear elastic		Strength													Parameters						
Drainage type		Drained		c_inc	kN/m^2/m	0	0	0	0	0	0	0	0	0	0		Material set						
Colour		RGB 5, 60, 138		y_ref	m	0	0	0	0	0	0	0	0	0	0		Identification number		2	3	4	5	6
Strength				Tension cut-off		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		Identification		Unit 41a - New Landfill	Unit 41b - Old Landfill	Unit 41a - Soil Fill	Unit 42b - Alluvium	Unit 42b - Colluvium
Strength		Rigid		Tensile strength	kN/m^2	0	0	0	0	0	0	0	0	0	0		Material model		Soft soil creep	Soft soil creep	Soft soil creep	Soft soil creep	Soft soil creep
R_inter		1		Interfaces													Drainage type		Drained	Drained	Drained	Drained	Drained
Real interface thickness				Material set													Colour		RGB 95, 112, 114	RGB 58, 73, 74	RGB 236, 136, 14	RGB 228, 248, 13	RGB 202, 176, 7
δ_inter		0		Identification number		1	8	9	10	11	12	13	14	15	16		Stiffness						
Initial				Identification		Unit 43 - Residual Soil	Interface Unit 12-16P	Unit 6 - Base Material	Interface Unit 6-18	Interface Unit 15-17R	Unit 4 - Clay Rich bearing	Interface Unit 16-17R	Interface Unit 12-16R	Interface Unit 16-17P	Interface Unit 14-15		λ* (lambda*)		0.08696	0.08696	0.02899	0.0587	0.02609
Material set				Material model		Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb		κ* (kappa*)		0.01739	0.01739	5.80E-03	0.02609	8.70E-03
Identification number		7		Drainage type		Drained	Drained	Drained	Drained	Drained	Drained	Drained	Drained	Drained	Drained		μ*		8.70E-03	8.70E-03	8.70E-03	2.17E-03	1.04E-03
Identification		Unit 44 to 47 - Rock		Colour		RGB 244, 31, 230	RGB 195, 229, 249	RGB 164, 241, 101	RGB 184, 250, 61	RGB 241, 39, 120	RGB 161, 226, 232	RGB 134, 234, 162	RGB 88, 245, 15	RGB 236, 232, 156	RGB 182, 226, 190		Alternatives						
Material model		Linear elastic		Strength													Use alternatives		No	No	No	No	No
Drainage type		Drained		Strength		Rigid	Manual	Manual	Rigid	Rigid	Rigid	Rigid	Manual	Rigid	Manual		C_c		0.6	0.6	0.2	0.27	0.15
Colour		RGB 5, 60, 138		R_inter		1	0.67	0.89	1	1	1	1	0.67	1	0.67		C_s		0.06	0.06	0.02	0.06	0.025
K0 settings				Real interface thickness													C_α		0.06	0.06	0.06	0.01	6.00E-03
K_0 determination		Automatic		δ_inter		0	0	0	0	0	0	0	0	0	0		e_init		2	2	2	1	1.5
K_0,x		1		Initial													Strength						
Flow parameters				Material set													c_ref	kN/m^2	2	2	2	2	2
Material set				Identification number		1	8	9	10	11	12	13	14	15	16		ϕ (phi)	°	30	30	26	25	27
Identification number		7		Identification		Unit 43 - Residual Soil	Interface Unit 12-16P	Unit 6 - Base Material	Interface Unit 6-18	Interface Unit 15-17R	Unit 4 - Clay Rich bearing	Interface Unit 16-17R	Interface Unit 12-16R	Interface Unit 16-17P	Interface Unit 14-15		ψ (psi)	°	0	0	0	0	0
Identification		Unit 44 to 47 - Rock		Material model		Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb		Advanced						
Material model		Linear elastic		Drainage type		Drained	Drained	Drained	Drained	Drained	Drained	Drained	Drained	Drained	Drained		Set to default values		Yes	Yes	Yes	Yes	Yes
Drainage type		Drained		Colour		RGB 244, 31, 230	RGB 195, 229, 249	RGB 164, 241, 101	RGB 184, 250, 61	RGB 241, 39, 120	RGB 161, 226, 232	RGB 134, 234, 162	RGB 88, 245, 15	RGB 236, 232, 156	RGB 182, 226, 190		Stiffness						
Colour		RGB 5, 60, 138		K0 settings													v_ur		0.15	0.15	0.15	0.15	0.15
Model				K_0 determination		Automatic	Automatic	Automatic	Automatic	Automatic	Automatic	Automatic	Automatic	Automatic	Automatic		K_0^nc		0.5	0.5	0.5616	0.5774	0.546
Data set		Standard		K_0,x		0.5	0.5933	0.4701	0.5152	0.8092	0.5305	0.7921	0.7412	0.5933	0.7412		M		1.589	1.589	1.407	1.221	1.379
Soil				Flow parameters													Interfaces						
Type		Coarse		Material set													Material set						
< 2 μm	%	10		Identification number		1	8	9	10	11	12	13	14	15	16		Identification number		2	3	4	5	6
2 μm - 50 μm	%	13		Identification		Unit 43 - Residual Soil	Interface Unit 12-16P	Unit 6 - Base Material	Interface Unit 6-18	Interface Unit 15-17R	Unit 4 - Clay Rich bearing	Interface Unit 16-17R	Interface Unit 12-16R	Interface Unit 16-17P	Interface Unit 14-15		Identification		Unit 41a - New Landfill	Unit 41b - Old Landfill	Unit 41a - Soil Fill	Unit 42b - Alluvium	Unit 42b - Colluvium
50 μm - 2 mm	%	77		Material model		Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb		Material model		Soft soil creep	Soft soil creep	Soft soil creep	Soft soil creep	Soft soil creep
Parameters				Drainage type		Drained	Drained	Drained	Drained	Drained	Drained	Drained	Drained	Drained	Drained		Drainage type		Drained	Drained	Drained	Drained	Drained
Set to default values		No		Colour		RGB 244, 31, 230	RGB 195, 229, 249	RGB 164, 241, 101	RGB 184, 250, 61	RGB 241, 39, 120	RGB 161, 226, 232	RGB 134, 234, 162	RGB 88, 245, 15	RGB 236, 232, 156	RGB 182, 226, 190		Colour		RGB 95, 112, 114	RGB 58, 73, 74	RGB 236, 136, 14	RGB 228, 248, 13	RGB 202, 176, 7
k_x	m/day	8.60E-03		Model													Strength						
k_y	m/day	8.60E-03		Data set		Standard	Standard	Standard	Standard	Standard	Standard	Standard	Standard	Standard	Standard		Strength		Rigid	Rigid	Rigid	Rigid	Rigid
-ψ_unsat	m	0		Soil													R_inter		1	1	1	1	1
e_init		0.5		Type		Medium	Coarse	Coarse	Coarse	Coarse	Coarse	Coarse	Coarse	Coarse	Coarse		Real interface thickness						
Change of permeability				< 2 μm	%	19	10	10	10	10	10	10	10	10	10		δ_inter		0	0	0	0	0
c_k		1.00E+15		2 μm - 50 μm	%	41	13	13	13	13	13	13	13	13	13		Initial						
				50 μm - 2 mm	%	40	77	77	77	77	77	77	77	77	77		Material set						
				Parameters													Identification number		2	3	4	5	6
				Set to default values		No	No	No	No	No	No	No	No	No	No		Identification		Unit 41a - New Landfill	Unit 41b - Old Landfill	Unit 41a - Soil Fill	Unit 42b - Alluvium	Unit 42b - Colluvium
				k_x	m/day	8.60E-04	0	0.86	0	0	0	0	0	0	0		Material model		Soft soil creep	Soft soil creep	Soft soil creep	Soft soil creep	Soft soil creep
				k_y	m/day	8.60E-04	0	0.86	0	0	0	0	0	0	0		Drainage type		Drained	Drained	Drained	Drained	Drained
				-ψ_unsat	m	1.00E+04	0	0	0	0	0	0	0	0	0		Colour		RGB 95, 112, 114	RGB 58, 73, 74	RGB 236, 136, 14	RGB 228, 248, 13	RGB 202, 176, 7
				e_init		0.5	2	0.5	0.5	0.5	0.5	0.5	2	0.5	2		K0 settings						
				Change of permeability													K_0 determination		Automatic	Automatic	Automatic	Automatic	Automatic
				c_k		1.00E+15	1.00E+15	1.00E+15	1.00E+15	1.00E+15	1.00E+15	1.00E+15	1.00E+15	1.00E+15	1.00E+15		K_0,x		1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.285
																	Overconsolidation						
																	OCR		1.1	1.1	1.5	1.2	3
																	POP	kN/m^2	20	20	20	10	0
																	Flow parameters						
																	Material set						
																	Identification number		2	3	4	5	6
																	Identification		Unit 41a - New Landfill	Unit 41b - Old Landfill	Unit 41a - Soil Fill	Unit 42b - Alluvium	Unit 42b - Colluvium
																	Material model		Soft soil creep	Soft soil creep	Soft soil creep	Soft soil creep	Soft soil creep
																	Drainage type		Drained	Drained	Drained	Drained	Drained
																	Colour		RGB 95, 112, 114	RGB 58, 73, 74	RGB 236, 136, 14	RGB 228, 248, 13	RGB 202, 176, 7
																	Model						
																	Data set		Standard	Standard	Standard	Standard	Standard
																	Soil						
																	Type		Coarse	Coarse	Coarse	Fine	Medium fine
																	< 2 μm	%	10	10	10	46	19
																	2 μm - 50 μm	%	13	13	13	26	74
																	50 μm - 2 mm	%	77	77	77	28	7
																	Parameters						
																	Set to default values		No	No	No	No	No
																	k_x	m/day	8.64	8.64	8.60E-03	8.60E-04	8.60E-03
																	k_y	m/day	8.64	8.64	8.60E-03	8.60E-04	8.60E-03
																	-ψ_unsat	m	0	0	0	1.00E+04	1.00E+04
																	e_init		2	2	2	1	1.5
																	Change of permeability						
																	c_k		1.00E+15	1.00E+15	1.00E+15	1.00E+15	1.00E+15

| **Geogrid** | | |

APPENDIX E

Limitations

LIMITATIONS

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APPENDIX D

International Peer Review

JP GIROUD, INC.

Dr. Gary Schmertmann
Golder Associates
124 Pacific Highway,
St. Leonards,
New South Wales 2065,
Australia

2012 April 25

PROJECT: Whytes Gully New Cell Design, Preliminary (50%) Design Review

Dear Dr. Schmertmann,

During the past three months, I performed a review of the design as it was progressing, and I gave my comments. I believe this interactive approach is far more effective than reviewing a voluminous report at the last minute. Indeed, an interactive approach can prevent expenditure of effort on inappropriate design options and streamlines the final review process.

My involvement in the review began in September 2011 when I visited the Whytes Gully site and participated in a project design workshop with the design team. I was provided with draft sections of the design as soon as January 2012. Furthermore, considering the importance of the project and knowing that your team was working diligently, I took advantage of being in New Zealand in January to spend four days in Sydney with your team. I must say that this interactive review was productive, because I have noted in reviewing the documents I have received from you since March 2012 that all of the comments I had made during these intensive four days in Sydney had been implemented or had been used to improve drawings, refine analyses and clarify descriptions.

As a result, in the final stage of my review of the 50% design, I have only minor suggestions, which do not affect my review conclusions.

This letter summarizes my review of the 50% design.

Documents used for the preliminary (50%) design review

To perform my review, I was provided with the Report for Preliminary Design, dated April 2012. In fact, I received various sections of this report as soon as March 2012, as they became available, which was helpful.

I was also provided with the Appendices A, B and C to the Report for Preliminary Design: Appendix A, Drawings; Appendix B, Technical Specifications; and Appendix C, Geotechnical Interpretation and Analyses.

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Review of the Report for Preliminary Design

In reviewing the Report for Preliminary Design, I noted the following:

- The Report is well written and well organized.
- Key issues are properly identified. For example, the decision regarding including the piggyback lining system in the eastern gully is appropriate and I completely agree with this decision.
- The technical issues related to the piggyback lining system have been properly identified, namely: impact on leachate, impact on landfill gas, impact of settlement on the piggyback lining system, etc.
- The piggyback design issues have been addressed using state-of-the-art methods, as discussed later in this letter.
- The regulatory aspects are adequately addressed. I fully agree with the decision of following the Victoria BPEM guidelines for landfill lining, which are consistent with international regulations and practice. In particular, the composite liner concept is clearly presented and adequately used.
- Great attention has been paid to design details. This is important, because, in the disciplines of waterproofing and drainage, one detail that is incorrect from a conceptual or constructability standpoint may have detrimental consequences.

In conclusion, the Report for Preliminary Design is satisfactory. In fact, in my opinion, it contains more details than normally needed at the 50% design stage. This is beneficial as it will certainly facilitate the preparation of the 90% design.

Review of Appendix A, Drawings

I reviewed three successive sets of Drawings, starting in mid-January. During my visit in January, I made numerous comments and recommendations to improve the clarity of the drawings and the consistency between the different drawings. I also made important technical comments on design details such as connections between different drainage materials. My general evaluation of the drawings is that the final set of drawings I reviewed has appropriate technical content and contains all the drawings needed for a 50% design.

Review of Appendix B, Technical Specification

I did not review in detail Appendix B, Technical Specification. However, I reviewed Chapter 2, the material property requirements, and Chapter 3, the requirements for construction activities and construction quality management.

In reviewing the material property requirements (i.e. Chapter 2), I made sure that the specifications were consistent with international practice. It is important to note that that the scope of the technical specification at the 50% design stage is necessarily limited because some

properties cannot be specified before the 90% design is completed. This is the case in particular of the drainage geocomposite material.

Regarding the requirements for construction activities and construction quality management (i.e. Chapter 3), my evaluation is that key items such as geomembrane installation, testing and documentation (items which were examined during the course of the review) have been adequately considered for this stage of the design.

In conclusion, Appendix B addresses all the materials that need to be specified and the important aspects of construction and construction quality that need to be addressed at the 50% design stage. However, more work is needed to finalize this appendix at the 90% design stage.

Review of Appendix C, Geotechnical Interpretation and Analyses

I did not review in detail all parts of Appendix C, Geotechnical Interpretation and Analyses. However, during the course of the interactive review process, I reviewed key items such as settlement analysis, piggyback liner deformation analysis/geogrid design and landfill slope stability. I discussed my comments with the design team. The comments were used to improve the analyses and my evaluation is that these comments have been adequately considered.

I was particularly interested in the "Deformation Analysis Results" section because it is essential to the piggy-back design, and because state-of-the-art methodology used. This is due in great part to the fact that you are very knowledgeable about all important publications on the subject of deformation analysis, as I could see during our discussions in January.

I noted that Appendix C does not contain a section on liquid control/drainage design. I indicated to the design team that I agree that such a section is not required at this stage, because it is more appropriate to do the drainage design last (i.e. after settlement and deformation analyses). A section on drainage design will need to be added at the 90% design stage. In the meantime, I noted that the leachate collection drainage length shown in the 50% design drawings is reasonable and no drastic change should be needed as a result of the calculations to be performed for the 90% design.

In conclusion, my evaluation is that Appendix C addresses all the issues that need to be considered at the 50% design stage. In particular, important issues such as slope stability, settlement and liner deformation are addressed thoroughly. Furthermore, Appendix C contains all of the numerical results needed at the 50% design stage.

General evaluation of the design

In the process of my review, I made numerous comments on non-technical points (e.g. terminology, consistency, clarity of explanations) to make sure the work product would be

presented in a manner that is well accepted by landfill experts and would be informative for non-expert readers.

It is important to note that, while making non-technical comments, I was not distracted from my essential mission which is to ensure that the landfill cell design is technically sound. From this viewpoint, my impression is very positive and can be summarized as follows:

- The set of drawings contains all the drawings needed for a 50% design and the drawings are presented in a clear and consistent manner. Technical details in the drawings are adequate.
- The geotechnical design report will address all design aspects when a section on liquid control/drainage design is added at the 90% design stage.
- The methodology used for all aspects of design relevant to the 50% design (i.e. stability, settlement, and deformation) is correct, and the analyses are performed with advanced analytical and numerical tools and an excellent knowledge of the state of the art.

This last comment is perhaps my most important comment on the review I performed of the 50% design.

Conclusion

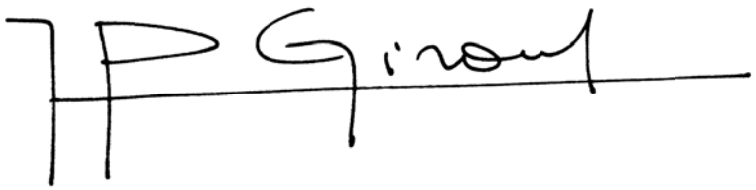
Based on this review, I can state that the 50% design is satisfactory. All the important issues have been identified. All the design methods used are correct and are implemented with the latest published information available and advanced analytical and numerical tools, particularly for the piggyback lining system. My experience indicates that the design is consistent with international practice and is likely to be adequate from a regulatory standpoint.

In my opinion and based on my experience, the degree of detail in the design report and in the numerical analyses exceeds what is typically expected for a 50% design.

I am very pleased that the interactive approach to design review, as we have practiced since January, has been fruitful. As a result, I have no suggestion for changes.

I thank you for the opportunity that was given to me to review this excellent work.

Sincerely,



J.P. Giroud

APPENDIX P

Landfill Environmental Management Plan (LEMP)

March 2012

DRAFT LANDFILL ENVIRONMENTAL MANAGEMENT PLAN

Whytes Gully New Landfill Cell

Submitted to:
Wollongong City Council

REPORT

Report Number. 117625003-061-R-Rev0

Golder Associates

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1.0 INTRODUCTION

1.1 Objectives

This Landfill Environmental Management Plan (LEMP) describes the operating and management procedures for waste disposal and general operation of the Whytes Gully Resource Recovery Park (RRP) (the site). The site is operated by Wollongong City Council (Council). The LEMP has been prepared to provide easily accessible procedures for environmentally sound and operationally efficient management of the site.

The LEMP will specifically serve as:

- A management tool for site operation;
- A means of identifying and concentrating on the key operational, environmental and rehabilitation issues;
- A guidance document for monitoring and reporting; and
- A guidance document for interaction with relevant Government authorities such as the NSW Office of Environment and Heritage (OEH).

This plan follows the expected format of a Landfill Environmental Management Plan and the criteria established in the NSW Environmental Guidelines: Solid Waste Landfills (EPA, 1996).

This LEMP is considered a working document that will be updated by Council on a regular basis as management requirements change. The document will be reviewed on an annual basis to identify sections requiring revision.

A Landfill Extension Environmental Management Plan was prepared by Maunsell Pty Ltd in 1998 (Maunsell 1998). This LEMP supersedes the document prepared by Maunsell.

The WGRRP is subject to Environment Protection Licence (EPL) 5682 and the conditions outlined in Development Applications No. DA-1984/228, DA-1992/662 and DA-1982/459. Refer Appendix A.

1.2 Document Structure

The document has been structured to encourage its use on a day to day basis and to outline the procedures required to manage key environmental factors pertaining to operation of the WGRRP.

The document addresses the benchmark techniques outlined in the NSW Environmental Guidelines: Solid Waste Landfills (EPA, 1996) and follows a structure that encourages its use by operational staff. The document structure is summarised as follows:

Section 2 – Site Overview:

This section describes the natural setting (geological, hydrological, climate, etc.) of the site as well as its history.

Section 3 – Operations Overview:

This section describes the current and proposed operations of the site. It elaborates on the landfill design and describes the proposed filling plan of the site and discusses how the landfill life is maximised by measures such as recycling and resource recovery.

Section 4 – Structure and Responsibilities:

This section outlines the organisational and management structure of the facility and outlines responsibilities for key staff members.

Section 5 - Gatehouse Operations:

This section outlines the procedures for operation of the gatehouse, in particular how the receipt of materials is managed, how customers are managed and how the quality of received waste is controlled. The section also describes the management of tyres and the cleaning of vehicles.

Section 6 - Filling Operations:

This section describes the efficient management of tip face operations including waste filling, fillings plans, compaction of waste and covering of waste.

Section 7 - Water Quality Management:

This section describes how surface water, groundwater and leachate are managed and how the off site impact of water is minimised. Contingency measures for remediation of groundwater and surface water impacts are discussed. The section describes a detailed water monitoring program.

Section 8 - Air Quality Management:

This section describes control measures to reduce air emissions, in particular landfill gas emissions, originating from the site operation and outlines a monitoring program as well as contingency measures for remediation of air pollution.

Section 9 - Hazards and Loss of Amenity:

This section outlines management procedures to control the impact of the facility on the amenity of stakeholders and to reduce other hazards originating from the facility. The main impacts of the site on amenity of stakeholders are security, litter, dust, pests, vermin, noxious weeds, odour, noise, traffic impacts and fires.

Section 10 - Site Closure:

This section outlines the proposed approach for site closure and rehabilitation.

Section 11 - Reporting:

This section outlines the reporting requirements at the facility both internally and externally.

Section 12 - References and Bibliography:

This section summarises the relevant reference documents for this LEMP.

2.0 SITE OVERVIEW

2.1 Site Description

2.1.1 Regional Setting

The Wollongong Local Government Area (LGA) is located 80 kilometres south of Sydney and covers approximately 714 km^2. Wollongong LGA is bordered by the Royal National Park to the north, Lake Illawarra to the south, the Tasman Sea to the east and the Illawarra escarpment to the west.

WGRRP is located approximately 10 km to the south west of the Wollongong CBD and is approximately 65 ha in size. Figure 1 identifies the WGRRP regional context and local government area.

2.1.2 Site Location

The WGRRP is located on Reddalls Road, Kembla Grange NSW (refer Figure 2). The site is generally bounded by Reddalls Road to the south and west, rural residential lands to the north, north-east and north-west, and a water treatment plant to the south east. An industrial area lies to the south of Reddalls Road and Dapto Creek lies to the west.

The residential suburb of Farmborough Heights is located approximately 360 m to the north east over a ridgeline. Two individual residences are located within 120 m of the site boundary..

2.1.3 Site Ownership, Zoning and Tenure Details

The site is located approximately 10 kilometres to the south west of the Wollongong Central Business District, on Reddalls Road, Kembla Grange, and within the Wollongong City Council LGA.

The WGRRP is owned by Council and consists of:

- Part Lot 501, DP 1079122;
- Lot 502, DP 1079122;
- Lot 2, DP 240557;
- Lot 52, DP 1022266;
- Lot 53, DP 1022266; and
- Lot 51, DP 1022266.

This land is zoned as IN2 Light Industrial under the *Wollongong Local Environment Plan (West Dapto) 2010* (LEP).

2.1.4 Surrounding Land Uses

The surrounding area is identified as follows:

- To the north and north east is zoned E1 and E2 to predominantly to identify and protect the escarpment area.
- To the north west and west is zoned RU2 (Rural Landscape). Isolated residential properties are also scattered through this zoning.
- To the west is zoned E3 (Environmental Management) to protect potential watercourses.
- To the south is zoned IN3 (Heavy Industrial). Use is generally low intensity light industrial.

To the east is zoned IN2 (Light Industrial) land.

2.2 Site History and Development

All locations referred to in this section are shown in Figure 3 –Site Layout.

The Whytes Gully RRP was established in 1984 at a site known as Whyte's farm. As identified within "*Environmental Impact Statement – Proposed Waste Disposal Depot at Reddalls Road West Dapto"* prepared by Scott and Furphy in 1982 (Western Gully EIS), the site is defined by two gullies known as the western and eastern gullies separated by a central north-south trending ridgeline. Whyte's farm initially comprised an area of 35.6 ha of mostly cleared, improved grazing land owned by Mr Whyte for a period of approximately 40 years prior to the sites development as a landfill.

An area of land to the south of Whyte's farm adjacent to the eastern gully was also purchased by Wollongong City Council to accommodate the Whytes Gully RRP development as a landfill. A stockyard remains near the central western boundary of the site which is remnant from this prior use.

2.2.1 Western Gully

Development consent for landfilling in the Western Gully was granted in 1984, in accordance with the Western Gully EIS. Landfilling commenced in the Western Gully in 1984.

Site Preparation – It is understood that colluvium and residual soil were stripped from the natural slopes during preparation works prior to landfill being placed in the area. From discussions with Council staff involved in this stripping operation it appears that the natural slopes are likely to have been almost completely stripped to rockhead, but that colluvium and residual soil were not removed to full depth at the base of the natural slopes.

Lining - The Western Gully Landfill is unlined.

Leachate Collection –Collection of leachate was originally through a central 100 mm diameter perforated pipe located at the base of the landfill. From discussions with Council staff we understand that this pipe did not have filter protection and became non-functional early on during the filling process. These discussions also indicate that an alternate leachate collection system was constructed where leachate collection horizons were established successively at approximate 5 m vertical intervals within the landfill mass comprising a network of finger drains. At the low point on each horizon, flows in the finger drains enter a shallow 300 mm concrete or HDPE pipe and are conveyed to the base of the landfill batter. At the toe of the landfill batter the shallow 300 mm pipe extends through the landfill bund wall to the current leachate collection pit near the current landfill access road, from where it is transferred to the leachate collection ponds.

Irrigation of leachate is also understood to have historically been undertaken on the Western Gully Landfill but has not been practiced in recent years.

Volume - The Western Gully Landfill received approximately 980,000 cubic meters (cu.m.) of waste during its 9.5 year life from 1984 to 1993 (Forbes Rigby, 2001).

Filling - Landfilling commenced following the construction of a large soil bund wall at the toe of the landfill with a height of 5 m and a crest elevation of RL 35 m . The bund wall extends from one side of the Western Gully to the other. After site preparation, waste was subsequently placed in the gully behind the bund wall. Once waste was placed to the height of the bund wall, a second, smaller, bund wall was placed to a height of approximately 37.5 m AHD. Waste was then placed to the crest level of the second bund wall. This filling technique of bund construction followed by waste filling was continued throughout the life of the landfill with each bund wall being approximately 2.5 m high. The maximum waste thickness is approximately 30 m.

Bund wall and cover material was won from site preparation works prior to filling of each lift. The external bund wall surfaces were subsequently vegetated following completion of each lift.

Capping – the Western Gully Landfill is covered with a varying depth of cover materials comprising generally low to medium plasticity sandy clay ranging in thickness from 0.3 m to 2.5 m (Golder 2012).

Profile - The profile of the landfill batter comprises an average surface slope of approximately 20% with indistinct benches at approximate 5 m to 10 m vertical intervals. The landfill surface above RL 80 m has gentler slopes, generally flatter than 10%.

Footprint – The approximate footprint of the Western Gully landfill is 10 ha.

2.2.2 Eastern Gully

Development consent for landfilling in the Eastern Gully was granted in 1993 in accordance with the "Whytes Gully Landfill Extension Environmental Impact Statement" undertaken by Maunsell in 1992 (Eastern Gully EIS).

Site Preparation - As with the Western Gully we understand that colluvium and residual soil were stripped from the natural slopes during preparation works prior to landfill being placed in the area. From discussions with Council Staff involved in this stripping operation it appears that the natural slopes are likely to have been almost completely stripped to rockhead, but that colluvium and residual soil were not removed to full depth at the base of the natural slopes.

Leachate Barrier - The Eastern Gully landfill was constructed as a lined landfill, with the barrier component of the lining system comprising a high density polyethylene (HDPE) geomembrane liner (2 mm thickness). The HDPE geomembrane liner has a textured surface in sloped areas to enhance landfill stability.

The HDPE geomembrane liner is underlain by a groundwater drainage layer comprising an approximate 500 mm thick fine gravel layer that is intended to collect any groundwater seepage from natural materials below the liner. This layer incorporates a 100 mm diameter collection pipe that drains by gravity to a surface water pond at the toe of the Eastern Gully landfill. Sampling shows that water collected in the groundwater system may be impacted by leachate. We understand that when high water levels develop in the surface water pond, it is pumped to the leachate management system.

Leachate Collection - The HDPE geomembrane liner is overlain by a blanket leachate drainage layer comprising an approximate 300 mm thick clean sand layer. This layer incorporates two 300 mm diameter leachate collection pipes that drain by gravity to the toe of the landfill – one pipe drains Stage 1 and the other pipe drains Stage 2 (refer below for stage description). Collected leachate is transferred to leachate ponds.

Filling - has been undertaken in four stages. Stage 1 commenced in 1993 and was located in the upper portion of the Eastern Gully. Stage 2, located on the lower section of the Eastern Gully commenced in 2001. Stages 1 and 2 together received approximately 1,250,000 cu.m. of waste to the year 2004. Stage 3 is located over the Stage 1 and Stage 2 filling area and had an estimated 610,000 cu.m. capacity over a five year period (2004 to 2009). Stage 4, located in the upper portion of the gully over Stage 3 and Stage 1 is currently underway and has an estimated 750,000 cu.m. capacity over a four year period (2009 to 2013) with completion of filling expected in 2013 (Forbes Rigby, 2001 and WCC Drawing No. 1475, 2004, Survey Drawings KFW dated December 2000, December 2001, June 2004 and December 2009 drawing numbers 2982, 3156, 3705, 4600 respectively).

Capping - Capping materials encountered had a variable composition of materials throughout the existing cap. The thickness of the capping observed by Golder (2012a) ranged from 0.1 m (GAHA04) to 0.6 m (GAHA01) across the Eastern Gully landfill.

Profile - The current landfill batter has an average slope of approximately 25% and is terraced with benches at 2m to 3m vertical intervals, bench widths at 3m to 5m, and slope inclinations of 2H:1V to 3H:1V between benches.

Refer to the draft Landfill Environmental Management Plan (LEMP) (Appendix P) for drawings of the Western Gully and Eastern Gully landfill.

2.2.3 Site Access

Access to the Whytes Gully RRP has changed several times during its operation based on changes to the alignment of Reddalls Road and changes to the site access point. Prior to site development, Reddalls Road turned to the north west to the east side of Glengarry Cottage. A section of the road was realigned around

the time of commencement of landfilling such that the road continued westward to the south of Glengarry Cottage and then turning north between the current Materials Recycling Facility (MRF) location and Glengarry Cottage.

At the time of commencement of the Eastern Gully landfill it was recognised that the location of Reddalls Road presented difficulties for the long term development of the landfill and for local residents who had to pass through the facility to access the local road network. To address these issues Reddalls Road was deviated to the south west in 2001 after preparation of the "Review of Environmental Factors for Proposed Deviation of Reddalls Road, Kembla Grange" (REF) in 2001. The REF states that the Wollongong City Council LEP (1990) would allow such works to proceed without development approval.

In 2007 the current entrance and weighbridge was approved and located to the west of the existing MRF and east of the Leachate Treatment Plant.

The currently disused weighbridge is located on the main site access road near the oil recycling area and the intersection with old Reddalls Road. This facility consists of the pitless weighbridge (approximately 16 m by 5 m), a concreted traffic island (approximately 50 m in length) and a weighbridge office. Reinforced concrete slabs associated with the discussed weighbridge are 100 mm thick (underneath the weighbridge) and 200 mm thick on either end of the weighbridge with footings up to 800 mm thick. Vehicles currently accessing the landfill and the materials drop off areas pass by the disused weighbridge. This weighbridge and foundations will be demolished during construction of the project.

The existing landfill access road is a two-lane, paved road extending approximately 1.7 km from the existing weighbridge at approximate elevation RL 20 m to the northern edge of the Eastern Gully Landfill at approximate elevation RL 75 m. The road traverses existing Western Gully waste for a distance of approximately 250 m at approximate elevation RL 65 m. Access tracks suitable for 4WD vehicles extend: (a) from the landfill toe up the central ridge to the landfill access road; and (b) up the eastern ridge.

2.3 Environmental Setting

2.3.1 Topography

The landfill is sited on a south facing slope, which is dominated by an east-west trending ridgeline to the north. The landfill is located in two historical gullies, the western gully and the eastern gully, which correspond to the two landfill developments at the site; the Eastern Gully landfill and the Western Gully landfill. The northwest and eastern extents of the landfill are bounded by ridgelines, with a small central north-south trending ridgeline separating the two historical gullies, the upslope portion of which is still visible today. The site rises from RL 15 m at the south west to RL 100 m to the north east. Figure 4 presents the existing site contours.

2.3.2 Soil and Geology

Based on the 1:100,000 geological map 'Wollongong-Port Hacking' (Department of Primary Industries, 1985) the WGRRP is on the boundary of two major geological formations. The southern part of the site is underlain by fluvial sands, silts and clays associated with Dapto Creek. Sandstone of the Budgong Sandstone formation underlies these alluvials. The Budgong Sandstone formation typically composes red, brown and grey lithic sandstone. The northern portion of the site is underlain by interbedded lithic sandstone, coal, carbonaceous claystone, siltstone and claystone of the Pheasants Nest Formation. It appears that the Pheasants Nest formation is mainly encountered on the ridgelines.

The Western Gully EIS (1982) indicates that prior to landfilling, volcanic sandstone covered most of the site with a transition to andesitic sandstone with coal seams, carbonaceous shale and mudrock in the higher section (above approximately RL 100 mAHD) and a zone of alluvium, gravels and sands in the lower sections (below approximately RL 30 mAHD). Bedrock is reported to appear at the surface in the upper sections of the site.

The geotechnical investigation carried out by Golder Associates (Golder 2012a) summarises the conditions encountered as outlined in the following paragraphs.

The report describes the site geological setting as four different geological areas. These areas are:

Geological Area 1 – Pheasants Nest Formation: This area is located on the upper slopes across the northern portion the site. The material encountered is generally weathered sandstone that grades into a fresh sandstone at depths typically less than 10 m. The residual soil is generally less than 2 m thick. Siltstone was encountered in zones throughout the sandstone at depths greater than about 15 m (based on the Maunsell 1992 investigation). Siltstone was not encountered in the Golder 2012a investigation.

Geological Area 2 – Budgong Sandstone Formation: This area is located across the southern portion of the site. This sandstone generally has a weathering profile that extends to depths up to 15 m. Zones of weathered siltstone, up to approximately 3m thick, are located intermittently throughout this formation.

Geological Area 3 – Alluvial Soils: This geological area consists of colluvial / alluvial soil material (silty clay and silt with some sands and sub angular gravels and cobbles) and is located across the middle and south west portion of the site. The thickness of this material varies to a maximum of approximately 11m. This geological area is expected to be underlain by Budgong Sandstone.

Geological Area 4 – Capping Layer and Landfill: This geological area is located across the northern slope. The capping material consists of generally low to medium plasticity sandy clay and is typically less than 1.5m thick. Landfill waste is located beneath the capping layer and consists of general waste such as paper, plastic, wood, rubble and other materials. The depth to the base of the general waste fill is not well defined, however old topographical data suggests that the thickness of the fill could be up to 52 m within the Eastern Gully landfill. This geological area is expected to be underlain by the Pheasants Nest Formation.

The geological areas are identified in Figure 5 and investigation locations are presented in Figure 15.

2.3.3 Climate

Climate data for the site has been collated from a number of Bureau of Meteorology's (BoM) weather stations as no nearby weather station has a continuous long term record of weather data and variability in rainfall patterns in particular is known in the area. The weather stations in closest proximity to the site are summarised in the Table 6.1.

Table 2.1: Weather Stations

Station	BoM Reference	Approximate Distance to Site (km)	Station Open	Data selected
Albion Park (Wollongong Airport)	068241	10	1999 to present	Temperature, solar exposure, wind speed, humidity
Dapto West (Stane Dykes)	068023	5	1898 to 1987	Rainfall
Berkeley (Northcliffe Drive)	068110	4	1963 to present	Rainfall
Sydney Airport	066037	67	1974 to present	Mean Daily Evaporation

Mean monthly rainfall, temperature, evaporation, wind speed and humidity is presented in Table 6.3.

Table 2.2: Monthly Climate Statistics (BOM, 2011)

Statistic Element	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean Rainfall (mm)[1]	100.6	133.2	140.1	112.9	85.7	106	54.5	66.2	58.2	93	96.5	76.8	1125.4
Mean Rainfall (mm)[2]	123.5	130.2	140.9	106.7	101.7	101.3	78.6	70.9	59.6	85.8	92.3	97.6	1192.4
Mean Rainfall (mm)[3]	116.1	157.5	183.7	92.9	89.0	140.3	62.6	87.7	55.0	108.0	94.3	90.4	1278.6
Mean max temperature (°C)[4]	26.8	26.3	25.2	23.1	20.3	18.2	17.5	18.9	21.4	22.7	23.7	25.5	22.5
Mean max temperature (°C)[3]	24.1	24.4	24.1	22.4	19.4	17.5	16.7	17.3	19.2	20.7	22.4	23.4	21.0
Mean min temperature (°C) [4]	16.7	17.2	15.3	11.9	8.6	6.9	6.2	6.4	8.4	10.7	13.3	15.0	11.4
Mean min temperature (°C)[3]	18.4	18.7	18.0	15.7	12.7	10.9	9.8	10.3	11.8	13.7	15.3	17.1	14.4
Mean daily evaporation (mm) [5]	7.2	6.4	5.4	4.2	2.9	2.5	2.7	3.7	4.9	5.8	6.5	7.4	5.0
Mean daily solar exposure (MJ/m^2) [4]	22.7	20.0	17.4	13.9	10.4	8.7	9.8	13.3	17.0	19.8	21.1	23.0	16.4
Mean 9am wind speed (km/hr) [4]	11.6	9.8	8.1	10.7	12.4	13.6	14.4	15.0	15.3	14.4	12.9	12.7	12.6
Mean 9am wind speed (km/hr) [3]	17.4	16.1	14.7	14.7	16.7	17.4	17.7	18.5	18.7	19.7	19.5	18.1	17.4
Mean 3pm wind speed (km/hr) [4]	21.6	20.0	18.9	17.7	17.1	17.6	18.1	21.8	22.6	20.9	20.9	21.5	19.9
Mean 3pm wind speed (km/hr) [3]	24.4	23.7	22.9	22.8	21.9	22.0	24.6	25.4	27.1	26.3	26.5	25.5	24.4
Mean 9am relative humidity (%)[4]	68	74	76	68	69	73	68	61	57	58	67	66	67
Mean 3pm humidity (%)[4]	63	67	64	61	58	57	54	49	53	58	63	61	59

[1] Mean data for Dapto West (Stane Dykes) weather station, (068023)

[2] Mean data for Berkeley (Northcliffe Drive) weather station, (068110)

[3] Mean data for Port Kembla (Signal Station) weather station, (068053), data from 1950 to 1976 and from 1957 to 1976 for wind speed

[4]Mean data for Albion Park (Wollongong Airport) weather station, (068241)

[5] Mean data for Sydney Airport weather station (066037), data from 1974 to 2010.

For the Dapto West (Stane Dykes) weather station, which is the station in operation for the longest period, the average annual rainfall is 1192.4 mm. The rainfall distribution throughout the year is higher for summer, with winter and spring months experiencing on average the driest weather.

Monthly wind roses for the Wollongong Airport weather station (BoM reference: 068241) are shown in Appendix K. As wind directions vary significantly depending on the site location, wind roses from the Port Kembla signal station (BoM reference: 068053, data available from 1957 to 1977) have also been included for comparative purposes.

Wind directions at the site are seasonal and are dominated by strong westerly winds during the winter months. Northeasterly winds dominate during the remainder of the year.

2.3.4 Hydrology

The site lies at the foot of Mt Kembla and is located within the catchment of Dapto Creek which discharges to Lake Illawarra via the larger Mullet Creek. The site is approximately one kilometre upstream of Dapto Creek and five kilometres upstream of Lake Illawarra.

There is no major continuous watercourse flowing from the site. Both gully's feed into one minor ephemeral watercourse which discharges under Reddalls Road into Dapto Creek.

Dapto Creek discharges into the much larger Mullet Creek catchment which is approximately 74.5 km^2. Mullet Creek rises at the escarpment at an elevation of about 600m AHD, and flows a distance of about 22 Km before reaching the tidal Lake Illawarra. These steep catchment conditions provide for dynamic flooding and geomorphic conditions in the catchment.

The headwaters for the Mullet Creek catchment are mainly forested and much of its catchment is still used for rural activities. However Dapto, Horsley, Brownsville, Kembla Grange and Farmborough Heights represent significant urban use.

The general surface water drainage direction on the site is from the north east towards the south west. The catchment area of the site is approximately 50 ha and extends from a ridge to the north of the site to Reddalls Road to the south. Run-on to the site is minimal due to the site being bounded by ridgelines.

Surface water runoff from covered areas of the Western and Eastern Gully landfills is captured by swales on the landfill surface. The swales divert the runoff towards drains around the perimeter of the landfills and to a central drain between the Eastern and Western Gully landfills. Runoff from the natural slope above the northern edge of the Eastern Gully landfill (rainforest area) is also directed to the central drain.

Surface water runoff reports to the surface water ponds at the southwest corner of the site before discharge to Dapto Creek.

2.3.5 Hydrogeology

Regionally the site is located within the southern portion of the Sydney Basin, a geological basin stretching from the Illawarra Plateau in the south to the Lower Hunter Valley region in the north, and incorporating the topographically low Cumberland Basin in the centre. Generally, the dip of the geological formations within the Sydney Basin is from the topographically higher ground in the north and south towards the topographic low ground in the centre of the basin, although this varies locally based on structural features.

The regional hydrogeological setting of the site includes groundwater resources associated principally with the sandstone formations of the Hawkesbury Sandstone, Narrabeen Group, Illawarra Coal Measures and the Shoalhaven Group. Each of these geological groups generally comprise of varying proportions of sandstone, siltstone, claystone, shale and coal. Groundwater resources are generally described as occurring as stacked aquifer systems associated with the sandstone formations, separated by lower permeability strata acting as aquitards. Structural contours presented on the 1:100,000 geological map ‘Wollongong-Port Hacking’ (Department of Primary Industries, 1985) indicate a local geological dip direction approximately towards the north to northwest in the vicinity of the site, which would be expected to influence the regional groundwater flow direction.

On the site scale, groundwater occurrence is generally associated with two shallow systems: groundwater present in the upper weathered and fractured profile of the local bedrock geology, and groundwater present in the unconsolidated deposits that infill the two gullies at the site at the toe of the sloping topography. Water levels measured in wells installed within the shallow weathered bedrock in the sloping northern portion of the site generally range from 5 to 10 metres below ground level (mbgl), whereas water levels in wells installed in both the shallow bedrock and unconsolidated material in the flatter southern portion of the site are shallower, generally on the order of 1 to 3 mbgl. The water level associated with GABH03 is approximately 0.4 m above ground level, indicating local artesian conditions within the shallow bedrock at this location.

Shallow groundwater flow associated with the weathered bedrock horizon is inferred to be sympathetic to the sloping topography of the northern portion of the site, with a south to southwest flow direction. Anecdotal information indicates that a number of springs were present in the former gullies in which the existing landfill cells were developed. Groundwater within the unconsolidated deposits on the southern portion of the site also exhibits a south-southwest flow direction. Where nested wells were installed, an upward vertical hydraulic gradient was evident between the shallow weathered bedrock and the overlying unconsolidated deposits, which is likely attributable to the significant hydraulic gradient from the sloping terrain on the northern portion of the site. On the basis of the lithological logs and water level observations, it is considered that the weathered bedrock groundwater system is semi-confined beneath the unconsolidated deposits, but there is likely to be a degree of hydraulic connectivity between the systems.

Hydraulic testing of wells completed within both the shallow weathered bedrock and in the unconsolidated deposits indicated hydraulic conductivity values on the order of 10^{-5} to 10^{-6} m/s, which is consistent with the range of published values for the lithologies encountered.

2.3.6 Flora and Fauna

A Flora and Fauna assessment was carried out by Biosis (Biosis 2012). The following sections summarise the flora and fauna generally occurring on site. Figures showing the location and extent of Flora and Fauna communities are shown in Biosis 2012 and Figure 6.

Flora

Five vegetation communities have been identified by Biosis at the site (Biosis 2012). These are:

- **Lowland Dry Subtropical Rainforest**, which occurs along a south facing slope within the northeast of the Study Area;
- **Moist Box Redgum Foothills Forest**, which occurs within the north east of the Study Area in a relatively narrow strip adjoining the Lowland Dry Subtropical Rainforest occurring downslope
- **Forest Red Gum Open Forest/Woodland**, which occurs in relatively small patches in the north of the Study Area and in a larger area in the east of the site
- **Acacia Scrub/Exotic vegetation community**, which occurs in disturbed areas that have been previously cleared, as well as revegetated areas around the edges of landfill; and
- **Closed Exotic Grassland**, which is the most common vegetation community, occurring throughout the Study Area in cleared areas as well as over the landfill.

In addition, a number of native trees have been planted along the road leading from the weighbridge towards the landfill area.

The flora survey found one threatened ecological community that occurs in a steep area to the north of the Eastern Gully landfill (Figure 6):

- Lowland Dry Subtropical Rainforest corresponds with the TSC Act listed Illawarra Subtropical Rainforest (ISTR) EEC.

A total of 87 plant species were recorded from the Study Area during the current survey. The flora species inventory includes 64 locally occurring native species and 23 introduced species. Of the 23 introduced species, two are listed as noxious under Order 20 of the NSW *Noxious Weeds Act 1993* for the Wollongong LGA:

- Lantana - Class 4; and,
- African Lovegrass - Class 4

The legal requirement for a Class 4 noxious weed is that the growth and spread of the plant must be controlled according to the measures specified in a management plan published by the local control authority and the plant may not be sold or knowingly distributed.

Fauna

Biosis identified the following four major fauna habitats are present within the Study Area:

- **Aquatic Environments** – including the three surface water ponds located in the south-western section of the Study Area, ephemeral drainage lines, decommissioned ponds and various other water bodies (including the Primary and Secondary Leachate Ponds);

- **Open Forest/Woodland** – highly disturbed habitat encompassing the Forest Red Gum Open Forest/Woodland located in the south-eastern section of the Study Area;
- **Closed Forest** – encompassing the Moist Box Redgum Foothills Forest and Lowland Dry Subtropical Rainforest located in the north-eastern section of the Study Area; and,
- **Cleared and Disturbed** – including the operational areas of the Resource Recovery Park, easements, Cleared Exotic Grasslands and Acacia Scrub.

A total of 63 fauna species were recorded in the Study Area, which included 57 (90%) native species. A total of six introduced fauna species were recorded. Two threatened species, the Grey-headed Flying-fox *Pteropus poliocephalus* and Southern Myotis *Myotis macropus,* (probable detection) were recorded within the Study Area. The aquatic habitats provide potential habitat for the threatened Green and Golden Bell Frog *Litoria aurea.*

There is also a high likelihood of an additional five threatened fauna species occurring in the Study Area. These species include;

- Eastern Bentwing-bat *Minopterus schreibersii oceanensis*;
- Yellow-bellied Sheathtail-bat *Saccolaimus flaviventris*;
- Eastern Freetail Bat *Mormopterus norfolkensis*;
- Eastern False *Pipistrelle Falsistrellus tasmaniensis*; and,
- Greater Broad-nosed Bat *Scoteanax rueppellii*.

Four targeted surveys were undertaken for the Green and Golden Bell Frog and Australian Painted Snipe with no recordings.

2.4 Cultural Heritage

2.4.1 Aboriginal Heritage

Heritage assessments completed at the site to assess the potential impacts of the Project upon indigenous and non-indigenous heritage are reported in “Whytes Gully New Landfill Cell Aboriginal Cultural Heritage Assessment Report” Biosis Research (January 2012) and “Whytes Gully New Landfill Cell: Historical Heritage Assessment” Biosis Research (January 2012). These assessments identified three Aboriginal archaeological sites:

- Whytes Gully 1 – an isolated artefact
- Whytes Gully 2 – a low density artefact scatter; and,
- Whytes Gully 3 – shell material that has been imported into the Study Area as part of a fill deposit..

The location of these sites is presented on Figure 7.

2.4.2 European Heritage

The only identified European heritage item on site is Glengarry Cottage and the surrounding curtilage. (Biosis 2012). Glengarry Homestead is listed on the Historical Register for Regional significance as it is the last of the Veteran's Land Grants homes at Kembla Grange (Wollongong City Council webpage 2011). The cottage currently houses Council offices and will not be impacted by the landfill operations.

3.0 OPERATIONS OVERVIEW

3.1 Regulatory Background

3.1.1 Consents and Licences

The following Table summarises consents and licenses relevant to the site.

Table 3: Relevant Consents and Licences

Reference	Type	Description
EPL5862	NSW EPA Environment Protection Licence (EPL)	The site landfill licence
TWA 11205	Trade Waste Agreement	Trade Waste Agreement with Sydney Water for discharge of treated leachate to sewer
DA-1982/459	Development Consent Conditions	Lot 2 DP 240557 & PT Por 9 – Waste Disposal Site
DA-1984/228	Development Consent Conditions	Develop and Operation of a Waste Disposal Depot
DA-1992/662	Development Consent Conditions	Upgrading The Existing Western Gully Landfill & Extending The Land Filling Operation Into the Adjacent Eastern Gully
DA-2005/1635	Development Consent Conditions	Extension of MRF
DA-2008/1425	Development Application	Replacement of current scrap metal and Small Vehicles Recoverables Drop Off centre compounds
D2240/02	Development Consent Conditions	Construction of new leachate and stormwater treatment ponds
TBA	Development Consent Conditions	Leachate Treatment Plant
TBA	Development Consent Conditions	Reddalls Road Realignment
TBA	Development Consent Conditions	Weighbridge and new site entrance
TBA	Development Consent Conditions	MRF construction

Appendix A presents the current EPL and the trade waste agreement.

3.1.2 Guidelines and Legislation

The NSW EPA (1996) *Environmental Guidelines: Solid Waste Landfills* (referred to as the Landfill Guidelines) presents a non-prescriptive, performance-based approach to managing putrescible and non-putrescible solid waste landfills across NSW. Although the environmental goals identified in the Landfill Guidelines are not laws, operation of solid waste landfills should meet these goals where appropriate. Appendix A of the Landfill Guidelines outlines possible benchmark techniques which may be adopted in Landfill Environmental Management Plans in order to achieve the environmental goals. The compliance level for each of these benchmark techniques is included in the Covering Statement attached to this LEMP.

A number of NSW Acts and their associated regulations also apply to the management of the facility and are summarised below in Table 5. Those highlighted in **bold** are the most relevant to the site operations.

Table 4: NSW Legislation that relates to the operation of the facility.

Act	*Associated Regulations*	*General Intent*	*Relation to the Operation of the Facility*
Waste Avoidance and Resource Recovery Act 2001	-	To minimise the consumption of natural resources and the final disposal of waste and achieve integrated waste and resource management planning.	The operation of the facility must uphold principles of ecologically sustainable development and focus on waste minimisation and resource recovery over disposal.
Environmental Planning and Assessment Act 1979	Environmental Planning and Assessment Regulation 2000	To encourage the proper management, development and conservation of natural and artificial resources and protection of the environment.	Determines the development approval process.
Environmentally Hazardous Chemicals Act 1985	**Environmentally Hazardous Chemicals Regulation 2008**	To control activities related to chemical waste.	Affects permissible waste type.
Heritage Act 1977	Heritage Regulation 2005	To conserve heritage items.	Operations affected if heritage items are nearby.
Local Government Act 1993	Local Government (General) Regulation 2005	To provide the legal framework for an effective, efficient, environmentally responsible and open system of local government in NSW.	Gives Councils a role in managing and developing resources and encourages community consultation.
National Parks and Wildlife Act 1974	National Parks and Wildlife Regulation 2009	To conserve natural ecosystems, landforms and places of social significance.	Protection of places of sites of natural and Aboriginal significance must be considered.
Native Vegetation Act 2003	Native Vegetation Regulation 2005	To protect native vegetation and prevent broadscale clearing.	Re-vegetation at the facility should be encouraged.
Noxious Weeds Act 1993	Noxious Weeds Regulation 2008	To reduce the negative impact of weeds on the economy, community and environment.	A Weed Management Strategy is required.
Occupational Health and Safety Act 2000	**Occupational Health and Safety Regulation 2001**	To secure and promote the health, safety and welfare of people at work.	The facility must provide a safe work environment.

Act	*Associated Regulations*	*General Intent*	*Relation to the Operation of the Facility*
Ozone Protection Act 1989	-	To control atmospheric pollutants that contribute to the depletion of ozone in the stratospheric ozone layer.	The emission of atmospheric pollutants must be managed.
Protection of the Environment Operations Act 1997	Protection of the Environment Operations (Clean Air) Regulation 2002 Protection of the Environment Operations (General) Regulation 2009 Protection of the Environment Operations (Noise Control) Regulation 2008 **Protection of the Environment Operations (Waste) Regulation 2005**	To enhance the quality of the environment in NSW.	Outlines requirements for a range of activities related to waste facilities including licensing, monitoring, reporting.
Public Health Act 1991	-	To increase the standard of health in NSW.	Outlines requirements for safe drinking water.
Soil Conservation Act 1938	-	To conserve soil resources.	Land degradation, soil erosion must be managed.
Threatened Species Conservation Act 1995	Threatened Species Conservation Regulation 2002	To protect threatened species, populations, ecological communities and habitats.	The potential impact of the development on threatened species must be considered.
Water Management Act 2000	-	To protect, enhance and restore water sources, associated ecosystems and water quality.	Effect of facility on surface and groundwater must be managed.

In addition to the above NSW legislation and regulations, a number of Environmental Planning Instruments (EPIs) also apply to the planning and management of waste facilities and have been listed below in Table 5.

Table 5: NSW EPIs that relate to the operation of the facility.

EPI	***General Intent***	***Relation to the Operation of the Facility***
State Environmental Planning Policy (SEPP) (Infrastructure) 2007	To facilitate the effective delivery of infrastructure across NSW	Determines allowable locations of waste facilities
SEPP (Major Development) 2005	To determine the development assessment and approval process	Determines the approval process for waste facilities
SEPP No.55 – Remediation of Land 1998	To provide for a Statewide planning approach to the remediation of contaminated land	Identifies the process and consent required to remediate land should contamination occur
SEPP No.33 – Hazardous and Offensive Development 1992	To determining whether a development is a hazardous or offensive industry and minimise the adverse impact of the development	Outlines the development consent required for a Hazardous and Offensive Development

3.2 Key Site Features

A site layout plan presenting the existing site features is presents in Figure 3. The main site features are listed following.

- Eastern and Western gully landfills;
- amenities building, chemical and fuel stores;
- surface water ponds ;
- leachate ponds (Primary Pond and Secondary Pond);
- leachate treatment plant;
- weighbridge;
- local heritage listed Glengarry Cottage, currently in use as Council offices;
- green waste recycling facility, operated by contractor (to be relocated offsite in 2012);
- “Small Vehicles Recoverables Drop Off” resource recovery centre, operated by contractor ;
- materials recycling facility (MRF), operated by contractor; and
- small vehicle transfer station (located within the former solid waste to energy recycling facility (SWERF) building).
- tree and shrub plantings along the site boundary have been undertaken during the site development to provide a visual buffer from neighbouring properties.

Works as Executed Drawings for the main infrastructure at the site are presented in Appendix C.

3.2.1 Easements

A number of easements exist on site. These are summarised as follows and are presented on Figure 8:

- An easement for the 132 kV overhead power transmission line which runs east to west across the site, situated south of the Eastern Gully landfill and north of Reddalls Road.
- Power lines as well as a Telstra line run along Old Reddalls Road.
- Power supply easement for the LTP runs from Old Reddalls Road near Glengarry Cottage along the northern edge of the MRF property.
- A private power line easement exists in the northern part of the site and crosses the Western Gully landfill. It is understood this line is de energised and due for decommissioning.
- Municipal water supply is provided to amenities buildings via an underground water pipe running from Reddalls Road across the Lot 53 DP 1022266 to Glengarry Cottage.
- A 70 mm high density polyethylene (HDPE) sewer connection runs between the leachate treatment plant and sewer along Reddalls Road.

3.2.2 Small Vehicle Transfer Station

A small vehicle transfer station is located in the former SWERF building at the toe of the eastern gully landfill. Waste dropped off at the transfer station is inspected and then transported by Council to the tipping face where it is spread, placed and compacted. Recyclables or unacceptable waste is removed from the transfer station for appropriate management.

3.2.3 Leachate Pond

Leachate collected at the landfill is piped to the leachate ponds (Primary and Secondary Leachate Pond) from where the leachate is pumped to the on-site leachate treatment plant.

3.2.4 Leachate Treatment Plant

The leachate treatment plant is a biological treatment process using sequencing batch reactor (SBR) technology. Treated leachate is discharged to sewer under a Trade Waste Agreement with Sydney Water up to 250 kL per day.

3.2.5 Surface Water Ponds

All surface water flows are directed into the surface water treatment system, which comprises a series of surface water ponds approved in 2003. The system is located in the south west corner of the site and comprises two reed beds (Reed Beds 1 2) and an upper and lower surface water polishing pond. The total capacity of the surface water treatment system is 40,000 cu.m. The design of the ponds is detailed in design drawings prepared by Forbes Rigby within “Whytes Gully Waste Disposal Facility Leachate and Stormwater Ponds Civil Works, Reddalls Road, Kembla Grange for Wollongong City Council” (Forbes Rigby 2003) and provided in the draft LEMP (Appendix Q). Discharge from the ponds is to Dapto Creek.

3.2.6 Green Waste Processing

Green waste is dropped off separate from mixed general waste at the green waste processing area at the toe of the Western Gully landfill. The green waste collected is shredded on a regular basis and subsequently exported from site for reuse.

3.2.7 Recoverables Drop Off and Buy Back (Revolve)

The Recoverables Drop Off and Buy Back (Revolve) is located to the north of the old SWERF building. Customers can drop off reusable items at the Revolve Centre, where they are sold back to the public.

3.2.8 Small Vehicle Recyclables Drop Off

Small Vehicle Recyclables Drop off is located at the toe of the Western Gully landfill and is shown on Figure 3.

Resource Recovery at the WGRRP consists of the acceptance of the following recyclable materials:

- Comingled recyclables (Glass bottles,
- Paper and cardboard);
- Mobile phones;
- Car batteries;
- Scrap metal (including white goods, steel, brass, aluminium, copper);
- Gas bottles and fire extinguishers;
- Fluorescent lights and CFL's;
- Waste oil (motor oil, transmission oil, gear oil, kerosene and Diesel, no cooking oil or petrol are accepted);
- Green Waste;
- E Waste; Computers and Televisions;
- Mattresses; and
- Tyres.

3.3 Future Operations and Key Site Features

The future landfill operation will comprise a number of new stages (Stage 1, Stage 2A, Stage 2B, Stage 3, Stage 4), which will cover current and previous landfill areas in addition to previously unfilled areas. The staging sequence is shown on Figure 9 and Staging Plans are presented in the Landfill Master Plan (Appendix D). The following table outlines the construction staging and description of staging of the project.

Table 6: Summary of Construction Staging (approximate)

Stage	Area (m^2)	Airspace including Cap (cum)	Life of Cell (Years)	Operation Period	Proposed Capping Construction Period (*)	Proposed Liner Construction Period (*)
1	82,000	912,000	4.4	2013 - 2018	2016 - 2019	2013 - 2016
2A	22,500	343,000	2.4	2018 - 2020	2020 - 2021	2017 – 2018
2B	81,200	2,134,000	15.2	2020 - 2035	2023 - 2036	2019 – 2031
3	67,200	1,589,000	11.3	2035 - 2046	2038 - 2047	2035 – 2041
4	69,000	1,007,000	7.2	2046 - 2054	2048 - 2055	2046 – 2050
TOTAL	**321,900**	**5,985,000**	**40.5**			

* Not continuous during period

Figure 9 presents the staging sequence and Figure 10 presents the footprint of the future operations.

Stage 1 covers the Eastern Gully landfill, a section of the Western Gully landfill and a non-landfilled area at the foot of the Eastern Gully landfill that is occupied by roads and stormwater infrastructure.

Stage 2 covers part of the Western Gully landfill, a non-landfilled area at the toe of the Western Gully landfill that is occupied by roads and stormwater infrastructure and a non-landfilled ridge line between the Eastern and Western Gully landfills.

Stage 3 covers part of the Western Gully landfill and a non-landfilled area at the toe of the Western Gully that is occupied by roads, the green waste process area and stockpiling areas.

Stage 4 covers an area to the west of the Western Gully landfill that has previously not been landfilled as well a non-landfilled area at the toe of the Western Gully landfill that is currently occupied by roads and the Primary and Secondary Leachate Ponds.

In addition to landfilling:

- Green Waste activities will be relocated offsite in March 2012.
- Leachate ponds will be relocated at the end of Stage 3 prior to commencing Stage 4 construction.
- Surface water pond will be down sized at the end of Stage 3 prior to commencing Stage 4 construction.
- Landfill Gas extraction and flaring will be installed in the existing waste in 2012.
- Landfill Gas extraction and electricity generation will be installed progressively in the new waste from 2014.
- The MRF will be relocated and upgraded in 2014.

3.4 Cell Construction Activities

Construction of the new landfill cells would comprise the following general steps:

- Site Preparation
- Cell Preparation
- Liner and leachate collection system construction
- Landfilling and cover
- Final Capping and Rehabilitation

Three distinct types of ground conditions can be identified for proposed new landfill areas of the Project :

1) Non-landfilled areas primarily occupied by infrastructure such as roads, soil fill placement, and ponds,. (south of existing landfill Footprint) and would include Cells 1 to 4.
2) Non-landfilled areas that have remained largely undisturbed (Western Ridge and Central Ridge) including Cells 2A, 2B and 4A.
3) The Eastern Gully and Western Gully landfill (Existing Waste) including Piggy Back 1, 2A, 2B, 3.

The future landfill operation involves a number of preparatory stages prior to placement of waste, which differ depending on the presence of ground condition types 1 through to 3 described above. The preparatory measures for each ground condition are described in the following sections.

1) Non-landfilled areas occupied by infrastructure such as roads, ponds, etc. (Cells 1,2,3,4):

- Stripping of vegetation where present;
- Removal of road surfaces and subgrades, building demolition, service removal, and service trench backfilling;
- Removal of lining systems of ponds and removal of sludge from ponds;
- Smoothing of abrupt changes in grade by cutting and filling;
- Filling of ponds and areas as required to maintain an adequate groundwater separation distance;
- Compaction and proof rolling of subgrade including formation of cell bund walls and leachate sumps;
- Placement of lining system for New Cell area including leachate collection system.

2) Non-landfilled areas that have remained largely undisturbed (Cells 2A, 2B and 4A):

- Stripping of vegetation;
- Excavation and profiling of up to 5 m of soil and rock and stockpiling for re-use as cover material;
- Compaction and proof rolling of subgrade including formation of cell bund walls; and
- Placement of composite liner system for non landfilled areas including leachate collection system.

3) Eastern Gully and Eastern Gully Landfill (Piggy Back 1, 2A, 2B, 3):

- Stripping of vegetation where present;
- Smoothing of abrupt changes in grade by minor cutting/filling of existing cover soils and removal of existing terrace bunds on the Eastern Gully landfill batter;
- Compaction and proof rolling of subgrade including formation of cell bund walls; and
- Placement of 'piggy-back' lining system including landfill gas under drainage layer, base layer and leachate collection layer

3.5 Landfilling Activities

Landfilling of solid waste for the Project comprises:

- Dumping of waste in the active filling area and placement of waste in layers.
- Compaction of waste using a Compactor and a Loader used to assist spreading the waste.
- Placement of landfill lids and/or daily cover (150 mm) over exposed waste at the end of each working day.
- Removal of landfill lids prior to recommencement of filling in an area and/or removal or puncturing of daily cover prior to placement of waste.
- Placement of intermediate cover (300 mm) on finalised lifts and batters. Intermediate cover would be applied over landfilled surfaces in areas that are not going to be used for more than the next 90 days. Intermediate cover areas would be revegetated with grasses.
- Stripping of intermediate cover prior to placement of the subsequent layer of waste and reuse of the intermediate cover for future lifts.
- The intermediate cover over the final landfill lift would remain in place to form part of the landfill capping layer subgrade.

While one cell is being filled with waste, the liner for the succeeding cell would be constructed. In addition finalised cells would be capped and rehabilitated whilst waste is being landfilled in subsequently staged cells. Progressive staging plans are shown in the Landfill Master Plan (Appendix D).

3.6 Hours of Operation

The hours of operation of the site are outlined in the following table.

Table 7: Hours of Operation

Activity	***Day***	***Time***
Operation	*Monday – Friday*	*7:30am to 4:30pm*
	Saturday, Sunday and Public Holidays	*8:00am to 4:00pm*

3.7 Nature and Quality of Waste Received

According to the EPL 5862, the site is licensed to receive the following waste types:

- General solid waste (non-putrescible) as defined in Schedule 1 of the Protection of the Environment Operations (PoEO) Act (1997).
- General solid waste (putrescibles) as defined in Schedule 1 of the PoEO Act (1997)
- Asbestos waste as defined in Schedule 1 of the PoEO Act (1997), however, Council does not accept asbestos waste at the facility
- Any waste that is received below licensing thresholds in Schedule 1 of the PoEO Act (1997), as is in force from time to time.

Waste not accepted at the site is referred to as ‘excluded waste’.

3.8 Life of Landfill and Disposal Rates

The landfill has an approximate life of 40 years. The Table 6 outlines the approximate timelines for each stage of the project. Timelines are based on placing 140,000 m^3 of waste per annum.

4.0 STRUCTURE AND RESPONSIBILITIES

4.1 Staffing and Responsibilities

Requirements

The Solid Waste Landfill Guidelines (EPA 1996) provide the following requirements in Benchmark Technique BT39 'Staffing and Training Requirements'.

'*The level and nature of staffing and training should be adequate for environmentally responsible and safe management of the landfill. Staffing requirements will vary as a function of size, type of wastes, diversity and complexity of site operations.*

Landfill occupiers are to provide adequate staff to ensure that during operating hours all continuous tasks (including waste reception and security, compaction and covering) are completed in compliance with an approved LEMP.

At a minimum, staff training is to ensure that:

- *all operators of compaction or earthworks equipment are skilled at undertaking all tasks required of them*
- *all those who operate gas testing, water sampling or water testing apparatus are familiar with required testing and sample retention protocols, to a standard approved by the EPA*
- *all those who are to inspect or direct the placement of incoming wastes are capable of accurate data recording, and skilled at identifying wastes that are unacceptable.*'

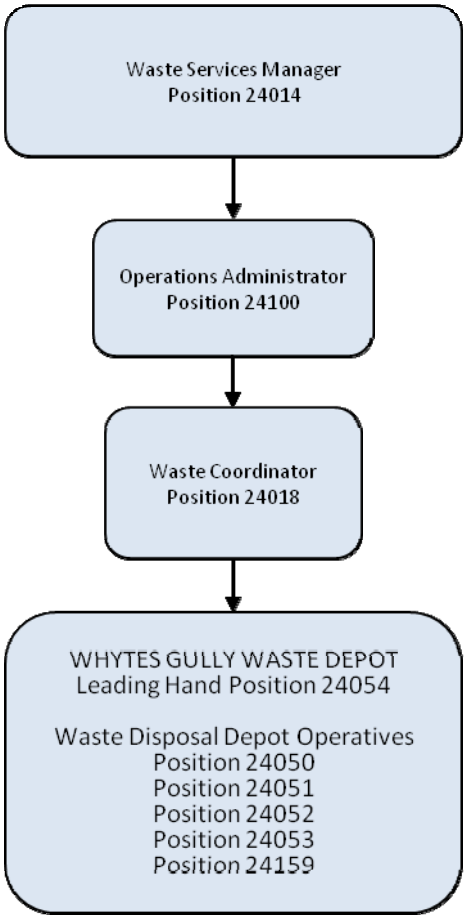
Objectives

Waste management facilities require adequate staffing levels to ensure that during operating hours all continuous tasks are completed in compliance with the LEMP. Clear definition of staff function, roles and responsibilities is necessary to ensure this.

Management Strategy

Chart 1 presents an organisational chart for the key staff involved in the management and operation of the WGRRP.

Chart 1: WGRRP Organisational Structure



The following sections comprise a summary of the roles and responsibilities of each staff member.

Waste Services Manager (WSM)

Overall responsibility for operational management of the facility.

Responsibilities include:

- managing the Operations Administrator, Waste Coordinator, Weighbridge Operators, Plant Operators and Contractors on site;
- managing all onsite staff issues;
- preparing reports, budgets and monitoring income generation;
- ensuring staff training program are implemented;
- managing construction activities on the site;
- managing safety issues at the site;
- ensuring outgoing product quality control.

Operations Administrator (OA)

Overall responsibility for the strategic planning and environmental management of the landfill facility. This responsibility includes:

- ensuring that landfill operations are carried out in accordance with the LEMP and Landfill Licence and other environmental legislative requirements;
- managing the preparation of annual reports;
- managing site resource recovery and transfer station contractors and activities;
- reporting to DECCW;
- managing regular review of the LEMP and annual review;
- managing environmental monitoring programs, groundwater assessment programs and remediation programs;
- managing training and inductions;
- managing design activities for the site; and
- reviewing filling and compaction rates.

Waste Coordinator (WC)

- supervising activities in accordance with the LEMP and Landfill Licence;
- supervising Weighbridge Operators, Plant Operators, Labourers and Contractors on site;
- induction of Contractors and induction and training of Weighbridge Operator, Plant Operators and General labourers;
- ensuring all activities and directions issued by the Operations Administrator and Waste Services Manager are carried out;
- directing safety issues within the landfill;
- supervising the maintenance of road, fence, sedimentation and erosion traps, signs , leachate pumps, ponds and general infrastructure within the landfill;
- rostering of staff at the landfill;
- maintenance of vehicles and plant;
- management of unacceptable waste loads;
- managing disposal areas for “special waste types”;
- recording and acting on complaints; and
- managing the progress of filling and managing cover materials.

Leading Hand (LH)

- Manages tasks of the WC in the case the WC is not on site
- supervising Weighbridge Operators, Plant Operators, Labourers and Contractors on site;
- induction of Contractors and induction and training of Weighbridge Operator, Plant Operators and General labourers;
- Confirms that operational staff is competent in their assigned tasks following inductions and training period;
- directing safety issues within the landfill;
- supervising the maintenance of road, fence, sedimentation and erosion traps, signs , leachate pumps, ponds and general infrastructure within the landfill;
- rostering of staff at the landfill;
- maintenance of vehicles and plant;
- management of unacceptable waste loads;
- managing disposal areas for “special waste types”; and
- managing the progress of filling and managing cover materials.

Weighbridge Operator (WO)

- operating weighbridge;
- opening and closing gatehouse;
- keeping gatehouse and surrounds in a clean and tidy manner;
- screening of all waste to allow only permitted waste into the landfill according to the Landfill Licence and this LEMP; and
- directing all vehicles to the appropriate tipping area.

Plant Operators (POs)

- efficient operation of equipment;
- processing waste in accordance with the LEMP and Licence conditions including identifying unacceptable materials at the tip face;
- relieving at the gatehouse when required;
- maintain a safe tipping area;
- covering the waste at the end of the day; and
- maintain the plant in a good working condition.

Waste Disposal Depot Operatives

- picking up litter around the landfill;
- maintaining sedimentation and erosion controls within the landfill;
- maintaining the landfill amenities;
- maintaining all infrastructure within the landfill; and
- relieving the gatehouse operator when required.

Small Vehicle Transfer Station Supervisor

- Supervising the small vehicle transfer facility area;
- Screening of waste delivered by small vehicle drop offs; and
- Ensuring that only approved waste is dropped off at the transfer station.

Small Vehicle Recyclables Drop Off Attendant

- Supervising the Small Vehicle Recyclables Drop Off area;
- Screening of waste delivered;
- Ensuring that only approved waste is dropped off at the area; and
- Ensuring that waste is dropped off in the appropriate stockpile.

Recoverables Drop Off Centre Attendant

- Supervising the Recoverables Drop Off Centre;
- Screening of waste delivered;
- Ensuring that only approved items are dropped off at the Recoverables Drop Off Centre; and
- Communicate with customers purchasing items from the Recoverables Drop Off Centre.

4.2 Training

Staff training should be adequate for environmentally responsible and safe management of the facility, and to meet the conditions relating to staff competency outlined above. According to the Landfill Guidelines (Benchmark technique Number 39), at a minimum staff training should ensure that:

- All operators of compaction or earthworks equipment are skilled at undertaking all tasks required of them.
- All those who operate gas testing, water sampling or water testing apparatus are familiar with the required testing and sample retention protocols, to a standard approved by the EPA.
- All those who are to inspect or direct the placement of incoming waste are capable of accurate data recording, and skilled at identifying wastes that are unacceptable.

The management of training at the WGRRP incorporates four elements as summarised below:

- position competency requirements;
- general induction training;
- site specific induction training; and
- ongoing training.

Position Competency Requirements

Table 8 presents qualifications/ competencies that are prerequisites for performing each of the landfill roles.

Table 8: Competencies

Role	Prerequisite Qualifications/Competencies
Waste Services Manager (WSM)	■ Qualifications or equivalent experience in waste management desirable
Operations Administrator (OA)	■ Qualifications or equivalent experience in waste management desirable
Waste Coordinator (WC)	■ Qualifications and/or equivalent experience in managing solid waste landfills desirable ■ TAFE certificate or equivalent in civil engineering or waste management discipline ■ Class “C” drivers license
Leading Hand (LH)	■ Competent in the identification of waste types ■ Competent in the use of computers and knowledge of MS Word ■ Class “C” drivers license
Weighbridge Operator (WO)	■ Competent in the use of computers and knowledge of MS Word ■ Possess keyboard skills to certificate level ■ Experience in use of weighbridge

Role	Prerequisite Qualifications/Competencies
	■ Possess good public relations and communication skills ■ Competent in the identification of waste types
Plant Operators (PO)	■ Class “C” drivers license ■ Workcover accreditation as front end loader operator ■ Workcover certificate of competency as a “dogman” ■ Accredited traffic controller’s certificate

General Induction Training

All staff employed by Council undergo a formal induction program relating to their position. The training program comprises:

- Occupational Health and Safety (OH&S) Training;
- Code of Conduct Training; and
- Risk assessment training.

First aid training if offered to all staff, but is an optional training element.

Site Specific Induction Training

Site induction and training of landfill staff (WO, POs) is undertaken by the Waste Coordinator. Training involves:

- Training in all applicable Standard Operating Procedures (SOPs), depending on the staff member:
  - Daily Inspections;
  - OH&S Record keeping;
  - End of day operations;
  - The general site management plan;
  - Cash handling;
  - Armed hold ups;
  - General weighbridge operation;
  - Traffic control;
  - Bin emptying using hooklift trucks;
  - Visitors to Waste depot;
  - Receipt of Waste;
  - Water tank operation;
  - Special Waste handling;

  - Leachate dosing;
  - Landfill lid operation;
  - 18 litre hand spray pump operation;
  - Herbicides application;
  - Fire management;
  - Mower operation (John Deere and Victa);
  - Plant maintenance procedures;
  - Plant operator's end of day's procedures
  - Loader tip face operations; and
  - Compactor tip face operations.
- Breathing apparatus training;
- Site specific fire management procedure;.
- Gas testing, water testing and water sampling;
- Accurate data recording;
- Emergency Response Plan; and
- 'on-the-job' training for plant operators and weighbridge operators. The OA assesses staff competency for tasks assigned and confirms competency once achieved.

Contractors also undergo a site specific induction, conducted by the Waste Coordinator or Leading Hand.

Ongoing Training

Ongoing training requirements will be reviewed on an annual or as-needs basis depending on staffing at the site and triggers for ongoing training such as equipment upgrades, review of procedures or change in regulatory requirements.

Some staff may be required to obtain tickets or licenses to operate plant or conduct certain tasks. A register of tickets and licenses for each staff member is maintained by Council.

Actions for Compliance

- Training for correct identification of excluded waste should be included in the training program.

Performance Indicators

- The level of skill and performance of the work force.
- The outcome of performance reviews of the staff.
- The number of errors in data recording and reporting.
- Level of operational and administrative efficiency.

Responsible Persons

- Waste Services Manager.
- Operations Administrator.
- Waste Coordinator.
- Leading Hand.

Reporting

- Annual Report (refer Section 11.5).

Corrective Actions

- If annual reviews detect a failing, then measures will be put in place to increase the staffing levels and/or training requirements.

4.3 Complaints

The EPL contains the following requirements for management of complaints.

'M4.1 The licensee must keep a legible record of all complaints made to the licensee or any employee or agent of the licensee in relation to pollution arising from any activity to which this licence applies.

M4.2 The record must include details of the following:

(a) the date and time of the complaint;

(b) the method by which the complaint was made;

(c) any personal details of the complainant which were provided by the complainant or, if no such details were provided, a note to that effect;

(d) the nature of the complaint;

(e) the action taken by the licensee in relation to the complaint, including any follow-up contact with the complainant; and

(f) if no action was taken by the licensee, the reasons why no action was taken.

M4.3 The record of a complaint must be kept for at least 4 years after the complaint was made.

M4.4 The record must be produced to any authorised officer of the EPA who asks to see them.

M5.1 The licensee must operate during its operating hours a telephone complaints line for the purpose of receiving any complaints from members of the public in relation to activities conducted at the premises or by the vehicle or mobile plant, unless otherwise specified in the licence.

M5.2 The licensee must notify the public of the complaints line telephone number and the fact that it is a complaints line so that the impacted community knows how to make a complaint.

M5.3 Conditions M5.1 and M5.2 do not apply until 3 months after:

(a) the date of the issue of this licence or

(b) if this licence is a replacement licence within the meaning of the Protection of the Environment Operations (Savings and Transitional) Regulation 1998, the date on which a copy of the licence was served on the licensee under clause 10 of that regulation.'

Objectives

The purpose of maintaining a Complaints Register is to record and monitor the number of complaints received to improve site operations.

Management Strategy, Tasks and Actions

A complaints register will be maintained to log public complaints regarding odours, vermin, litter, dust and noise received at the WGRRP. The date, time and nature of any complaint is recorded and the /subsequent actions taken to help minimise or eliminate the concerns will be logged. A complaints register form is presented in Appendix E. All Council communication including communication relating to complaints are maintained in Council's record keeping system TRIM.

All staff will be trained in the requirement to notify and record any public complaints.

Council's main customer service line is 4227 7111. This number is widely advertised and calls to this number are promptly allocated to the responsible officer.

The telephone number for the WGRRP is (02) 4227 7197 and is a public listing and is also displayed on the front gate.

Performance Indicators

- Number of complaints recorded.

Responsible Person

- Operations Administrator.

Reporting

- Annual Report (refer Section 11.5).

Corrective Actions

- If complaints are not being recorded, staff may need further training in this area.

5.0 GATEHOUSE OPERATIONS

5.1 Introduction

The adoption of sound land management and conservation principles is one of the primary environmental goals of the LEMP. Two important aspects of this are the diversion of wastes that can be re-used or recycled to minimise the loss of landfill capacity, and managing the site to ensure that unsuitable wastes are not received and that the nature of wastes that are received is known.

The gatehouse represents an important control point for the WGRRP, and control of the following operations is essential in meeting the above goal:

- Waste screening;
- Waste measurement and recording;
- Recycling;
- Tyre Management;
- Waste Transfer Station; and
- Cleaning of vehicles.

These aspects, including the specific guideline conditions applying to them, are discussed in the following sections.

5.2 Waste Screening

Requirements

The following EPL licence conditions relate to waste screening at the WGRRP.

'L5.1 The licensee must not cause, permit or allow any waste to be received at the premises, except the wastes expressly referred to in the column titled "Waste" and meeting the definition, if any, in the column titled "Description" in the table below.

Any waste received at the premises must only be used for the activities referred to in relation to that waste in the column titled "Activity" in the table below.

Any waste received at the premises is subject to those limits or conditions, if any, referred to in relation to that waste contained in the column titled "Other Limits" in the table below.

Condition L5.1 does not limit any other conditions in this licence.

Code	Waste	Description	Activity	Other Limits
NA	General Solid Waste (non-putrescible)	As defined in Schedule 1 of the POEO Act, as in force from time to time.	Waste Disposal (application to land)	NA
NA	General Solid Waste (putrescible)	As defined in Schedule 1 of the POEO Act, as in force from time to time.	Waste Disposal (application to land)	NA
NA	Asbestos Waste	As defined in Schedule 1 of the POEO Act, as in force from time to time.	Waste Disposal (application to land)	NA

Code	Waste	Description	Activity	Other Limits
NA		*Any waste received on site that is below licensing thresholds in Schedule 1 of the POEO Act, as in force from time to time*		*NA*

O8.1 The licensee must have in place and implement procedures to identify and prevent the disposal of any waste not permitted by this licence to be disposed of at the premises.

M7.1 The licensee must maintain a record of all events involving the removal of any waste that was brought to the facility and which is not permitted to be disposed of at the facility.'

Council does not accept asbestos waste at the WGRRP.

Objectives

The purpose of screening the wastes received is to ensure that the site receives only those wastes that it is licensed to receive.

Management Strategy

The following provisions are in place at the WGRRP to prevent the disposal of unacceptable wastes. Detailed procedures are presented in the SOP's in Appendix F.

- Signs are presented at the entrance to WGRRP which clearly indicate the types of wastes that are accepted and those that are not accepted.
- All incoming vehicles enter via the weighbridge/gatehouse, where the vehicle registration number is entered.
- Customer declares type and source of waste.
- If the Weighbridge Operator is suspicious about the waste load, the load is inspected.
- If waste is from an industrial source and application for disposal is to be submitted by Customer and assessed.
- Screen and check incoming waste at the weighbridge where load is not covered. An overhead CCTV is installed to enable visual inspection of loads by the Weighbridge Operator.
- Screen and check waste at Small Vehicle Transfer Station and tipping face. Refer Section 3.2.2 and 6.2.
- All information is entered on a computer where records are regularly backed up and archived. Records are kept for at least four years.
- When loads of excluded wastes are identified at the weighbridge, the Weighbridge Operator informs the customer that the waste is not acceptable and the customer is refused entry. The customer is informed of the correct waste disposal procedure or location.
- When loads or partial loads of excluded waste are identified at the waste transfer station, the customer is asked to remove the excluded waste from the site and is informed of the correct waste disposal procedure or location.
- When loads or partial loads of excluded waste are identified at the tipping face, the customer is asked to remove the excluded waste from the site and is informed of the correct waste disposal procedure or location. Where no customer can be identified, Council removes the excluded waste and the waste is transferred to an approved disposal or treatment location.

- Pesticides and chemical drums are not accepted for disposal nor are hazardous, restricted solid, liquid or special waste.

Refer to Appendix F for SOP's for screening waste, including forms and records and procedures for dealing with hazardous and unacceptable waste.

Actions for Compliance

- Tip face waste screening to be undertaken by someone other than the compactor operator.

Performance Indicators

- Quantity of unacceptable waste types rejected.
- Number of detection reports of any waste rejected.
- Number of incidents whereby unacceptable wastes are discovered at the tipping face.
- Monitoring data indicating consistent occurrences of unacceptable waste being detected.

Inspection, Monitoring and Maintenance Schedule

ACTION	FREQUENCY	TIMING
Random vehicle audits	Daily	Random
Screening of Waste	Continuous	Continuous
Screen when truck tipping at tip face or tipping at transfer station.	Continuous. Refer Section 6.2	Continuous. Refer Section 6.2

Responsible Party

- Weighbridge Operator
- Waste Coordinator
- Leading Hand
- Plant Operator at Tipping Face

Reporting

- Receipt of significant amounts of unacceptable waste at the site constitutes an incident. Incident Reporting (refer Section 11.2).
- Monthly Waste Contributions Report (refer Section 11.4).
- Annual Report (refer Section 11.5)
- Maintain register of all events involving the removal of waste that was brought to the site and is not permitted to be accepted at the site.

Corrective Actions

- If unacceptable waste is detected at the weighbridge, direct truck offsite. If it is a repeat offender, exclude from landfill.
- If unacceptable waste is detected at Small Vehicle Transfer Station or tipping face, collect waste and send to appropriate landfill.
- If the annual review process identifies waste screening procedures need to be augmented, the program could be modified. This modification would depend on the types unacceptable waste but will likely include:

  i) Training of staff;

  ii) Increased stringency in the screening procedure; and/or

  iii) Education of waste generators and haulers.

5.3 Waste Measurement and Recording

Requirements

The following Licence Conditions (EPL 5862) relate to the Waste measurement recording at the WGRRP:

L5.2 The licensee must not dispose of any tyres on the premises which;

(a) have a diameter of less than 1.2 metres; and

(b) are delivered at the premises in a load containing more than 5 whole tyres; and

(c) became waste in the Sydney Metropolitan Area.

Note

This condition does not apply where:

(i) The tyres received comply with the EPA Tyre Disposal Specifications; or

(ii) The premises have the capacity, at the time of unloading the tyres, to comply with the EPA Tyre Disposal Specifications; or

(iii) The premises have the capacity, at the time of unloading the tyres, to recycle or reprocess the tyres into a saleable product, including retreading the tyres.

L5.3 Tyres stockpiled on the premises must:

(a) not exceed fifty (50) tonnes of tyres at any one time; and

(b) be located in a clearly defined area away from the tipping face; and

(c) be managed to control vermin; and

(d) be managed to prevent any tyres from catching fire.

M7.1 The licensee must maintain a record of all events involving the removal of any waste that was brought to the facility and which is not permitted to be disposed of at the facility.

O8.1 The licensee must have in place and implement procedures to identify and prevent the disposal of any waste not permitted by this licence to be disposed of at the premises.

Objectives

The objectives of recording the quantities, types and sources of waste received are to enable the effective monitoring of incoming waste and to aid in reporting requirements.

Management Strategy

The weighbridge is a self indicating Mettler Toledo 7560 with a maximum capacity of 60 tonnes and eight load cells mounted in pairs and is located near the site entry off Reddalls Road. The weighbridge consists of identical weighbridges for incoming and outgoing vehicles. The terminal for the weighbridge is an 'IND310drive' terminal. Associated with the weighbridge is the following infrastructure:

- Concrete ramps for vehicle access to the weighbridge;
- Roof to protect the weighbridge and customers from rain;
- Weighbridge office including amenities for staff; and
- CCTV cameras, which relay footage of vehicles at the weighbridge to the operator.

Gross weights are recorded as the vehicle enters and tare weights recorded before departure. The weighbridge is certified annually (certification number 6/10B/46C).

The weighbridge used will have a valid Calibration Certificate in accordance with the requirements of the National Trade Measurement Regulations, 2009 at all times.

The amount, type and source classification of all waste received is recorded by the Weighbridge Operator on computer in accordance with the Weighbridge Operations Manual. The waste codes used based on the nomenclature used for the National Waste Classification System.

A register of the amount, weight and type of tyres stored on site is to be maintained.

Formal volumetric surveys of the filling area are conducted on a six monthly basis for correlation with waste measurements made at the Weighbridge.

Each month, Council provides data to OEH on the amount, type and source of waste in the Monthly Contributions Report. Refer Section 11.4.

Performance Indicators

- The number of occurrences the weighbridge is inoperative.
- Comparison between waste volumes recorded at the Weighbridge and results of regular volumetric surveys.

Responsible Party

- Weighbridge Operator.
- Waste Coordinator.
- Leading Hand.

Inspection, Monitoring and Maintenance Schedule

Table 9: Inspection, Monitoring and Maintenance Schedule

ACTION	FREQUENCY	TIMING
Measurement of waste	continuous	continuous
Site survey	twice per year	June, December
Weighbridge Certification	once per year	December

Reporting

- Monthly Report to OEH. Refer Section 11.4.
- Annual Report. Refer Section 11.5.
- If for any reason, the weighbridge is inoperative, Council will notify OEH, and all vehicles will be recorded and tonnages calculated from OEH truck factors. This procedure is provided in the SOPs Appendix F.

Corrective Actions

- If the weighbridge at the site becomes inoperative or inaccurate, repair and/or calibration is required as soon as practicable.

5.4 Recycling

5.4.1 Requirements

There are no specific conditions relating to recycling in the Licence. The Landfill Guidelines call for a plan to recover and recycle, re-use or reprocess wastes that can be viably recycled.

Objectives

The primary objective of resource recovery and recycling is to prolong the life of the site.

Management Strategy

The WGRRP includes a Small Vehicles Transfer Station where recyclable materials are sorted from waste received as well as a Small Vehicles Recyclables Drop Off area at the toe of the Western Gully landfill.

Once inside the WGRRP, small vehicle customers dropping of recyclable materials are directed to the Small Vehicles Recyclables Drop Off Area at the toe of the Western Gully landfill . Council accepts the following recyclable items at the WGRRP:

- Commingled/mixed recyclables;
- Glass bottles;
- Paper and cardboard;
- Mobile phones;
- Car batteries;
- Scrap metal (white goods, steel, brass, aluminium, copper);
- Gas bottles & fire extinguishers;
- Fluorescent lights and CFL's; and
- Waste oil (eg. sump oil, engine and lubricating oils. Fuel, petrol, diesel, heater oil, thinners or cooking oils are not accepted).

Recyclables dropped off at the Waste Transfer Station in the former SWERF building at the toe of the Eastern Gully Landfill are separated by Council staff and transferred to the recyclables drop off area.

At the recyclables drop off area, separate storage is provided for reusable and recyclable material. Reusable material is removed for re-processing as required. Recyclables are sent offsite to various recycling contractors including the Materials Recovery Facility (MRF) adjacent to the site.

Once inside the WGRRP, customers dropping of green waste are directed to the green waste drop off area in the western part of the site at the foot of the Western Gully Landfill. At the green waste drop off area, the green waste is stockpiled and mulched as required. The processed material is converted into mulch or sent off site for composting as required.

A 'Small Vehicles Recoverables Drop Off' centre is located to the north of the former SWERF building and accepts reusable items that have some resale value. All public traffic is directed past the Small Vehicles Recoverables Drop Off Centre first to assist Council in promoting resource recovery. Signage is posted at the entry to the Small Vehicles Recoverables Drop Off Centre advising customers of what types of materials should be directed to the Small Vehicles Recoverables Drop Off Centre. Second hand goods recovered from the facility are sold at the Small Vehicles Recoverables Drop Off Centre. Vehicle parking is provided for customers of the Small Vehicles Recoverables Drop Off Centre. In addition:

- Direction and advice is provided at the weighbridge by the weighbridge operator.
- Small Vehicles Recoverables Drop Off Centre Attendant provides assistance and advice to customers to increase the opportunity for resource recovery.

To promote customer separation and patronage the Small Vehicles Recoverables Drop Off Centre should always be maintained in a clean, accessible and safe condition. Items should not obstruct access.

In the future:

- Green waste will be relocated offsite in 2012 to a facility in owned and operated by subcontractor Soilco.
- additional facilities for resource recovery and waste treatment may be implemented by Council, which would affect the resource recovery infrastructure on site. The Council Waste Management Strategy (Wollongong City Council 2011) outlines short, medium and long term objectives to increase resource recovery, recycling and composting.

Performance Indicators

- Quantity of material recovered

Responsible Party

- Weighbridge Operator;
- Leading Hand;
- Recyclables Drop Off Area Attendant;
- Small Vehicles Recoverables Drop Off Centre Attendant;
- Transfer Station Attendant.

Inspection, Monitoring and Maintenance Schedule

ACTION	FREQUENCY	TIMING	Responsible Person
Recording quantities of recovered materials	Continuous	Continuous	Recyclables Drop Off Area Attendant; Small Vehicles Recoverables Drop Off Centre Attendant
Assist customers with identifying opportunity for resource recovery	Continuous	Continuous	Recyclables Drop Off Area Attendant; Small Vehicles Recoverables Drop Off Centre Attendant

ACTION	FREQUENCY	TIMING	Responsible Person
Monitor the cleanliness of the Recoverables and Recyclables Drop Off Centre	Continuous	Continuous	Recyclables Drop Off Area Attendant; Recoverables Drop Off Centre Centre Attendant

Reporting

- Included in Section 5.3.

Corrective Actions

- If the quantity of resources recovered falls over time, the recycling strategy and recovery practice will be reviewed.

5.5 Tyre Management

5.5.1 Requirements

The following Licence Conditions (EPL 5862) relate to tyre management at the WGRRP:

L5.2 The licensee must not dispose of any tyres on the premises which;

(a) have a diameter of less than 1.2 metres; and

(b) are delivered at the premises in a load containing more than 5 whole tyres; and

(c) became waste in the Sydney Metropolitan Area.

Note

This condition does not apply where:

(i) The tyres received comply with the EPA Tyre Disposal Specifications; or

(ii) The premises have the capacity, at the time of unloading the tyres, to comply with the EPA Tyre Disposal Specifications; or

(iii) The premises have the capacity, at the time of unloading the tyres, to recycle or reprocess the tyres into a saleable product, including retreading the tyres.

L5.3 Tyres stockpiled on the premises must:

(a) not exceed fifty (50) tonnes of tyres at any one time; and

(b) be located in a clearly defined area away from the tipping face; and

(c) be managed to control vermin; and

(d) be managed to prevent any tyres from catching fire.

Objectives

The objectives of tyre management include minimising landfill space used and prevention of fires and vermin.

Management Strategy

Customers with tyres in their loads are discouraged from disposing of them at the landfill. If tyres are received they are stockpiled at the Small Vehicles Recyclables Drop Off and sent offsite for recycling. Tyres discovered at the tip face or the Waste Transfer Station are separated and also stockpiled at the recyclables drop off area. Bulk loads of tyres are not accepted.

Tyres are transferred off site for recycling on a regular basis in order to not exceed the maximum allowable amount of tyres stored on site (50 tonnes) and to control vermin. Tyres are stockpile in a separate stockpile away from flammable goods.

Performance Indicators

- The number of times tyres not conforming to the requirements of licence condition L5.2 are discovered at the landfill will indicate the effectiveness of tyre management at the WGRRP.
- Tyre fires and infestation of the tyre stockpile with vermin are indications that the tyres have not been managed in accordance with the requirements of licence condition L5.3.

Responsible Party

- Weighbridge Operator.
- Plant Operators.
- Waste Coordinator.
- Leading Hand.

Inspection, Monitoring and Maintenance Schedule

ACTION	FREQUENCY	TIMING
Waste Screening at Tip Face and Waste Transfer Station	Continuous	Continuous

Reporting

- Annual Report. Refer Section 11.5.

Corrective Actions

- If whole tyres are discovered on site they are separated and stockpiled at the Recoverables Drop Off Centre.
- Should whole tyres start being discovered on a regular or increasing frequency, waste screening procedures may need to be reviewed and modified.

5.6 Cleaning of Vehicles

Requirements

The following Licence Conditions (EPL 5862) relate to the cleaning of vehicles at the WGRRP:

O12.1 The licensee must control the tracking of waste and mud by vehicles before departing the waste facility to minimise the tracking of waste and mud from these vehicles once they are outside of the waste facility.

The Environmental Guidelines: Solid Waste Landfills (EPA 1996) specify that:

- *The landfill occupier should provide a wheel-washing or wheel-cleaning facility for use by customers. The occupier is responsible for deciding the appropriate cleaning method, taking into consideration site traffic and local road conditions. Hand-held pressure washing hoses, drive-through immersion bunds and vibration grids are all options which may suit different operations.*

- *The landfill occupier should display signs advising customers that it is the vehicle operator's responsibility to ensure that the remnants of their load or the material stuck to the underside of the vehicle or the wheels does not litter public roads.*

Objectives

The objectives of cleaning vehicles are to:

- Minimise the effects on local amenity; and
- Minimise the effects on quality of stormwater runoff.

Management Strategy

- The tipping face access road is bitumen sealed to within 100 m of the tipping face. This limits the amount of mud and clay that can collect on the wheels and undercarriage of vehicles. The tipping area and access road are maintained free from debris.
- Access roads used by small vehicles are either sealed or covered with gravel.
- A water cart is permanently available at the WGRRP. This cart is used for dust suppression and also washing mud etc. from the sealed roads as required. A high pressure water cleaner is located on site and will be used for cleaning of vehicles if required.
- During wet weather, aggregate is placed on the tipping area to prevent vehicles coming in contact with excessive mud and provide a safe tipping environment.
- A wet weather tipping area covered with gravel and breckets only is used during times of inclement weather to limit the exposure of vehicles to mud.
- Signs 'Cover Your Load' are installed at the site entry and exit.
- A wet weather tipping area is maintained by Council to reduce the dispersion of mud across the site. The wet weather tipping area utilises 'breckets', a gravelly slag product, as cover material to reduce generation of mud.

Actions for Compliance

- Clear signage indicating location and availability of high pressure water cleaner should be installed.

Performance Indicators

- Number of complaints from the community regarding mud and litter on trucks leaving site.
- Mud and litter found on roadways surrounding the site.

Inspection, Monitoring and Maintenance Schedule

ACTION	FREQUENCY	TIMING
Visual check of the site access road	Daily	End of Day
Random audit of trucks leaving site.	Weekly	End of Week

Responsible Party

- Waste Coordinator.
- Leading Hand.

Reporting

- Annual Report. Refer Section 11.5
- A record of any complaints will be maintained. Refer Section 4.3.

Corrective Actions

- Corrective action will be taken based on complaints or observations.
- Trucks found not to be using the wheel wash bay will be directed to use it.

6.0 FILLING OPERATIONS

6.1 Introduction

Operations at the tip face are important for the effective environmental management of the facility for the reasons listed below:

- Land management and conservation is affected through tipping supervision, waste compaction and the plan adopted for filling and final contouring of the site; and
- Water pollution, air pollution and hazards and loss of amenity are affected through covering of wastes.

Tip face operations, including the relevant Benchmark Techniques (EPA 1996), are discussed in the following sections.

6.2 Tipping Supervision

Requirements

There are no specific conditions in the Licence relating to tipping supervision.

The Landfill Guidelines recommend supervision of tipping activity at the tip face when wastes are received at all landfills. It is noted that where facilities receive in excess of 500 tonnes per week (25,000 tonnes per annum) this supervision should be undertaken by someone other than the compactor driver.

Objectives

The objective of tipping supervision is to ensure the accountability of those depositing unacceptable wastes at the site. Supervision at the tipping site is an extension of waste screening at the weighbridge and hence also has the objective of ensuring that only those wastes that Council are licensed to receive are disposed of at the WGRRP.

Management Strategy

- Full time supervision of tipping at the Small Vehicle Transfer Station by the Waste Transfer Station Supervisor.
- SOPs outline tipping supervision requirements at the tip face. Refer SOPs Appendix F.
- The tip face is inspected daily prior to tipping.
- The Compactor Driver undertakes screening at the tip face.

Actions for Compliance

- Currently, the tipping is supervised by the compactor and loader operators. Council should provide a full time supervisor other than the Compactor Driver.
- An SOP should be developed for the Small Vehicle Transfer Station.

Performance Indicators

- The number of incidents whereby unacceptable wastes are discovered at the Small Vehicle Transfer Station and tipping face.

Inspection Monitoring and Maintenance Schedule

ACTION	FREQUENCY	TIMING
Screen when truck tipping at tip face or tipping at transfer station.	Continuous.	Continuous.

Responsible Party

- Plant Operators.
- Waste Transfer Station Operator.

Reporting

- Receipt of significant amounts of unacceptable waste at the site constitutes an incident. Incident Reporting refer Section 11.2.

Corrective Actions

- If unacceptable waste is detected at the Small Vehicle Transfer Station or the tipping face, collect waste and send to appropriate landfill.
- If annual review process identifies waste screening procedures need to be augmented, the program could be modified. This modification would depend on the types unacceptable waste but will likely include:

  Training of staff; and/or

  a. Increased stringency in the screening procedure; and/or

  b. Education of waste generators and haulers.

6.3 Filling Plan/ Contours

6.3.1 Requirements

There are no specific conditions in the Licence relating to a filling plan and the landfill contours.

The EPA (1996) Landfill Guidelines (Benchmark Technique 27) recommend that a filling plan be maintained that identifies areas to be used in the disposal of waste. The filling plan must be regularly updated.

Objectives

The objectives of producing filling plans/contours are to demonstrate that the site operations are being controlled in a planned manner and to estimate the volume of waste land filled.

Management Strategy

Filling is directed in general accordance with the filling plan. The filling plan is saved in the compactor on board GPS system to guide the operator on the filling. Filling is controlled by the conduct of frequent informal surveys by means of on board survey data collected by the waste compactor as well as formal surveys on a six monthly basis. The survey results are reviewed continuously and changes to the filling activities are implemented as required.

The proposed final landform contours for the Whytes Gully New Landfill Cell are illustrated on Figure 11.

As discussed in Section 3.5, the future landfill operation will comprise a number of new stages (Stage 1, Stage 2A, Stage 2B, Stage 3, Stage 4), which will cover current and previous landfill areas in addition to previously unfilled areas. Each stage is subdivided into a number of cells. The staging sequence is shown on Figure 9. Staging Plans are presented in the Landfill Master Plan (Appendix D). An outline of staging timeframes is provided in Section 3.3.

Filling methodology should be undertaken in accordance with the principals of separation of waters as described in section 7.0 and in particular surface water and sediment controls. Management of surface waters during filling should include diversion of clean surface waters away from filling areas and preventing runoff from waste areas entering surface waters through the use of temporary bunds up gradient and down gradient of the filling area as required by the filling area geometry. The area of waste exposed should be

minimised to the extent practicable to limit the potential for generation of leachate contaminated surface waters.

Large commercial vehicles are directed to the active tip face for dumping, while smaller commercial vehicles are directed to an alternative tip face that is compacted at the end of each day using the same filling and compaction methodology.

Performance Indicators

- The results of regular surveys are used to assess the progress in filling the site.

Inspection, Monitoring and Maintenance Schedule

ACTION	FREQUENCY	TIMING
Final filling plans/contours completed six months after each completed cell.	As required	As required
Informal Progress Surveys	As required	As required
Six monthly survey	Six monthly	June, December

Responsible Party

- Operations Administrator.
- Waste Coordinator.

Reporting

- Annual Report (refer Section 11.5).

Corrective Actions

- The Waste Coordinator reviews the ongoing progress of the filling plan and determines the necessary modifications to the filling activities on a daily basis.

6.4 Compaction of Waste

6.4.1 Requirements

There are no specific conditions in the Licence relating to compaction of waste.

The EPA (1996) Landfill Guidelines (Benchmark Technique 24) recommends that maximum compaction must be achieved for the capacity of the machines used. For landfills receiving over 50,000 tonnes of waste per annum, the waste compaction goal is 0.85 tonnes per cubic metre, excluding cover material.

Objectives

The objective of waste compaction is to minimise the amount of landfill space and land used to dispose of waste. Compaction also improves the stability of landfills, and minimises voids that would encourage vermin, fires or excess generation of leachate. A well compacted landfill will also suffer less settlement problems.

Management Strategy

The compactor and front end loader operate continuously at the tip face in accordance with the SOP's presented in Appendix F.

- Waste is placed in layers with a maximum thickness of 0.3 m and in 3 m high runs of waste. Each run has a width of between 15 m and 20 m, depending on the geometry of the filling area, but never more than 2½ times the width of the compactor.
- The front end loader operator acts to push the waste into the compaction area in even layers with a thickness of 300 mm. The front end loader used is a Caterpillar 950H machine with an operating weight of 18.4 t.
- The Compactor Operator acts to spread and compact waste in layers of a maximum thickness of 500 mm. The compactor used is a Caterpillar 836H with an operating weight of 55.6 t.
- The working face is at a grade of less than 1V:5H.
- Waste is compacted by a maximum of five passes of the compactor.
- The compactor operator uses an on board GPS system to assess the level of compaction achieved. The GPS system indicates settlement achieved following each pass by the compactor. Placement of further waste only occurs when the GPS system indicates that a sufficient level of compaction has been achieved.
- The filling plan is saved in the compactor GPS system to guide the operator on the filling.
- The progress of compaction is monitored frequently, as are the filling plan/ contours, using survey data collected from the compactor GOS survey system and recorded waste measurement data.
- The waste density achieved is calculated twice per year based on weighbridge and survey data.

Performance Indicators

- The compaction aim for waste is 1 t/m³ as calculated from the waste mass measured at the weighbridge and the volumetric surveys.

Inspection, Monitoring and Maintenance Schedule

ACTION	FREQUENCY	TIMING
Assess waste compaction with compactor survey system	ongoing	ongoing
Six monthly review of compaction data	Twice per year	June, December

Responsible Party

- Plant Operators.
- Waste Coordinator.
- Leading Hand.

Reporting

- Annual Report (refer Section 11.5).

Corrective Actions

If compaction data falls below performance indicator, operating procedures will be reviewed. This may require spreading and compacting thinner layers or specifying additional passes with the compactor.

6.5 Covering of Waste

Requirements

The following Licence Conditions (EPL 5862) relate to covering of waste at the WGRRP:

O3 Covering of Waste

O3.1 Daily cover must be either:

i. Virgin excavated natural materials ("VENM");

ii. Blast furnace slag or asphalt chipping in accordance the alternative daily cover specifications outlined in the DECC's correspondence dated 15 November 2007;

iii. A steel framed and fabric covered moveable structure; or

iv. A polymer and fibre based cover as outlined in the Wollongong City Council's correspondence to DECC dated 2 October 2007.

O3.2 For the purpose of condition O3.1, daily cover must be applied over all exposed landfilled waste prior to ceasing operations at the end of each day.

O3.3 Daily cover under condition O3.1 (i) and (ii) must be applied at a minimum depth of 150 mm over all exposed landfilled waste.

O4 Polymer & Fibre Alternative Daily Cover – Operational Trial

O4.1 The licensee may conduct an operational trial using polymer and fibre based alternative daily cover for a twelve (12) month period.

O4.2 The twelve (12) month operational trial period shall commence from the first day polymer and fibre based alternative daily cover is utilised at the premises.

O4.3 A polymer and fibre based alternative daily cover trial must conclude no later than 31 December 2008.

O4.4 The licensee must provide a written report to the DECC's Manager Waste Operations within thirty (30) days of the end of any operational trial. The report must include, but is not limited to:

(a) A qualitative assessment of the effectiveness of polymer and fibre based alternative daily cover in meeting the objectives of Benchmark Technique 33 of the DECC's Environmental Guidelines: Solid Waste Landfills (dated 1996); and

(b) A qualitative assessment of the in-field operational effectiveness of using polymer and fibre based alternative daily cover.

General requirements for covering of waste are further outlined in Benchmark Technique 33 of the Solid Waste Landfill Guidelines (EPA 1996) and comprise:

- Daily soil cover of at least 15 cm thickness.
- Intermediate cover of at least 30 cm thickness in areas which will be exposed for more than 90 days using an approach as decided by the design philosophy.
- Maintenance of a stockpile of two weeks of cover material where cover material cannot be won on site.

Objectives

The objectives of cover material are to:

- Limit run-on and reduce infiltration of water;
- Control and minimise the risk of fire;
- Minimise the emission of landfill gas;
- Suppress site odour;
- Reduce pest and vermin; and
- Decrease litter generation.

Management Strategy

Cover material is classified as daily, intermediate or final:

- Landfill Lids and/or daily cover to 150 mm soil – are used as daily cover on exposed areas of waste at the end of the day. Council currently own four landfill lids that cover an area of 70 square meters each.
- A stockpile of intermediate cover material suitable for two weeks is maintained next to the tipping face. This may be supplemented from time to time with cover material sourced on site or imported from off site. Imported cover material can comprise 'breckets', a slag product produced by Bluescope Steel, Port Kembla. 'Breckets' are used as cover during wet weather filling or for access tracks.
- Intermediate Cover - is placed over each completed 3 m high lift, or when there will be waste surfaces exposed for more than 90 days. It is applied to a minimum 0.3 m thickness. Any water runoff from the intermediate cover will be treated as clean water.
- Final Cover - is placed on final surfaces of the landfill. The final capping is designed to reduce rain water infiltration into the landfill. Surface water runoff from the final cap will be treated as clean water. Design of the final capping is discussed in Section 10.2.

Performance Indicators

- Quantity of daily, intermediate and final cover material used.
- Effective sealing of the waste from the environment. Daily cover controls windblown litter, pest species and landfill odours. For this reason, client, visitor or resident identification of windblown litter, vermin and landfill odours in the complaints register forms the performance indicators for adequacy of cover material.
- Surface gas emission monitoring will provide a performance indicator for areas covered with intermediate or final cover.
- Surface water quality monitoring.

Inspection, Monitoring and Maintenance Schedule

ACTION	FREQUENCY	TIMING
Visual inspection of daily cover	Daily	End of Day
Inspection after completion of land filling in each cell	As required	As required
Surface Gas Emissions	Refer Section 8.3.2	Refer Section 8.3.2
Surface water quality monitoring	Refer Section 7.3.3	Refer Section 7.3.3

Responsible Party

- Plant Operator.
- Waste Coordinator.
- Leading Hand.

Reporting

- Annual Report (refer Section 11.5).

Corrective Actions

- If there is evidence of litter or odour nuisance due to insufficient cover being placed on the daily working face, a thicker daily cover should be utilised. If the material being used as cover material is assessed to be inappropriate for use as cover material, an alternative material will be located and used.

7.0 WATER QUALITY MANAGEMENT

7.1 Introduction

The environmental goals for water pollution management are:

- preventing water pollution by leachate and sediments;
- detecting water pollution; and
- remediating water pollution.

7.2 Prevention of Water Pollution by Leachate

The following management techniques used to prevent pollution of water by leachate are:

- leachate barrier system;
- leachate collection system;
- surface water and sediment controls; and
- leachate monitoring program.

7.2.1 Leachate Barrier System

Requirements

The EPA (1996) Landfill Guidelines (Benchmark Technique 1) require that a suitable leachate barrier system be designed in order to contain leachate over the time that the waste poses a potential environmental risk thus reducing the potential for environmental impacts caused by the landfill.

Objectives

The primary objective of the leachate barrier system is to provide a physical barrier to leachate migration during the time that it poses significant environmental risk so that neither groundwater nor surface water are affected.

Management Strategy

Western Gully Landfill

The Western Gully landfill does not have a liner system.

Eastern Gully Landfill

The Eastern Gully landfill was constructed as a lined landfill, with the barrier component of the lining system comprising a high density polyethylene (HDPE) geomembrane liner (2 mm thickness). The HDPE geomembrane liner is underlain by a groundwater drainage layer comprising an approximate 500 mm thick fine gravel layer that is intended to collect any groundwater seepage from natural materials below the liner. This layer incorporates a 100 mm diameter collection pipe that drains by gravity to a pond at the toe of the landfill.

Future Development

The design of the leachate barrier system is presented in the Preliminary Design Report in Appendix G and summarised herein.

Cells 1, 2, 3 and 4 Base Elevation

The cell design includes a separation distance of 2 m between the ground water level and the base of the waste. This based on a groundwater level of 1 m below ground level. This groundwater level will be verified

for detailed design of the cells from analysis of data currently being collected from data loggers installed in the proposed cell footprint area.

Perimeter Bund and Internal Bunds

The cell design includes a perimeter bund. The perimeter bund provides a physical boundary for the limit of placement of waste within the cell and also provides a termination point for both the base liner system and the barrier layer in the capping system.

Internal bunds between sub-cells will be constructed to provide a physical barrier to waste and water movement during sequential excavation, lining, and filling.

Liner

Three distinct types of ground conditions can be identified for future landfilling areas:

4) Non-landfilled areas occupied by infrastructure such as roads, ponds, etc. (South of Existing Landfill Footprint) ie Cells 1 to 4

5) Non-landfilled areas that have remained largely undisturbed (Western Ridge and Central Ridge) ie Cells 2A, 2B and 4A

6) The Eastern Gully and Western Gully landfill (Existing Waste)

The type of liner varies depending on the ground conditions as follows :

New Cell Liner for Cells 1 to 4

The leachate barrier system for the New Cell Floor comprises from bottom to top:

- 200 mm bearing layer (clay rich soil);
- Geosynthetic clay liner;
- 1.5 mm high density polyethylene (HDPE) geomembrane lining layer;
- cushion geotextile; and
- 300 mm drainage aggregate and filter geotextile with periodic pipes.

New Cell Liner for Cells 2A, 2B and 4A

The leachate barrier system for these cells comprises:

- 200 mm bearing layer (clay rich soil);
- GCL;
- 1.5 mm high density polyethylene (HDPE) geomembrane lining layer; and
- leachate collection layer (geocomposite drainage net) with filter geotextile and periodic pipes; and
- 300 mm protection layer.

Piggy Back Liner for Existing Waste

The leachate barrier system for the Piggyback Cells comprises from bottom to top comprises:

- gas drainage trenches with perforated gas collection pipes;
- reinforcement layer consisting of 500 mm of base material and a geogrid;

- 200 mm bearing layer;
- GCL;
- 1.0 mm linear low density polyethylene (LLDPE) geomembrane capping layer with filter geotextile and periodic pipes;
- leachate collection layer (geocomposite drainage net) with geotextile;
- leachate collection layer (geonet); and
- 300 mm protection layer.

Performance Indicators

- The leachate barrier system will be constructed in accordance with the construction specifications refer Preliminary Design Report (Appendix G).
- Results of the ongoing monitoring of groundwater, surface water, leachate and landfill gas.

Inspection, Monitoring and Maintenance Schedule

ACTION	FREQUENCY	TIMING
Regular earthworks monitoring and testing during construction to ensure quality assurance	Refer Preliminary Design Report Appendix G	Refer Preliminary Design Report Appendix G
Groundwater and surface water and leachate monitoring	Refer Section 7.3	Refer Section 7.3
Landfill Gas Monitoring	Refer Section 8.3	Refer Section 8.3

Responsible Person

- Waste Services Manager.
- Operations Administrator.

Reporting

- Annual Report (refer Section 11.5).

Corrective Actions

- Section 5.3 identifies the actions to be undertaken if the monitoring results indicate that conditions have changed and leachate has a potential to cause environmental degradation of the groundwater or surface waters.

7.2.2 Leachate Collection System

Requirements

O7.3 The licensee must maintain a leachate management system to collect and direct all leachate to a point for treatment and disposal to sewer.

Objectives

The primary objective of the leachate collection system is to ensure that leachate in excess of field capacity of the waste is collected and managed in a responsible manner to prevent escape from the landfill into groundwater, surface water or subsoil.

Management Strategy

Western Gully Landfill

Collection of leachate was originally through a central 100 mm diameter perforated pipe located at the base of the landfill. From discussions with Council staff we understand that this pipe did not have filter protection and became non-functional early on during the filling process. These discussions also indicate that an alternate leachate collection system was constructed. Leachate collection horizons were established successively at approximate 5 m vertical intervals within the landfill mass comprising a network of finger drains. At the low point on each horizon, flows in the finger drains enter a shallow 300 mm concrete or HDPE pipe and are conveyed to the base of the landfill batter; a pipe pit was installed at each horizon. At the toe of the landfill batter the shallow 300 mm pipe extends through the landfill bund wall to the current leachate collection pit near the current landfill access road, from where it is transferred to the leachate collection ponds.

Eastern Gully Landfill

The HDPE geomembrane liner in the Eastern Gully is overlain by a blanket leachate drainage layer comprising an approximate 300 mm thick clean sand layer. This layer incorporates two 300 mm diameter leachate collection pipes that drain by gravity to the toe of the landfill – one pipe drains Stage 1 and the other pipe drains Stage 2. Collected leachate is transferred to leachate ponds.

Future Cells

The leachate collection system in all new liner areas comprises a continuous blanket collection layer, either geocomposite drain or aggregate layer, with a network of leachate collection pipes. The collection pipes are positioned to provide an approximate 50 m (maximum) flow distance from point of entry into the blanket to the nearest pipe and to maintain positive drainage after long-term landfill settlement. The system is sized to provide for long-term clogging resistance and for pipe clean out access points.

The base of Cells 1 to 4 are graded to drain to the south, with a leachate collection sump positioned in a southern corner of each cell. Leachate will drain to the leachate collection sump via gravity. Leachate from the piggy back cells and Cells 2A and 2B and 4A would also drain to one of these four sumps. The sumps are essentially depressions that are filled with drainage aggregate. Each sump drains via gravity to a leachate sump riser outside the perimeter bund. Each leachate sump riser is subsequently drained via gravity through a new leachate drainage pipe to a single external leachate pumping pit for pumping to the leachate ponds. For the first stages of the Project, the existing leachate well near the leachate ponds will be the pumping location; while in subsequent stages a new pumping pit will be constructed near the south west corner of the landform. From this point leachate is pumped to the appropriate storage pond.

Performance Indicators

- Results of the ongoing monitoring of groundwater, surface water and leachate.
- Construction of leachate collection system in accordance with construction specification (refer Preliminary Design Report Appendix G).

Inspection Monitoring and Maintenance Schedule

Action Item	Frequency	Timing
Regular monitoring during construction to ensure quality **assurance.**	Refer Appendix G.	Refer Appendix G.
Inspection of leachate pump and pond operation	Weekly and daily during rainfall	End of Week
Preventative maintenance of leachate pumps	Bi-annual with full overhaul every 3 years	End of Week
Inspection of leachate ponds including liner integrity	Quarterly	March, June, September, December
Leachate disposal quantity (recorded from flowmeter)	Monthly	End of month
Inspection of Irrigation Area prior to irrigation	Daily	Work Days
Groundwater and surface water monitoring	Refer Section 7.3	Refer Section 7.3

Responsible Person

- Waste Services Manager.
- Operations Administrator.

Reporting

- Annual Report (refer Section 11.5).

Corrective Actions

- If the leachate collection system is found to be not performing, it may need to be flushed or repaired.
- Section 7.4 identifies the actions to be undertaken if the monitoring results indicate that conditions have changed and leachate has a potential to cause environmental degradation of the groundwater or surface waters.

7.2.3 Surface Water and Sediment Controls

Requirements

L1.2 There must be no discharge of contaminated stormwater to waters under dry weather conditions or storm event(s) of less than 1:10 year 24 hour recurrence interval, that is 297.4mm of rainfall within a 24 hour time period.

***"dry weather"** means less than ten millimetres of rain falling within a 24 hour period.*

Discharges of contaminated stormwater from the ponds following a 1:10 year 24 hour storm event (297.4mm of rainfall within a 24 hour time period) or greater do not constitute a breach of this licence.

L1.3 There must be no discharge of leachate to waters under dry weather conditions or storm event(s) of less than 1:25 year 24 hour recurrence interval, that is 371.5mm of rainfall within a 24 hour time period.

***"dry weather"** means less than ten millimetres of rain falling within a 24 hour period.*

Discharges of leachate from the leachate pond following a 1:25year 24 hour storm event (371.5mm of rainfall within a 24 hour time period) or greater do not constitute a breach of this licence.

O7.1 Drainage from areas not subject to waste disposal activities must be directed away from the existing leachate collection pond(s).

O7.2 Disturbed areas must be provided with separate water quality controls for the treatment of runoff containing suspended or turbid pollutants.

The DECC has outlined guidelines for surface water, erosion and sediment control at waste landfills in DECC (2008).

Objectives

The objectives of surface water controls are to:

- prevent unacceptable sediment loads in receiving waters;
- prevent any surface water mixing with waste;
- prevent erosion of cover material and/or waste; and
- avoid generation of excessive leachate.

Management Strategy

The following terminology is adopted for surface water categories;

- "clean" stormwater: Runoff from areas of the site where soil and vegetation have not been disturbed or vegetation has been established is considered to be 'clean'.
- "dirty" stormwater: Runoff from areas of the site where soils have been disturbed and are likely to generate sediment are considered to be "dirty", including areas of intermediate cover or areas of final capping that have not yet been vegetated; and
- "leachate": comprises runoff from areas of waste or daily cover material as well as leachate generated by the landfill.

Existing

Control and Management of "Clean" Stormwater

Runon into the site is minimal due to the site being bounded by ridgelines.

Runoff from the Western Ridge is diverted offsite via a culvert under Reddalls Road to Dapto Creek.

Runoff entering the Western Gully Landfill from the Western Ridge area combines with the "dirty" stormwater system.

Runoff from the woodland to east of the Eastern Gully Landfill area either combines with the "dirty" stormwater system or is diverted around the Eastern Gully Landfill in a diversion drain, which subsequently discharges into the "dirty" stormwater system.

Runoff from the vegetated ridge to the north of the Western Gully Landfill currently discharges through the depression between the Eastern and the Western Gully Landfill and combines with the "dirty" stormwater flow.

Control and Management of "Dirty" Stormwater

Surface water runoff from the Western Gully and Eastern Gully landfills is captured by swale drains on the landfill surface. The swale drains divert the runoff towards drains around the perimeter of the landfills and a

central drain located between the Eastern Gully and Western Gully landfills. Runoff from the natural slope above the northern edge of the Eastern Gully landfill is also directed to the central drain. Runoff from the western ridge is directed offsite and discharges to Dapto Creek via a culvert under Reddalls Road.

All surface water flows are directed into the surface water treatment system, which comprises a series of surface water ponds approved in 2003. The system is located in the south west corner of the site and comprises two reed beds (Reed Beds 1 and 2) and an upper and lower surface water polishing pond. The total capacity of the surface water treatment system is 40,000 cu.m. The design of the ponds is detailed in design drawings within Forbes Rigby 2003 and provided in Appendix C). Discharge from the ponds is to Dapto Creek.

Control and Management of Leachate Water

Surface water which falls within an active cell, whether it be covered with daily cover or exposed waste, is considered leachate and is directed to the leachate management system from where it is diverted to the leachate treatment plant.

Leachate is collected from the Eastern Gully and Western Gully landfills at collection points at each landfill toe. The collected leachate is piped to the leachate ponds (Primary and Secondary Leachate Pond). The leachate ponds are 18,000 cum capacity plus 300 mm freeboard. Leachate is pumped from the ponds to the on site leachate treatment plant. The leachate treatment plant is a sequencing batch reactor technology.

The leachate ponds and leachate treatment plant are monitored daily. Discharge from the leachate treatment plant is monitored in general accordance with the Trade Waste Agreement.

Future works

The surface water management controls would be progressively developed as the landfilling areas are developed. A drainage philosophy has been designed based on the construction staging of the landfill cells and offsite discharge constraints. As increasing areas of the landfill are covered and revegetated with time, clean runoff from the landfill surface as well as clean run-on will be separated from dirty stormwater and discharged off site without treatment directly to Dapto Creek. Dirty surface water will be directed to the surface water ponds. The existing surface water ponds (2 reed beds and polishing ponds) will be used up to the completion of Stage 3 of the new landfill cell. Between Stage 3 and 4 the volume of the existing surface water ponds can be reduced to the footprint of just the polishing pond due to the 60% catchment reduction and used as the new surface water pond. This will allow for the relocation of the leachate ponds to the footprint of the 2 existing reed beds. The leachate ponds will be relocated prior to construction of Stage 4. The reduced surface water pond will remain in place for the Stage 4 works. A plan outlining surface water management during the development of the site is shown in drawing D051 in the design drawings refer Appendix E). The following summarises the staged approach.

Stage 1 and Stage 2A:

The drainage philosophy up to the completion of Stage 2A is to discharge the whole 50 ha catchment to the existing sediment pond. Forbes Rigby Pty Ltd (2002), “Whytes Gully Landfill Leachate Management Study” and RIENCO Consulting (2008), “Whytes Gully Landfill Surface Water and Leachate Management Plan 2008” reports suggest and Golder have verified that there is sufficient capacity in the existing surface water management system for the whole 50 ha catchment.

A minor existing discharge offsite from the western ridge would be maintained.

Stage 2B:

After completion of Stage 2B the Eastern Gully would become fully capped and therefore surface runoff would become ‘clean’ runoff. During Stage 2B a new ‘clean’ drain can be constructed to bypass the sediment pond and discharge directly to the Dapto creek outfall. This drain would be constructed between the existing leachate treatment plant and the surface water ponds. On completion of stage 2B, approximately 24 ha will discharge directly to Dapto Creek and 26 ha to the existing sediment pond.

Stage 3:

On completion of Stage 3, approximately 30 ha will be discharged directly to Dapto Creek and 20 ha to the existing sediment pond. Due to the extent of the Stage 4 works the existing leachate ponds will require relocating towards the end of Stage 3. At this stage it is proposed that the leachate pond is relocated to the footprint of the two reed bed ponds and downsize the existing surface water pond. The downsizing of the surface water pond at this stage is possible due to approximately 60 percent of the original 50 ha catchment now discharging directly to the Dapto Creek outfall.

Stage 4:

The downsized surface water pond is designed for a 20 ha catchment. The clean 30 ha catchment would discharge unrestricted to the Dapto Creek outfall. The surface water pond would be made up of sediment pond and onsite surface water detention pond. The outflow from the pond to the Dapto Creek outfall would be restricted to meet discharge constraints and the resultant attenuated runoff detained within the surface water pond.

Cap Drainage and Perimeter Drain

Benching and drop structures would be implemented and constructed into the formation of the landfill cells to reduce the runoff velocities and prevent scouring and sediment migration on the landfill cap. The design of the landform will include positive grades in all areas, batters (4H:1V), cell top (5 percent), and bench (3 to 5 percent cross fall), to collect and convey runoff generated from rainfall on the cell.

The cell design includes a perimeter drainage swale, which serves to collect and convey runoff water from cap drainage.

Erosion Control

Erosion control works are required for all works where the possibility for soil erosion exists and are used to control and minimise erosion and sedimentation. Erosion control measures employed at the site incorporate the following:

- reducing the area of exposed soil including recently constructed sections of the landfill;
- diverting clean run on away from disturbed areas;
- reducing the length and steepness of slopes;
- rehabilitating capped areas in the timely manner;
- applying sediment control measures to intercept and retain sediment on site (eg drains around perimeter and sedimentation ponds); and
- an inspection maintenance and cleaning program for control structures to maintain capacity and integrity;
- wheel wash facilities would be at site egress points, to prevent the tracking of mud or loose sediment off site; and
- using designated access roads and paths where possible.

7.2.4 Control and Management of Leachate

Leachate is deemed to include all water that has come into contact with waste. A range of appropriate measures would be implemented to minimise, contain, collect and dispose of leachate generated during landfilling at the site. All practicable measures would be undertaken to minimise the volume of leachate generated at the site, including:

- Diverting upstream, clean stormwater runoff around the landfilling operation, where able;

- Staging the landfilling operation, to minimise the active footprint of the landfill;
- Minimising exposed areas at the active landfilling area by regular covering of the landfilled waste;
- Grading filled areas to direct surface water runoff away from the active waste landfilling area;
- Applying intermediate cover on all areas of the landfill that are left inactive for periods greater than 90 days; and
- Progressive capping and rehabilitation of landfilled areas.

Existing

Leachate is collected in leachate collection systems in the Eastern and Western Gully landfills. The leachate is piped to the leachate ponds The leachate treatment system at the site currently incorporates aeration and biological treatment with the Primary and Secondary Leachate Ponds and subsequent treatment in the leachate treatment plant using sequencing batch reactor technology. Leachate is discharged to sewer in accordance with the site trade waste agreement as described in Section 7.5. The leachate treatment plant as well as the leachate ponds are inspected and monitored on a daily basis.

Future

It is proposed to retain the existing leachate treatment system in place until the end of the first year of Stage 1 (end of 2014) of the Project.

During the first year of the Project it is proposed there would be significant works undertaken at the Whytes Gully RRP site including operational changes that are expected to significantly impact and reduce the leachate generation rates. These include capping and reprofiling the existing Eastern Gully landfill batter (considered to be a significant source of infiltration and stormwater contribution to the leachate collected at the site) in addition to capping of the current landfilling area and commencement of the Piggy Back Liner in Stage 1.

Additionally, Sydney Water may in this time develop firm upgrade plans for the sewer along Reddalls Road and consider an increased discharge limit to sewer for the Project site.

Wollongong City Council would log and review the resultant leachate generation volumes and rainfall amounts during 2014 and reassess the water balance model assumptions for infiltration rates and continue to liaise with Sydney Water on timing for sewer capacity upgrade and quantify and assess the need to upgrade the leachate treatment plant.

The following contingency actions for leachate storage and/or treatment are considered feasible, and could be implemented in a short period of time at the Project site if necessary:

- Discharge to sewer directly from the leachate storage ponds during periods of low ammonia concentrations to increase leachate storage capacity (this approach is known to be acceptable to Sydney Water and has been implemented successfully in the past year).
- Leachate reinjection over short-term into new waste proposed for the new cell through surface application across the daily cover area (10 000 m^2);
- Trucking of leachate to sewage treatment plant for disposal;
- ‘Package’ plants: proprietary package treatment plants are available that can be mobilised to the Whytes Gully RRP site should increased leachate treatment capabilities be temporarily required;
- Until the end of Stage 1 store excess leachate in the former surface water pond at the toe of the Western Gully, or construct a new leachate overflow storage pond in the Cell 2 or Cell 3 area;

- Upgrade the existing leachate treatment plant to increase volume throughput and/or efficiency of treatment process/new technologies; and
- Construct a cover over the existing leachate ponds to reduce the effects of direct rainfall.

Actions for Compliance

- Separate “clean” and “dirty” stormwater collection systems and discharge “clean” stormwater off site.
- Vegetate all drains
- Separate “dirty” stormwater and leachate water flows
- Repair bare areas or areas showing surface erosion.

7.2.5 Performance Indicators

- Quantity of sediment in sediment control structures;
- Level of maintenance to sediment control measures;
- Visual inspection of the control systems; and
- Results of the ongoing monitoring of surface water.

7.2.6 Responsible Party

- Operations Administrator.
- Waste Coordinator.

7.2.7 Inspection, Monitoring and Maintenance Schedule

ACTION	FREQUENCY	TIMING
Inspection of surface water reed beds and surface water polishing ponds	Quarterly and after rainfall events	March, June, September, December
Inspection of storm water diversion drains	Quarterly and after rainfall events	March, June, September, December
Surface water monitoring	Refer Section 7.3	Refer Section 7.3
Inspection of integrity of leachate ponds	Quarterly	March, June, September, December
Groundwater monitoring around leachate ponds	Refer Section 7.3	Refer Section 7.3
Monitor leachate pond levels and LTP operation	Daily	Daily
Sampling Discharge from LTP	Refer Section 7.5	Refer Section 7.5
Maintenance of Leachate Management System	Monthly	End of Month

7.2.8 Reporting

- Annual Report (refer Section 11.5).

7.2.9 Corrective Actions

- Maintain and repair sediment control structures when required (clean out sediment when surface water ponds reach capacity, clean out table drains etc to maintain capacity).
- Repair of bare areas or areas showing surface erosion.

7.3 Detecting Water Pollution

The following management techniques will be applied for early detection of surface water and groundwater pollution:

- Groundwater Monitoring Network.
- Groundwater Monitoring Program.
- Groundwater Assessment Program.
- Surface Water Monitoring Program.-

7.3.1 Groundwater Monitoring Network

Requirements

The EPL specifies monitoring of surface water and ground water monitoring points 1 and 2 for the analytes and at the sampling frequencies outlined below. However, Council currently conducts additional groundwater monitoring at monitoring locations BH4, BH4A BH5, BH5A, BH6 and BH6A. The EPL further specifies that *'the licensee must make available to the EPA the results of monthly Trade Waste Monitoring of leachate and include these results in the Annual Report.'*

Benchmark Technique 4 for groundwater monitoring network in the EPA (1996) Landfill Guidelines provides technical guidance regarding the construction of groundwater monitoring wells. The groundwater monitoring network must allow for the collection of representative samples of groundwater. It is therefore important that wells comprising the monitoring network are:

- strategically located to maximise the opportunity for intercepting any discharge from the landfill; and
- constructed appropriately to ensure sample representativeness.

Objectives

A groundwater monitoring network is necessary to demonstrate that there is limited potential for migration of hazardous constituents from a solid waste landfill to the surrounding groundwater, during the active life of the landfill and the post-closure care period. The wells employed for a groundwater network should be strategically located, to maximise the opportunity for intercepting groundwater flow onto the site as well as any discharge from the landfill site.

Management Strategy

In addition to the monitoring undertaken at monitoring locations BH4, BH4A BH5, BH5A, BH6 and BH6A , 17 additional wells recently (2011) installed are being monitored on a quarterly frequency. Refer Figure 12 for groundwater monitoring locations.

Well installation locations were selected to provide long term monitoring locations that are unlikely to require relocation or decommissioning during construction of the new landfill cells (based on the current proposed development footprint). A summary of the wells is provided in Table 10 below.

Table 10: Well installation locations and rationale

Well ID	Location	Unit screened	Rationale
GMW101	North of western gully landfill	Shallow rock	Upgradient data coverage
GMW103	Northeast of active cell (eastern gully landfill)	Shallow rock	Upgradient coverage - boundary
GMW104	West of western gully landfill	Shallow rock	Cross-gradient coverage - boundary
GMW105	East of active cell (eastern gully landfill), eastern ridge	Shallow rock	Cross-gradient coverage
GMW106	Southeast of eastern gully landfill	Shallow rock	Cross/downgradient coverage
GMW108S	South of future cells (east of weigh station)	Alluvials	Downgradient coverage
GMW108D	South of future cells (east of weigh station)	Shallow rock	Downgradient coverage
GMW109S	Southwest corner of property	Alluvials	Downgradient coverage - boundary
GMW109D	Southwest corner of property	Shallow rock	Downgradient coverage - boundary
GMW110	West of proposed leachate pond	Shallow rock	Downgradient coverage - boundary
GMW111	West of proposed new cells	Shallow rock	Downgradient coverage - boundary
GABH01	Within proposed cell footprint	Shallow rock	New cell footprint coverage
GABH02	Within proposed cell footprint	Shallow rock	New cell footprint coverage
GABH03	Within proposed cell footprint	Shallow rock	New cell footprint coverage
GABH06S	Within proposed cell footprint	Alluvials	New cell footprint coverage
GABH06D	Within proposed cell footprint	Shallow rock	New cell footprint coverage

At each location, one well was installed into shallow weathered rock to provide site-wide coverage of this shallow groundwater system. In addition, three locations (GMW108, GMW109 and GABH06) were completed as paired wells with an additional shallow well completed in the alluvial/ colluvial soil profile overlying the shallow rock.

Based on initial rounds of monitoring completed in 2011, a groundwater contour map for the site has been created and is shown in Figure 16.

Borelogs and Monitoring Well Construction Logs are presented in Appendix H.

7.3.2 Groundwater Monitoring Program

Requirements

Benchmark Technique 5 for groundwater monitoring program in the EPA (1996) Landfill Guidelines provide recommended groundwater indicator parameters and respective detection limits. Sampling on a quarterly basis is recommended and detailed sampling and Quality Assurance/ Quality Control methodologies are also provided in the Landfill Guidelines.

Objectives

The objective of the groundwater monitoring program is to effectively monitor and report groundwater character, and ensure early detection and reporting of possible pollution of groundwater.

Management Strategy

The following monitoring program is being undertaken in order to provide a robust baseline dataset of groundwater quality. This monitoring program should be reviewed following completion of the first two rounds and again after the completion of an annual quarterly monitoring cycle to optimise the program based on the observations from the baseline data set (i.e. reduce the frequency and analytical suite to focus on groundwater quality indicators identified as being of relevance to the site).

The following suites of analytes are considered for the proposed monitoring regime:

- General water quality parameters:
  - Field water quality suite (temperature, pH, EC, ORP and DO);
  - Cations and anions (calcium, magnesium, sodium, potassium, chloride, sulphate, fluoride, speciated alkalinity);
- Leachate indicator suite:
  - Nitrate, nitrite, ammonia, total Kjeldahl nitrogen (TKN);
  - Biochemical oxygen demand (BOD);
  - Total organic carbon (TOC);
- Metals and metalloids (aluminium, arsenic, cadmium, chromium, copper, iron, manganese, mercury, nickel, lead and zinc);
- Organic suite - limited (for quarterly monitoring):
  - TPH;
  - Benzene, toluene, ethylbenzene and xylenes (BTEX) + naphthalene;
- Organic suite - extended (for annual monitoring):
  - TPH;
  - VOCs (includes BTEX); and
  - SVOCs (includes PAHs, pesticides, speciated phenols and PCBs).

A proposed monitoring frequency is provided in Table 11. It is noted that the proposed program is in addition to current monitoring undertaken in conjunction with the EPL conditions. Observations to date indicate that some of the organic analytical suites are unlikely to be relevant for ongoing monitoring once the baseline dataset has been established, and would be culled with regard to future monitoring.

In addition, the nominated wells may be modified if new wells are installed, or if a revision to the number of monitoring locations can be rationalised following review of the monitoring results.

Table 11: Proposed Groundwater Monitoring Program for Baseline Water Quality Assessment

Well No.	General Water Quality Suite	Leachate Indicator Suite	Metals and metalloids	Organic Suite - limited	Organic Suite - extended	Rationale for Location
GMW101	Quarterly	Quarterly	Annually	Quarterly	Annually	Upgradient data coverage
GMW103	Quarterly	Quarterly	Annually	Quarterly	Annually	Upgradient coverage - boundary
GMW104	Quarterly	Quarterly	Annually	Quarterly	Annually	Cross-gradient coverage - boundary
GMW105	Quarterly	Quarterly	Annually	Quarterly	Annually	Cross-gradient coverage
GMW106	Quarterly	Quarterly	Annually	Quarterly	Annually	Cross/downgradient coverage
GMW108S	Quarterly	Quarterly	Annually	Quarterly	Annually	Downgradient coverage
GMW108D	Quarterly	Quarterly	Annually	Quarterly	Annually	Downgradient coverage
GMW109S	Quarterly	Quarterly	Annually	Quarterly	Annually	Downgradient coverage - boundary
GMW109D	Quarterly	Quarterly	Annually	Quarterly	Annually	Downgradient coverage - boundary
GMW110	Quarterly	Quarterly	Annually	Quarterly	Annually	Downgradient coverage - boundary
GMW111	Quarterly	Quarterly	Annually	Quarterly	Annually	Downgradient coverage - boundary
GABH01	Quarterly	Quarterly	Annually	Quarterly	Annually	New cell footprint coverage
GABH02	Quarterly	Quarterly	Annually	Quarterly	Annually	New cell footprint coverage
GABH03	Quarterly	Quarterly	Annually	Quarterly	Annually	New cell footprint coverage
GABH06S	Quarterly	Quarterly	Annually	Quarterly	Annually	New cell footprint coverage
GABH06D	Quarterly	Quarterly	Annually	Quarterly	Annually	New cell footprint coverage
BH6^	Quarterly	Quarterly	Annually	Quarterly	Annually	Downgradient coverage - boundary

Note: ^The 2009/10 Annual Monitoring Report describes BH6 as being installed by WCC. BH6 lithology is assumed to be that of BH3 "New Entry Gate" WCC reference W9872, installed by WCC in March 2009. The location and measured depth of BH6 (from 2009/10 Annual Monitoring Report, GHD 2010) are consistent with the bore report and location for BH3.

7.3.3 Surface Water Monitoring Program

Requirements

The EPL specifies monitoring of surface water monitoring point 1 annually and during overflow.

Benchmark Technique 7 for surface water monitoring program in the EPA (1996) Landfill Guidelines require establishment of surveyed monitoring points, to be sampled on a quarterly basis for the recommended groundwater indicator parameters.

Objectives

The objective of the surface water monitoring program is to effectively monitor and report surface water character, and ensure early detection and reporting of possible pollution of surface water.

Management Strategy

Six surface water monitoring locations are currently being monitored quarterly to provide a baseline data set for the site for the analytes outlined below. Refer Figure 13 for monitoring locations. As with the groundwater monitoring program these locations and analytes may be rationalised following receipt of results of the first two rounds of results or after completion of 1 annual cycle of monitoring.

- Field suite (temperature, pH, electrical conductivity, dissolved oxygen, oxidation reduction potential);

- General water quality (TDS, TSS);
- Cations and anions (calcium, magnesium, sodium, potassium, chloride, sulphate, fluoride, alkalinity);
- Total Metals and metalloids (aluminium, arsenic, cadmium, chromium, copper, iron, manganese, mercury, nickel, lead and zinc) (unfiltered samples);
- Nitrate, ammonia, total Kjeldahl nitrogen (TKN);
- Total petroleum hydrocarbons (TPH);
- Volatile organic compounds (VOCs);
- Polycyclic aromatic hydrocarbons (PAHs);
- Total phenolics;
- Biochemical oxygen demand (BOD); and
- Total organic carbon (TOC).

7.3.4 Leachate Monitoring Program

Requirements

The EPL specifies monitoring of leachate monitoring point 2 for the analytes monthly

The EPL further specifies that *'the licensee must make available to the EPA the results of monthly Trade Waste Monitoring of leachate and include these results in the Annual Report.'*

Benchmark Technique 8 for leachate monitoring program in the EPA (1996) Landfill Guidelines require initial characterisation testing of leachate with additional quarterly or batch testing of a representative samples.

Objectives

The objective of the leachate monitoring program is to chemically characterise the leachate to allow assessment of the potential environmental harm and impacts.

Management Strategy

The leachate monitoring currently comprises monitoring of flow volume at monitoring point 2 and regular chemical analysis for leachate treatment plant operation and analysis of treated leachate in accordance with the site trade waste agreement as outlined in Section 7.5.

One monitoring location is currently being monitored quarterly to provide a baseline data set for the site for the analytes outlined in Section 7.3.2. Refer Figure 4 for monitoring location. As with the groundwater monitoring program these locations and analytes may be rationalised following receipt of results of the first two rounds of results or after completion of 1 annual cycle of monitoring.

7.3.5 Groundwater Assessment Program

Requirements

The Landfill Guidelines Benchmark Technique Number 6 requires a groundwater assessment program if groundwater monitoring detects a possible failure of the leachate containment system.

Objectives

The objective of the groundwater assessment program is to set procedures in place if the Groundwater Monitoring Program detects a possible failure of the leachate containment system.

Management Strategy, Tasks and Actions

Groundwater will be monitored and background concentrations will be established for all analytes. If a significant change in concentration for any of the indicator parameters is detected over two consecutive monitoring periods, then the affected groundwater monitoring bores will be resampled as soon as possible. Statistical comparisons of key indicator parameters may be required to identify statistically significant evidence of contamination between key indicator parameters.

If the anomaly is verified by resampling, the OEH will be notified by telephone and in writing within 14 days of verification of the increase in the groundwater indicator contaminants (refer Section11.2).

Within 28 days of the notification, Council will prepare a Groundwater Assessment Plan for submission to OEH.

The Groundwater Assessment Plan will include:

- Identification of the specific contaminants and extent of the pollution to the groundwater;
- An assessment of whether further monitoring or investigation is required;
- A list of proposed analytes (including justification); and
- A monitoring program for sampling the wells and/ or installing further wells.

Any information obtained during this assessment will be used to prepare the Water Contamination Remediation Plan (refer Section 5.3).

7.3.6 Performance Indicators

- Groundwater, surface water and leachate monitoring analytical results.
- ANZECC Water Quality Guidelines 2000 values for protection of 95% of species in a marine environment and background surface water quality.

7.3.7 Inspection Monitoring and Maintenance Schedule

Action	Frequency	Timing
Groundwater Assessment Program	When significant increases in indicator concentrations in groundwater occur	As required
Surface water monitoring	Annually and during overflow	March, June, September, December
Groundwater Monitoring	Quarterly	March, June, September, December
Leachate Monitoring	Monthly and during overflow	March, June, September, December

7.3.8 Responsible Party

- Operations Administrator.

7.3.9 Reporting

- Annual Report (refer Section 11.5).

7.3.10 Corrective Actions

- Development of a Water Contamination Remediation Plan (refer Section 7.4).

7.4 Water Contamination Remediation Plan

Requirements

There are no specific conditions relating to the Water Contamination Remediation Plan in the Licence.

The Landfill Guidelines Benchmark Technique 9 calls for development and implementation of a groundwater contamination remediation plan if contamination to groundwater is confirmed by the groundwater assessment program.

Objectives

The objective of the Water Contamination Remediation Plan is to describe the process to protect the water from further contamination and nominate a means to return the water to the original quality down hydraulic gradient of the landfill.

Management Strategy

Water Contamination Remediation Plans are developed on an individual basis dependent on the nature and degree of contamination detected. Rather than include a plan for any groundwater or surface water contingency, it is more important to define the concept and highlight responsibilities and likely actions. The specific plan can then be developed to suit the event.

Groundwater Contingency Plans

The need to develop a Groundwater Contingency Plan will flow from the Groundwater Assessment Program (Section 7.3.5). The assessment program will define the nature and general extent of contamination.

A remediation plan will utilise the information obtained in the assessment program. There will need to be a formal determination if sufficient information was obtained in that assessment. Should a groundwater specialist determine that there are data gaps, it will be necessary to fill these before developing the plan.

Data gaps for groundwater contamination may include insufficient mapping of the extent of contamination. In order to improve this situation it may be necessary to drill a larger number of monitoring locations in the zone that contamination was discovered.

There are three general options for controlling groundwater contamination in an aquifer. These options include:

- installation of groundwater extraction wells;
- installation of interception trenches; and
- use of bentonite slurry to encapsulate and contain the contaminants.

Groundwater extraction wells and interception trenches would be the primary means for controlling the movement of contaminants in most plausible incidents at the site.

The contaminants would need to be treated at the surface following extraction prior to discharge. The treatment system would be dependent on the nature of contamination and allowable discharge limits. It may be necessary for Council to engage specialist engineers to design and test a treatment plant to control the contamination.

Surface Water Contingency Plan

Surface water monitoring or visual observations may indicate the need to control surface water discharges to the environment. If monitoring results indicate that the limit concentrations have been breached, it will be necessary to establish the cause for that violation.

Determining the source will require the development of a plan. This plan may require sampling and testing from the point of the violation and moving upstream until a source can be located. Once the source has been

identified, Council will be able to isolate the source and develop plans to control the discharge. The discharge may be contained by mechanical means or by restricting the flow off-site.

Once the action has been taken to contain the pollution, Council will prepare a report for OEH detailing the nature and source of contamination and the actions put in place to prevent recurrence.

Performance Indicators

Performance indicators for contingency plans would be the amount of time following determination that successful control actions are established. The time will be a function of the severity of the incident and the nature of the controls. Successful control can be assessed from the results of ongoing monitoring.

Responsible Party

- Operations Administrator

Reporting

Specific contingency plans and reporting activities are not required until uncontrolled release of pollutants have been identified. Reporting will be necessary to demonstrate to OEH that the situation is under control.

7.5 Trade Waste Agreement

Requirements

The trade waste agreement (TWA) number 11205 specifies substances and daily masses as well as maximum daily volumes that Council is allowed to discharge to sewer, in particular discharges from the leachate treatment plant at the WGRRP. The TWA also specifies sampling and reporting requirements.

Objectives

The objective of the TWA is to ensure that Council discharges leachate from the WGRRP within the daily masses and volumes allowed by Sydney Water.

Management Strategy, Tasks and Actions

The main management tasks and actions comprise sampling and reporting in accordance with the TWA. For detailed requirements, the current TWA should be referred to. The requirements of Sydney Water's published analytical methods shall be followed for all sampling and analysis. Some of the key management tasks and action items relating to the TWA are summarised in the sections below. Refer Appendix A for TWA.

Performance Indicators

- Number of events where a sample has not been collected;
- Number of events where the specified concentrations or load limits have been exceeded;
- Number of events where the reporting requirements of the TWA were not complied with; and
- The charges for trade wastewater discharge paid by Council to Sydney Water.

Responsible Party

- Waste Services Manager;
- Operations Administrator.

Inspection, Monitoring and Maintenance Schedule

- Sampling will occur at a point specified by Sydney Water;
- Sampling will occur over a full production day by combining equal volumes taken at 30 minute intervals;

- Sampling will occur on 7 May 2010 and every eight days thereafter;
- Discrete samples will be collected at the start and finish of each sample day and shall be analysed for pH;
- Composite samples will be analysed for:
  - Ammonia as N;
  - Biochemical Oxygen Demand;
  - Suspended solids;
  - Total dissolved solids;
- The flow meter shall be accessible to Sydney Water for inspection.

Reporting

- Results of analytical testing must be submitted to Sydney Water within 21 days of sampling;
- The results of the trade waste sampling shall be summarised in the annual report;
- Sydney Water must be notified in writing within seven days of:
  - any failure to obtain samples;
  - any loss of analytical data; and
  - any failure in the discharge flow meter.

Corrective Actions

- If sampling and reporting requirements are not met on a regular basis, reasons for this failure will be investigated and a more revised sampling procedure will be implemented; and
- If concentrations and load limits are not achieved on a regular basis, the performance of the leachate treatment plant will be investigated.

8.0 AIR QUALITY MANAGEMENT

8.1 Introduction

The environmental goals for air quality management are:

- preventing landfill gas emissions;
- detecting landfill gas emissions; and
- remediating landfill gas emissions.

8.2 Preventing Air Pollution

The management techniques used to control landfill gas emissions are:

- landfill gas containment system;
- extraction and disposal of landfill gas;
- fire prevention;
- controlled burning of waste; and
- site closure.

8.2.1 Landfill Gas Containment System

Requirements

There are no specific conditions relating to landfill gas containment in the Licence. The Landfill Guidelines recommend that landfill gas should be contained by a combination of the leachate barrier system, site capping and revegetation and covering of waste.

Objectives

The objective of the landfill gas containment system is to minimise emissions of landfill gas through the surface of the landfill in order to minimise greenhouse gas emissions, odours and emissions of airborne impurities, pathogens and toxins that may pose a health risk to the community.

Management Strategy

The site adopts a strategy for day to day management of landfill gas emissions via a combination of the leachate barrier system and covering of wastes, discussed in Sections 7.2.1 and 6.5 respectively. In the long term, landfill gas containment is achieved by site capping and revegetation. Site capping and revegetation is discussed in Section 10.2.

Performance Indicators

- Results of Landfill Gas Monitoring (refer Section 8.3)
- Identification of Odours.

Inspection Monitoring and Maintenance Schedule

Action Item	Frequency	Timing
Odour observations	**Continuous**	**Continuous**
Landfill Gas Monitoring	Refer Section 8.3	Refer Section 8.3

Responsible Person

- Waste Services Manager

Reporting

- Complaint Reporting (Section 4.3)

Corrective actions

- Section 8.4 identifies the actions to be undertaken if the monitoring results indicate the presence of landfill gas.

8.2.2 Landfill Gas Extraction/ Disposal

Requirements

There are no specific conditions relating to landfill gas extraction/ disposal in the Licence. The Landfill Guidelines recommend installation of an appropriate landfill gas extraction and disposal system should perimeter wells or on-site structures show methane at concentrations above 1.25 percent (v/v) (25% of the LEL) (Benchmark Technique Number 11).

Objectives

The objectives of extraction and disposal of landfill gas are to:

- reduce the risk of explosion and fire;
- reduce the contribution to greenhouse gases; and
- lower the level of toxic organic compounds emitted from the landfill.

Management Strategy

Current

There is currently no landfill gas extraction at the site. Although historically landfill gas extraction was adopted at the site in both the Western and Eastern Gullies, this was decommissioned in 2004.

Future

Modelling of Landfill Gas (LFG) emissions undertaken in accordance with the *National Greenhouse and Energy Reporting System Measurement - Technical Guidelines for the estimation of greenhouse gas emissions from facilities in Australia*, Department of Climate Change and Energy Efficiency, July 2011, predicts a significant volume of LFG generation from within both the existing landfill and the proposed new landfill cell as a result of the Project. Modelling methodology and results are presented in Chapter 11 and Appendix E of the EA based on 50 percent capture flaring and LFG combustion, which are considered feasible at the Whytes Gully RRP site.

The existing landfill is estimated to run out of air space during late 2013 and as such the construction of the Project is required to commence early 2013 (pending EA approval). Therefore, the management of LFG within the existing landfill waste is required prior to the construction of proposed new landfill cells in late 2013. Wollongong City Council plan to implement landfill gas extraction at the site according to the following phased approach:

- Phase 1: Revitalise existing LFG collection system on Western Gully, install additional vertical gas wells and commission a flare – mid 2012.
- Phase 2: Install vertical gas wells within the Eastern Gully and prepare for construction of piggyback liner – by mid 2013.

- Phase 3: Collection of LFG from new landfill cells including the installation of sacrificial horizontal gas wells (initially) followed by vertical gas wells – from 2014/2015.

In addition to active gas extraction gas collection layers are incorporated into the Piggy Back Liner and the Cap (refer Section 7.2.1 and Section 10.2).

The design of the piggyback lining system will accommodate the continuing operation of vertical gas wells in the existing waste that will be installed in Phase 1 and Phase 2, with potential design features described in the Preliminary Design Report (Appendix G). It is noted, however, that the need to continue extraction from these wells would depend on the quantum of future gas generation expected at the time of piggy back lining construction, and there would be less need to preserve Phase 1 (Western Gully) wells due to the advanced age of the existing waste at the time of piggy back lining. The design of the piggyback lining system will also include gas collection vents beneath the lining to reduce the risk of increased lateral gas migration developing after lining construction.

Performance Indicators

- Results of Landfill Gas Monitoring (refer Section 8.3)

Inspection Monitoring and Maintenance Schedule

- Landfill Gas Monitoring (refer Section 8.3)

Responsible Person

- Waste Services Manager.

Reporting

- Complaint Reporting (refer Section 4.3)

Corrective actions

- Section 8.4 identifies the actions to be undertaken if the monitoring results indicate the presence of landfill gas.

8.2.3 Fire Prevention

Requirements

The EPL outlines the following requirements for prevention and recording of fires.

O10 Fire control

O10.1 The licensee must take all necessary steps to extinguish all fires burning in wastes as soon as possible. The necessary steps must be taken within 30 minutes of the fire being ignited during the hours when the site is open to the public and within one hour of being notified of the existence during the hours when the site is not open to the public.

O10.2 The licensee must maintain a log recording:

(a) The time and date and location of any fire ignited or reported at the site.

(b) The prevailing weather conditions together with observations made in regard to smoke direction and dispersion.

(c) The time and date that the fire burnt out or was extinguished.

R4 Recording of fires

R4.1 The licensee must maintain a daily log and record the following data of fires at the site:

(a) Time and date when the fire was deliberately started or reported.

(b) Whether the fire was authorised by the licensee, and, if not, the circumstances which ignited the fire.

(c) The time and date that the fire ceased and whether it burnt out or was extinguished.

(d) The location of fire (eg. clean timber stockpile, putrescible garbage cell, etc).

(e) Prevailing weather conditions.

(f) Observations made in regard to smoke direction and dispersion.

(g) The amount of waste that was combusted by the fire.

(h) Action taken to extinguish the fire.

R4.2 The licensee or its employees or agents must notify the EPA in accordance with conditions R2.1 and R2.2 of all fires at the premises as soon as practical after becoming aware of the incident.

Objectives

The objectives of fire prevention are to minimise emissions to the atmosphere and to increase the level of safety on site.

Management Strategy, Tasks and Actions

Landfill and Vehicle Fires

The following control measures will be addressed to prevent fires, as a minimum:

- Burning is not permitted on site .
- Good compaction procedures are undertaken to reduce void spaces that would encourage fires
- Signs will be on display to the public advising that hazardous or liquid wastes are not permitted on the site. This will be reinforced by advice to customers at the gatehouse and inspection of loads at the tip face.
- Stockpiles of approved amounts of combustibles for recycling and composting (such as tyres, wood or vegetation) will be divided into small piles or windrows so that any burning material can be kept away from or readily separated from additional fuel. The amount of tyres stored on site at any time will be limited to less than 50 tonnes.
- Cell construction, compaction and use of cover material will be undertaken in a manner conducive to the prevention of a landfill fire.
- All sealed or contaminated drums will be banned from landfill unless they are delivered as a special waste whose contents are clearly identified and suitable for acceptance.
- All fuels or flammable solvents for operational use will be stored in an appropriately ventilated and secure store. Waste oil will be stored within a bund of 110% capacity of the volume of those flammable liquids so that any release of raw or burning fuel will not cause a fire in the filled waste, or impact on stormwater.
- Stockpiles of combustibles, fuels and flammable solvents stored will be inspected once per quarter for fire risk.
- Any fire occurring on site will be investigated and the causes, damage and impact will be fully documented.
- Fighting of fires will be undertaken in accordance with the Fire Fighting Procedure (Appendix F)

Bushfires

The following control measures will be addressed for Bushfire Protection:

Asset Protection Zone

i) An asset protection zone (APZ) of 10 m should be maintained around existing site buildings.

Firebreak

ii) A perimeter firebreak cleared of all vegetation is to be established around the entire site (roads and access tracks may be utilised to form the fire break). Reddalls Road may be considered to serve this purpose provided access to the site is maintained. Where a road is utilised it must be constructed to comply with AS 2890.2 – 2002. (The remnant Lowland Dry Subtropical Rainforest and Moist Box Redgum Foothills Forest vegetation associations are to be protected).

iii) The firebreak is to be 5 m wide and is to be constructed by an approved method or combination of methods (ploughing, cultivating, scarifying, raking, burning, chemical spraying) so as to remove flammable matter within that 5 metre wide firebreak to a height of 5 metres.

iv) The firebreak is to be inspected monthly and maintained clear by physical or herbicide removal of weeds and plant material including litter.

v) A firebreak 5 m wide is to be maintained around temporary site buildings during construction of the new cells or site infrastructure.

Access

vi) Roads (or fire trails) must be maintained to provide safe access and egress and defendable space for emergency services.

vii) A secondary site access and egress should be maintained such as the site road adjacent to Glengarry Cottage.

viii) Fire hydrant outlets at the site are to be maintained clear of vegetation so as to facilitate unrestricted access.

Fuel reduction

ix) Planted trees that are retained on the site are to have the lower branches trimmed (cut off) to a height of **2 m** above the ground. (The remnant Lowland Dry Subtropical Rainforest and Moist Box Redgum Foothills Forest vegetation associations are to be protected and are not subject to this requirement). The tree trimming works may be staged with priority given to the protection of assets and fuel load reduction adjacent to roads.

x) The canopy of any tree retained at the site is to be not less than **10 m** from any building, where this separation distance cannot be achieved by trimming branches consideration is to be given to the removal of the tree. Advice may be sought on a case by case basis taking into consideration the building construction, location and purpose.

xi) A vegetation management plan (including weed management) should ensure that grass cover on landfill cells is kept mowed or slashed so as not to exceed a fuel load of 2 t/ha. It is preferable that slashed or mown material is removed (this can be mulched on site). Weeds are to be managed at the site by a control program to ensure that they do not constitute a fire hazard. Lantana (and any WoNS) is to be removed.

xii) Wind-blown litter is to be controlled as outlined in Section 9.3.

xiii) Roadside vegetation adjacent to internal site access roads is to be slashed or mown for at least a distance of 1 m up slope and 4 m down slope and maintained cleared during the declared bushfire season.

Landscaping

xiv) The site vegetation (landscaping) should not exceed a fuel load of 2 t/ha.

xv) Tree planting within 20 m of buildings should be minimal and vegetation screening should be avoided.

xvi) Trees planted within 20 m of a building should be spaced so as to ensure that crowns are no closer than 10 m apart.

xvii) Trees planted must be more than 10 m away from a building at their closest point when mature i.e. crown no closer than 10 m when mature.

xviii) Tall shrubs are not to be planted in clumps within close proximity of a building.

xix) Landscaping plants used close to a building (within 20 m) should be low in profile.

xx) Coarse or inorganic mulch should be utilised and moisture should be retained by irrigation.

xxi) The overall canopy cover within 20 m of a building should be no more than 15%.

Controlled Burning

There will be no controlled burning at the site.

Performance Indicators

- Results of Landfill Gas Monitoring (refer Section 8.3).
- Identification of Odours.
- The number of fires occurring on site.

Inspection Monitoring and Maintenance Schedule

Action Item	Frequency	Timing
Odour observations	Continuous	Continuous
Landfill Gas Monitoring	Refer Section 8.3	Refer Section 8.3
Stockpiles of combustibles, fuels and flammable solvents stored inspected for fire risk	Quarterly	March, June Sept, Dec
Bushfire maintenance inspection	Annually and during bushfire season	Prior to Bushfire Season.

Responsible Party

- Waste Coordinator.
- Leading Hand.

Reporting

- Annual Report (refer Section 11.5).
- The occurrence of fires constitutes an incident. Incident Reporting (refer Section 11.2).

Corrective Actions

- The cause of any fire will be determined and appropriate work practices will be put in place to reduce the occurrence.
- An investigation into volumes and appropriate disposal methods of landfill gas may be necessary if gas monitoring indicates a build up of gas/gas migration.
- Section 8.4 identifies the actions to be undertaken if the monitoring results indicate the presence of landfill gas.

8.3 Detecting Air Pollution

The following management techniques will be applied for detecting air pollution:

- subsurface gas monitoring wells;
- subsurface gas monitoring program;
- surface gas emission monitoring; and
- gas accumulation monitoring.

8.3.1 Subsurface Gas Monitoring

Requirements

There are currently no requirements for monitoring of subsurface landfill gas in the EPL. The EPA NSW (EPA NSW 1996) Landfill Guidelines Benchmark Technique Number 15 provides technical guidance regarding the construction of subsurface gas monitoring devices and monitoring of subsurface landfill gas concentrations.

Current best practice guidance for design of landfill gas monitoring bore systems is provided in the Victorian Landfill Guidelines (EPA VIC 2010) (BPEM). The guidelines provide guidance on the location of monitoring bores. The guidelines give further guidance for monitoring bore depth, bore construction design and bore construction CQA.

Objectives

The objective of subsurface gas monitoring wells is to be capable of detecting migration of landfill gas offsite.

Management Strategy, Tasks and Actions

The nearest developments to the landfill are the homestead to the north west of the site (distance of approximately 50 m from the edge of the landfill) and the homestead to the north east of the site (distance of approximately 170 from the edge of the landfill.

The geology of the site has been classified as sandstone in most areas (Golder 2011a) and while not many large fractures were observed, staining on some fractures indicates that gas flow may be fissure or fracture flow-dominated. An area to the south of the landfill between GABH03 and GMW107 is dominated by a uniform low-permeability stratum (clay).

The subsurface landfill gas monitoring system proposed for the site is shown in Figure 14 and comprises 37 monitoring bores (LFGMW01 through to LFGMW37). The spacing of the wells has been determined with consideration of the BPEM guideline.

The installation of the landfill gas monitoring bores would be staged, with the first stage of development concentrating on areas where landfilling of waste currently occurs and where the largest risk to residents may exist.

Wells to be installed initially are located along the eastern boundary of the landfill LFGMW01 through to LFGMW12). The monitoring system would be expanded as the active tipping face moves towards the west.

However, installation along the north western boundary of the site will be a priority as this is the area closest to the nearest residence (LFGMW20 through to LFGMW31).

All monitoring bores will be installed to the top of groundwater levels as required by the NSW EPA landfill guidelines (NSW EPA 1996) and will be constructed in accordance with the requirements of the Victorian EPA guidelines (VIC EPA 2010), which are outlined in the following table.

Table 12: Typical construction details for landfill gas bore construction

Component	Value
Drilled bore diameter (mm)	100 – 150
Pipework casing diameter outer diameter (mm)	50
Pipework casing size of perforations (mm)	3-5
Depth of top bentonite seal (m)	1
Length of solid casing below ground level (m)*	1
Perforated casing pipe work (% open space)	10-0
Size range of gravel backfill (mm)	5-0
Gravel type	Gravel to be rounded to subrounded, and noncalcareous (< 5%)

The EPA (1996) Landfill Guidelines Benchmark Technique 16 recommends monitoring of landfill gas on a quarterly frequency.

Monitoring of landfill gas will be carried out in accordance with the requirements of the Victorian EPA guidelines for monitoring of fugitive landfill gas emissions (VIC EPA 2011). Sampling of each monitoring well will be taken using a calibrated and appropriately maintained landfill gas monitor and the compounds tested will include methane (% v/v), carbon dioxide (% v/v), oxygen (% v/v), hydrogen sulphide (ppm) and carbon monoxide (ppm).

8.3.2 Surface Gas Monitoring

8.3.2.1 Requirements

The following Licence Conditions relate to surface gas emission monitoring at the WGRRP:

'M2.3 Landfill gas monitoring program

M2.3.1 The licensee must monitor the landfill for surface gas emissions and gas accumulation in accordance with the procedures described in Benchmark Techniques 17 and 18 of the Landfill Guidelines. The sampling must be carried out at the following points:'

Table 13: Surface Gas Monitoring Locations

EPA ID no.	*Parameter*	*Description of location*	*Frequency*
3	*Methane v/v*	*Areas where intermediate or final cover has been placed*	*Quarterly. Monthly if an initial survey indicates significant gas.*

R5 Landfill Gas Hazard Reporting

R5.1 The licensee must notify the EPA within 24 hours in accordance with condition R2.1 if surface monitoring detects methane above 1.25% (v/v), and increase the frequency of monitoring to daily, until the EPA determines otherwise.

The EPA (1996) Landfill Guidelines Benchmark Technique Number 17 provides technical guidance regarding the methodology for monitoring surface gas.

Objectives

The objective of surface gas emission monitoring is to demonstrate that the landfill cover material, capping and/or the gas extraction system are effective in controlling the emission of landfill gas. Monitoring the surface of the landfill should locate any point sources or fissures that may be emitting landfill gas.

Management Strategy, Tasks and Actions

- Surface gas monitoring is conducted in accordance with the Licence conditions listed above.
- Surface gas monitoring is undertaken on a quarterly basis. Monitoring on the surface is undertaken in a series of transverses over the landfilled areas spaced at 25 m intervals.
- Surface gas monitoring is undertaken in accordance with industry standard Environmental Monitoring Procedures.

8.3.3 Gas Accumulation Monitoring Program

8.3.3.1 Requirements

M2.3.1 The licensee must monitor the landfill for surface gas emissions and gas accumulation in accordance with the procedures described in Benchmark Techniques 17 and 18 of the Landfill Guidelines. The sampling must be carried out at the following points:'

Table 14: Gas Accumulation Monitoring Locations

EPA ID no.	*Parameter*	*Description of location*	*Frequency*
4	*Methane v/v*	*Inside all buildings within 250m of deposited wastes*	*Quarterly. Monthly if an initial survey indicates significant gas.*

Objectives

The objective of gas accumulation monitoring is to monitor gas build up which may have the potential for explosion. In addition monitoring for methane in buildings is intended to protect human health. Methane is both an asphyxiant and explosive and can accumulate in buildings, particularly if they were constructed over landfilled materials.

Management Strategy, Tasks and Actions

Gas accumulation monitoring is conducted in accordance with the Licence conditions.

Gas accumulation monitoring is undertaken on a quarterly frequency. Monitoring for methane is conducted in all site buildings within 250 m of waste filled areas (refer Figure 14).

Council currently undertake gas accumulation monitoring in all buildings within 250 m of waste filled areas. This radius encompasses non Council owned buildings.

Gas accumulation monitoring is undertaken in accordance with the industry standard Environmental Monitoring Procedures.

If any surface structures or buildings are planned to be built within 250 m of deposited waste, they will be designed so as not to accumulate methane gas.

8.3.4 Performance Indicators

- Perimeter wells are not to have gas concentrations exceeding 1.25% methane (v/v) (EPA, 1996).
- Threshold concentration for potential action for surface gas monitoring is 500 ppm methane (v/v) or 1% LEL. Threshold concentration for Incident Reporting is 1.25%v/v.

- Buildings are not to have gas concentrations exceeding 1.25% methane (v/v) (EPA, 1996).

8.3.5 Responsible Party

- Waste Coordinator

8.3.6 Inspection, Monitoring and Maintenance Schedule

Action Item	Frequency	Timing
Surface Gas Monitoring	Quarterly	March, June Sept, Dec
Subsurface Gas Monitoring	Quarterly	March, June Sept, Dec
Building Gas Accumulation Monitoring	Quarterly	March, June Sept, Dec

8.3.7 Reporting

- Annual Report (refer Section11.5).
- The detection of methane concentrations above 1.25% v/v during the subsurface, surface or building accumulation monitoring constitutes an incident. Refer Incident Reporting (refer Section 11.2). If the concentration of methane is detected at greater than 1.25% (v/v), OEH will be notified within 24 hours. A written assessment of the emissions and management controls implemented, or proposed to be implemented to prevent further emissions, will be provided to OEH within 14 days of the incident.

8.3.8 Corrective Actions

- Remediation of uncontrolled landfill gas emissions (refer Section 8.4) is required if methane at concentrations greater than 1.25% (v/v) is detected in on-site structures, in monitoring wells.
- If the methane concentration exceeds 1.25% (v/v) within monitoring wells, an increase in testing frequency to monthly, weekly or daily will be required depending on the outcome of a risk assessment. The risk assessment will be carried out in accordance with CIRIA C665 (CIRIA 2007) and will comprise measurement of flow in monitoring wells.
- If the methane concentration exceeds 1.25% (v/v) within buildings, daily testing will be undertaken until ventilation or other measures control the methane build up.
- If the concentration exceeds 500 ppm (v/v) of methane at any point on the landfill surface, corrective action is necessary. This action will include, but may not be limited to:
  - repairing or replacing cover material; and
  - adjusting or installing gas venting/extraction equipment.

8.4 Remediation of Uncontrolled Landfill Gas Emissions

8.4.1 Requirements

There are no specific conditions relating to the remediation of uncontrolled landfill gas emissions in the Licence. OEH has established monitoring thresholds that, if exceeded, require remedial actions. OEH thresholds are (Benchmark Technique Number 17 and Benchmark Technique Number 19):

1) Methane at concentrations greater than 1.25% (v/v) in sub-surface wells or in on-site structures, and greater than 0.05% (v/v) on the surface;

2) A one hour oxidised nitrogen (NO_x) average level above 320 $\mu g/m^3$ from electricity generating equipment; and

3) Non methane organic compounds (NMOC) destruction efficiency in the gas combustion equipment lower than 98%.

For the site only the first of these thresholds is currently relevant.

Objectives

The purpose of remediating uncontrolled landfill gas emissions is to prevent further emissions from occurring.

Management Strategy

OEH must be notified within 24 hours of any landfill gas detection above the 1.25% (v/v).

A written assessment of the emissions and management controls implemented or proposed to prevent further emissions will be provided to OEH within 14 days of the incident.

Management controls to remediate uncontrolled landfill gas emissions are developed on an individual basis dependent on the nature and degree of emissions detected. Rather than include a plan for any landfill gas contingency, it is more important to define the concept and highlight responsibilities and likely actions. The specific plan can then be developed to suit the event, if required.

Surface Gas Emissions

Corrective actions in the event of excessive landfill gas emissions from the landfill surface may include:

- A review of waste screening procedures to ensure unacceptable waste is not being accepted at the site;
- Providing a thicker cover or changing the material used as cover, such as use of materials with greater cohesive properties; and/or
- Installation of passive or gas extraction wells within the waste mass; and/or
- Installation of perimeter gas collection trenches.

If these measures are not successful in controlling gaseous emissions, an assessment will be made as to the need to adopt engineering solutions.

Subsurface Landfill Gas

Should the monitoring program demonstrate lateral migration of landfill gas through soil or rock, the extent of the lateral migration will be established by increased monitoring and installation of additional monitoring wells, if required. Contingency measures will be developed on a risk basis using CIRIA C665 (CIRIA 2007) and may include:

- Increased monitoring;
- Extraction bores;
- Subsurface extraction drains; or
- Subsurface cutoff walls.

Building Accumulation

Should the monitoring program demonstrate that corrective actions are necessary these may take the form of improving the ventilation within the buildings, continuous methane measurements or, in the short term, evacuation.

Performance Indicators

- The results of monitoring are the key indicators for determining the effectiveness of the remediation.

Responsible Party

- Waste Coordinator

Reporting

- Specific contingency plans and reporting activities are not necessary until uncontrolled release of pollutants have been identified. Review and reporting will be necessary to demonstrate that the situation is under control.

9.0 HAZARDS AND LOSS OF AMENITY

9.1 Introduction

The Environmental Goals of Avoidance of Hazards and Loss of Amenity are:

- Preventing Unauthorised Entry;
- Preventing Degradation of Local Amenity;
- Preventing Noise Pollution;
- Fire Fighting Capacity; and
- Staffing and Training.

9.2 Security of Site

9.2.1 Requirements

The following Licence Conditions (EPL 5862) relate to the security of the site:

O11.1 The licensee must take all practicable steps to control entry to the premises.

O11.2 The licensee must ensure that all gates are locked whenever the landfill is unattended.

Objectives

The objective of the security at the site is to prevent unauthorised entry at the facility. Unauthorised entry to landfills can lead to waste dumping, fires and vandalism of pollution control devices, as well as loss of amenity.

Management Strategy

- The landfill site is bounded by a security fence along the perimeter of the site. In the north east of the site, the fence is partially located on a neighbouring property due to topographical constraints on the site.
- The main access gate is locked outside of business hours, whilst other gates on the boundary are permanently locked and opened only when access is required by authorised vehicles.
- The main access gate and the weighbridge building are alarmed outside business hours.

End of day closure and security procedures are outlined in Appendix F.

Performance Indicators

- Number of intruders found.
- Any waste illegally disposed.
- Number of complaints with regard to access to the Depot.
- Number of reports detailing damage or vandalism.
- Weekly inspections of the perimeter fence conditions.

Responsible Party

- Waste Coordinator
- Leading Hand

Inspection, Monitoring and Maintenance Schedule

ACTION	FREQUENCY	TIMING
Perimeter Inspection of Fence Condition	Weekly	End of Week

Reporting

- Annual Report (refer Section 11.5).

Corrective Actions

- Repairs which are necessary will be undertaken promptly to ensure security.
- Segregation of dumped waste from approved waste.
- Notification to OEH that illegal dumping has breached site security (refer Section11.2).
- Evaluate the nature of the problem, determine its source and implement actions to prevent recurrence.

9.3 Litter Control

9.3.1 Requirements

There are no specific conditions relating to the litter control in the Licence. The EPA (1996) Landfill Guidelines (Benchmark Technique 31) state that local amenity should not be degraded by litter. The specific requirements of Benchmark Technique 31 comprise:

- *The occupier should introduce procedures that prevent the unnecessary proliferation of litter. Such procedures might include continuous compaction and use of litter fences, and the occupier is responsible for ensuring that all wind-blown litter that leaves the site is retrieved.*
- *All litter fences, perimeter fences and gates should be inspected daily and cleared of litter on a daily basis or as required.*
- *Entry and exit signs need to advise transport operators that they can be fined for any litter on public roads resulting from their improper transportation of waste.*
- *All litter that leaves the site should be retrieved on a daily basis.*

Objectives

The objective of litter control at the site is to prevent degradation of local amenity by litter. Windblown litter is a nuisance to the community in the vicinity of landfill sites.

Management Strategy

Generation of litter is primarily through wind movement of litter which has not yet been covered. To minimise this:

- The active land filling operation will have a combination of daily cover and landfill lids applied to the surface at the end of each working day and intermediate cover applied to the surface of each finalised lift.
- A litter fence is located at the perimeter of the landfill around the northern, eastern and western side of the active filling area.
- Local litter fences are used immediately around the tip face.

- Load covering signs are located along the site access road.
- Personnel are employed specifically to collect litter at the perimeter
- Inspection and clearing of the litter fence, perimeter fence and surrounding areas.
- The litter fences are repaired or replaced as required.
- Tip face orientation in high winds particularly during the windy months.

Actions for Compliance

- Litter fences are currently inspected and cleared from litter on a weekly basis. The landfill guidelines require inspection and clearing daily.

Performance Indicators

- Number of complaints received regarding litter escape.
- Quantity of litter and refuse found in nearby land and waterways.

Responsible Party

- Waste Coordinator
- Leading Hand

Inspection, Monitoring and Maintenance Schedule

ACTION	FREQUENCY	TIMING
Litter fence, perimeter fence and surrounding roadsides inspection/ litter retrieval	Daily or as required depending on the extent of litter produced	Afternoon

Reporting

- Annual (refer Section 11.5).

Corrective Actions

The corrective actions that may be employed if litter is observed or reported to be a nuisance include:

- Collection and removal of the litter; and
- Review litter control measures including open loads should be covered, compact and cover the waste more frequently during the day, confine dumping to a reduced surface area.

9.4 Dust Control

9.4.1 Requirements

The following licence conditions (EPL 5862) relate to dust control at the WGRRP:

O5.1 *All operations and activities occurring at the premises must be carried out in a manner that will minimise the emission of dust from the premises.*

O5.2 *Facilities and/or equipment must be provided for the application of water to disturbed areas to minimise the generation of airborne dust from any area disturbed by activities associated with the development.*

O5.3 *All sealed surfaces intended to carry vehicular traffic must be kept clean.*

O5.4 *Unsealed roads used for material haulage must be kept sufficiently damp to prevent wind-blown or traffic generated dust.*

Objectives

The objectives of dust controls are to:

- Minimise pollutants leaving the site as airborne dust;
- Reduce stormwater sediment load; and
- Protect local amenity.

Management Strategy

Emissions causing a reduction in air quality can originate from the land filling operations, including cell construction, liner preparation, dumping and compaction, capping, vehicle traffic and machinery used in land filling.

Dust emissions are more likely to occur in the warmer months, especially during windy days. The magnitude of the impact will depend upon the type and size of the land filling operation, prevailing wind speed and direction, adjacent land use and the occurrence of natural and/or constructed wind breaks, wind abatement measures or buffers.

The management strategy for dust control at the WGRRP comprises:

- Unsealed trafficable areas and stockpiles are watered on a regular basis.
- Internal roads are sealed to within approximately 100 m of the tip face. The access road to the tip face is covered with breckets (a gravelly slag product).
- Plant operating at the tip face is not entering other areas of the landfill to prevent access roads from becoming impacted by dirt.
- Site roads are frequently cleaned with a water cart if found to be impacted by dirt.
- Revegetate capped areas as soon as possible after forming.
- Revegetate stockpiles that will not be used for some time.
- Reduce vehicular speeds on site to reduce dust.
- Mechanical plant and equipment are properly serviced and maintained in an efficient operating condition.
- Restricting the size of disturbed areas as much as practicable.

- Prevention of truck over-loading and covering dusty loads.
- Washing down trucks before they leave the site.
- Temporarily suspending operations under extreme wind speed conditions.
- Plant and equipment are fitted with appropriate pollution control devices.

Dust is to be monitored visually to ensure immediate response with mitigation.

Performance Indicators

- The number of complaints by affected clients, visitors and nearby residents regarding dust.
- The dust deposition rate of 4g/m^2 per month (as an annual mean for total solids) will not be exceeded outside the site boundary (EPA, 1996).

Responsible Party

- Waste Coordinator
- Operations Administrator

Inspection, Monitoring and Maintenance Schedule

ACTION	FREQUENCY	TIMING
Visual dust observations.	Daily	Continuous

Reporting

- Annual Report (refer Section 11.5).
- Dust complaints reporting is undertaken in accordance with Section 4.3

Corrective Actions

- If dust is observed or reported control measures will be undertaken to reduce/mitigate dust generation (see tasks and actions) such as increase the frequency of water spray applied at the site.
- Increased revegetation of covered areas can also be considered to prevent dust generation.

9.5 Pest, Vermin and Noxious Weed Control

9.5.1 Requirements

The following licence conditions (EPL 5862) relate to control of pests and vermin at the WGRRP:

L5.3 Tyres stockpiled on the premises must:

(c) be managed to control vermin;

The EPA (1996) Landfill Guidelines (Benchmark Technique 35) state that pests, vermin and noxious weeds should not be present at the site in sufficient numbers to pose an environmental hazard or loss of amenity in the areas neighbouring the site.

The specific requirements of Benchmark Technique 35 comprise:

- *Waste should be compacted and covered, keeping the amount of exposed waste to a minimum. Additional effort may be required for loads containing large amounts of highly biodegradable wastes.*
- *The landfill occupier should take steps to ensure that surfaces are adequately drained to prevent ponds of water forming on the site.*
- *If alternative cover materials or systems (see 33. Covering of waste) are used, occupiers should specify the method by which they will quantitatively monitor changes in vermin population as a result of the new cover.*
- *A plan to manage pests, vermin and declared noxious weeds should be developed and detailed in the LEMP*.

Objectives

The objective of pest controls is to minimise the impact of vermin and noxious weeds on the surrounding environment.

Management Strategy

- Rodenticide bait stations at various locations will be continued to control the Black Rat.
- Deer culling occurs on the site on a regular basis.
- Fox baiting occurs on site occasionally as part of a regional fox baiting program.
- Insecticides and pesticides will be used when necessary.
- Ensure the area of tipping face is minimised and covered regularly to limit food sources and breeding areas.
- Surfaces will be free draining to prevent ponded water.
- Weeds will be managed at the site by a control program to ensure that they do not constitute a fire hazard in accordance with the Bushfire Mitigation Measures. Lantana (and any WoNS) is to be removed.

Actions for Compliance

- A Weed Management Strategy shall be developed.

Performance Indicators

- Number of complaints about pests/vermin/noxious weeds on site and from local nearby residents about pests/vermin moving off site.

- Number of pests/vermin found by pest control contractor.
- Amount of infestation of noxious weeds.

Responsible Party

- Waste Coordinator
- Operations Administrator

Inspection, Monitoring and Maintenance Schedule

ACTION	FREQUENCY	TIMING
Visual observation for when pest/ vermin/ weed species seem to be increasing	Daily	Continuous
Bait stations for vermin	Monthly	End of Month
Noxious weed survey by site staff	Quarterly	Mar, June, Sept, Dec
Trapping programs	As required	As required

Reporting

- Annual Report (refer Section 11.5).

Corrective Actions

- Increase number of bait stations and trapping if vermin numbers rise.
- Increase frequency of weed eradication if monitoring indicates spread of weeds.
- Deterrence programs for seagulls, ibis, pelicans and other birds have been carried out unsuccessfully by the NSW Parks and Wildlife Services. Birds continue to be a nuisance at the site.

9.6 Odour Control

9.6.1 Requirements

There are no specific conditions relating to odour control in the Licence. The EPA (1996) Landfill Guidelines (Benchmark Technique 36) state that landfills should have no odour impact and that a buffer zone to residents should be considered to minimise the odour impact.

Objectives

The objective of odour control at the site is to prevent degradation of local amenity by odour.

Management Strategy

- Good covering procedures to keep the amount of exposed waste to a minimum (refer Section 0).
- Fast identification and attention to odorous waste loads.
- Identification and management of odourous loads
- Avoid a queue of the incoming or outgoing trucks for extended periods of time;
- Spill management procedures to include immediate clean up of any spill/leakage from the incoming and outgoing trucks;

- Maintaining a complaint logbook and in the event of a complaint immediately investigate any unusual odour sources (including spill or leakage in the traffic areas) within the site boundary and take appropriate action to eliminate these (refer Section 11.2; and
- Consider using a thicker cover, of up to 300 mm during Stages of landfilling closer to residences.

Performance Indicators

- Number of complaints by affected clients, visitors and nearby residents regarding odour

Responsible Party

- Waste Coordinator
- Leading Hand

Reporting

- Odour complaints reporting is undertaken in accordance with Section 4.3. These will be correlated with prevailing weather conditions and waste reception circumstances.

Corrective Actions

- The first step following receipt of an odour complaint is to correlate this with weather conditions and deliveries of particularly odorous wastes. If these are identified as the cause, remedial actions which could be undertaken include increasing the thickness of the cover.
- If the source of the odour complaint is identified as poor control of landfill gas, corrective actions detailed in Section 8.4 will be considered.

9.7 Noise Control

9.7.1 Requirements

The licence conditions (EPL 5862) list Noise Limits as ‘Not Applicable’.

The EPA (1996) Landfill Guidelines (Benchmark Technique 37) outline requirements for management of noise.

Objectives

As outlined in the EPA (1996) Landfill Guidelines (Benchmark Technique 37), noise generation during the operation of the facility should be managed to meet the following objectives:

- Noise from any single source does not intrude generally above the prevailing background noise level; and
- The background noise level does not exceed the level appropriate for the particular locality and land use.

Management Strategy

- Mechanical plant and equipment will be maintained regularly.
- All contractors onsite shall make a commitment to minimise the levels of noise from their activities.
- The operating hours of the landfill are limited in accordance with approved times.

Actions for Compliance

- Noise attenuation devices should be installed on all equipment on site.

Performance Indicators

- Number of complaints by affected clients, visitors and nearby residents regarding noise.
- Noise Criteria as outlined in the Environmental Assessment (Golder, 2012).

Responsible Party

- Waste Coordinator
- Leading Hand

Reporting

- Noise complaint reporting is undertaken in accordance with Section 4.3. This will be correlated with noise related activities on the site.

Corrective Actions

- A comprehensive review of operations and practices will be performed if excessive numbers of complaints about noise occur, or noise levels are in excess of performance indicator. Solutions aimed at attenuating any noise nuisance may include measures such as the use of residential grade exhaust silencers and acoustic engine enclosures.

9.8 Traffic Control

9.8.1 Requirements

There are no specific requirements relating to traffic control in the Licence or the Landfill Guidelines.

Objectives

The objective of traffic control at the site is to ensure the safety of clients, visitors and staff at the WGRRP.

Management Strategy

- Signposting of slow speed limits.
- Allocation of separate areas for truck usage versus cars/ trailers/ utes where possible.
- Signposting of colour coded access routes to disposal areas for dump trucks, commercial users, small vehicle customers and recyclable drop off customers.

Performance Indicators

- Number of accidents or incidents involving vehicular traffic.

Responsible Party

- Waste Coordinator
- Leading Hand

Inspection, Monitoring and Maintenance Schedule

ACTION	FREQUENCY	TIMING
Traffic Flow	Continuous	Continuous

Reporting

Corrective Actions

- If traffic incidents commonly occur at the site, the traffic management should be reviewed. This may include construction of speed humps or stricter enforcement and signposting of speed limits if speeding is a significant problem.

9.9 Fire Fighting Capacity

9.9.1 Requirements

The following Licence Conditions (EPL 5862) relate to fire control at the WGRRP:

O10.1 *The licensee must take all necessary steps to extinguish all fires burning in wastes as soon as possible. The necessary steps must be taken within 30 minutes of the fire being ignited during the hours when the site is open to the public and within one hour of being notified of the existence during the hours when the site is not open to the public.*

O10.2 *The licensee must maintain a log recording:*

(a) The time and date and location of any fire ignited or reported at the site.

(b) The prevailing weather conditions together with observations made in regard to smoke direction and dispersion.

(c) The time and date that the fire burnt out or was extinguished.

The EPA (1996) Landfill Guidelines (Benchmark Technique 38) recommend that landfill operators have the ability to adequately fight fires at any part of the landfill site.

Objectives

The primary environmental objective for this aspect is to ensure that the site occupiers have the ability to adequately manage the fighting of fires at any part of the landfill site.

Management Strategy

- All plant, including contract plant on site, must have an appropriate classification fire extinguisher in their cabin.
- Fire extinguishers of appropriate classification are to be located in a prominent position in the Gatehouse.
- All extinguishers are to be current and checked monthly by site personnel and annually by external subcontractor.
- All staff are to be familiar with the operations of fire extinguishers.
- Select landfill staff are trained in fire fighting techniques and a site specific fire management plan/procedure has been devised (refer Fire Fighting Procedure in Appendix F).
- In the event of fire, the Waste Coordinator and employees will ensure the safety of personnel and visitors on site.
- In the event of fire, the entry gate will be closed immediately and the public will be asked to vacate the WGRRP.
- The Waste Coordinator will immediately take all action possible to prevent the fire from spreading to the waste and sources of fuel.

- In the case that the Waste Coordinator is not on site, the Leading Hand will take immediate action and will contact the Waste Coordinator and the Fire Brigade immediately.
- The Waste Coordinator will immediately contact the emergency services and local Fire Brigade (**through 000**) and advise them of the fire.
- The Waste Coordinator will arrange for the water tankers and mobile fire fighting unit to help extinguish the fire.

Internal roads act as suitable fire breaks and provide protection/access if any fire outbreak occurs in stockpiles, buildings or filled areas.

Actions for Compliance

- Mitigation measures outlined in Section 8.2.3 for bushfire protection should be implemented.

Performance Indicators

- The occurrence of fires.
- Number of fire fighting vehicles and appliances available.
- The length of time required to extinguish a fire.

Responsible Party

- Waste Coordinator
- Leading Hand

Inspection, Monitoring and Maintenance Schedule

ACTION	FREQUENCY	TIMING
Inspection of fire extinguishers (by contractor)	Annually	December
Inspection of fire extinguishers (by Waste Coordinator or Leading Hand)	Monthly	End of Month
All fire fighting equipment and facilities shall be checked for damage/condition	Weekly basis	End of Week
All fire fighting equipment and facilities shall be test operated	Three monthly basis	May, June, Sept, Dec
Check fire equipment signposting to Australian Standards and accessibility	Three monthly basis.	May, June, Sept, Dec
Review capacity of fire fighting	Every 12 months.	December

Reporting

- A fire at the site constitutes an incident (refer Section 11.2).
- Annual Reporting (refer Section 11.5).

Corrective Actions

- If the performance indicators detect a failing, then measures will be put in place to increase the fire fighting capacity.
- If it is identified that the fire fighting procedures need to be augmented to improve performance, the procedures should be modified. This modification may include additional training of staff.

10.0 SITE CLOSURE

10.1 Introduction

The Management Techniques used for remediating the landfill after closure are:

- Site Capping and Revegetation; and
- Landfill Closure and Post Closure Monitoring and Maintenance.

10.2 Site Capping and Revegetation

10.2.1 Requirements

The following Licence Conditions (EPL 5862) relate to a closure plan for the WGRRP:

O6 *Closure plan*

O6.1 *The last licensee must prepare and submit to the EPA within 3 months of the last load of waste being landfilled, a closure plan in accordance with section 76 of the Protection of the Environment Operations Act 1997.*

O9 *Completion of landfill cells*

O9.1 *The licensee must ensure that the landfill cells are capped progressively during operations and specifically at times when the level of waste reaches final heights specified in the LEMP.*

Objectives

The objectives of site capping and revegetation are to ensure that the final surface provides a barrier to the migration of water into the waste, controls emissions to the atmosphere and reduce the risk of hazards.

Management Strategy, Tasks and Actions

The final site capping and revegetation will be carried out as described in the Landscape Strategy (Appendix I. The site rehabilitation is summarised in the following sections.

10.2.1.1 Landform

The final landform is presented on Figure 11.

The final landform footprint is proposed to be roughly rectangular and measure approximately 850 m (E-W) by 550 m (N-S), extending between the crests of the natural eastern and western ridge lines at the Whytes Gully RRP site. The footprint includes pulling back from the current extent of waste by up to 35 m in the area of the proposed eastern waste cutback. The total landform footprint area is approximately 35 ha.

The peak of the landform is at elevation is proposed to have an RL of 111 m. From the high point, slopes extend to the north to meet the natural ground surface at RL 75m to RL 95m. The lowest point of the landform is at RL 19 m along the southern edge, with a 500 m length of the southern edge at RL 25m or less.

The principal landform batter is south and southwest-facing with a maximum height of greater than 80 m and a 4.5H:1V average inclination. North and east-facing batters would have a steeper average inclination of 4H:1V and but a maximum height of less than 30 m.

The batters of the final landform are proposed to be at a slope of 4H:1V towards the landform toe and would be intersected by 5 m wide grassed benches every ten vertical metres. This would result in an average slope of approximately 4.5H:1V. The benches would have a fall of 2 percent towards the surface water drop structures and perimeter drains along the eastern and western toe of the proposed final landform. The purpose of the slope benches is to reduce runoff velocity and erosion potential for the final capping system to increase overall landform slope stability, and to provide access on the slope for capping system and gas extraction system inspection and maintenance.

A small area near the peak of the landform has relatively flat design grades of approximately 5 percent.

The Project landform design allows for access around the entire site perimeter and to the landform summit for groundwater monitoring, site inspection and maintenance, and bushfire protection. The design also includes surface water drains along the entire perimeter, with combined drains and access tracks in some areas. In addition, the design setback distance of 20 m along the western ridge property boundary also provides space for a nature strip and screening planting.

The proposed distance from the design limit of landfill waste placement to the closest adjacent residence buildings is approximately 70 m to the residence near the western ridge and 160 m for the residence to the north of the Eastern Gully landfill area. It is noted the design limit of landfill waste placement is approximately 10 m inside the edge of the landform footprint.

Refer to the Preliminary Design Report (Appendix G) for further detail of final landform.

10.2.1.2 Capping System

The capping system will be constructed progressively as the landfill is being filled and is designed to minimise infiltration into the landfill waste and therefore reducing the amount of leachate generated and the potential for contamination of groundwater. Impact on air quality and odour emissions are controlled by reducing landfill gas emissions, which are controlled by installation of a landfill gas collection system as part of the cap design. The cap is designed to provide after users with an accessible and visually attractive vegetated surface.

The capping system is shown in the design report and will comprise (from top to bottom):

- 500 mm to 1 m revegetation layer, specifically designed to encourage growth of the selected plant species.
- Geocomposite drainage system with geotextile covers to prevent clogging of the system from sediment migration. The geocomposite layer conveys water infiltrating through the vegetation layer into collection pipes which will discharge into the grassed benches and drop structures. This system is designed to reduce the surface water head on the LLDPE liner, reduce infiltration through the cap and increase surficial slope stability.
- Linear Low Density Polyethylene (LLDPE) geomembrane liner as the key layer to prevent infiltration of water into the landfilled waste. The LLDPE geomembrane is flexible to prevent damage to the capping system as a result of the expected landfill settlement.
- 200 mm clay rich bearing layer to form a low permeability and smooth base for geomembrane liner placement. The layer is designed to reduce infiltration through the capping system and to reduce the likelihood of damage to the LLDPE geomembrane.
- 500 mm intermediate cover remaining from the landfill operation.
- Landfill gas collection trenches underneath the cap, consisting of gravel aggregate and perforated collection pipes connected to an active landfill gas collection system.

The capping system will be constructed progressively as landfilled areas have achieved their final level. The progressive capping will reduce the amount of leachate generated.

10.2.1.3 Revegetation

The revegetation of the landfill is summarised below and is outlined in more detail in the Landscape Strategy (Appendix I).

The Landscape Strategy incorporates the following Key Components:

- staging of the revegetation will aim to ensure the area of un-vegetated landfill slope is minimised by progressively establishing a vegetation cover on each section of slope as it is completed;

- existing vegetation on the portions of site not required for landfill, particularly mature remnant trees, will be retained wherever possible to provide visual screening and contribute to the landscape character of the site;
- vegetation to be established on the landfill slopes will include a mix of shrubs and small trees with areas of grass that will create a landscape character similar to adjoining rural areas;
- the top of the new landform will be visually modified to ensure it is visually compatible with the surrounding topography;
- views to the coast will be maintained from the potential lookout area on the landfill ridgeline and from properties upslope of the site;
- screen planting with dense tall tree planting on natural ground will be used to block views to the site, particularly from adjoining residences;
- biodiversity and habitat values will be maintained and increased where possible by planting a range of indigenous species;
- the potential will be created for future public open space facilities such as a lookout and passive recreation areas with access provided by upgrading the maintenance track to the top of landfill landform;
- the visibility of drainage channels on the slopes will be minimised by design options that could include the use of dark coloured stone and native grasses;
- provision of a maintenance program that includes regular removal of identified weed species; and
- coordination of vegetation planting with bushfire management requirements that include access tracks and fuel management zones.

The proposed landscape strategy is presented in Appendix I. A full list of species selected for the revegetation of the site is provided in the Landscape Strategy (Appendix I). The proposed plant species and planting structure will establish vegetation that forms a sustainable ecosystem similar to the adjoining areas of remnant vegetation providing wildlife habitat and contributing to the ecological values of the region.

10.2.1.4 Surface Water Management

Capped areas of the landfill will be vegetated as soon as feasible. Until vegetation has been fully established, the capped areas as well as the run off from these areas will be treated in accordance with Managing Urban Stormwater Volume 2B (DECC 2008). This will include intensive management of revegetated surfaces for the first few months after sowing. Management will include use of silt fences, establishment of sedimentation basins and full reestablishment and vegetation of capped areas where erosion has occurred. Existing sedimentation basins will be maintained until vegetation has been fully established or at least for two years following vegetation of the landfill cap.

Surface water management following closure of the site will comprise diversion of surface water run-on around the landfill in grassed diversion drains constructed during the operating life of the landfill. This surface water can be discharged directly into surrounding water bodies.

10.2.1.5 Leachate Management

The landfill will continue to generate leachate into the foreseeable future. The leachate will continue to be collected in the leachate collection system piped to the leachate dams and the leachate treatment plant and treated. The treated leachate will continue to be discharged to sewer under the trade waste agreement (TWA).

10.2.1.6 Landfill Gas

The landfill will continue to generate landfill gas into the foreseeable future. The leachate will continue to be collected and extracted by the landfill gas collection and extraction system.

10.2.1.7 Final Land Use

The proposed final land use of the Whytes Gully RRP landfill cell will be passive open space. Given the long timeframe until completion of the landfill, a more detailed plan of the final landuse of the site may be prepared in the future.

10.2.2 Implementation

The final site capping and revegetation will be carried out as described in the Design Report (Appendix G). Site capping will occur progressively when final waste heights are reached.

10.3 Landfill Closure and Post-Closure Monitoring and Maintenance

10.3.1 Requirements

The following Licence Conditions (EPL 5862) relate to preparation of a closure plan and post closure monitoring and maintenance for the WGRRP:

'O6 Closure plan

O6.1 The last licensee must prepare and submit to the EPA within 3 months of the last load of waste being landfilled, a closure plan in accordance with section 76 of the Protection of the Environment Operations Act 1997.'

Objectives

The objective of the landfill closure and post-closure monitoring and maintenance is to ensure that the landfill continues to be non-polluting and does not cause environmental harm after site closure.

Management Strategy, Tasks and Actions

A site closure plan will be submitted to the OEH within three months of the completion of the landfill's waste receipt operations. The Closure Plan will include putting into place a post-closure monitoring and maintenance program which ensures the long-term integrity of the landfill.

It is expected that the environmental monitoring of surface water, groundwater, leachate and landfill gas will continue in the same manner as during operation in order to detect deficiencies or damages to the containment system. Post closure monitoring will also involve site walkovers to detect areas of cap degradation, excessive settlement, erosion and slumping.

Sections 7.4 and 8.4 also outline contingency and remediation measures should environmental monitoring indicate that the landfill is impacting the air, surface water, groundwater or amenity of residents.

The following section describes the proposed components of the Closure Plan:

Leachate, Gas and Stormwater Monitoring

All leachate collection, gas collection and stormwater sediment controls, monitoring and reporting practices shall be described including the continued operation of the leachate treatment plant, until leachate volume and concentrations have reduced to an acceptable level.

Groundwater Monitoring

Groundwater monitoring will be described and will map the movement of any leachate plume in the groundwater over time. Monitoring will continue until the quality of groundwater reaches environmentally acceptable levels.

Maintenance

A description of how the following items shall be maintained, at a standard equivalent to that during the operational life of the landfill, for the period until the landfill does not pose a threat the environment:

- sediment retention basins;
- vegetation;
- rehabilitated land; and
- vermin and pest control.

Complaints

A description of how residents near the landfill are to be advised of contact persons to discuss any problems. Records of complaints shall be kept in the same manner as during operation of the landfill.

Waste Receipt

Description of the means to ensure waste materials will not be received for disposal by the facility after landfill operations cease. Waste materials that are intended for use in the rehabilitation and remediation shall be documented and reported in the same way as for an operating facility.

10.4 Statement of Completion

When sufficient evidence can be provided that the landfill is stable and non-polluting, Council may seek to complete all obligations and settle any financial assurance by submitting a certified Statement of Completion which states that the site remediation work has been completed and further environmental management of the site is not required. The statement shall be expected to show that:

- Gas concentration levels in all perimeter gas wells have fallen to less than 1% methane (v/v) and less than 1.5% carbon dioxide for a period of 24 months;
- Waste stabilisation has been completed. This would be documented by the composition of the leachate changing to a low level of contamination, and posing no hazard to the environment;
- Groundwater monitoring has indicated no failure of the landfill liner that would pose a threat to groundwater quality;
- The landfill capping has been assessed over some years and found to be stable with acceptable surface water drainage;
- Documentation that all functions in the closure planning and the written confirmation that closure planning has been completed.

Once OEH has approved the certified statement of completion, Council can cease the maintenance and monitoring of the site, and any of the financial assurance requirements will lapse.

11.0 REPORTING

Reporting is required to produce systematic, comprehensive and informative reports on the environmental monitoring and operational activities of the landfill. Performance assessments are based on the reports and provide the basis of information to the OEH for review of the LEMP. The reports required are described in the following sections.

11.1 General

The following Licence Conditions (EPL 5862) relate to general reporting conditions for the WGRRP:

'6 Reporting conditions

R1 Annual return documents

What documents must an Annual Return contain?

R1.1 The licensee must complete and supply to the EPA an Annual Return in the approved form comprising:

(a) a Statement of Compliance; and
(b) a Monitoring and Complaints Summary.

A copy of the form in which the Annual Return must be supplied to the EPA accompanies this licence. Before the end of each reporting period, the EPA will provide to the licensee a copy of the form that must be completed and returned to the EPA.

Period covered by Annual Return

R1.2 An Annual Return must be prepared in respect of each reporting period, except as provided below.

Note: The term "reporting period" is defined in the dictionary at the end of this licence. Do not complete the Annual Return until after the end of the reporting period.

R1.3 Where this licence is transferred from the licensee to a new licensee:

(a) the transferring licensee must prepare an Annual Return for the period commencing on the first day of the reporting period and ending on the date the application for the transfer of the licence to the new licensee is granted; and

(b) the new licensee must prepare an Annual Return for the period commencing on the date the application for the transfer of the licence is granted and ending on the last day of the reporting period.

Note: An application to transfer a licence must be made in the approved form for this purpose.

R1.4 Where this licence is surrendered by the licensee or revoked by the EPA or Minister, the licensee must prepare an Annual Return in respect of the period commencing on the first day of the reporting period and ending on:

(a) in relation to the surrender of a licence - the date when notice in writing of approval of the surrender is given; or

(b) in relation to the revocation of the licence - the date from which notice revoking the licence operates.

Deadline for Annual Return

R1.5 The Annual Return for the reporting period must be supplied to the EPA by registered post not later than 60 days after the end of each reporting period or in the case of a transferring licence not later than 60 days after the date the transfer was granted (the 'due date').

Licensee must retain copy of Annual Return

R1.7 The licensee must retain a copy of the Annual Return supplied to the EPA for a period of at least 4 years after the Annual Return was due to be supplied to the EPA.

Certifying of Statement of Compliance and signing of Monitoring and Complaints Summary

R1.8 Within the Annual Return, the Statement of Compliance must be certified and the Monitoring and Complaints Summary must be signed by:

(a) the licence holder; or

(b) by a person approved in writing by the EPA to sign on behalf of the licence holder.

R1.9 A person who has been given written approval to certify a certificate of compliance under a licence issued under the Pollution Control Act 1970 is taken to be approved for the purpose of this condition until the date of first review of this licence.

R1.10 The Annual Return must be accompanied by/or include an Annual Report which must contain an assessment of environmental performance relevant to licence conditions including:

a) tabulated results of all monitoring data required to be collected by this licence;

b) a graphical presentation of data from at least the last three years (if available) in order to show variability/and or trends. Any statistically significant variations or anomalies should be highlighted and explained;

c) an analysis and interpretation of all monitoring data;

d) an analysis of and response to any complaints received;

e) identification of any deficiencies in environmental performance identified by the monitoring data, trends or incidents and of remedial action taken or proposed to be taken to address these deficiencies; and

f) recommendations on improving the environmental performance of the facility.

R2 Notification of environmental harm

Note: The licensee or its employees must notify the EPA of incidents causing or threatening material harm to the environment as soon as practicable after the person becomes aware of the incident in accordance with the requirements of Part 5.7 of the Act.

R2.1 Notifications must be made by telephoning the Environment Line service on 131 555.

R2.2 The licensee must provide written details of the notification to the EPA within 7 days of the date on which the incident occurred.

R3 Written report

R3.1 Where an authorised officer of the EPA suspects on reasonable grounds that:

(a) where this licence applies to premises, an event has occurred at the premises; or

(b) where this licence applies to vehicles or mobile plant, an event has occurred in connection with the carrying out of the activities authorised by this licence,

and the event has caused, is causing or is likely to cause material harm to the environment (whether the harm occurs on or off premises to which the licence applies), the authorised officer may request a written report of the event.

R3.2 The licensee must make all reasonable inquiries in relation to the event and supply the report to the EPA within such time as may be specified in the request.

R3.3 The request may require a report which includes any or all of the following information:

(a) the cause, time and duration of the event;

(b) the type, volume and concentration of every pollutant discharged as a result of the event;

(c) the name, address and business hours telephone number of employees or agents of the licensee, or a specified class of them, who witnessed the event;

(d) the name, address and business hours telephone number of every other person (of whom the licensee is aware) who witnessed the event, unless the licensee has been unable to obtain that information after making reasonable effort;

(e) action taken by the licensee in relation to the event, including any follow-up contact with any complainants;

(f) details of any measure taken or proposed to be taken to prevent or mitigate against a recurrence of such an event; and

(g) any other relevant matters.

R3.4 The EPA may make a written request for further details in relation to any of the above matters if it is not satisfied with the report provided by the licensee. The licensee must provide such further details to the EPA within the time specified in the request.

R4 Recording of fires

R4.1 The licensee must maintain a daily log and record the following data of fires at the site:

(a) Time and date when the fire was deliberately started or reported.

(b) Whether the fire was authorised by the licensee, and, if not, the circumstances which ignited the fire.

(c) The time and date that the fire ceased and whether it burnt out or was extinguished.

(d) The location of fire (eg. clean timber stockpile, putrescible garbage cell, etc).

(e) Prevailing weather conditions.

(f) Observations made in regard to smoke direction and dispersion.

(g) The amount of waste that was combusted by the fire.

(h) Action taken to extinguish the fire.

R4.2 The licensee or its employees or agents must notify the EPA in accordance with conditions R2.1 and R2.2 of all fires at the premises as soon as practical after becoming aware of the incident.

R5 Landfill Gas Hazard Reporting

R5.1 The licensee must notify the EPA within 24 hours in accordance with condition R2.1 if surface monitoring detects methane above 1.25% (v/v), and increase the frequency of monitoring to daily, until the EPA determines otherwise.'

11.2 Incident Reporting

11.2.1 Requirements

In addition to the general reporting conditions outlined above, the following Licence Conditions (EPL 5862) relate to incident reporting at the WGRRP:

'M7 Non-permitted waste incidents

M7.1 The licensee must maintain a record of all events involving the removal of any waste that was brought to the facility and which is not permitted to be disposed of at the facility.'

11.2.2 Incident Definition

OEH will be notified of any incident that represents a threat to the environment and which may lead to a breach of licence conditions. Such incidents include (as outlined in the Landfill Guidelines):

- Identifying non-domestic quantities (more than 200 mL/tonne or 200 g/tonne) of hazardous substances among the waste.
- Fires at the landfill, either surface or subsurface.
- Mixing of leachate and stormwater, or waste and stormwater.
- Identification of any failure of an environmental protection system.
- Identification of significant difference in groundwater indicator parameters.
- Detection of landfill gas in surface or building monitoring at concentrations greater than 1.25% methane (v/v).
- Any other incident or observation that could potentially pose an immediate environmental hazard outside normal operating conditions.
- Any proposed change in the landfill's ownership or occupier. (OEH approval required before the ownership or occupier may change, ie transfer of licence).

11.2.3 Telephone Reporting

Initial contact can be made via the OEH's 24 hour Pollution Line within three hours of the incident first being identified. The Pollution Line can be reached on 131 555, or 02 9995 5555, if calling from outside NSW.

11.2.4 Written Reporting

A written notice of any incidents as defined above should be made to the NSW OEH within seven days of the incident occurring.

11.2.5 Responsible Party

- Waste Coordinator.
- Operations Administrator.

11.3 Trade Waste Agreement

A trade waste agreement (TWA) for the leachate treatment plant of the site has been issued by Sydney Water on 15 November 2011. The TWA (Consent No.11205) specifies load limits and concentrations for ammonia, biochemical oxygen demand (BOD), suspended solids (SS) and Total dissolved solids (TDS) for the discharge of treated leachate as well as sampling and reporting requirements.

Council's reporting requirements under the TWA are as follows:

- Results of analytical testing must be submitted to Sydney Water within 21 days of sampling;
- The results of the trade waste sampling shall be summarised in the annual report;
- Sydney Water must be notified in writing within seven days of:
  - any failure to obtain samples;
  - any loss of analytical data; and
  - any failure in the discharge flow meter.

In addition, Council will make the results of the trade waste monitoring available to the OEH in the annual report.

11.4 Monthly Reporting (OEH)

The landfill guidelines (EPA 1996) require the landfill operator to submit to the OEH a report on the total tonnage of waste received and tonnages of specific source-separated wastes. This report is due by the 14th day of the following month in a format specified by the OEH in the landfill guidelines.

11.5 Annual Reporting and Annual Returns

11.5.1 Requirements

In addition to the general reporting conditions outlined in Section 11.1, the following Licence Conditions (EPL 5862) relate to annual reporting and annual returns at the WGRRP:

'M2.2 The licensee must make available to the EPA the results of monthly Trade Waste Monitoring of leachate and include these results in the Annual Report.

11.5.2 Management Strategy, Task and Actions

The Annual Return comprises a form provided by OEH, which should be filled in by Council and returned to OEH. This will be provided each year in support of the annual licence renewal application (with all information up to date to within 60 days of the licence renewal date). The Annual Return will be accompanied by an Annual Report, which will include the following sections:

- *Summary Report* - this will include the total non-hazardous waste received during the previous 12 months (including cover material), its composition and its eventual fate (including recycling markets).
- *Landfill Volume Report* - this will include a report from Council's Surveyor of the volume of landfill space consumed in the period for which the report is prepared and the estimate of compaction that this volume represents. An estimation of remaining landfill capacity and life based on current and projected waste acceptance rates will be made.
- *Hydrogeological Report* - this will assess the changes detected in the groundwater monitoring results over the period of operation, updated for the last 12 months. Any changes in hydraulic gradient or statistically significant variations in contaminant concentrations should be highlighted and explained.
- *Leachate Collection Report* - this will identify the quantity and composition of any leachate generated over the past 12 months. Any trends should be highlighted and explained in terms of the biological

activity within the landfill. The trends should generally be related to monthly rainfall and quarterly sampling results.

- *Surface Water Report* - this will summarise the surface water monitoring results over the period of operation for the past 12 months. Any changes in water levels and statistically significant variations in contaminants should be highlighted and explained.
- *Landfill Gas Emissions Report* - this will summarise the gas monitoring results over the period of operation for the past 12 months. Any trends should be highlighted and explained.
- *Dust Report* - this will summarise all dust monitoring results gathered over the past 12 months, with statistically significant variations explained.
- *Incident Report* - this will summarise any incident reported for the 12 month period.
- *Complaints Report* - this will record odour, litter, noise or other complaints received by the facility in the past 12 months, including comments on their correlation with prevailing weather conditions or waste reception circumstances.
- *Rehabilitation Report* - describing rehabilitation works carried out over the past twelve months
- *Proposed Site Operations for the Following year* – describing the landfilling operations, environment protection, construction works and rehabilitation planned for the following year.

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Whytes Gully Waste Disposal Depot Borrow Pit Geotechnical Investigation Laboratory Report (Wollongong City Council Geotechnical Services, 27 June 2010)

Whytes Gully Waste Disposal Depot New Cell Floor Investigation Laboratory Report (Wollongong City Council Geotechnical Services, 26 June 2010)

Small Vehicle Transfer Station Whytes Gully Waste Disposal Depot Kembla Grange (Kevin Bogie, Wollongong City Council pers. comm., 1 May 2010)

Report for Whytes Gully and Helensburgh Landfill Sites Landfill Gas Surface Emissions, Building Accumulation and Manifold Monitoring (GHD, April 2011).

Report Signature Page

GOLDER ASSOCIATES PTY LTD





Daniel Dohle
Senior Waste Management Engineer

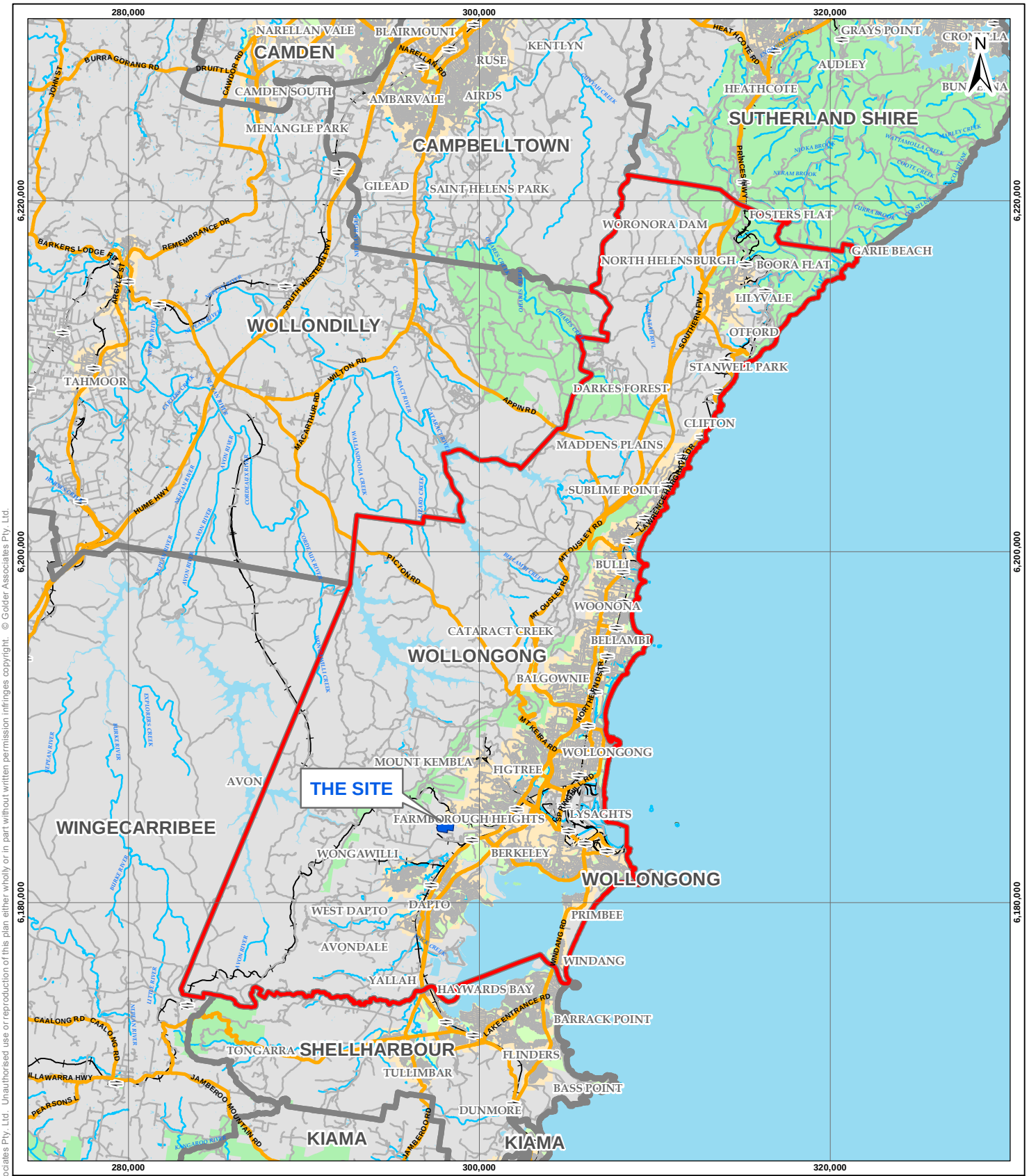
Jacinta McMahon
Principal Environmental Engineer

DD/JLM/df,gl

A.B.N. 64 006 107 857

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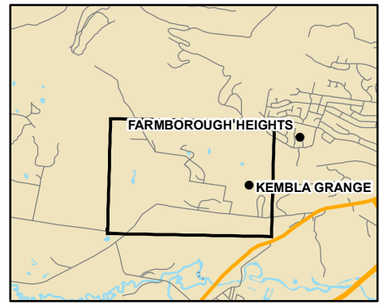
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WHYTES GULLY NEW LANDFILL CELL LANDFILL ENVIRONMENTAL MANAGEMENT PLAN

WOLLONGONG CITY COUNCIL

SITE LOCATION PLAN, LOCAL



LEGEND

- Site Boundary
- Approximate Extent Of Waste
- Extent of Landfill Works

NOTES

Imagery copyright Microsoft Corporation

Extent of waste based on site observations and information provided by Council.

Extent of landfill works as per Golder Design Report.

0 50 100 200 300 metres

SCALE (at A3) **1:7,000**

Coordinate System: GDA 1994 MGA Zone 56

PROJECT: **117625003**
DATE: **6/03/2012**
DRAWN: **FA`**
CHECKED: **JMc**

FIGURE 2

Golder Associates

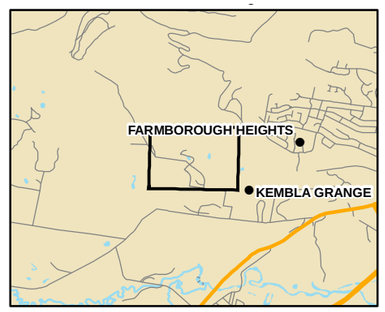
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WHYTES GULLY NEW LANDFILL CELL LANDFILL ENVIRONMENTAL MANAGEMENT PLAN

WOLLONGONG CITY COUNCIL

EXISTING SITE LAYOUT



298,000

6,184,000

N

Western Gully Landfill

Current Tipping Area

Eastern Gully Landfill

Waste Oil Drop Off

Old Weighbridge

Recoverables Drop Off and Buy Back

Secondary Leachate Pond

Green Waste Area

Small Vehicles Recyclables Drop Off

Leachate Treatment Plant

Primary Leachate Pond

Small Vehicle Waste Transfer Station in Former SWERF Building

Weighbridge

Surface Water Reed Beds

Materials Recovery Facility

Glengarry Cottage

Surface Water Polishing Pond

Main Site Entry

Surface Water Discharge Point

Secondary Site Entry

REDDALL'S ROAD

298,000

6,184,000

LEGEND

- Site Boundary
- Extent of Waste
- Extent of Landfill Works

NOTES

Extent of waste based on site observations and information provided by Council.

Aerial Ortho-Photograph provided by AAM Pty. Ltd. taken on 16 May 2011, Reference 18763A. Image Georeferenced.

Extend of landfill works as per Golder Design Report.

0 15 30 60 90 120 150 metres

SCALE (at A3) **1:3,800**

Coordinate System: GDA 1994 MGA Zone 56

PROJECT:	**117625003**
DATE:	**22/02/2012**
DRAWN:	**FA**
CHECKED:	**JMc**

FIGURE 3

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298,000



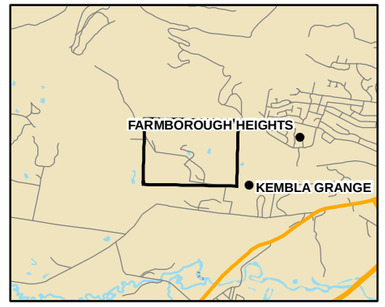
6,184,000

298,000

WHYTES GULLY NEW LANDFILL CELL LANDFILL ENVIRONMENTAL MANAGEMENT PLAN

WOLLONGONG CITY COUNCIL

EXISTING SITE CONTOURS AND CURRENT MONITORING LOCATIONS



LEGEND

- Existing Monitoring Location
- Site Contours
- Site Boundary
- Approximate Extent Of Waste
- Extent of Landfill Works

NOTES

Extent of waste based on site observations and information provided by Council.

Aerial Ortho-Photograph provided by AAM Pty. Ltd. taken on 16 May 2011, Reference 18763A. Image Georeferenced.

Extent of landfill works as per Golder Design Report.

Site contours based on survey by KFW Williams, dated 20/07/2011

0 12.5 25 50 75 100 125 150 metres

SCALE (at A3) 1:4,000

Coordinate System: GDA 1994 MGA Zone 56

PROJECT:	117625003
DATE:	12/03/2012
DRAWN:	FA
CHECKED:	JMc

FIGURE 4

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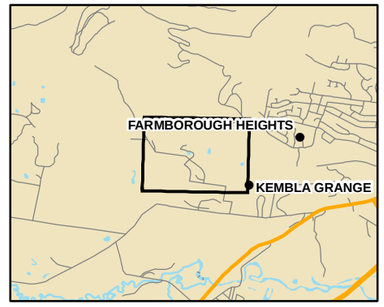
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WHYTES GULLY NEW LANDFILL CELL LANDFILL ENVIRONMENTAL MANAGEMENT PLAN

WOLLONGONG CITY COUNCIL

GEOLOGICAL AREAS



LEGEND

- Site Boundary
- Approximate Extent Of Existing Landfill Boundary

Geological Area

- Area 1 - Pheasants Nest Formation
- Area 2 - Budgong Sandstone Formation
- Area 3 - Alluvial Soils
- Area 4 - Capping Layer and Landfill

NOTES

Geological Areas as per the Wollongong - Port Hacking (DPI,1985) Geological Map (1:100,000)

Aerial Ortho-Photograph provided by AAM Pty. Ltd. taken on 16 May 2011, Reference 18763A. Image Georeferenced.

0 15 30 60 90 120 150 metres

SCALE (at A3) 1:4,500

Coordinate System: GDA 1994 MGA Zone 56

PROJECT: **117625003**
DATE: **12/03/2012**
DRAWN: **FA**
CHECKED: **BJF**

FIGURE 5

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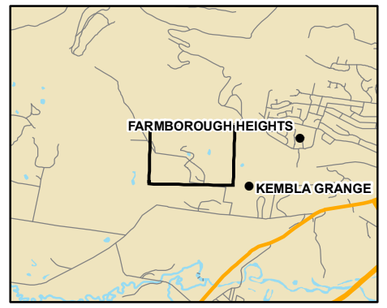
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WHYTES GULLY NEW LANDFILL CELL LANDFILL ENVIRONMENTAL MANAGEMENT PLAN

WOLLONGONG CITY COUNCIL

FLORA AND FAUNA



LEGEND

- White-flowered Wax Plant
- Site Boundary
- Extent of Landfill Works

Habitat

- High
- Moderate

Endangered Ecological Communities

- Coastal Grassy Red Gum Forest
- Lowland Dry-Subtropical Rainforest
- Lowland Woollybutt-Melaleuca Forest

Biosis Vegetation

- Acacia Scrub/Exotic
- Closed Exotic Grasslad
- Forest-Redgum Open Forest/Woodland
- Lowland Dry Subtropical Rainforest
- Moist-Box Redgum Foothills Forest
- Planted

NOTES

Aerial Ortho-Photograph provided by AAM Pty. Ltd. taken on 16 May 2011, Reference 18763A. Image Georeferenced.

Extent of landfill works as per Golder design report.

Ecological data as provided by Biosis Pty Ltd on 20 December 2011.

0 25 50 100 150 metres

SCALE (at A3) 1:3,600

Coordinate System: GDA 1994 MGA Zone 56

PROJECT: 117625003
DATE: 6/03/2012
DRAWN: FA
CHECKED: BJF

FIGURE 6

Golder Associates

File Location: J:\GIS\Jobs\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Workspaces\117625003_061_R_F0006_LEMP_Rev0.mxd

298,000



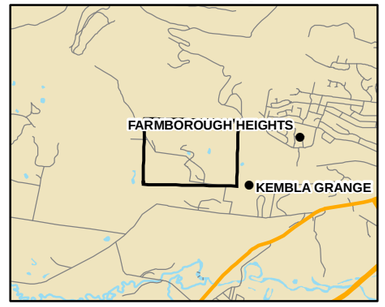
6,184,000

298,000

WHYTES GULLY NEW LANDFILL CELL LANDFILL ENVIRONMENTAL MANAGEMENT PLAN

WOLLONGONG CITY COUNCIL

HERITAGE AND ARCHAEOLOGICAL ITEMS



LEGEND

- AHIMS Results in Study Area
- Heritage Area (Glengarry Cottage)
- Aboriginal Archaeological Sites
- Site Boundary
- Extent of Landfill Works
- Cadastre

NOTES

Glengarry cottage heritage area provided by Council.

Aerial Ortho-Photograph provided by AAM Pty. Ltd. taken on 16 May 2011, Reference 18763A. Image Georeferenced.

Extent of landfill works as per Golder Design Report.

Aboriginal heritage areas as identified by Biosis (2011).

0 12.5 25 50 75 100 125 150 metres

SCALE (at A3) 1:4,000

Coordinate System: GDA 1994 MGA Zone 56

PROJECT: **117625003**
DATE: **5/03/2012**
DRAWN: **FA**
CHECKED: **JMc**

FIGURE 7

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298,000

PAH
7/12/2011

PAH
8/09/2011

Open Site
52-2-3867

ASF
8/09/2011

90

90

N

6,184,000

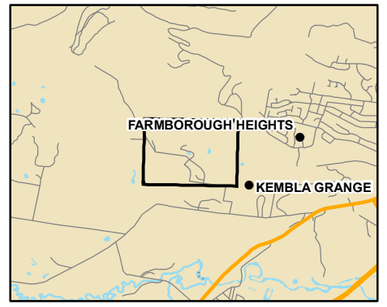
6,184,000

298,000

WHYTES GULLY NEW LANDFILL CELL LANDFILL ENVIRONMENTAL MANAGEMENT PLAN

WOLLONGONG CITY COUNCIL

DEVELOPMENT CONSTRAINTS



LEGEND

- Site Boundary
- Cadastre
- Easement
- Flood Planning Area (West Dapto LEP)
- Interpreted Flood Planning Area (50 cm Freeboard)
- Heritage
- Aboriginal Archaeological Sites (12/01/2012)
- AHIMS Results in Study Area (12/01/2012)
- Extent of Landfill Works

NOTES

Historic locations digitised by Golder from reports supplied by Wollongong City Council

Aerial Ortho-Photograph provided by AAM Pty. Ltd. taken on 16 May 2011, Reference 18763A. Image Georeferenced.

Site contours based on survey by KFW Williams, dated 20/07/2011

0 12.5 25 50 75 100 125 150 metres

SCALE (at A3) 1:4,000

Coordinate System: GDA 1994 MGA Zone 56

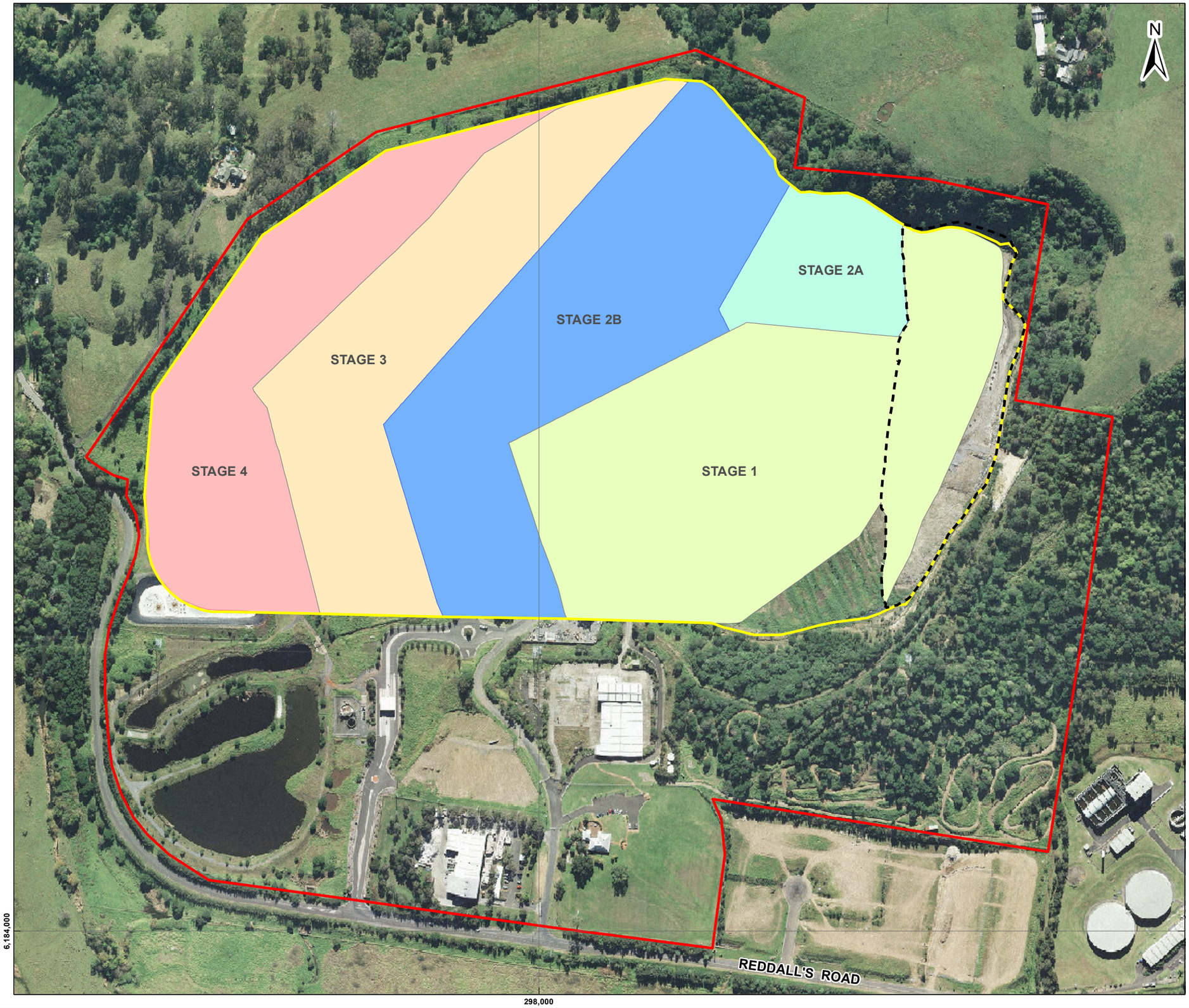
PROJECT: **117625003**
DATE: **26/03/2012**
DRAWN: **FA**
CHECKED: **JMc**

FIGURE 8

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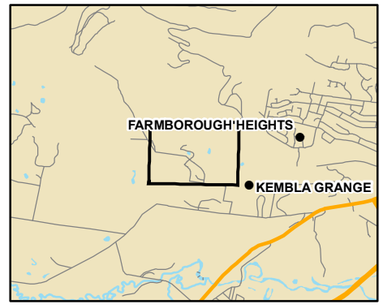


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WHYTES GULLY NEW LANDFILL CELL LANDFILL ENVIRONMENTAL MANAGEMENT PLAN

WOLLONGONG CITY COUNCIL

PROJECT STAGING



LEGEND

- Site Boundary
- Extent of Landfill Works
- Proposed Area of Waste Cut
- Stage1
- Stage2a
- Stage2b
- Stage3
- Stage4

NOTES

Extent of waste based on site observations and information provided by Council.

Aerial Ortho-Photograph provided by AAM Pty. Ltd. taken on 16 May 2011, Reference 18763A. Image Georeferenced.

Extent of landfill works as per Golder Design Report.

0 25 50 100 150 metres

SCALE (at A3) 1:3,800

Coordinate System: GDA 1994 MGA Zone 56

PROJECT: **117625003**
DATE: **26/03/2012**
DRAWN: **FA**
CHECKED: **JMc**

FIGURE 9

Golder Associates

File Location: J:\GIS\Jobs\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Workspaces\117625003_116_R_F0001_ProjectStaging_Rev1.mxd

298,000

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85
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20

Western Gully Landfill

Eastern Gully Landfill

Indicative New Leachate Pond Footprint

LTP

Indicative New Surface Water Pond Footprint

REDDALL'S ROAD

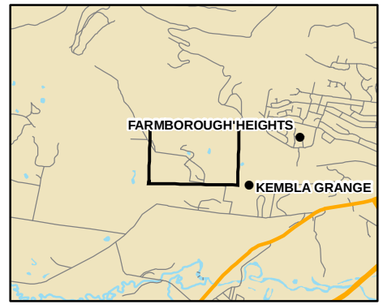
6,184,000

298,000

WHYTES GULLY NEW LANDFILL CELL LANDFILL ENVIRONMENTAL MANAGEMENT PLAN

WOLLONGONG CITY COUNCIL

PROJECT FOOTPRINT



LEGEND

- Contours of Final Landform (5 m interval)
- Site Boundary
- Approximate Extent of Waste
- Extent of Landfill Works
- Indicative New Leachate Pond Footprint
  New Leachate Pond to be established prior to commencement of Stage 4 construction
- Indicative New Surface Water Pond Footprint
  Surface Water Pond to be reduced in size prior to commencement of Stage 4 construction
- Indicative, augmented LTP footprint.
  LTP footprint will be assessed at the end of 2014.
- Existing Leachate Treatment Plant (LTP) Footprint

NOTES

Extent of waste based on site observations and information provided by Council.

Aerial Ortho-Photograph provided by AAM Pty. Ltd. taken on 16 May 2011, Reference 18763A. Image Georeferenced.

Extent of landfill works as per Golder Design Report.

0 25 50 100 150 metres

SCALE (at A3) 1:3,800

Coordinate System: GDA 1994 MGA Zone 56

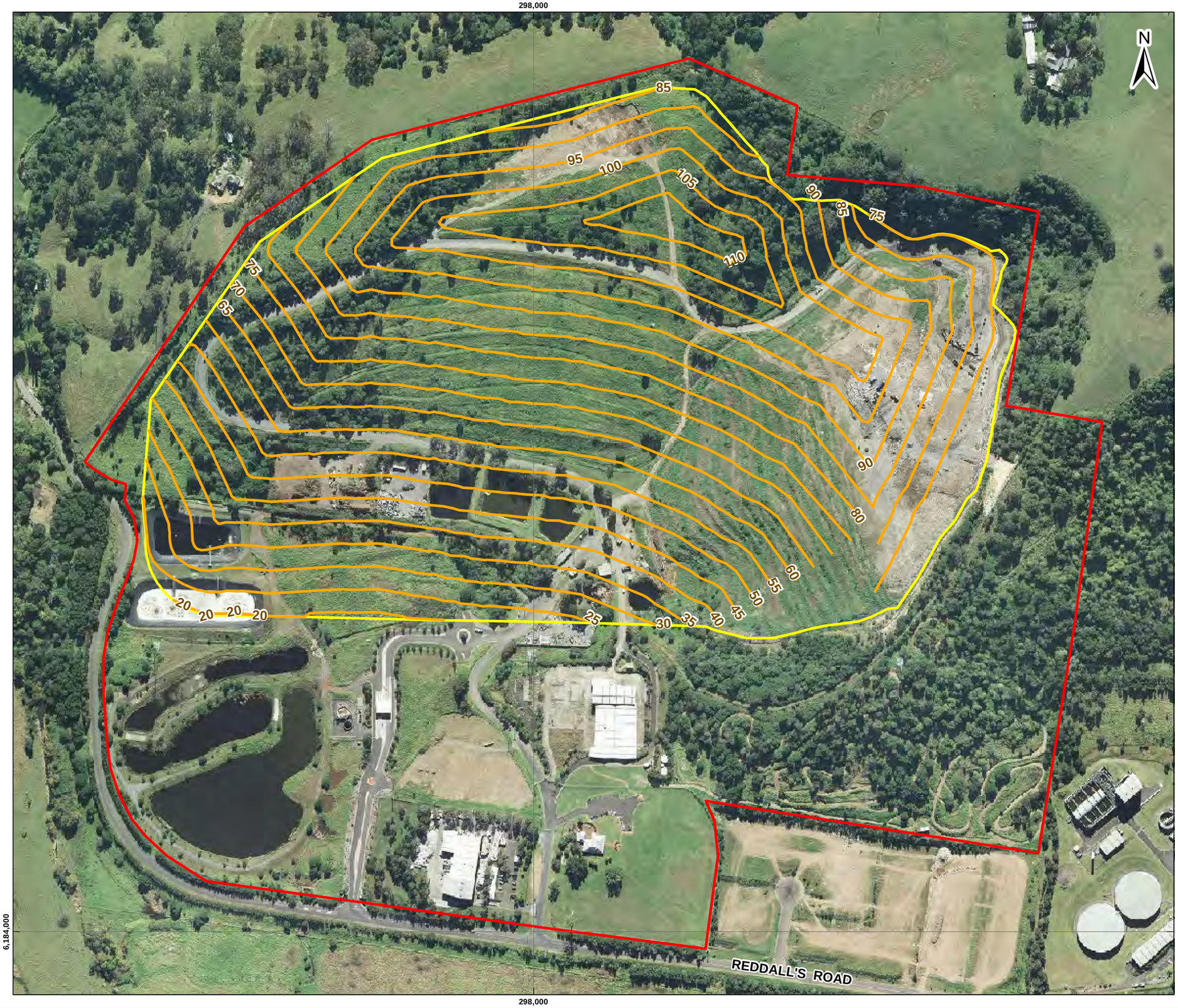
PROJECT: **117625003**
DATE: **22/02/2012**
DRAWN: **FA**
CHECKED: **JMc**

FIGURE 10

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WHYTES GULLY NEW LANDFILL CELL
LANDFILL ENVIRONMENTAL
MANAGEMENT PLAN
WOLLONGONG CITY COUNCIL

FINAL LANDFORM

LEGEND

- Contours of Final Landform (5 m interval)
- Site Boundary
- Extent of Landfill Works

NOTES

Aerial Ortho-Photograph provided by AAM Pty. Ltd. taken on 16 May 2011, Reference 18763A. Image Georeferenced.

Extent of landfill works and final contours as per Golder Design Report.

0 25 50 100 150 metres

SCALE (at A3) 1:3,800

Coordinate System: GDA 1994 MGA Zone 56

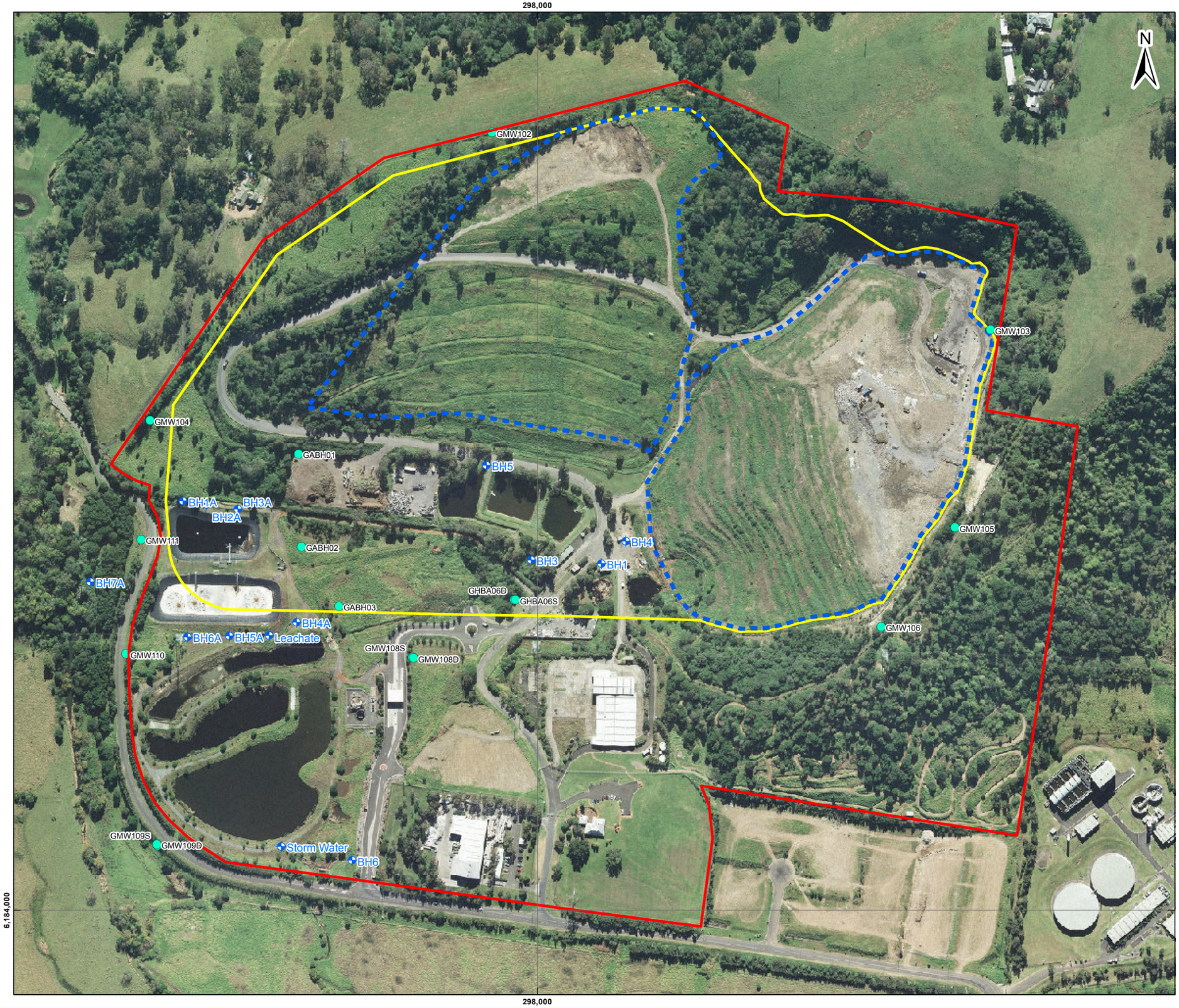
PROJECT: 117625003
DATE: 5/03/2012
DRAWN: FA
CHECKED: JMc

FIGURE 11

Golder Associates

File Location: J:\GIS\Jobs\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Workspaces\117625003_128_R_F0001_Landform_Rev0.mxd

298,000



6,184,000

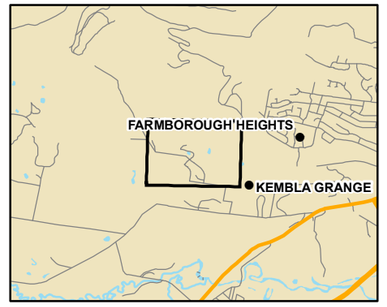
298,000

6,184,000

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WHYTES GULLY NEW LANDFILL CELL
LANDFILL ENVIRONMENTAL MANAGEMENT PLAN
WOLLONGONG CITY COUNCIL

PROPOSED WATER MONITORING LOCATIONS



LEGEND

- Proposed Ground Water Monitoring Locations
- Existing Monitoring Location
- Approximate Extent Of Waste
- Extent of Landfill Works
- Site Boundary

NOTES

Extent of waste based on site observations and information provided by Council.

Aerial Ortho-Photograph provided by AAM Pty. Ltd. taken on 16 May 2011, Reference 18763A. Image Georeferenced.

Extent of landfill works as per Golder Design Report.

Investigation locations surveyed by KFW Williams.

0 25 50 100 150 metres

SCALE (at A3) **1:4,000**

Coordinate System: GDA 1994 MGA Zone 56

PROJECT: **117625003**
DATE: **26/03/2012**
DRAWN: **FA`**
CHECKED: **JMc**

FIGURE 12

Golder Associates

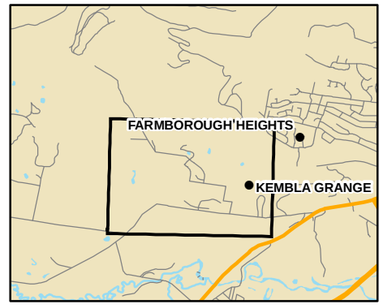
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WHYTES GULLY NEW LANDFILL CELL LANDFILL ENVIRONMENTAL MANAGEMENT PLAN

WOLLONGONG CITY COUNCIL

PROPOSED SURFACE WATER MONITORING LOCATIONS



297,000 297,500 298,000 298,500 299,000

6,184,500 6,184,000 6,183,500

FARMBOROUGH RD
Farmborough Road
Moss Vale Unanderra Railway
Kanahs Place
REDDALL Reddalls Road
West Dapto Road
WEST DAPTO RD
Kembla Grange
DAPTO CREEK
CREEK
Wylies Road
Moss Vale Unanderra Railway
Jess Road

1 2 3 4 5 6

N

LEGEND

- Existing Monitoring Well Location
- Surface Water Monitoring Locations
- Site Boundary
- Approximate Extent Of Waste
- Extent of Landfill Works

NOTES

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More information can be found here:
http://www.nearmap.com/

Extent of waste based on site observations and information provided by Council.

Extent of landfill works as per Golder Design Report.

0 50 100 200 300 metres

SCALE (at A3) 1:7,000

Coordinate System: GDA 1994 MGA Zone 56

PROJECT: 117625003
DATE: 26/03/2012
DRAWN: FA
CHECKED: JMc

FIGURE 13

Golder Associates

File Location: J:\GIS\Jobs\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Workspaces\117625003_120_R_F0005_ProposedSurfaceWaterMonitoringLocations_Rev2.mxd

298,000



6,184,000

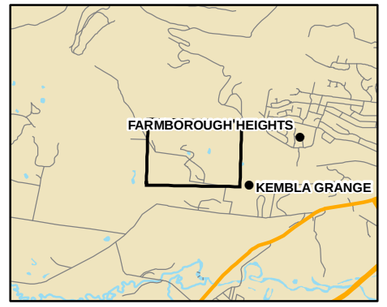
298,000

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WHYTES GULLY NEW LANDFILL CELL LANDFILL ENVIRONMENTAL MANAGEMENT PLAN

WOLLONGONG CITY COUNCIL

PROPOSED LANDFILL GAS MONITORING LOCATIONS



LEGEND

- Proposed Landfill Gas Monitoring Wells (Stage 1)
- Proposed Landfill Gas Monitoring Wells (Future Stages)
- Site Boundary
- Approximate Extent Of Waste
- Extent of Landfill Works

NOTES

Extent of waste based on site observations and information provided by Council.

Aerial Ortho-Photograph provided by AAM Pty. Ltd. taken on 16 May 2011, Reference 18763A. Image Georeferenced.

Extent of landfill works as per Golder Design Report.

Rationale for landfill gas monitoring locations is outlined in LEMP and EA chapter 12. Monitoring wells to be installed in stages during development of landfill.

0 25 50 100 150 metres

SCALE (at A3) 1:4,000

Coordinate System: GDA 1994 MGA Zone 56

PROJECT: 117625003
DATE: 6/03/2012
DRAWN: FA`
CHECKED: JMc

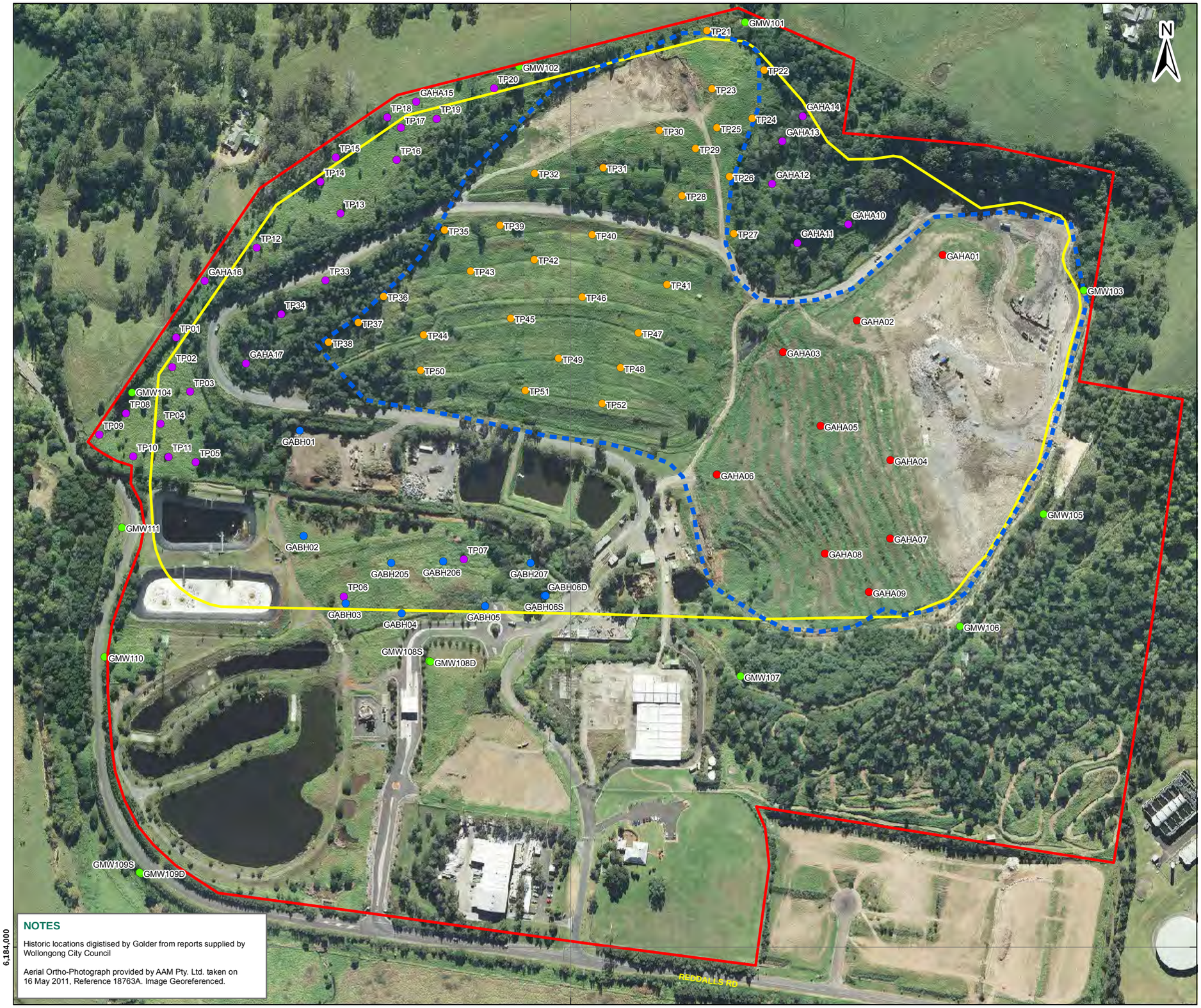
FIGURE 14

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File Location: J:\GIS\Jobs\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Workspaces\117625003_061_R_F0014_Proposed_LFG_MonitoringLocations_Rev0.mxd

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NOTES

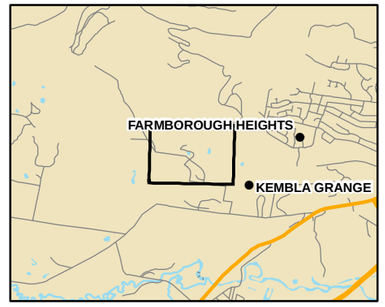
Historic locations digitised by Golder from reports supplied by Wollongong City Council

Aerial Ortho-Photograph provided by AAM Pty. Ltd. taken on 16 May 2011, Reference 18763A. Image Georeferenced.

WHYTES GULLY NEW LANDFILL CELL LANDFILL ENVIRONMENTAL MANAGEMENT PLAN

WOLLONGONG CITY COUNCIL

CURRENT SITE INVESTIGATION LOCATIONS



LEGEND

- New Cell Floor Investigation Location and Monitoring Well
- Ground Water Monitoring Well
- Exisiting Capping Hand Auger Location
- Exisiting Capping Test Pit Location
- Borrow Pit Test Pit Hand Auger Investigation Location
- Site Boundary
- Final Landfill Footprint
- Approximate Extent Of Waste

0 12.5 25 50 75 100 125 metres

SCALE (at A3) 1:3,600

Coordinate System: GDA 1994 MGA Zone 56

PROJECT: 117625003
DATE: 6/03/2012
DRAWN: FA
CHECKED: BJF

FIGURE 15

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File Location: J:\GIS\Jobs\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Workspaces\117625003_077_R_F0004_CurrentSiteInvestigationLocations_Rev03.mxd

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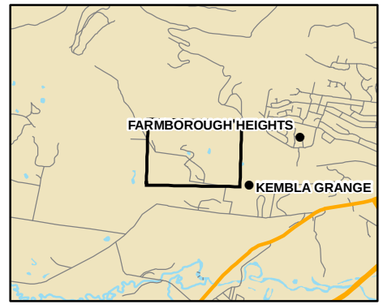
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WHYTES GULLY NEW LANDFILL CELL
LANDFILL ENVIRONMENTAL MANAGEMENT PLAN
WOLLONGONG CITY COUNCIL

GROUNDWATER CONTOURS



LEGEND

- Groundwater Level (mAHD) - August 2011
- Groundwater Contours
- Site Boundary
- Approximate Extent Of Waste
- Extent of Landfill Works

Note: groundwater elevation contours have been estimated by linear interpolation between well locations, with minor adjustments based on professional judgement. Actual groundwater elevations in areas of limited data coverage (e.g. within the existing cells) may differ to an unknown extent from the estimated contour locations presented.

NOTES

Extent of waste based on site observations and information provided by Council.

Aerial Ortho-Photograph provided by AAM Pty. Ltd. taken on 16 May 2011, Reference 18763A. Image Georeferenced.

Extent of landfill works as per Golder Design Report.

0 25 50 100 150 metres

SCALE (at A3) 1:4,000

Coordinate System: GDA 1994 MGA Zone 56

PROJECT: 117625003
DATE: 22/02/2012
DRAWN: RB/FA
CHECKED: LBJ

FIGURE 16

Golder Associates

APPENDIX A

Development Consent Conditions, Environment Protection Licence and Trade Waste Agreement

Section 55 Protection of the Environment Operations Act 1997

Environment Protection Licence

Licence - 5862

Licence Details	
Number:	5862
Anniversary Date:	29-May

Licensee

WOLLONGONG CITY COUNCIL
LOCKED BAG 8821
WOLLONGONG NSW 2500

Licence Type

Premises

Premises

WHYTE'S GULLY WASTE DISPOSAL FACILITY
REDDALLS ROAD
KEMBLA GRANGE NSW 2526

Scheduled Activity

Waste disposal (application to land)

Fee Based Activity	Scale
Waste disposal (application to land)	0 - All

Region

Waste Operations (Wollongong)
59-61 Goulburn Street
SYDNEY NSW 2000
Phone: 02 9995 5000
Fax: 02 9995 5999

PO Box A290 SYDNEY SOUTH
NSW 1232

Environment Protection Licence

Licence - 5862

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Information about this licence

Dictionary

A definition of terms used in the licence can be found in the dictionary at the end of this licence.

Responsibilities of licensee

Separate to the requirements of this licence, general obligations of licensees are set out in the Protection of the Environment Operations Act 1997 ("the Act") and the Regulations made under the Act. These include obligations to:

- ensure persons associated with you comply with this licence, as set out in section 64 of the Act;
- control the pollution of waters and the pollution of air (see for example sections 120 - 132 of the Act); and
- report incidents causing or threatening material environmental harm to the environment, as set out in Part 5.7 of the Act.

Variation of licence conditions

The licence holder can apply to vary the conditions of this licence. An application form for this purpose is available from the EPA.

The EPA may also vary the conditions of the licence at any time by written notice without an application being made.

Where a licence has been granted in relation to development which was assessed under the Environmental Planning and Assessment Act 1979 in accordance with the procedures applying to integrated development, the EPA may not impose conditions which are inconsistent with the development consent conditions until the licence is first reviewed under Part 3.6 of the Act.

Duration of licence

This licence will remain in force until the licence is surrendered by the licence holder or until it is suspended or revoked by the EPA or the Minister. A licence may only be surrendered with the written approval of the EPA.

Licence review

The Act requires that the EPA review your licence at least every 5 years after the issue of the licence, as set out in Part 3.6 and Schedule 5 of the Act. You will receive advance notice of the licence review.

Fees and annual return to be sent to the EPA

For each licence fee period you must pay:

- an administrative fee; and
- a load-based fee (if applicable).

The EPA publication "A Guide to Licensing" contains information about how to calculate your licence fees.

The licence requires that an Annual Return, comprising a Statement of Compliance and a summary of any monitoring required by the licence (including the recording of complaints), be submitted to the EPA. The Annual Return must be submitted within 60 days after the end of each reporting period. See condition R1 regarding the Annual Return reporting requirements.

Usually the licence fee period is the same as the reporting period.

Transfer of licence

The licence holder can apply to transfer the licence to another person. An application form for this purpose is available from the EPA.

Public register and access to monitoring data

Part 9.5 of the Act requires the EPA to keep a public register of details and decisions of the EPA in relation to, for example:

- licence applications;
- licence conditions and variations;
- statements of compliance;
- load based licensing information; and
- load reduction agreements.

Under s320 of the Act application can be made to the EPA for access to monitoring data which has been submitted to the EPA by licensees.

This licence is issued to:

WOLLONGONG CITY COUNCIL
LOCKED BAG 8821
WOLLONGONG NSW 2500

subject to the conditions which follow.

1 Administrative conditions

A1 What the licence authorises and regulates

A1.1 Not applicable.

A1.2 This licence authorises the carrying out of the scheduled activities listed below at the premises specified in A2. The activities are listed according to their scheduled activity classification, fee-based activity classification and the scale of the operation.

Unless otherwise further restricted by a condition of this licence, the scale at which the activity is carried out must not exceed the maximum scale specified in this condition.

Scheduled Activity
Waste disposal (application to land)

Fee Based Activity	Scale
Waste disposal (application to land)	0 - All

A1.3 Not applicable.

A2 Premises to which this licence applies

A2.1 The licence applies to the following premises:

Premises Details
WHYTE'S GULLY WASTE DISPOSAL FACILITY
REDDALLS ROAD
KEMBLA GRANGE
NSW
2526
LOTS 50, 52 & 53 DP 1022266; LOT 2 DP 240557

A3 Other activities

A3.1 Not applicable.

A4 Information supplied to the EPA

A4.1 Works and activities must be carried out in accordance with the proposal contained in the licence application, except as expressly provided by a condition of this licence.

In this condition the reference to "the licence application" includes a reference to:
(a) the applications for any licences (including former pollution control approvals) which this licence replaces under the Protection of the Environment Operations (Savings and Transitional) Regulation 1998; and
(b) the licence information form provided by the licensee to the EPA to assist the EPA in connection with the issuing of this licence.

A4.2 The Whytes Gully Landfill Environmental Management Plan (LEMP), dated May 1998 is not to be taken as part of the documentation in A4.1, other than those parts specifically referenced in this licence.

2 Discharges to air and water and applications to land

P1 Location of monitoring/discharge points and areas

P1.1 The following points referred to in the table below are identified in this licence for the purposes of monitoring and/or the setting of limits for the emission of pollutants to the air from the point.

Air

EPA Identification no.	Type of Monitoring Point	Type of Discharge Point	Description of Location
3	Air emissions monitoring		Areas where intermediate or final cover has been placed.
4	Air emissions monitoring		Inside all buildings within 250 metres of deposited waste.

P1.2 The following points referred to in the table are identified in this licence for the purposes of the monitoring and/or the setting of limits for discharges of pollutants to water from the point.

P1.3 The following utilisation areas referred to in the table below are identified in this licence for the purposes of the monitoring and/or the setting of limits for any application of solids or liquids to the utilisation area.

Water and land

EPA identification no.	Type of monitoring point	Type of discharge point	Description of location
1	Stormwater monitoring and discharge point	Stormwater monitoring and discharge point	Overflow from spillway at south eastern corner of final stormwater pond, near western boundary of the recycling compound.
2	Water quality and volume monitoring		Eastern leachate dam, leachate collection well overflow
5	Groundwater quality monitoring		Directly east of Main Gate - BH-1.
6	Groundwater quality monitoring		Between leachate ponds and main sewer pump station

3 Limit conditions

L1 Pollution of waters

L1.1 Except as may be expressly provided in any other condition of this licence, the licensee must comply with section 120 of the Protection of the Environment Operations Act 1997.

L1.2 There must be no discharge of contaminated stormwater to waters under dry weather conditions or storm event(s) of less than 1:10 year 24 hour recurrence interval, that is 297.4mm of rainfall within a 24 hour time period.

"dry weather" means less than ten millimetres of rain falling within a 24 hour period.

Discharges of contaminated stormwater from the ponds following a 1:10 year 24 hour storm event (297.4mm of rainfall within a 24 hour time period) or greater do not constitute a breach of this licence.

L1.3 There must be no discharge of leachate to waters under dry weather conditions or storm event(s) of less than 1:25 year 24 hour recurrence interval, that is 371.5mm of rainfall within a 24 hour time period.

"dry weather" means less than ten millimetres of rain falling within a 24 hour period.

Discharges of leachate from the leachate pond following a 1:25year 24 hour storm event (371.5mm of rainfall within a 24 hour time period) or greater do not constitute a breach of this licence.

L2 Load limits

L2.1 Not applicable.

L2.2 Not applicable.

L3 Concentration limits

L3.1 For each monitoring/discharge point or utilisation area specified in the table\s below (by a point number), the concentration of a pollutant discharged at that point, or applied to that area, must not exceed the concentration limits specified for that pollutant in the table.

L3.2 Where a pH quality limit is specified in the table, the specified percentage of samples must be within the specified ranges.

L3.3 To avoid any doubt, this condition does not authorise the pollution of waters by any pollutant other than those specified in the table\s.

Water and Land

POINT 1

Pollutant	Units of Measure	50 percentile concentration limit	90 percentile concentration limit	3DGM concentration limit	100 percentile Concentration Limit
pH	pH				6.5 - 8.5
TSS	milligrams per litre				50

L4 Volume and mass limits

L4.1 Not applicable.

L5 Waste

L5.1 The licensee must not cause, permit or allow any waste to be received at the premises, except the wastes expressly referred to in the column titled “Waste” and meeting the definition, if any, in the column titled “Description” in the table below.

Any waste received at the premises must only be used for the activities referred to in relation to that waste in the column titled “Activity” in the table below.

Any waste received at the premises is subject to those limits or conditions, if any, referred to in relation to that waste contained in the column titled “Other Limits” in the table below.

Condition L5.1 does not limit any other conditions in this licence.

Code	Waste	Description	Activity	Other Limits
NA	General Solid Waste (non-putrescible)	As defined in Schedule 1 of the POEO Act, as in force from time to time	Waste Disposal (application to land)	
NA	General Solid Waste (putrescible)	As defined in Schedule 1 of the POEO Act, as in force from time to time	Waste Disposal (application to land)	
NA	Asbestos Waste	As defined in Schedule 1 of the POEO Act, as in force from time to time	Waste Disposal (application to land)	
NA		Any waste received on site that is below licensing thresholds in Schedule 1 of the POEO Act, as in force from time to time		NA

L5.2 The licensee must not dispose of any tyres on the premises which;
(a) have a diameter of less than 1.2 metres; and
(b) are delivered at the premises in a load containing more than 5 whole tyres; and
(c) became waste in the Sydney Metropolitan Area.

Note

This condition does not apply where:
(i) The tyres received comply with the EPA Tyre Disposal Specifications; or
(ii) The premises have the capacity, at the time of unloading the tyres, to comply with the EPA Tyre Disposal Specifications; or
(iii) The premises have the capacity, at the time of unloading the tyres, to recycle or reprocess the tyres into a saleable product, including retreading the tyres.

L5.3 Tyres stockpiled on the premises must:
(a) not exceed fifty (50) tonnes of tyres at any one time; and
(b) be located in a clearly defined area away from the tipping face; and
(c) be managed to control vermin; and
(d) be managed to prevent any tyres from catching fire.

L6 Noise Limits

L6.1 Not applicable.

L6.2 Not applicable.

4 Operating conditions

O1 Activities must be carried out in a competent manner

O1.1 Licensed activities must be carried out in a competent manner.

This includes:
(a) the processing, handling, movement and storage of materials and substances used to carry out the activity; and
(b) the treatment, storage, processing, reprocessing, transport and disposal of waste generated by the activity.

O2 Maintenance of plant and equipment

O2.1 All plant and equipment installed at the premises or used in connection with the licensed activity:
(a) must be maintained in a proper and efficient condition; and
(b) must be operated in a proper and efficient manner.

O3 Covering of Waste

O3.1 Daily cover must be either:

i. Virgin excavated natural materials ("VENM");
ii. Blast furnace slag or asphalt chipping in accordance the alternative daily cover specifications outlined in the DECC's correspondence dated 15 November 2007;
iii. A steel framed and fabric covered moveable structure; or
iv. A polymer and fibre based cover as outlined in the Wollongong City Council's correspondence to DECC dated 2 October 2007.

O3.2 For the purpose of condition O3.1, daily cover must be applied over all exposed landfilled waste prior to ceasing operations at the end of each day.

O3.3 Daily cover under condition O3.1 (i) and (ii) must be applied at a minimum depth of 150 mm over all exposed landfilled waste.

O4 Polymer & Fibre Alternative Daily Cover – Operational Trial

O4.1 The licensee may conduct an operational trial using polymer and fibre based alternative daily cover for a twelve (12) month period.

O4.2 The twelve (12) month operational trial period shall commence from the first day polymer and fibre based alternative daily cover is utilised at the premises.

O4.3 A polymer and fibre based alternative daily cover trial must conclude no later than 31 December 2008.

O4.4 The licensee must provide a written report to the DECC's Manager Waste Operations within thirty (30) days of the end of any operational trial. The report must include, but is not limited to:

(a) A qualitative assessment of the effectiveness of polymer and fibre based alternative daily cover in meeting the objectives of Benchmark Technique 33 of the DECC's Environmental Guidelines: Solid Waste Landfills (dated 1996); and

(b) A qualitative assessment of the in-field operational effectiveness of using polymer and fibre based alternative daily cover.

O5 Dust and litter control

O5.1 All operations and activities occurring at the premises must be carried out in a manner that will minimise the emission of dust from the premises.

O5.2 Facilities and/or equipment must be provided for the application of water to disturbed areas to minimise the generation of airborne dust from any area disturbed by activities associated with the development.

O5.3 All sealed surfaces intended to carry vehicular traffic must be kept clean.

O5.4 Unsealed roads used for material haulage must be kept sufficiently damp to prevent wind-blown or traffic generated dust.

O6 Closure plan

O6.1 The last licensee must prepare and submit to the EPA within 3 months of the last load of waste being landfilled, a closure plan in accordance with section 76 of the Protection of the Environment Operations Act 1997.

O7 Water pollution management

O7.1 Drainage from areas not subject to waste disposal activities must be directed away from the existing leachate collection pond(s).

O7.2 Disturbed areas must be provided with separate water quality controls for the treatment of runoff containing suspended or turbid pollutants.

O7.3 The licensee must maintain a leachate management system to collect and direct all leachate to a point for treatment and disposal to sewer.

O8 Screening of waste

O8.1 The licensee must have in place and implement procedures to identify and prevent the disposal of any waste not permitted by this licence to be disposed of at the premises.

O9 Completion of landfill cells

O9.1 The licensee must ensure that the landfill cells are capped progressively during operations and specifically at times when the level of waste reaches final heights specified in the LEMP.

O9.2 The surface of filled areas must have a minimum slope of one per cent with suitable design to prevent ponding of water. Any surface depressions that develop must be restored, graded and compacted to prevent further ponding of water.

O10 Fire control

O10.1 The licensee must take all necessary steps to extinguish all fires burning in wastes as soon as possible. The necessary steps must be taken within 30 minutes of the fire being ignited during the hours when the site is open to the public and within one hour of being notified of the existence during the hours when the site is not open to the public.

O10.2 The licensee must maintain a log recording:
(a) The time and date and location of any fire ignited or reported at the site.
(b) The prevailing weather conditions together with observations made in regard to smoke direction and dispersion.
(c) The time and date that the fire burnt out or was extinguished.

O11 Unauthorised entry

O11.1 The licensee must take all practicable steps to control entry to the premises.

O11.2 The licensee must ensure that all gates are locked whenever the landfill is unattended.

O12 Tracking of mud and waste

O12.1 The licensee must control the tracking of waste and mud by vehicles before departing the waste facility to minimise the tracking of waste and mud from these vehicles once they are outside of the waste facility.

5 Monitoring and recording conditions

M1 Monitoring records

M1.1 The results of any monitoring required to be conducted by this licence or a load calculation protocol must be recorded and retained as set out in this condition.

M1.2 All records required to be kept by this licence must be:
(a) in a legible form, or in a form that can readily be reduced to a legible form;
(b) kept for at least 4 years after the monitoring or event to which they relate took place; and
(c) produced in a legible form to any authorised officer of the EPA who asks to see them.

M1.3 The following records must be kept in respect of any samples required to be collected for the purposes of this licence:

(a) the date(s) on which the sample was taken;
(b) the time(s) at which the sample was collected;
(c) the point at which the sample was taken; and
(d) the name of the person who collected the sample.

M2 Requirement to monitor concentration of pollutants discharged

M2.1 For each monitoring/discharge point or utilisation area specified below (by a point number), the licensee must monitor (by sampling and obtaining results by analysis) the concentration of each pollutant specified in Column 1. The licensee must use the sampling method, units of measure, and sample at the frequency, specified opposite in the other columns:

Water and Land

POINT 1

Pollutant	Units of measure	Frequency	Sampling Method
Alkalinity (as calcium carbonate)	milligrams per litre	Special Frequency 1	Grab sample
Ammonia	milligrams per litre	Special Frequency 1	Grab sample
Calcium	milligrams per litre	Special Frequency 1	Grab sample
Chloride	milligrams per litre	Special Frequency 1	Grab sample
Conductivity	milligrams per litre	Special Frequency 1	Grab sample
Dissolved Oxygen	milligrams per litre	Special Frequency 1	Grab sample
Filterable iron	milligrams per litre	Special Frequency 1	Grab sample
Fluoride	milligrams per litre	Special Frequency 1	Grab sample
Magnesium	milligrams per litre	Special Frequency 1	Grab sample
Nitrate	milligrams per litre	Special Frequency 1	Grab sample
Potassium	milligrams per litre	Special Frequency 1	Grab sample
Sodium	milligrams per litre	Special Frequency 1	Grab sample
Sulfate	milligrams per litre	Special Frequency 1	Grab sample
Temperature	degrees Celsius	Special Frequency 1	In situ
Total Phenolics	milligrams per litre	Special Frequency 1	Grab sample
Total organic carbon	milligrams per litre	Special Frequency 1	Grab sample
Total suspended solids	milligrams per litre	Special Frequency 1	Grab sample
pH	pH	Special Frequency 1	Grab sample

POINT 2

Pollutant	Units of measure	Frequency	Sampling Method
Volume	cubic metres	Monthly	In situ

POINT 5

Pollutant	Units of measure	Frequency	Sampling Method
Ammonia	milligrams per litre	Quarterly	Grab sample
Biochemical oxygen demand	milligrams per litre	Quarterly	Grab sample
Conductivity	millisiemens per centimetre	Quarterly	Grab sample
Total Kjeldahl Nitrogen	milligrams per litre	Quarterly	Grab sample
Total suspended solids	milligrams per litre	Quarterly	Grab sample
pH	pH	Quarterly	Grab sample

POINT 6

Pollutant	Units of measure	Frequency	Sampling Method
Ammonia	milligrams per litre	Quarterly	Grab sample
Biochemical oxygen demand	milligrams per litre	Quarterly	Grab sample
Conductivity	millisiemens per centimetre	Quarterly	Grab sample
Total Kjeldahl Nitrogen	milligrams per litre	Quarterly	Grab sample
Total suspended solids	milligrams per litre	Quarterly	Grab sample
pH	pH	Quarterly	Grab sample

Special Frequency 1 means annually and whenever overflows occur.

M2.2 The licensee must make available to the EPA the results of monthly Trade Waste Monitoring of leachate and include these results in the Annual Report.

M2.3 Landfill gas monitoring program

M2.3.1 The licensee must monitor the landfill for surface gas emissions and gas accumulation in accordance with the procedures described in Benchmark Techniques 17 and 18 of the Landfill Guidelines. The sampling must be carried out at the following points:

Point	Parameter	Frequency
Point 3	Methane v/v	Monthly if an initial survey indicates significant gas.
Point 4	Methane v/v	Monthly if an initial survey indicates significant gas.

M3 Testing methods - concentration limits

M3.1 Not applicable.

M3.2 Subject to any express provision to the contrary in this licence, monitoring for the concentration of a pollutant discharged to waters or applied to a utilisation area must be done in accordance with the Approved Methods Publication unless another method has been approved by the EPA in writing before any tests are conducted.

M4 Recording of pollution complaints

M4.1 The licensee must keep a legible record of all complaints made to the licensee or any employee or agent of the licensee in relation to pollution arising from any activity to which this licence applies.

M4.2 The record must include details of the following:
(a) the date and time of the complaint;
(b) the method by which the complaint was made;
(c) any personal details of the complainant which were provided by the complainant or, if no such details were provided, a note to that effect;
(d) the nature of the complaint;
(e) the action taken by the licensee in relation to the complaint, including any follow-up contact with the complainant; and
(f) if no action was taken by the licensee, the reasons why no action was taken.

M4.3 The record of a complaint must be kept for at least 4 years after the complaint was made.

M4.4 The record must be produced to any authorised officer of the EPA who asks to see them.

M5 Telephone complaints line

M5.1 The licensee must operate during its operating hours a telephone complaints line for the purpose of receiving any complaints from members of the public in relation to activities conducted at the premises or by the vehicle or mobile plant, unless otherwise specified in the licence.

M5.2 The licensee must notify the public of the complaints line telephone number and the fact that it is a complaints line so that the impacted community knows how to make a complaint.

M5.3 Conditions M5.1 and M5.2 do not apply until 3 months after:
(a) the date of the issue of this licence or
(b) if this licence is a replacement licence within the meaning of the Protection of the Environment Operations (Savings and Transitional) Regulation 1998, the date on which a copy of the licence was served on the licensee under clause 10 of that regulation.

M6 Requirement to monitor volume or mass

M6.1 Not applicable.

M7 Non-permitted waste incidents

M7.1 The licensee must maintain a record of all events involving the removal of any waste that was brought to the facility and which is not permitted to be disposed of at the facility.

6 Reporting conditions

R1 Annual return documents

What documents must an Annual Return contain?

R1.1 The licensee must complete and supply to the EPA an Annual Return in the approved form comprising:
(a) a Statement of Compliance; and
(b) a Monitoring and Complaints Summary.
A copy of the form in which the Annual Return must be supplied to the EPA accompanies this licence. Before the end of each reporting period, the EPA will provide to the licensee a copy of the form that must be completed and returned to the EPA.

Period covered by Annual Return

R1.2 An Annual Return must be prepared in respect of each reporting period, except as provided below.

Note: The term "reporting period" is defined in the dictionary at the end of this licence. Do not complete the Annual Return until after the end of the reporting period.

R1.3 Where this licence is transferred from the licensee to a new licensee:
(a) the transferring licensee must prepare an Annual Return for the period commencing on the first day of the reporting period and ending on the date the application for the transfer of the licence to the new licensee is granted; and
(b) the new licensee must prepare an Annual Return for the period commencing on the date the application for the transfer of the licence is granted and ending on the last day of the reporting period.

Note: An application to transfer a licence must be made in the approved form for this purpose.

R1.4 Where this licence is surrendered by the licensee or revoked by the EPA or Minister, the licensee must prepare an Annual Return in respect of the period commencing on the first day of the reporting period and ending on:
(a) in relation to the surrender of a licence - the date when notice in writing of approval of the surrender is given; or
(b) in relation to the revocation of the licence - the date from which notice revoking the licence operates.

Deadline for Annual Return

R1.5 The Annual Return for the reporting period must be supplied to the EPA by registered post not later

than 60 days after the end of each reporting period or in the case of a transferring licence not later than 60 days after the date the transfer was granted (the 'due date').

Notification where actual load can not be calculated

R1.6 Not applicable.

Licensee must retain copy of Annual Return

R1.7 The licensee must retain a copy of the Annual Return supplied to the EPA for a period of at least 4 years after the Annual Return was due to be supplied to the EPA.

Certifying of Statement of Compliance and signing of Monitoring and Complaints Summary

R1.8 Within the Annual Return, the Statement of Compliance must be certified and the Monitoring and Complaints Summary must be signed by:
(a) the licence holder; or
(b) by a person approved in writing by the EPA to sign on behalf of the licence holder.

R1.9 A person who has been given written approval to certify a certificate of compliance under a licence issued under the Pollution Control Act 1970 is taken to be approved for the purpose of this condition until the date of first review of this licence.

R1.10 The Annual Return must be accompanied by/or include an Annual Report which must contain an assessment of environmental performance relevant to licence conditions including:
a) tabulated results of all monitoring data required to be collected by this licence;
b) a graphical presentation of data from at least the last three years (if available) in order to show variability/and or trends. Any statistically significant variations or anomalies should be highlighted and explained;
c) an analysis and interpretation of all monitoring data;
d) an analysis of and response to any complaints received;
e) identification of any deficiencies in environmental performance identified by the monitoring data, trends or incidents and of remedial action taken or proposed to be taken to address these deficiencies; and
f) recommendations on improving the environmental performance of the facility.

R2 Notification of environmental harm

Note: The licensee or its employees must notify the EPA of incidents causing or threatening material harm to the environment as soon as practicable after the person becomes aware of the incident in accordance with the requirements of Part 5.7 of the Act.

R2.1 Notifications must be made by telephoning the Environment Line service on 131 555.

R2.2 The licensee must provide written details of the notification to the EPA within 7 days of the date on which the incident occurred.

R3 Written report

R3.1 Where an authorised officer of the EPA suspects on reasonable grounds that:
(a) where this licence applies to premises, an event has occurred at the premises; or
(b) where this licence applies to vehicles or mobile plant, an event has occurred in connection with the carrying out of the activities authorised by this licence,
and the event has caused, is causing or is likely to cause material harm to the environment (whether the harm occurs on or off premises to which the licence applies), the authorised officer may request a written report of the event.

R3.2 The licensee must make all reasonable inquiries in relation to the event and supply the report to the EPA within such time as may be specified in the request.

R3.3 The request may require a report which includes any or all of the following information:
(a) the cause, time and duration of the event;
(b) the type, volume and concentration of every pollutant discharged as a result of the event;
(c) the name, address and business hours telephone number of employees or agents of the licensee, or a specified class of them, who witnessed the event;
(d) the name, address and business hours telephone number of every other person (of whom the licensee is aware) who witnessed the event, unless the licensee has been unable to obtain that information after making reasonable effort;
(e) action taken by the licensee in relation to the event, including any follow-up contact with any complainants;
(f) details of any measure taken or proposed to be taken to prevent or mitigate against a recurrence of such an event; and
(g) any other relevant matters.

R3.4 The EPA may make a written request for further details in relation to any of the above matters if it is not satisfied with the report provided by the licensee. The licensee must provide such further details to the EPA within the time specified in the request.

R4 Recording of fires

R4.1 The licensee must maintain a daily log and record the following data of fires at the site:
(a) Time and date when the fire was deliberately started or reported.
(b) Whether the fire was authorised by the licensee, and, if not, the circumstances which ignited the fire.
(c) The time and date that the fire ceased and whether it burnt out or was extinguished.
(d) The location of fire (eg. clean timber stockpile, putrescible garbage cell, etc).
(e) Prevailing weather conditions.
(f) Observations made in regard to smoke direction and dispersion.
(g) The amount of waste that was combusted by the fire.
(h) Action taken to extinguish the fire.

R4.2 The licensee or its employees or agents must notify the EPA in accordance with conditions R2.1 and R2.2 of all fires at the premises as soon as practical after becoming aware of the incident.

R5 Landfill Gas Hazard Reporting

R5.1 The licensee must notify the EPA within 24 hours in accordance with condition R2.1 if surface monitoring detects methane above 1.25% (v/v), and increase the frequency of monitoring to daily, until the EPA determines otherwise.

General conditions

G1 Copy of licence kept at the premises

G1.1 A copy of this licence must be kept at the premises to which the licence applies.

G1.2 The licence must be produced to any authorised officer of the EPA who asks to see it.

G1.3 The licence must be available for inspection by any employee or agent of the licensee working at the premises.

Pollution studies and reduction programs

U1 Leachate and surface water management

U1.1 By **4.00pm Friday 19 December 2008** the licensee must provide to the Manager Waste Operations DECC, PO Box A290, Sydney South, NSW, 1232 an updated "leachate and surface water management plan" which details the following (but need not be limited to):

a. the ways leachate and surface water circuits are to be kept separate at the premises,
b. details of drainage, conveyance and storage infrastructure for leachate and surface water,
c. an assessment of the adequacy (including a leachate balance and current capacity) of the existing leachate drainage, conveyance and storage infrastructure,
d. proposed and/or existing treatment and disposal methods for leachate and surface water (including daily treatment and disposal capacities, limits and quantities),
e. predictions and/or actual data on leachate and surface water volumes stored in waste disposal cells and dams at the premises.

U1.2 By **Friday 5 December 2008** the licensee must complete works to cap leachate risers within western gully at the premises.

U1.3 By **Friday 5 December 2008** the licensee must complete works to seal leachate pits at the toe of western gully at the premises.

U1.4 By **Friday 5 December 2008** the licensee must complete works to decommission the "old" leachate ponds so that only stormwater is stored.

U1.5 By **Friday 5 December 2008** the licensee must complete all works necessary at the premises to ensure that surface water run-off as a result of rainfall does not enter the leachate collection system.

U1.6 By Friday **19 December 2008** the licensee must provide a written report to the Manager Waste Operations DECC, PO Box A290, Sydney South, NSW, 1232 which provides evidence (including but not limited to photographs, diagrams, surveys) that the licensee has complied with conditions above.

U2 **Implementation of groundwater and surface water monitoring plan**

U2.1 By **Friday 27 February 2009** the licensee must install the works and implement the recommendations in accordance with section 8 of the report titled "*Technical Review of the Groundwater Monitoring Network for Whytes Gully Waste Management Facility*" dated 29 April 2008 as prepared by Earth2Water Pty Ltd.

U2.2 By **Friday 27 March 2009** the licensee must provide to the Manager Waste Operations DECC, PO Box A290, Sydney South, NSW, 1232 a written report outlining in writing how the works and recommendations in the report titled "*Technical Review of the Groundwater Monitoring Network for Whytes Gully Waste Management Facility*" were implemented by the licensee. This report must include (but need not be limited to) the location and construction details for all new monitoring bore holes installed at the Premises.

Special conditions

E1 Not applicable.

Dictionary

General Dictionary

In this licence, unless the contrary is indicated, the terms below have the following meanings:

3DGM [in relation to a concentration limit]	Means the three day geometric mean, which is calculated by multiplying the results of the analysis of three samples collected on consecutive days and then taking the cubed root of that amount. Where one or more of the samples is zero or below the detection limit for the analysis, then 1 or the detection limit respectively should be used in place of those samples
Act	Means the Protection of the Environment Operations Act 1997
activity	Means a scheduled or non-scheduled activity within the meaning of the Protection of the Environment Operations Act 1997
actual load	Has the same meaning as in the Protection of the Environment Operations (General) Regulation 1998
AM	Together with a number, means an ambient air monitoring method of that number prescribed by the *Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales*.
AMG	Australian Map Grid

anniversary date	The anniversary date is the anniversary each year of the date of issue of the licence. In the case of a licence continued in force by the Protection of the Environment Operations Act 1997, the date of issue of the licence is the first anniversary of the date of issue or last renewal of the licence following the commencement of the Act.
annual return	Is defined in R1.1
Approved Methods Publication	Has the same meaning as in the Protection of the Environment Operations (General) Regulation 1998
assessable pollutants	Has the same meaning as in the Protection of the Environment Operations (General) Regulation 1998
BOD	Means biochemical oxygen demand
CEM	Together with a number, means a continuous emission monitoring method of that number prescribed by the *Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales*.
COD	Means chemical oxygen demand
composite sample	Unless otherwise specifically approved in writing by the EPA, a sample consisting of 24 individual samples collected at hourly intervals and each having an equivalent volume.
cond.	Means conductivity
environment	Has the same meaning as in the Protection of the Environment Operations Act 1997
environment protection legislation	Has the same meaning as in the Protection of the Environment Administration Act 1991
EPA	Means Environment Protection Authority of New South Wales.
fee-based activity classification	Means the numbered short descriptions in Schedule 1 of the Protection of the Environment Operations (General) Regulation 1998.
flow weighted composite sample	Means a sample whose composites are sized in proportion to the flow at each composites time of collection.
general solid waste (non-putrescible)	Has the same meaning as in Part 3 of Schedule 1 of the Protection of the Environment Operations Act 1997
general solid waste (putrescible)	Has the same meaning as in Part 3 of Schedule 1 of the Protection of the Environment Operations Act 1997
grab sample	Means a single sample taken at a point at a single time
hazardous waste	Has the same meaning as in Part 3 of Schedule 1 of the Protection of the Environment Operations Act 1997
licensee	Means the licence holder described at the front of this licence
load calculation protocol	Has the same meaning as in the Protection of the Environment Operations (General) Regulation 1998
local authority	Has the same meaning as in the Protection of the Environment Operations Act 1997
material harm	Has the same meaning as in section 147 Protection of the Environment Operations Act 1997
MBAS	Means methylene blue active substances
Minister	Means the Minister administering the Protection of the Environment Operations Act 1997
mobile plant	Has the same meaning as in Part 3 of Schedule 1 of the Protection of the Environment Operations Act

	1997
motor vehicle	Has the same meaning as in the Protection of the Environment Operations Act 1997
O&G	Means oil and grease
percentile [in relation to a concentration limit of a sample]	Means that percentage [eg.50%] of the number of samples taken that must meet the concentration limit specified in the licence for that pollutant over a specified period of time. In this licence, the specified period of time is the Reporting Period unless otherwise stated in this licence.
plant	Includes all plant within the meaning of the Protection of the Environment Operations Act 1997 as well as motor vehicles.
pollution of waters [or water pollution]	Has the same meaning as in the Protection of the Environment Operations Act 1997
premises	Means the premises described in condition A2.1
public authority	Has the same meaning as in the Protection of the Environment Operations Act 1997
regional office	Means the relevant EPA office referred to in the Contacting the EPA document accompanying this licence
reporting period	For the purposes of this licence, the reporting period means the period of 12 months after the issue of the licence, and each subsequent period of 12 months. In the case of a licence continued in force by the Protection of the Environment Operations Act 1997, the date of issue of the licence is the first anniversary of the date of issue or last renewal of the licence following the commencement of the Act.
restricted solid waste	Has the same meaning as in Part 3 of Schedule 1 of the Protection of the Environment Operations Act 1997
scheduled activity	Means an activity listed in Schedule 1 of the Protection of the Environment Operations Act 1997
special waste	Has the same meaning as in Part 3 of Schedule 1 of the Protection of the Environment Operations Act 1997
TM	Together with a number, means a test method of that number prescribed by the *Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales*.
TSP	Means total suspended particles
TSS	Means total suspended solids
Type 1 substance	Means the elements antimony, arsenic, cadmium, lead or mercury or any compound containing one or more of those elements
Type 2 substance	Means the elements beryllium, chromium, cobalt, manganese, nickel, selenium, tin or vanadium or any compound containing one or more of those elements
utilisation area	Means any area shown as a utilisation area on a map submitted with the application for this licence
waste	Has the same meaning as in the Protection of the Environment Operations Act 1997
waste type	Means liquid, restricted solid waste, general solid waste (putrescible), general solid waste (non-putrescible), special waste or hazardous waste

Environment Protection Licence

Licence - 5862

Mr Bernie Weir

Environment Protection Authority

(By Delegation)

Date of this edition - 29-Jun-2010

End Notes

1	Licence varied by notice 1004923, issued on 28-Mar-2001, which came into effect on 19-Apr-2001.
2	Licence varied by notice 1006649, issued on 15-Jun-2001, which came into effect on 10-Jul-2001.
3	Licence varied by notice 1010783, issued on 22-Oct-2001, which came into effect on 16-Nov-2001.
4	Licence varied by notice 1013124, issued on 19-Mar-2002, which came into effect on 13-Apr-2002.
5	Licence varied by notice 1018823, issued on 11-Jul-2002, which came into effect on 05-Aug-2002.
6	Licence fee period changed by notice 1027159 on 07-May-2003.
7	Licence varied by notice 1040733, issued on 15-Mar-2005, which came into effect on 21-Mar-2005.
8	Licence varied by notice 1046062, issued on 11-Oct-2005, which came into effect on 05-Nov-2005.
9	Licence varied by change to DEC Region allocation, issued on 17-Mar-2006, which came into effect on 17-Mar-2006.
10	Licence varied by change to EPA Region, issued on 07-Aug-2006, which came into effect on 07-Aug-2006.
11	Licence varied by notice 1080328, issued on 20-Nov-2007, which came into effect on 20-Nov-2007.
12	Licence varied by notice 1092800, issued on 17-Oct-2008, which came into effect on 17-Oct-2008.
13	Condition A1.3 Not applicable varied by notice issued on <issue date> which came into effect on <effective date>
14	Licence varied by notice 1095240, issued on 28-Nov-2008, which came into effect on 28-Nov-2008.
15	Licence varied by Correction to EPA Region data record., issued on 28-Jun-2010, which came into effect on 28-Jun-2010.

wollongong
city of innovation

WOLLONGONG CITY COUNCIL

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Phone (02) 4227 7111 • **Fax** (02) 4227 7277 **Email** council@wollongong.nsw.gov.au
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013

Wollongong City Council
Attn: Michael Herraman
Locked Bag 8821
WOLLONGONG DC NSW 2500

APPLICATION	DA-2010/1088
Determination	Conditionally Approved
Approval Authority	Wollongong City Council
Endorsement Date	31 May 2011

CONSENT

NOTICE OF DETERMINATION OF DEVELOPMENT APPLICATION

Issued under Section 81 of the Environmental Planning and Assessment Act 1979

The development application described below has been determined:

Description	Construction of waste transfer facility at Whytes Gully waste facility
Location	Lot 2 DP 240557
	Whytes Gully Tip, 133 Reddalls Road, KEMBLA GRANGE NSW 2526

Consent has been granted subject to the following conditions:

Approved Plans and Specifications

1 The development is to be carried out in compliance with the plans and documentation listed below and endorsed with Council's stamp, except where amended by other conditions of this consent:

Plans and Specifications	Locality and drawing list - number 097623137-001-D-D001-C - dated 23 February 2011 - Golder Associates General notes plan - number 097623137-001-D-D002-C - dated 23 February 2011 - Golder Associates Existing site plan - number 097623137-001-D-D003-C - dated 23 February 2011 - Golder Associates Station site layout plan - number 097623137-001-D-D004-C - dated 23 February 2011 - Golder Associates Final levels earthworks and stormwater design plan - number 097623137-001-D-D010-C - dated 23 February 2011 - Golder Associates Landscape plan - number 096723137-001-D-D011-A - dated 23 February 2011 - Golder Associates Cross section plan - sheet 1 - number 097623137-001-D-D012-C - dated 23 Febuary 2011 - Golder Associates Cross section plan - sheet 2 - number 097623137-001-D-D013-C - dated 23 February 2011 - Golder Associates Typical transfer station bay setout plan - number 097623137-001-D-D015-C - dated 23 February 2011 - Golder Associates Typical details plan - number 097623137-001-D-D016-C - dated 23 February 2011 - Golder Associates Retaining wall detail plan - number 097623137-001-D-D017-C - dated 23 February 2011 - Golder

Associates
Traffic management plan - number 097623137-001-D-D020-C - dated 23 February 2011 - Golder Associates
Traffic management details plan - number 097623137-001-D-D021-C - dated 23 February 2011 - Golder Associates
Final levels and stormwater setout plan - number 097623137-001-D-D030-C - dated 23 February 2011 - Golder Associates
Final levels and stormwater setout table - number 097623137-001-D-D031-C - dated 23 February 2011 - Golder Associates
Geotechnical report - number W10393 - dated 1 May 2010 - Wollongong City Council
Statement of environmental effects - number 097623137-001-R-Rev2 - dated February 2011 - Golder Associates
Arborist report - number D1704 - dated 12 February 2011 - Allied Tree Consultancy
Bushfire risk assessment and protection measures report - dated 12 January 2011 - APZA Services
Traffic assessment report - number 097623137 - dated January 2011 - Golder Associates

General Matters

2 **Department of Environment, Climate Change and Water '(DECCW)**

The developer must operate the site in accordance with the existing Environment Protection Licence (No.5862). In this regard the Department of Environment, Climate Change and Water '(DECCW) does not consider that a variation to the existing Environment Protection Licence (No.5862) will be required as the size and scale of the transfer station will not be great enough to trigger the thresholds set out in Schedule 1 of the *Protection of the Environment Operations Act 1997 (POEO Act)*'.

'It should however be noted that the environmental standards and operating conditions on the Whytes Gully Licence apply to all activities being conducted within the premises boundary, and issues such as pollution of water, odour management, and dust control must be equally addressed through the construction and operational phases of the proposed transfer station.'

3 **NSW Rural Fire Service**

In recognition of the isolated location of the development, an emergency/evacuation plan is to be prepared consistent with the NSW Rural Fire Service document 'Guidelines for the Preparation of Emergency/Evacuation plan'.

4 **Building Work - Compliance with the Building Code of Australia**

All building work must be carried out in compliance with the provisions of the Building Code of Australia.

5 **Construction Certificate**

A Construction Certificate must be obtained from Council or an Accredited Certifier prior to work commencing.

A Construction Certificate certifies that the provisions of Clauses 139-148 of the Environmental Planning and Assessment Amendment Regulations, 2000 have been satisfied, including compliance with all relevant conditions of Development Consent and the Building Code of Australia.

Note: The submission to Council of two (2) copies of all stamped Construction Certificate plans and supporting documentation is required within **two (2)** days from the date of issue of the Construction Certificate, in the event that the Construction Certificate is not issued by Council.

6 **NSW WorkCover Authority – Dangerous Goods**

This consent does not authorise the commencement or use of the development until any required approval is granted by the NSW WorkCover Authority, pursuant to the requirements of the Dangerous Goods Act 1975 and Dangerous Goods General Regulation 1999.

7 **Disability Discrimination Act 1992**

This consent does not imply or confer compliance with the requirements of the Disability Discrimination Act 1992.

It is the responsibility of the applicant to guarantee compliance with the requirements of the Disability Discrimination Act 1992. The current Australian Standard AS1428.1 – Design for Access and Mobility is recommended to be referred for specific design and construction requirements, in order to provide appropriate access to all persons within the building.

8 **Tree Removal**
This consent permits the removal of trees as indicated on the Landscape Plan by Golder Associates dated 23 February 2011. No other trees shall be removed without prior written approval of Council.

9 **Tree Retention**
The developer shall retain existing trees indicated on the Landscape Plan by Golder Associates dated 23 February 2011.

All recommendations in Arborist's Report by Allied Tree Consultancy dated 12 February 2011 to be implemented including and not restricted to: remedial tree pruning, deadwooding, fencing and signage, sediment buffer, stem protection, establishing tree protection zones and watering and root hormone application if required.

10 **Separate Consent Required for Advertising Signage**
This consent does not authorise the erection of any advertising signage. Any such advertising signage will require separate Council approval, in the event that such signage is not exempt development, under Schedule 2 of Wollongong Local Environmental Plan 2009/Wollongong (West Dapto) Local Environmental Plan 2010.

Any new application for advertising signage must be submitted to Council in accordance with Chapter C1 – Advertising and Signage Structure of Wollongong Development Control Plan 2009.

11 **Maintenance of Access to Adjoining Properties**
Access to all properties not the subject of this approval must be maintained at all times and any alteration to access to such properties, temporary or permanent, must not be commenced until such time as written evidence is submitted to Council or the Principal Certifying Authority indicating agreement by the affected property owners.

12 **Protection of Public Infrastructure**
Council must be notified in the event of any existing damage to any of its infrastructure such as the road, kerb and gutter, road shoulder, footpath, drainage structures and street trees fronting the development site, prior to commencement of any work.

Adequate protection must be provided for Council infrastructure prior to work commencing and during building operations.

Any damage to Council's assets shall be made good, prior to the issue of any Occupation Certificate or commencement of the operation.

13 **Occupation Certificate**
A final Occupation Certificate must be issued by the Principal Certifying Authority prior to occupation or use of the development. In issuing an Occupation Certificate, the Principal Certifying Authority must be satisfied that the requirements of Section 109H of the Environmental Planning and Assessment Act 1979, have been complied with as well as all of the conditions of the Development Consent.

14 **Comply with geotechnical report**
The applicant must carry out all recommendations contained in the *geotechnical report* in order to ensure the *structural design* will incorporate the site geotechnical constraints to achieve the *acceptable risk* level as defined by Council *geotechnical DCP*.

15 **Oversized Transportation**
If transportation of oversized or over mass materials or machinery is required, the applicant shall obtain a permit for an oversized and over mass load from the RTA Special Permits Unit.

16 **Excavation Spoils**
Any excavation spoils in excess of the cut and fill requirement that is intended to be exported off site for disposal must be tested for organic and metal contaminants and is to be classified under DECCW's guidelines for solid waste classification and disposed of accordingly.

17 **Leachate**
Leachate generated from green waste bays must be collected and directed into the existing leachate pond.

18 **Stormwater Runoff**
Stormwater runoff from the Revolve Centre and Waste Transfer Station must be directed to the stormwater pond.

19 **Kerb and Channel**
The proposed Kerb and Channel must be extended and /or piped to the existing stormwater pond.

20 **Car Batteries Storage**
Car batteries must be kept in a bunded and under covered bay.

21 **White Goods**
All white goods containing refrigeration gases [e.g. CFC] (refrigerators, fridges, air conditioners, car air conditioners) must be drained and degassed prior to storage on the site.

Prior to the Issue of the Construction Certificate

22 **Scour Protection**
All stormwater outlets, overland flow paths and open drains must incorporate appropriate scour/erosion protection measures. The final details of the proposed scour protection measures shall be reflected on Construction Certificate plans.

23 **Existing/Proposed Levels**
Existing and proposed levels to Australian Height Datum (AHD), including floor, ground, grate, pipe inverts and pavement levels shall be shown on the detailed drainage design. This requirement shall be reflected on the Construction Certificate plans and supporting documentation.

24 **Open Drain**
Details of the proposed open drain on the site shall be provided with the detailed drainage design. The drain must be capable of catering for the 1 in 100 year storm event flows from the contributing upslope catchment area. Full Manning's calculations shall be provided on the capacity of the drain. These requirements shall be reflected on the Construction Certificate plans and supporting documentation.

25 **Maintenance Schedule**
A maintenance schedule shall be submitted for the proposed stormwater drain and leachate pit. This information shall be submitted with the Construction Certificate plans.

26 **Interceptor Drain**
Surface water interceptor drains/swales shall be provided across the slope uphill of the construction site, to divert stormwater run-off to watercourse gullies and/or stormwater sediment ponds to discharge points downhill from any permanent structures.

27 **Leachate Collection Pit Design**
The leachate collection pit shall incorporate a minimum 2.4m precast lintel, provision for access and maintenance purposes, provision for step irons where required, a debris control basket and a suitably graded invert to prevent ponding (i.e. no sump). These requirements shall be reflected on the Construction Certificate plans.

28 **Batter Slopes**
All grassed batter slopes shall not be greater than 1 vertical to 4 horizontal. Where this requirement cannot be met, a report shall be submitted to the Principal Certifying Authority demonstrating how access and maintenance will be achieved. This shall be provided with the supporting documentation issued for Construction Certificate.

29 **Fire Safety Schedule**
When issuing a Construction Certificate, a certifying authority must attach a Fire Safety Schedule specifying all of the fire safety measures required for the building to ensure the safety of persons in the building in the event of fire.

30 **Section 73 Compliance Certificate**
A Section 73 Compliance Certificate under the Sydney Water Act 1994 must be obtained from Sydney Water Corporation. Application must be made through an authorised Water Servicing Coordinator. Please refer to the Building Developing and Plumbing section of the web site www.sydneywater.com.au then refer to "Water Servicing Coordinator" under "Developing Your Land" or telephone 13 20 92 for assistance.

Following application, a "Notice of Requirements" will advise of water and sewer infrastructure to be built and charges to be paid. Please make early contact with the Coordinator, since building of water/sewer infrastructure can be time consuming and may impact on other services and building, driveway or landscape design.

The Notice of Requirements must be submitted to the Principal Certifying Authority prior to issue of the construction certificate.

31 **Integral Energy Requirements**
The submission of documentary evidence from Integral Energy to the Principal Certifying Authority is required confirming that satisfactory arrangements have been made with Integral Energy for the provision of electricity supplies to the development, prior to the release of the Construction Certificate.

Note: Applications should be made to Customer Connections – South Coast, Integral Energy PO Box 6366, Blacktown 2148.

32 The submission of final design details of proposed security systems to be installed within the development to the Principal Certifying Authority, in order to minimise crime and vandalism related matters is required, prior to the release of the Construction Certificate.

33 The development shall provide suitable light spillage mitigation measures within the development to mitigate against any adverse light spillage impacts upon surrounding properties. This requirement shall be reflected on the Construction Certificate plans. The implementation of the approved light spillage mitigation measures is required prior to the use or occupation of the development.

34 The designated loading/unloading facility shall be kept clear for that purpose at all times. The designated loading/unloading facility shall be shown on the Construction Certificate plans.

35 The development shall make provision for suitable barriers, line-marking and painted signage delineating vehicular flow movements within the car public access areas. These details shall be reflected on the Construction Certificate plans.

36 Gradients of ramps and access driveways shall be provided in accordance with Australian Standard AS2890.1. This requirement shall be reflected on the Construction Certificate plans.

37 The arrangements and costs associated with any adjustment to a public utility service shall be borne by the applicant/developer. Any adjustment, deletion and/or creation of public utility easements associated with the approved works are the responsibility of the applicant/developer. The submission of documentary evidence to the Principal Certifying Authority which confirms that satisfactory arrangements have been put in place regarding any adjustment to such services is required prior to the release of the Construction Certificate.

38 Overflow paths must be provided to allow for flows of water in excess of the capacity of the stormwater pipe/drainage system draining the land. Blocked pipe situations with 1 in 100 year ARI events must be incorporated in the design. Overflow paths must also be provided in low points and depressions. This requirement shall be reflected on the Construction Certificate plans prior to the release of the Construction Certificate.

39 The depth and location of all services (ie gas, water, sewer, electricity, telephone, etc) must be ascertained and reflected on the Construction Certificate plans and supporting documentation.

40 Details of the proposed leachate collection pit and associated pipeline, as well as the box culvert discharging from the open drain to the existing sediment pond shall be provided in conjunction with the detailed drainage design for the site. This requirement shall be reflected on the Construction Certificate plans and supporting documentation.

41 The submission of a final Landscape Plan to the Principal Certifying Authority, prior to the release of the Construction Certificate. The final Landscape Plan shall address the following requirements:

41.1 detail planting to be included in the areas marked as 'mulched' on the submitted Landscape Plan;

41.2 planting of indigenous plant species native to the Illawarra Region such as : *Melaleuca styphelioides, Myrsine variabilis, Brachychiton populneus* subsp. *populneus*, *Eucalyptus tereticornis, Eucalyptus bosistoana,* and *Eucalyptus eugenioides;*

41.3 a schedule of proposed planting, including botanic name, common name, and staking requirements as well as number of plants and pot sizes;

41.4 the location of all proposed and existing overhead and underground service lines. The location of such service lines shall be clear of the dripline of existing and proposed trees; and

41.5 any proposed hard surface under the canopy of existing trees shall be permeable and must be laid such that the finished surface levels match the existing level. Permeable paving is to be installed in accordance with the manufacturer's recommendations.

The completion of the landscaping works as per the final approved Landscape Plan is required, prior to the issue of Occupation Certificate.

42 The implementation of a landscape maintenance program in accordance with the approved Landscape Plan for a minimum period of 12 months to ensure that all landscape work becomes well established by regular maintenance. Details of the program must be submitted with the Landscape Plan to the Principal Certifying Authority prior to release of the Construction Certificate.

43 **Tree Protection and Management**

The existing trees are to be retained upon the subject property and any trees on adjoining properties shall not be impacted upon during the excavation or construction phases of the development. This will require the installation and maintenance of appropriate tree protection measures, including (but not necessarily limited to) the following:

43.1 Installation of Tree Protection Fencing - Protective fencing shall be 1.8 metre cyclone chainmesh fence, with posts and portable concrete footings. Details and location of protective fencing must be indicated on the architectural and engineering plans to be submitted to the Principal Certifying Authority prior to release of the Construction Certificate.

43.2 Mulch Tree Protection Zone: Areas within a Tree Protection Zone are to be mulched with minimum 75 mm thick 100% recycled hardwood chip/leaf litter mulch.

43.3 Irrigate: Areas within the Tree Protection Zone are to be regularly watered in accordance with the arborist's recommendations.

44 All site offices must be located on-site plan and are to be located in already cleared areas outside the canopy of any existing trees to be retained. Details of the location of the site offices shall be submitted to the Principal Certifying Authority, prior to release of the Construction Certificate.

45 **Compliance with Findings and Recommendations of the Bushfire Impact Assessment Report**

The findings and recommendations contained in the Bushfire Impact Assessment Report prepared by APZA Services and dated 12 January 2011 shall be implemented and maintained, except where amended by other conditions of this consent. This requirement shall be reflected on the Construction Certificate and supporting documentation.

46 **Retaining Wall Structures**

The proposed retaining wall(s) shall be constructed in accordance with Council's Retaining Wall Policy. This requirement is to be reflected on the Construction Certificate plans and shall be

supported by a certificate from a structural engineer which confirms the structural adequacy of the proposed retaining wall structure(s) and compliance with Council's Retaining Wall Policy.

47 **Engineering Plans and Specifications - Retaining Wall Structures**
The submission of engineering plans and supporting documentation of all proposed retaining walls to the Principal Certifying Authority for approval prior to the issue of the Construction Certificate. The retaining walls shall be designed by a suitably qualified and experienced civil and/or structural engineer. The required engineering plans and supporting documentation shall include the following:

47.1 the proposed method of subsurface and surface drainage, including water disposal.

48 **Dust Suppression Measures**
The submission of details of the proposed dust suppression measures for the demolition, excavation and construction phases of the development to the Principal Certifying Authority, prior to issue of the Construction Certificate.

49 **Dust Suppression Measures – Stockpile Management**
The preparation of suitable proposed dust suppression measures for stockpile management that will be implemented at times when weather conditions are conducive to dust generation impacts. The proposed dust suppression measures are required to be submitted to the Principal Certifying Authority, prior to the issue of the Construction Certificate.

Prior to the Commencement of Works

50 **Appointment of Principal Certifying Authority**
Prior to commencement of work, the person having the benefit of the Development Consent and a Construction Certificate must:

50.1 Appoint a Principal Certifying Authority (PCA) and notify Council in writing of the appointment. irrespective of whether Council or an accredited private certifier is appointed (if Council is nominated as the PCA please use the attached form); and
50.2 notify Council in writing (on the attached form) of their intention to commence the erection of the building (at least two days notice is required).

The Principal Certifying Authority must determine when inspections and compliance certificates are required.

51 **Site Management, Pedestrian and Traffic Management (Where Works are Proposed in or from a Public Road Reserve)**
The submission, as part of an application for a permit under Section 138 of the Roads Act 1993, of a Site Management, Pedestrian and Traffic Management Plan to Council's Manager Regulation and Enforcement for approval is required, prior to works commencing on the site. This plan shall address what measures will be implemented for the protection of adjoining properties, pedestrian safety and traffic management and shall be in compliance with the requirements of the latest versions of Australian Standard AS1742 - Traffic Control Devices for Works on Roads and the RTA Traffic Control at Worksites Manual.

This plan is required to maintain public safety, minimise disruption to pedestrian and vehicular traffic within this locality and to protect services, during demolition, excavation and construction phases of the development. This plan shall include the following aspects:

51.1 proposed ingress and egress points for vehicles to/from the construction site;
51.2 proposed protection of pedestrians, adjacent to the construction site;
51.3 proposed pedestrian management whilst vehicles are entering/exiting the construction site;
51.4 proposed measures to be implemented for the protection of all roads and footpath areas surrounding the construction site from building activities, crossings by heavy equipment, plant and materials delivery and static load from cranes, concrete pumps and the like;
51.5 proposed method of loading and unloading excavation machines, building materials formwork and the erection of any part of the structure within the site;

51.6 proposed areas within the site to be used for the storage of excavated material, construction materials and waste containers during the construction period;

51.7 proposed traffic control measures such as advanced warning signs, barricades, warning lights, after hours contact numbers etc are required to be displayed where works are in progress in any road reserve and shall be in accordance the latest versions of the NSW Roads and Traffic Authority's Specification - "Traffic Control at Work Sites Manual" and the Australian Standard AS1742. – "Manual of Uniform Traffic Control Devices" and accompanying field handbooks (SAA HB81);

51.8 proposed method of support of any excavation, adjacent to adjoining buildings or the road reserve. The proposed method of support is to be certified by an accredited certifier in Civil Engineering; and

51.9 proposed measures to be implemented, in order to ensure that no soil/excavated material is transported on wheels or tracks of vehicles or plant and deposited on the roadway.

The approved plan shall be implemented, prior to the commencement of any works upon the construction site.

Note: Any proposed works or placement of plant and equipment and/or materials within any road reserve will require the separate approval of Council, prior to the commencement of such works, pursuant to the provisions of the Roads Act 1993.

52 **Tree Protection**

All trees to be retained shall be protected by fencing according to AS 4970-2009 Protection of trees on development sites and to the detail provided in the Arborist's Report. The locations of the protective fences shall be determined by a qualified Arborist and the fences shall be installed prior to commencement of work. Any pruning of retained trees shall be carried out by a qualified arborist according to AS 4373-2007 Pruning of Amenity Trees.

53 **Compensatory Planting**

Supplementary Planting shall be carried out as compensation for the proposed removal of eight (8) indigenous trees in an area either adjacent to the Illawarra Lowlands Grassy Woodland patch or adjacent to the Illawarra Subtropical Rainforest patch. If adjacent to the woodland patch, the species shall be selected from:

Eucalyptus tereticornis, Eucalyptus bosistoana, Eucalyptus eugenioides, Myrsine variabilis, Brachychiton populneus subsp. *populneus* or *Melaleuca styphelioides.*

If adjacent to the rainforest patch, the species shall be selected from:
Pittosporum undulatum, Streblus brunonianus, Pouteria australis, Melicope micrococca, Diospyros australis, Elaeodendron australis or *Alectryon subcinereus.*

54 **Sign – Supervisor Contact Details**

Before commencement of any work, a sign must be erected in a prominent, visible position:

54.1 stating that unauthorised entry to the work site is not permitted;

54.2 showing the name, address and telephone number of the Principal Certifying Authority for the work; and

54.3 showing the name and address of the principal contractor in charge of the work site and a telephone number at which that person can be contacted at any time for business purposes.

This sign shall be maintained while the work is being carried out and removed upon the completion of the construction works.

55 **Temporary Toilet/Closet Facilities**

Toilet facilities are to be provided at or in the vicinity of the work site on which work involved in the erection or demolition of a building is being carried out at the rate of one toilet for every 20 persons or part of 20 persons employed at the site.

Each toilet provided must be:

55.1 a standard flushing toilet; and

55.2 connected to either:

55.2.1 the Sydney Water Corporation Ltd sewerage system or
55.2.2 an accredited sewage management facility or
55.2.3 an approved chemical closet.

The toilet facilities shall be provided on-site, prior to the commencement of any works.

56 **Enclosure of the Site**
The site must be enclosed with a suitable security fence to prohibit unauthorised access, to be approved by the Principal Certifying Authority. No building work is to commence until the fence is erected.

57 **Demolition Works**
Any demolition work must be carried out in accordance with Australian Standard AS2601 (2001): The Demolition of Structures or any other subsequent relevant Australian Standard and the requirements of the NSW WorkCover Authority.

No demolition materials shall be burnt or buried on-site. The person responsible for the demolition works shall ensure that all vehicles leaving the site carrying demolition materials have their loads covered and do not track soil or waste materials onto the road. Any unforeseen hazardous and/or intractable wastes shall be disposed of to the satisfaction of the Principal Certifying Authority. In the event that the demolition works may involve the obstruction of any road reserve/footpath or other Council owned land, a separate application shall be made to Council to enclose the public place with a hoarding or fence over the footpath or other Council owned land.

58 **Consultation with NSW WorkCover Authority**
Prior to any work commencing on the site it is the responsibility of the owner to contact NSW WorkCover Authority in writing in respect to any demolition or use of any crane, hoist, plant or scaffolding.

59 **Site Management Program – Sediment and Erosion Control Measures**
A site management program incorporating all sediment and erosion control measures (eg cleaning of sediment traps, fences, basins and maintenance of vegetative cover) is to be initiated prior to the commencement of any demolition, excavation or construction works and maintained throughout the demolition, excavation and construction phases of the development.

60 **Erosion and Sediment Control Measures**
Erosion and sediment control devices are to be installed prior to the commencement of any demolition, excavation or construction works upon the site. These devices are to be maintained throughout the entire demolition, excavation and construction phases of the development and for a minimum three (3) month period after the completion of the project, where necessary.

61 **Sediment Control Measures**
The developer must ensure that sediment-laden runoff from the site is controlled at all times subsequent to commencement of construction works. Sediment control measures must be maintained at all times and checked for adequacy at the conclusion of each day's work.

62 **Supervising Arborist – Tree Inspection and Installation of Tree Protection Measures**
Prior to the commencement of any demolition, excavation or construction works, the supervising arborist must certify in writing that tree protection measures have been inspected and installed in accordance with the arborist's recommendations and relevant conditions of this consent.

63 These plans should be presented to Sydney Water for their specific requirements.

64 **Notification to Council of any Damage to Council's Infrastructure**
Council must be notified in the event of any existing damage to any of Council's infrastructure including, but not limited to the road, kerb and gutter, road shoulder, footpath, drainage structures and street trees fronting the development prior to the commencement of work. Adequate protection must be provided to Council infrastructure prior to work commencing and during the construction period. Any damage to Council's assets shall be restored in a satisfactory manner prior to the issue of the Occupation Certificate.

During Demolition, Excavation or Construction

65 **Supervision of Engineering Works**
All engineering works associated with the development are to be carried out under the supervision of a practicing engineer and/or registered surveyor.

66 **No Adverse Run-off Impacts on Adjoining Properties**
The design of the development shall ensure there are no adverse effects to adjoining properties or upon the land as a result of flood or stormwater run-off. Attention must be paid to ensure adequate protection for buildings against the ingress of surface run-off.

67 **Re-direction or Treatment of Stormwater Run-off**
Allowance must be made for surface run-off from adjoining properties. Any redirection or treatment of that run-off must not adversely affect any other property.

68 **Protection of Public Places**
If the work involved in the erection or demolition of a building involves the enclosure of a public place or is likely to cause pedestrian/vehicular traffic in a public place to be obstructed or rendered inconvenient, or have the potential for conflict between pedestrians and vehicles:

68.1 A hoarding or fence must be erected between the work site and the public place;
68.2 an awning is to be erected, sufficient to prevent any substance from, or in connection with, the work falling into the public place;
68.3 the work site must be kept lit between sunset and sunrise if it is likely to be hazardous to persons in a public place;
68.4 safe pedestrian access must be maintained at all times;
68.5 any such hoarding, fence or awning is to be removed when the work has been completed.

69 **Branch or Root Pruning in accordance with Australian Standard**
Any branch or root pruning which has been given approval, must be carried out by a qualified arborist in accordance with Australian Standard AS4373 (2007).

70 **Copy of Consent to be in Possession of Person carrying out Tree Removal**
The applicant/developer must ensure that any person carrying out tree removal is in possession of this development consent and/or the approved landscape plan, in respect to the trees which have been given approval to be removed in accordance with this consent.

71 **Treatment of any Tree Damage by a Supervised Arborist**
Any damage inflicted on a tree during the construction phase which has been nominated for retention shall be treated by an approved arborist at the developer's expense.

72 **Restricted Hours of Work (not domestic residential scale)**
The developer must not carry out any work other than emergency procedures to control dust or sediment laden runoff outside the hours of 7.00 am to 5.00 pm, Monday to Friday and 7 am to 1.00 pm Saturdays without the prior written consent of the Principal Certifying Authority and Council.

No work is permitted on public holidays, Sundays or the Saturday adjacent to public holidays on Mondays or Fridays.

Any request to vary these hours shall be submitted to the **Council** in writing detailing:

72.1 the variation in hours required;
72.2 the reason for that variation;
72.3 the type of work and machinery to be used.

Note: The developer is advised that other legislation may control the activities for which Council has granted consent including but not limited to the Protection of the Environment Operations Act 1997. Developers must note that EPA Environmental Noise manual restricts use of power tools (electronic or pneumatic) to between the hours of 7.00 am to 5.00 pm Mondays to Fridays and 8.00 am to 4.00 pm on Saturdays.

73 The developer must carry out work at all times in a manner which will not cause a nuisance, by the generation of unreasonable noise, dust or other activity, to the owners and/or occupiers of adjoining and adjacent land.

74 The lighting of the premises must be directed so as not to cause nuisance to the owners or occupiers of adjoining premises or to motorists on adjoining or nearby roads.

75 **Site Management**
Stockpiles of sand, gravel, soil and the like must be located to ensure that the material:

75.1 Does not spill onto the road pavement; and
75.2 is not placed in drainage lines or watercourses and cannot be washed into these areas.

76 Vehicle access is to be controlled so as to prevent tracking of sediment onto adjoining roadways, particularly during wet weather or when the site has been affected by wet weather.

77 **Dust Suppression Measures**
Activities occurring during the construction phase of the development must be carried out in a manner that will minimise the generation of dust.

78 **Provision of Waste Receptacle**
The developer must provide an adequate receptacle to store all waste generated by the development, pending disposal. The receptacle must be regularly emptied and waste must not be allowed to lie or accumulate on the property other than in the receptacle. Consideration should be given to the source separation of recyclable and re-usable materials.

79 The building site must be kept free of rubbish at all times. All refuse capable of being wind blown must be kept in a suitable waste container.

80 **Compliance with Statutory Authorities/Government Departments**
Compliance with the requirements of any Statutory Authorities or Government Departments such as, but not limited to:

- NSW Workcover Authority;
- NSW Roads & Traffic Authority;
- NSW Environment Protection Authority;
- NSW Police Service; and
- NSW Fire Brigades.

Prior to the Issue of the Occupation Certificate

81 A Section 73 Certificate must be submitted to the Principal Certifying Authority prior to occupation of the development/release of the plan of subdivision.

82 **Fire Safety Certificate**
A Fire Safety Certificate must be issued for the building prior to the issue of an Occupation Certificate. As soon as practicable after a Fire Safety Certificate is issued, the owner of the building to which it relates:

82.1 Must cause a copy of the certificate (together with a copy of the current fire safety schedule) to be given to the Commissioner of New South Wales Fire Brigades, and
82.2 must cause a further copy of the certificate (together with a copy of the current fire safety schedule) to be prominently displayed in the building.

83 **Retaining Wall Certification**
The submission of a certificate from a suitably qualified and experienced structural engineer or civil engineer to the Principal Certifying Authority is required, prior to the issue of the Occupation Certificate or commencement of the use. This certification is required to verify the structural adequacy of the retaining walls and that the retaining walls have been constructed in accordance with plans approved by the Principal Certifying Authority.

84 **Occupation Certificate**
A final Occupation Certificate must be issued by the Principal Certifying Authority prior to occupation or use of the development. In issuing an Occupation Certificate, the Principal

Certifying Authority must be satisfied that the requirements of Section 109H of the Environmental Planning and Assessment Act 1979, have been complied with as well as all of the conditions of the Development Consent.

Operational Phases of the Development/Use of the Site

85 **Restricted Hours of Operation**
The hours of operation for the development shall be restricted to:

7.30am to 4.30pm - Monday to Friday,

8.00am to 4.00pm - Saturday and Sunday,

8.00am to 4.00pm – Public Holidays,

8.00am to 4.00pm – Good Friday, and

Closed – Christmas Day

Any alteration to the approved hours of operation will require separate Council approval.

86 **Fire Safety Measures**
All new and existing fire safety measures shall be maintained in working condition, at all times.

87 **Noise Restrictions on Industrial Development**
The noise ($L_{Aeq\ (15min)}$) emanating from industrial developments must not exceed 5 dB(A) above the background noise level ($L_{A90\ (15min)}$) of the area at any boundary of the land.

88 The applicant must not cause or permit the emission of offensive odours from the premises.

89 **Loading/Unloading Operations/Activities**
All loading/unloading operations are to take place at all times wholly within the confines of the site.

Reasons

The reasons for the imposition of the conditions are:

1 To minimise any likely adverse environmental impact of the proposed development.

2 To ensure the protection of the amenity and character of land adjoining and in the locality.

3 To ensure the proposed development complies with the provisions of Environmental Planning Instruments and Council's Codes and Policies.

4 To ensure the development does not conflict with the public interest.

Notes

1 This consent becomes effective and operates from the date shown as **"Endorsement Date"** on the front page of this notice. This consent will lapse unless development is commenced within five years from the endorsement date shown on this notice.

2 Section 97 of the Environmental Planning and Assessment Act confers on an applicant who is dissatisfied with the determination of a consent authority a right of appeal to the Land and Environment Court exercisable within twelve months from the date of receipt of this notice.

3 The holder of a development consent that is being acted upon must also hold a current:

a Construction Certificate under the provisions of the Environmental Planning and Assessment Act, 1979.

4 Where the consent is for building work or subdivision work, no temporary buildings may be placed on the site and no site excavation, filling, removal of trees or other site preparation may be carried out prior to the issue of a Construction Certificate and appointment of a Principal Certifying Authority.

5 A Tree Management Order has been proclaimed in the City of Wollongong. Under this order, no tree on the land the subject of this approval may be ringbarked, cut down, topped, lopped or wilfully destroyed except with the prior consent of Council which may be given subject to such conditions as Council considers appropriate. However, unless specified otherwise in this consent, those trees which are specifically designated to be removed on the plans approved under this consent or are within 3 metres of an approved building footprint may be removed, provided that a Construction Certificate has been issued for the development the subject of this consent and a Principal Certifying Authority appointed.

6 In this consent the developer means the applicant for development consent and any person or corporation who carries out the development pursuant to that consent.

7 Section 82A of the Environmental Planning and Assessment Act confers on an applicant who is dissatisfied with the determination of a consent authority a right to request the consent authority to review the determination. The request for review must be made within 12 months after the date on which the applicant received the notice of determination and must be accompanied by the fee set by the Regulations; it does not apply to an application in respect of Designated Development or Integrated Development.

8 Council recommends that NSW Wildlife Information and Rescue Service (WIRES) be contacted (phone (02) 4285 5630) for assistance in relocating native fauna prior to removal of trees and bushland.

9 **Prolonged Rainfall Events**
The applicant is advised that under existing conditions and during prolonged rainfall events, flooding of the site may occur and it is in the applicant's interest to take all necessary precautions to minimise the risk of property loss and/or damage.

This letter is authorised by

Geoffrey Hunt
Senior Development Project Officer
Wollongong City Council
Direct Line (02) 4227 7332

enc

The Manager
Forbes Rigby Pty Ltd
278 Keira Street
WOLLONGONG 2500

Dear Sir

NOTICE OF DETERMINATION OF DEVELOPMENT APPLICATION NO D2240/02

File No: D2240/02 **Our Ref: D.WT.LV**

Pursuant to section 81 of the Environmental Planning and Assessment Act, 1979, notice is hereby given of the determination of Development Application No D2240/02 relating to -

Lot 50 DP 1022266 (Whytes Gully) Reddalls Road, West Dapto

and being development described as -

Construction of New Leachate and Stormwater Treatment Ponds at Whytes Gully Waste Disposal Depot

as shown on the plans and as described and detailed in the documents listed below endorsed with Council's stamp.

- "Statement of Environmental Effects for New Leachate and Stormwater Treatment Ponds, Whytes Gully Waste Disposal Depot" – prepared by Forbes Rigby Pty Ltd for Wollongong City Council, dated November 2002;

- "Whytes Gully Landfill Leachate Management Study" prepared by Forbes Rigby Pty Ltd for Wollongong City Council dated August 2002;

- "Plan for Whytes Gully Waste Disposal Depot Proposal Leachate and Stormwater Treatment Upgrade" prepared by Forbes Rigby Pty Ltd dated 18 December 2002.

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The development has been classified under the Building Code of Australia as:

Class - 10a (Leachate and Stormwater Treatment Ponds)

The Development Application has been determined by **granting of consent subject to the following conditions:**

PART 1

CONDITIONS WHICH WOLLONGONG CITY COUNCIL REQUIRES TO BE IMPOSED AS PART OF THIS CONSENT ARE:-

BUILDING

1 All building work must be carried out in accordance with the provisions of the Building Code of Australia.

CONSTRUCTION CERTIFICATE

2 A **Construction Certificate** must be obtained from Council or an Accredited Certifier prior to work commencing. A construction certificate certifies that the provisions of Clauses 139-148 of the Environmental Planning and Assessment Amendment Regulations, 2000 have been satisfied, including compliance with the Building Code of Australia and conditions of Development Consent.

INSPECTIONS/CERTIFICATION

3 Prior to commencement of work, the person having the benefit of the Development Consent and a Construction Certificate shall:

a) appoint a **Principal Certifying Authority** and notify Council of the appointment (if Council is not appointed), and
b) notify Council of their intention to commence the erection of the building (at least 2 days notice is required).

The Principal Certifying Authority shall determine when **inspections and compliance certificates** are required.

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4 A final **Occupation Certificate** must be issued by the Principal Certifying Authority prior to occupation or use of the development. In issuing an occupation certificate, the Principle Certifying Authority must be satisfied that that the requirements of section 109H of the Environmental Planning and Assessment Act 1997 have been satisfied.

STORMWATER MANAGEMENT - DRAINAGE

5 The developer must ensure there are no adverse effects to adjoining properties or upon the land as a result of flooding and stormwater runoff. Attention must be paid to ensure adequate protection for buildings against the ingress of surface runoff.

6 The developer must make allowance for surface water run-off from adjacent properties. Any redirection or treatment of that run-off must not adversely affect any other properties.

7 The developer must ascertain the depth and location of all services (ie gas, water, sewer, electricity, telephone, traffic lights, etc) and account for these in the preparation of the working drawings to be submitted.

8 Detailed hydrologic and hydraulic calculations must be provided for approval by the Manager Design prior to release of the Construction Certificate. In this regard, the spillways of the proposed Leachate and Stormwater Treatment Ponds must be designed to cater for the 1% Annual Exceedance Probability Event. Further, an analysis of the Probable Maximum Flood must also be provided to ensure that a storm of this magnitude can safely pass through the system in a controlled manner.

9 Details of all proposed structures including the channel transition from the spillway of the polishing pond to the existing box culverts under Reddalls Road must be provided with the Construction Certificate application for approval by the Manager Design.

10 The developer must submit to the Principal Certifying Authority, prior to use of the Leachate and Stormwater Treatment Ponds full Works-As-Executed plans prepared and signed by a registered surveyor. The plans must include final locations and levels for all works associated with the development and the final volumes of the Leachate and Stormwater Treatment Ponds.

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11 The developer must prepare a detailed landscape plan for the proposed Leachate and Stormwater Treatment Ponds incorporating the following:

(a) a heavily landscaped buffer along Reddalls Road to visually screen the ponds;

(b) landscaping of the pond embankments and surrounding area;

(c) planting of aquatic and wetland species within the ponds as set out in Table 3.2 Typical Wetland Planting List on Page 26 of the approved Statement of Environmental Effects prepared by Forbes Rigby Pty Ltd dated November 2002 as follows :

Table 3.2 – Typical Wetland Planting List

Wetland Zone	Species
Inlet	*Schoenoplectus validus* (River Club-rush), *Phragmites australis* (Common Reed), *Juncus procerus* (rush)
Shallow Marsh	*Eleocharus acuta* (Common Spike rush), *Baumea acuta* (Pale Twig-rush), *Baumea ribiginosa* (Soft Twig-rush)
Marsh	Bolboschoenus medianus (Marsh Club-rush), *Baumea artrophylla* (rush), *Schoenoplectus pungens* (rush)
Deep Marsh	Schoenoplectus validus (River Club –rush), *Baumea articulata* (Jointed Twig-rush), *Eleocharus sphacelata* (Tall spike-rush).

FLORA AND FAUNA

12 The site of the proposed Leachate and Stormwater Treatment Ponds represents prime habitat for the Illawarra Lowlands Grassy Woodlands Endangered Ecological Community as indicated by the National Parks and Wildlife Service document *Native Vegetation of the Wollongong Escarpment and Coastal Plain* Report. The two forest types that make up the Illawarra Lowlands Grassy Woodlands including preferred habitat and species list are shown in Attachment 1 attached to this consent. All landscaping must be undertaken with respect to revegetating the area with species from the previously dominant vegetation community as set out in this species list.

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13 The developer should be aware that the creek that passes through the two existing water quality ponds and enters Dapto Creek to the south is identified as a "terrestrial and aquatic habitat" by the Department of Land and Water Conservation draft Riparian Corridor Management Study (RCMS). The strategies to protect the Dapto Creek Riparian Corridor require :

(a) Protection of environmental assets (remnant vegetation, wetlands, streams etc);

(b) Rehabilitation of degraded riparian vegetation;

(c) Maintenance of the viability of remnant vegetation.

All development on the site must take into account these strategies for the waterways affected by the development. The Department of Land and Water Conservation must be consulted about these strategies.

14 Dapto Creek is identified as a "wildlife corridor" by the Riparian Corridor Management Study. The strategies that accompany this designation require :

(a) Optimal riparian protection.

(b) Minimisation of road crossings and access points to the stream.

(c) The use of roads as the interface between the stream and developed areas.

(d) Optimisation of the corridor function in new land use decisions by stakeholders and approval agencies.

(e) Development of connectivity of vegetation between the coast (lake) and the escarpment.

(f) Protection of environmental assets (remnant vegetation, wetlands, streams etc).

(g) Rehabilitation of degraded riparian vegetation.

(h) Maintenance of the viability of remnant vegetation.

(i) Use flood compatible species that will not increase flood levels or flood hazard.

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(i) Natural solutions to be considered for stabilising watercourses and improving water quality.

All development on the site must take into account the strategies for each of the waterways affected by this development. The Department of Land and Water Conservation must be consulted about these strategies.

15 A Vegetation Management Plan must be developed and implemented prior to the commencement of work that addresses the matters in conditions 11 to 14.

HERITAGE

16 The developer must obtain a Section 90 consent permit from the National Parks and Wildlife Service for the site RR2 as identified in the Archaeological Report prepared by South East Archaeology, prior to commencement of earthworks on the site. A copy of the permit must be lodged with Council's Heritage Officer prior to the issue of the Construction Certificate.

TRAFFIC

17 The developer must prepare and implement a Traffic Management Plan for the construction phase of the proposed Leachate and Stormwater Treatment Ponds. This plan must be in accordance with the Roads and Traffic Authority's "Traffic Control at Work Sites Manual" (1998 edition). This plan must be submitted to Council's Traffic Engineer for approval prior to works commencing on the site.

GEOTECHNICAL

Lining of Leachate and Stormwater Treatment Ponds

18 To ensure the protection of groundwater, the Leachate and Stormwater Treatment Ponds must be designed and constructed so that pollution of groundwater does not occur.

Note : The minimum design requirements would be an appropriate high density polyethylene liner (HDPE) with permeability of all surfaces of the structures having a performance equivalent to or better than that of a clay liner with a permeability of 1 x 10-9 m/s or less and thickness of no less than 900mm.

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19 Prior to commencing construction the developer must engage the services of a qualified geotechnical/civil engineer with qualifications acceptable to the Institution of Engineers Australia to undertake detailed geotechnical investigations at this site. This engineer must provide a report detailing:

(i) Design and construction methods necessary to ensure compliance with Condition 18

(ii) Design and construction methods to ensure the structural stability of the leachate and stormwater treatment ponds.

Design and construction works on the leachate and stormwater treatment ponds must be undertaken strictly in accordance with this report.

20 The developer must ensure that all earthworks be subject to Level 1 engineering control as defined in AS3798. The Level 1 supervision of earthworks should include a Works-As-Executed geotechnical report which confirms that the completed construction will perform to the design intent in light of the encountered geotechnical conditions.

21 During the course of construction of the ponds all works associated with pond stability and pond lining must be supervised by a suitably qualified geotechnical engineer.

Certifications

22 Not later than 21 days after the completion of the leachate ponds and prior to any use of the ponds to store leachate, the proponent must submit to the Wollongong City Council and the Environment Protection Authority:

(a) a check survey undertaken by a qualified surveyor to confirm the capacity and demonstrate compliance with the volume detailed in the Statement of Environmental Effects; and

(b) certification from a qualified geotechnical engineer, confirming:

i) that the pond was constructed in accordance with the design and construction methods detailed in the report designed in Condition 19 above; and

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ii) compliance with Condition 18

ENVIRONMENTAL ISSUES

Air

23 To minimise air emissions on the site, the developer must ensure that a water truck is on site at all times during construction and establishment of landscaping.

Odour

24 The proposed Leachate Ponds must be designed and constructed so they comply with Section 129 of the Protection of the Environment Operations Act (POEO Act).

25 The developer must prepare and implement a Leachate Management Plan of the new Leachate Ponds which details the following :

- proposed aeration system;
- odour monitoring and recording;
- wetland performance and residence time;
- details of proposed Ammonia Plant Design and Operation.

This Plan must be submitted to the Environment Protection Authority and Council's Management Environment and Health prior to works commencing on the site.

Water Quality

26 The developer must ensure that during construction no overflow or pollution enters Dapto Creek.

27 A detailed Soil and Water Management Plan, consistent with best practice on stream management and restoration, must be prepared and implemented prior to works commencing on the site.

The Soil and Water Management Plan must include all the provisions outlined on Pages 29 and 30 of the approved Statement of Environmental Effects prepared by Forbes Rigby Pty Ltd dated November 2002.

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The Soil and Water Management Plan must be submitted to the Environment Protection Authority, the Department of Land and Water Conservation and Council's Manager Environment and Health prior to works commencing on the site.

Noise

28 The developer must prepare and implement a Noise Management Plan for the construction phase of the proposal, which incorporates the measures outlined on pages 31 and 32 of the approved Statement of Environmental Effects prepared by Forbes Rigby Pty Ltd dated November 2002.

29 The developer must undertake a noise assessment in accordance with the "Environment Protection Authority Industrial Noise Policy" to establish suitable noise levels for the operation of the new leachate ponds.

Monitoring and Reporting

30 Groundwater

To protect the long-term integrity of groundwater a series of piezometers must be installed on the downstream of the groundwater flow path. The piezometers must be constructed in a manner to intercept both failure of the liner integrity (ie. shallow bores) and the quality of the groundwater (ie. deep bores).

In this regard, at least five (5) piezometers should be located for the leachate ponds and five (5) piezometers for the stormwater treatment ponds.

The monitoring should be undertaken monthly, with a report submitted to the Environment Protection Authority and Council's Manager Environment & Health on an annual basis.

31 Stormwater

The developer must prepare and implement a stormwater monitoring and reporting program to assess the performance of the ponds and determine any occurrence of pollution. The program must address the following:

- overflows from the leachate ponds to the stormwater treatment ponds;

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- stormwater treatment pond management;
- overflow events;
- actions taken when pollution occurs.

A report must be submitted to the Environment Protection Authority and Council's Manager Environment & Health when overflow events occur.

Environmental Management Plan

32 The developer will need to amend the existing Landfill Environmental Management Plan (LEMP) for the site to take into account the new Leachate and Stormwater Treatment Ponds.

NUISANCE AND AMENITY

33 Construction work must take place at all times in a manner which does not cause a nuisance (by the generation of unreasonable noise or otherwise) to the owners and/or occupiers of adjoining and adjacent land.

APPROVAL FROM OTHER AUTHORITIES

34 The developer must comply with any requirements of the Work Cover Authority prior to the commencement of the development.

35 The developer must comply with any requirement of the Environment Protection Authority prior to the commencement of the development.

PART 2

CONDITIONS WHICH THE ENVIRONMENT PROTECTION AUTHORITY (EPA) REQUIRES TO BE IMPOSED AS PART OF THIS CONSENT, AND WILL BE REFLECTED IN AN ENVIRONMENT PROTECTION LICENSE (EPL) VARIATION FOR THE SITE:-

LIMIT CONDITIONS

Pollution of Waters

L1.1 The premises and activities carried out therein must not pollute surface or groundwater except as specified in the EPL for the premises.

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Construction Hours

L2.1 All construction activities at the premises which are audible at residential premises must be restricted to the following times:
- a) 7:00 am to 6:00 pm Mondays to Fridays;
- b) 8:00 am to 1:00 pm on Saturdays; and
- c) at no time on Sundays and Public Holidays.

OPERATING CONDITIONS

Construction Phase

O1.1 Activities occurring during the construction phase of the development must be carried out in a manner that will minimise the generation of dust.

Construction – Environmental Management

O1.2 Prior to commencing construction activities at the site, the developer must document measures that demonstrate how they will comply with Conditions L1.1 and O1.1 and manage foreseeable environmental risk. The documentation must detail but need not necessarily be limited to the following measures in Conditions O1.2.1 – O1.2.3, and O1.3. A copy of this document must be provided with the supporting information for an EPL variation and implemented prior to commencing construction.

O1.2.1 The documentation must describe measures to be used to comply with Condition O1.1 relating to the minimisation of dust.

O1.2.2 The documentation must describe measures to be employed to minimise soil erosion and the discharge of sediment and other pollutants to lands and/or waters during construction activities. The documentation should address but not necessarily be limited to:

(a) Details of existing and proposed soil and water management at the site;

(b) Management of any contaminated soils/materials;

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(c) Management of stockpiles to ensure they are confined to the smallest practicable area;

(d) Spoil Emplacement Activities;

(e) Separation of Clean and Dirty areas; and

(f) Bunding in accordance with the EPA Environment Protection Manual Technical Bulletin Bunding and Spill Management.

Note: The document titled Managing Urban Stormwater: Soils and Construction (available from the Department of Housing) can assist in providing suitable information that could assist in the development of appropriate documentation.

O1.2.3 The documentation must describe noise measures to be implemented to ensure compliance with Condition L2.1 and to minimize the potential to generate intrusive noise. The measures must include details about:

(a) compliance standards;

(b) community consultation;

(c) complaints handling monitoring/system;

(d) site contact person to follow up complaints;

(e) all reasonable and feasible measures for minimising construction noise and vibration impacts (Note: procedures must be developed to address any potential rock breaking activities);

(f) design/orientation of the proposed mitigation methods demonstrating best practice;

(g) construction times;

(h) contingency measures where noise complaints are received; and

(i) monitoring methods and program.

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Note: The EPA may include specific conditions relating to construction elements of the development and dependant on the adequacy of the above documented information.

Progressive Rehabilitation

O1.3 A progressive rehabilitation strategy must be prepared and implemented by the developer to address all areas impacted by the development including but not necessarily limited to:

(a) The identification of measures to prevent both wind blown dust emissions and contaminated stormwater runoff from any unsealed areas of the site,

(b) The identification of measures to prevent both wind blown dust emissions and contaminated stormwater runoff when the Pond is unused especially if the pond is lined with clay;

(c) All areas impacted by site operations including but not necessarily limited to the Stockpile and Spoil Emplacement areas;

(d) Exterior embankments of the ponds;

(e) Staging and timing for rehabilitation works at the premises;

(f) Ongoing management strategies to ensure the success of rehabilitation strategies; and

(g) Proposed growing mediums.

This strategy must be included with the documentation required in Condition 39.

Noise Assessment

O1.4 The developer must undertake a noise assessment in accordance with the EPA's *Industrial Noise Policy* regarding the operation of the proposed new leachate ponds. The noise assessment must include but need not necessarily be limited to:

a) The 24 hr operation of the facility in particular night-time operations;

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b) The identification of specific noise levels for plant and equipment;

c) The identification of any necessary noise amelioration measures; and

d) A suitable monitoring program to assess compliance.

A copy of the program must be forwarded to the EPA with the supporting information provided with the application for the EPL variation. The EPA may vary the EPL subject to the findings and recommendations of the assessment.

MONITORING AND RECORDING CONDITIONS

Groundwater Monitoring Program

M1.1 The developer must develop a groundwater monitoring program with an objective to detect any groundwater flow and direction and to determine any occurrence of groundwater pollution to ensure compliance with Condition L1.1 as a result of the operation of the proposed new Leachate Ponds.

The program must include details on but need not necessarily be limited to the following:

a) Location of bore holes to detect any pollution migration from the leachate storage ponds;

b) Monitoring the height of the groundwater table;

c) Monitoring to determine the direction of groundwater flow;

d) Monitoring methodologies and standards to be employed;

e) The parameters and substances that are proposed to be monitored;

f) Reporting and assessment of results;

g) Opportunities to integrate the monitoring program with other monitoring programs in the vicinity;

h) Monitoring frequency; and

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i) Representativeness of the sampling.

M1.1.1 The groundwater monitoring program must be independently reviewed by a suitably qualified groundwater expert on its adequacy in satisfying the objectives and specific requirements of the program detailed in condition M1.1. A report must be submitted to the EPA with a copy of the groundwater monitoring program with the application for EPL variation.

Note: The specific requirements of the program may be stipulated in the EPL.

Requirements to monitor concentration of pollutants discharged

M2.1 For each monitoring/discharge point specified below, the developer must monitor (by sampling and obtaining results by analysis) the concentration of each pollutant specified in Column 1. The developer must use the sampling method, units of measure, and sample at the frequency specified opposite in the other columns unless otherwise approved by the EPA:

EPA Identification No 7 Overflow Discharge from the Leachate Ponds to the Stormwater Ponds

Pollutant	*Units of measure*	*Frequency*	*Sampling Method*
Flow	kL/Day	Continuous	Continuously

Reporting

R1.1 The developer must notify the EPA pollution line service on 131 555 as soon as practicable after the developer or one of the developer's employees or agents becomes aware of any over flow discharge event from the Leachate Ponds.

R1.2 A report must be submitted to the EPA within 30 days of the event detailing information regarding any overflow discharge event from the leachate ponds. The aim of this reporting procedure is to monitor the frequency and causes for overflow discharge events and to ensure leachate ponds are operated so that overflow discharge events from the leachate ponds are minimised. The report must include but need not necessarily be limited to:

(a) Rainfall data in mm per hour;

(b) Duration of overflow discharge event;

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(c) Volume of overflow discharge event;

(d) Details of pumping regimes to sewer;

(e) Any measures to manage the stored leachate to reduce the risk for the overflow discharge event occurring;

(f) An assessment on whether any leachate or leachate contaminated waters left the premises and discharged to waters;

(g) Any environmental consequences as a result of the overflow discharge event including any follow up remedial actions if required;

(h) Any other information or reasons for the causes for the overflow discharge event; and

(i) An assessment against the design criteria of the leachate ponds.

Emergency Response Planning

G1.1 Prior to construction the developer must document and implement measures to minimise the environmental impacts of any emergency situations that could arise as a result of the construction and operation of the new leachate and stormwater ponds. The documentation must:

(a) identify any threats to the environment and/or public health that could arise from the operation or failure of the new leachate and stormwater ponds. These threats may include excessive rainfall, problems during construction and operation, pump failures, power or other utility failure, natural disaster, accidental spills and discharges, odours etc;

(b) identify any subsequent direct or indirect environmental effects that disruption in the operation of the new leachate and stormwater ponds may have on other operations at the premises;

(c) identify the pollution that would result due to the emergency situations and what impact the pollution would have on the health of the community and the environment;

(d) develop actions to effectively respond to the emergency situations so the risk of pollution is minimised, including any procedures to remedy the situation;

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(e) develop actions to respond to any possible impacts as a result of flooding including the identification of measures to effectively rehabilitate the new Leachate and Stormwater Ponds;

(f) develop a communications strategy for alerting relevant agencies and the potentially affected community in the event of any emergency situation leading to significant pollution;

(g) ensure that all relevant employees are familiar with the documentation; and

(h) when developing this documentation, identify any opportunities to integrate with the applicants emergency plans.

Prior to construction of the new leachate and stormwater ponds, a review of the adequacy of these measures must be undertaken by an independent person with appropriate expertise and skills.

The reasons for the imposition of the conditions are -

1 To minimise any likely adverse environmental impact of the proposed development.

2 To ensure the protection of the amenity and character of land adjoining and in the locality.

3 To ensure the proposed development complies with the provisions of Environmental Planning Instruments and Council's Codes and Policies.

4 To ensure the development does not conflict with the public interest.

ENDORSEMENT OF DATE OF CONSENT

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NOTES:

1 This consent becomes effective and operates from the date shown as **"Endorsement of date of consent"** on this notice.

2 This consent will lapse unless development is commenced within two years (three years with the approval of Council) from the date shown as **"Endorsement of date of consent"** on this notice.

3 Section 97 of the Environmental Planning and Assessment Act confers on an applicant who is dissatisfied with the determination of a consent authority a right of appeal to the Land and Environment Court exercisable within twelve months from the date of receipt of this notice.

4 The holder of a development consent must also hold a current Construction Certificate under the provisions of the Environmental Planning and Assessment Act, 1979.

5 Where the consent is for building work or subdivision work, no temporary buildings may be placed on the site and no site excavation, filling, removal of trees or other site preparation may be carried out prior to the issue of a **Construction Certificate** and appointment of a **Principal Certifying Authority**.

6 A **Tree Management Order** has been proclaimed in the City of Wollongong. Under this order, no tree on the land the subject of this approval may be ringbarked, cut down, topped, lopped or wilfully destroyed except with the prior consent of Council which may be given subject to such conditions as Council considers appropriate. However, unless specified otherwise in this consent, those trees which are specifically designated to be removed on the plans approved under this consent or are within 3 metres of an approved building footprint may be removed, provided that a Construction Certificate has been issued for the development the subject of this consent and a Principal Certifying Authority appointed and the required Bank Guarantees have been lodged with Council.

7 In this consent the developer means the applicant for development consent and any person or corporation who carries out the development pursuant to that consent.

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8 Section 82A of the Environmental Planning and Assessment Act confers on an applicant who is dissatisfied with the determination of a consent authority a right to request the consent authority to review the determination.

The request for review must be made within 28 days after the date of the determination and must be accompanied by the fee set by the Regulations.

The request for review does not apply to an application in respect of Designated Development or Integrated Development.

Yours faithfully

Wendy Todd
Senior Development Project Officer
Wollongong City Council
Direct Line (02) 4227 7314

Encl.

Received 27/5/11

In reply please quote:
If phoning ask for:
Direct line:

D.DL:ST D92/662
David Laing
27 7332

5 February 1993

Wollongong City Council

Address all correspondence to:
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Locked Bag 8821
South Coast Mail Centre NSW 2
Telephone (042) 27 7111
Facsimile (042) 27 7277
DX 5183

General Manager
Wollongong City Council
Locked Bag 8821
South Coast Mail Centre NSW 2521

Dear Sir

NOTICE OF DETERMINATION OF DEVELOPMENT APPLICATION NO D92/662

Pursuant to Section 92 of the Environmental Planning and Assessment Act, 1979, notice is hereby given of the determination of Development Application No D92/662 relating to -

Lot 301 DP 776338, Lot 2 DP 240557 and Lot 203 DP 708258
Reddalls Road West Dapto

and being development described as -

Upgrading the Existing Western Gully Landfill and Extending the Land Filling Operation into the adjacent Eastern Gully

Stage I - Stormwater Retention Dams

as shown on the plans endorsed with Council's stamp and attached to Development Consent No D92/662 Stage I.

The Development Application has been determined by granting of consent subject to the following conditions:

1 All the works subject to this consent shall be generally in accordance with the Environmental Impact Statement prepared by Maunsell Pty Limited for and on behalf of Wollongong City Council dated December 1992.

2 Weir velocity for both dams shall be no greater than 2m/s.

3 Suitable sediment control and erosion measures shall be in place prior to, and during, construction activities commencing on site.

4 Any requirements of the Environment Protection Authority shall be complied with.

The reasons for the imposition of the conditions are -

a To minimise any likely adverse environmental impact of the proposed development.

b To ensure the protection of the amenity and character of land adjoining and in the locality.

c To ensure the proposed development complies with the provisions of Environmental Planning Instruments and Council's Codes and Policies.

d To ensure the development does not conflict with the public interest.

ENDORSEMENT OF DATE OF CONSENT

5 February 1993

NOTES:

1 Consent shall become effective and operate from the **"Endorsement of date of consent"** on this Notice.

2 Consent shall lapse unless development is commenced within two years (three years with the approval of Council) from the **"Endorsement of date of consent"**, unless a Local Environmental Plan is made having the effect of prohibiting the development. (See Section 99 of the Environmental Planning and Assessment Act, 1979.)

3 Section 97(1) of the Environmental Planning and Assessment Act confers on an applicant who is dissatisfied with the determination of a consent authority a right of appeal to the Land and Environment Court exercisable within twelve months from the date of this letter.

4 A **Tree Preservation Order** has been proclaimed in the City of Wollongong. Under this Order, no tree on the land the subject of this approval shall be ringbarked, cut down, topped, lopped or wilfully destroyed except with the prior consent of Council which may be given subject to such conditions as Council considers appropriate. However, unless specified otherwise in this consent, those trees which are specifically designated to be removed on the approved plans under this consent may be removed.

Yours faithfully

R J Oxley
General Manager

In reply please quote: D.DL:DL D92/662
If phoning ask for: David Laing
Direct line: 27 7332

24 February 1993

Wollongong City Council

Address all correspondence to:
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South Coast Mail Centre NSW 2521
Telephone (042) 27 7111
Facsimile (042) 27 7277
DX 5183

General Manager
Wollongong City Council
Locked Bag 8821
South Coast Mail Centre NSW 2521

ATTENTION: PHIL HAWLEY

Dear Sir

NOTICE OF DETERMINATION OF DEVELOPMENT APPLICATION NO D92/662

Pursuant to Section 92 of the Environmental Planning and Assessment Act, 1979, notice is hereby given of the determination of Development Application No D92/662 relating to -

Lot 301 DP 776338, Lot 2 DP 240557 and Lot 203 DP 708258 Reddalls Road West Dapto

and being development described as -

Upgrading the Existing Western Gully Landfill and Extending the Land Filling Operation into the adjacent Eastern Gully

Stage II - Landfill Operation

as shown on the plans endorsed with Council's stamp and attached to Development Consent No D92/662 Stage II.

The Development Application has been determined by granting of consent subject to the following conditions:

1 Unless otherwise specified in this consent, all of the works the subject of this application shall be carried out in accordance with the following documents:

a Whyte's Gully Landfill Extension - Environmental Impact Statement and Addenda prepared by Maunsell Pty Ltd for and on behalf of Wollongong City Council dated December 1992, and;

Wollongong - A Quality City

b Whyte's Gully Landfill Extension - Landfill Management Plan prepared by Maunsell Pty Ltd for and on behalf of Wollongong City Council dated January 1993.

2 There shall be no receipt of refuse until all necessary licences have been obtained, including the following:

a Trade Waste Agreement confirming discharge of leachate to sewer from the Water Board ;

b Licencing of Groundwater Bores from the Department of Water Resources, and;

c Licence to discharge to receiving waters from the Environment Protection Authority.

3 Any additional requirements of the Environment Protection Authority shall be complied with.

WATER QUALITY

4 The applicant shall undertake periodic sampling of leachate and surface water discharge from both the East and West Gully in order to monitor the quality of water entering receiving waters. The frequency of collection and subsequent analysis of data is to be to the requirement of the Environment Protection Authority and Water board with the following minimum analysis:

Monthly Analysis

pH, Conductivity, Non-Filtrable Residue, Biochemical Oxygen Demand, Chemical Oxygen Demand, Total Kjeldahl Nitrogen and Total Phosphorus;

Annual Analysis

Aluminium, Arsenic, Cadmium, Chromium, Copper, Iron, Mercury, Manganese, Nickel, Lead and Zinc.

LANDSCAPING

5 Consent is given for removal of vegetation which, because of its location, would otherwise impede successful operations within the works area.

6 The remnant rainforest community in the Eastern Gully, as identified on the approved plans, shall be suitably protected during both the construction and operation phase of the project. In this regard a minimum buffer zone of 20m width surrounding the rainforest area shall be implemented immediately before commencement of any construction works adjacent to this area.

This area is to be fenced off with 25mm grid rabbit proof fence (extending underground to prevent burrowing) and mass planted with rainforest margin species.

7 No work of any kind, including site excavation, is permitted within this buffer zone.

8 A landscape rehabilitation plan for the Western Gully shall be prepared and approved by the Manager Planning. Planting, in accordance with the approved plans, shall be installed within 3 months of the commencement of refuse emplacement in the Eastern Gully.

9 The following landscape management plans shall be prepared for the Eastern Gully:

a Rehabilitation plans for the construction phase;

This plan shall include, but not be limited to, a detailed maintenance and irrigation programme for an initial 26 week planting establishment period in addition to the ongoing operation. Furthermore, particular reference shall be made to planting macrophytic aquatic species on shallow water benches in retention basins in order to firstly, reduce the area of standing water for Silver Gulls, and secondly, provide additional treatment of Nitrogen and Phosphorus.

b Rehabilitation plan for the ongoing fill operation;

c Final rehabilitation of site upon cessation of filling.

10 No emplacement of refuse shall take place until the rehabilitation plans for both the construction and fill operation phase have been prepared and approved by the Manager Planning.

ENVIRONMENTAL SAFEGUARDS

11 In order to minimise the potential for channel erosion, the 'V-shaped' contour drains along the final and interim covers of the landfill shall be re-designed to be either parabolic or trapezoidal in cross-section.

12 The applicant shall undertake regular inspections to monitor the success of works as proposed and also the effectiveness of environmental safeguards employed on site. If it is evident that adverse environmental conditions have resulted, then suitable rectifying works shall be immediately employed.

13 In order to minimise the noise generated on-site, all traffic movements within the site shall be restricted to 40 kph. Signs advising patrons of this requirement shall be placed at suitable locations.

14 Soil conservation measures are to be undertaken to protect topsoil which has been stockpiled from erosion.

15 Under no circumstances are any blasting operations to be undertaken during the construction phase of the project. Only material which is rippable is to be taken from the working face.

16 The Trickling Filter is to be located directly adjoining the existing leachate treatment dams on site, as shown on the approved plans.

17 All of the works, including landscaping, required to be carried out under the conditions of this approval shall be maintained at all times in good order and repair and to the satisfaction of Council.

COMMUNITY CONSULTATION

18 The Manager Engineering Services or a departmental representative shall consult with objectors to this development (see attached list) to determine a mutually acceptable liaison program to discuss problems that may arise between the landfill operation and local residents.

The reasons for the imposition of the conditions are -

a To minimise any likely adverse environmental impact of the proposed development.

b To ensure the protection of the amenity and character of land adjoining and in the locality.

c To ensure the proposed development complies with the provisions of Environmental Planning Instruments and Council's Codes and Policies.

d To ensure the development does not conflict with the public interest.

ENDORSEMENT OF DATE OF CONSENT 24 February 1993

NOTES:

1 Consent shall become effective and operate 28 days from the **"Endorsement of date of consent"** on this Notice.

2 Consent shall lapse unless development is commenced within two years (three years with the approval of Council) from the **"Endorsement of date of consent"**, unless a Local Environmental Plan is made having the effect of prohibiting the development. (See Section 99 of the Environmental Planning and Assessment Act, 1979.)

3 Section 97(1) of the Environmental Planning and Assessment Act confers on an applicant who is dissatisfied with the determination of a consent authority a right of appeal to the Land and Environment Court exercisable within twelve months from the date of this letter.

4 A **Tree Preservation Order** has been proclaimed in the City of Wollongong. Under this Order, no tree on the land the subject of this approval shall be ringbarked, cut down, topped, lopped or wilfully destroyed except with the prior consent of Council which may be given subject to such conditions as Council considers appropriate. However, unless specified otherwise in this consent, those trees which are specifically designated to be removed on the approved plans under this consent may be removed.

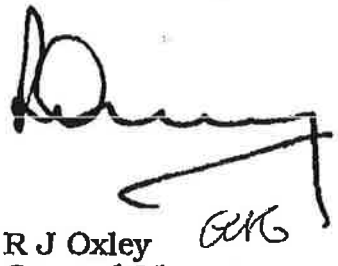
5 If it is found that the proposed new tipping practice does not significantly reduce the amount of litter generated from the site, then Council should consider the possibility of installing a waste transfer station.

5 If it is found that the proposed new tipping practice does not significantly reduce the number of Silver Gulls attracted to the site, then Council should consider the possibility of installing infra-sound distress call devices. In this regard contact should be made with Geoffrey Smith of N.P.W.S.

6 Where the Consent envisages the erection of buildings, no temporary buildings shall be placed on the site and no site excavation, filling, removal of trees or other site preparation shall be carried out prior to the issue of a Building Permit.

7 This Consent is for the development specifically described and Council reserves the right to approve or disapprove any additional use proposed for any part of the land or building and to impose additional conditions with any such approval.

Yours faithfully



R J Oxley
General Manager

Enclosure

APPENDIX B

Wind Roses

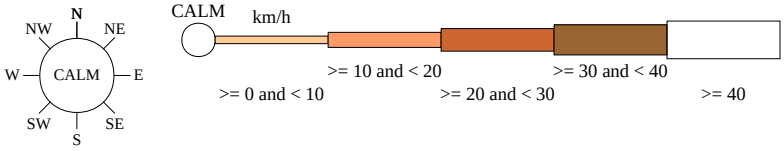
Rose of Wind direction versus Wind speed in km/h (05 Jun 1999 to 27 Feb 2010)

Custom times selected, refer to attached note for details

ALBION PARK (WOLLONGONG AIRPORT)

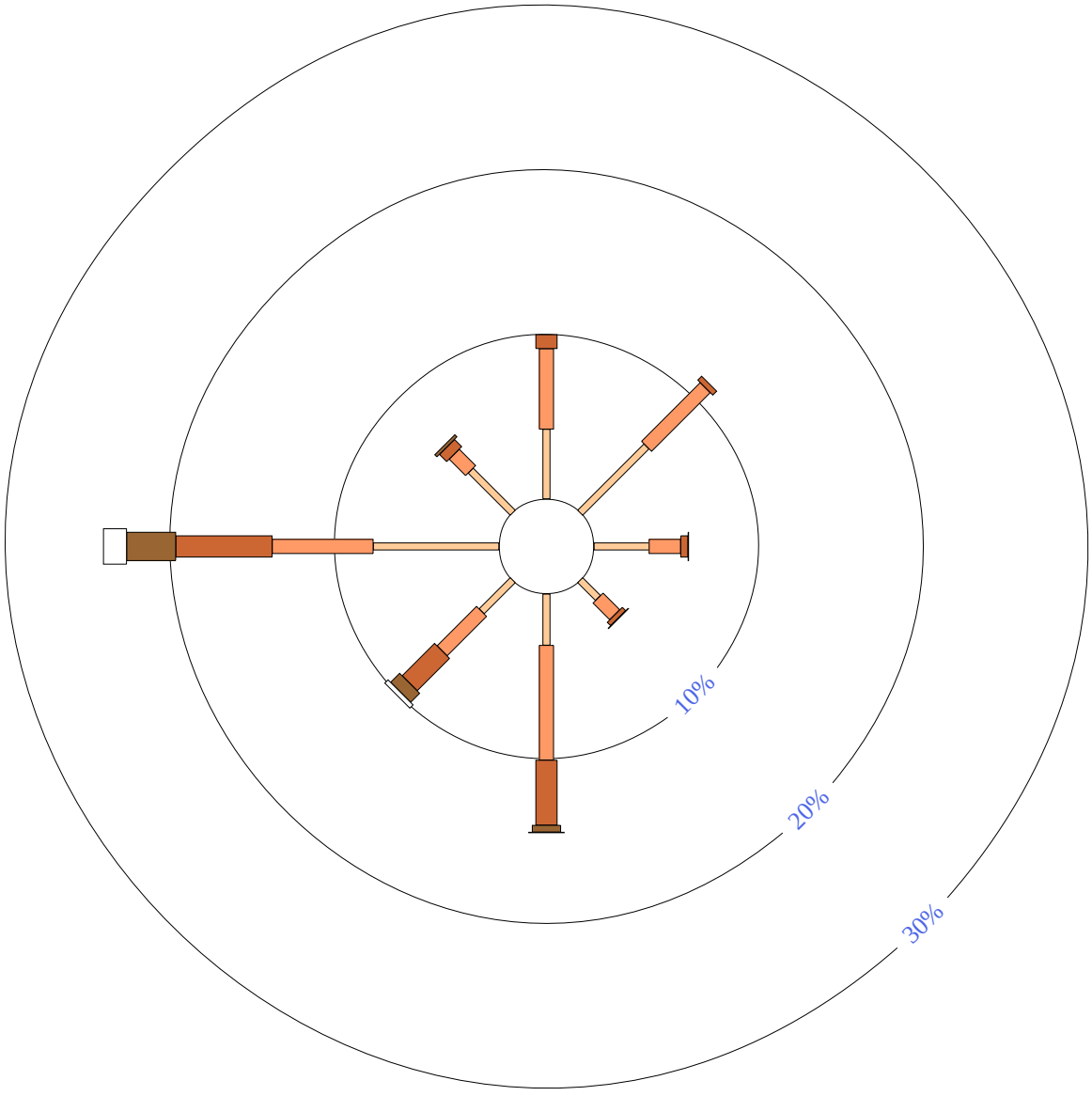
Site No: 068241 • Opened Jun 1999 • Still Open • Latitude: -34.5638° • Longitude: 150.79° • Elevation 8m

An asterisk (*) indicates that calm is less than 0.5%.
Other important info about this analysis is available in the accompanying notes.



9 am
3869 Total Observations

Calm 15%



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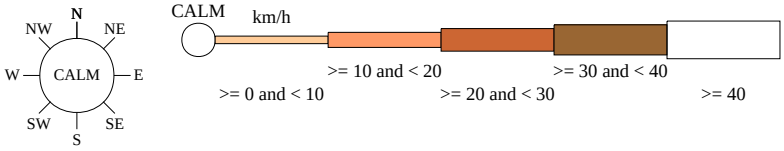
Rose of Wind direction versus Wind speed in km/h (05 Jun 1999 to 30 Sep 2010)

Custom times selected, refer to attached note for details

ALBION PARK (WOLLONGONG AIRPORT)

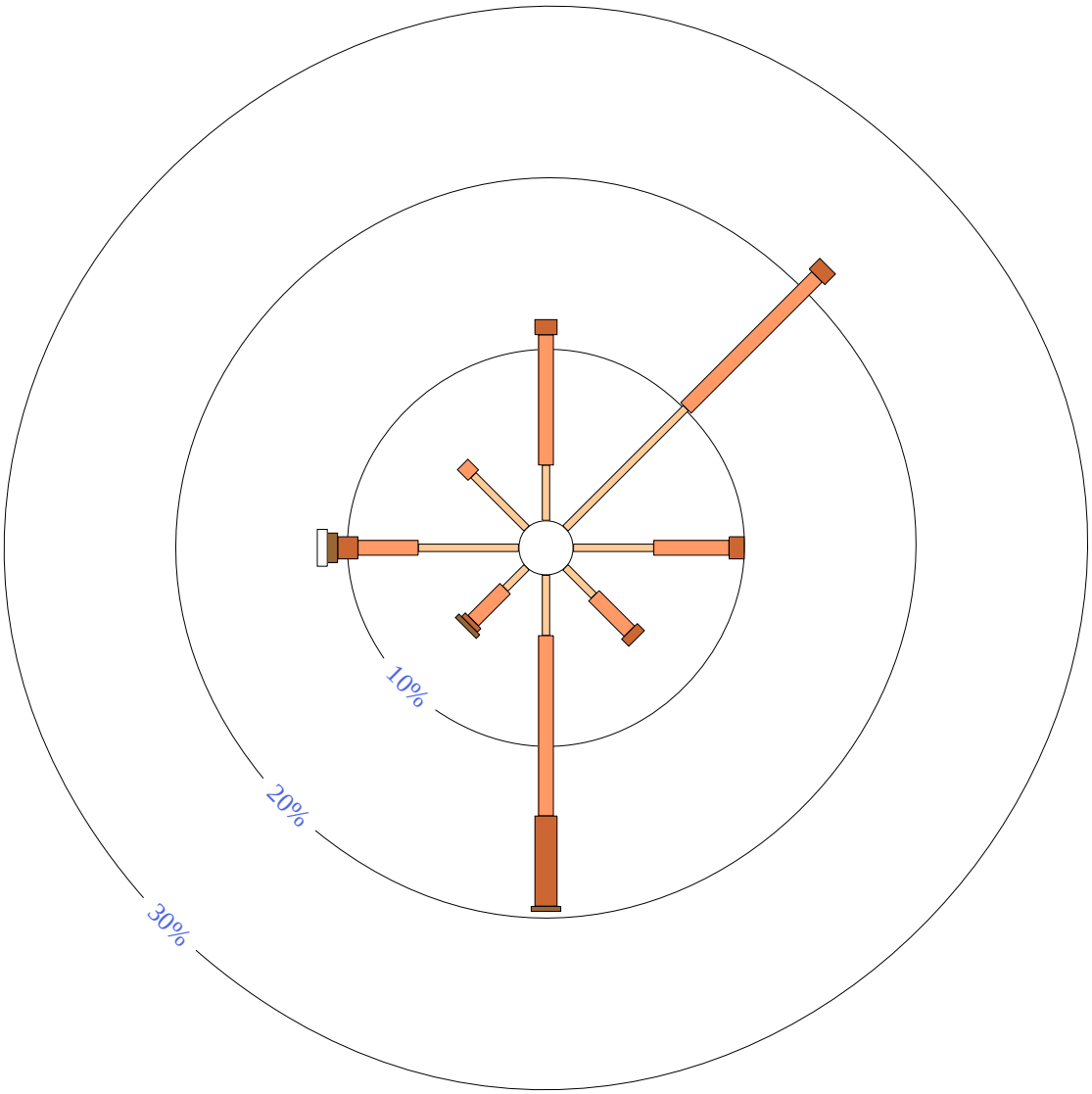
Site No: 068241 • Opened Jun 1999 • Still Open • Latitude: -34.5638° • Longitude: 150.79° • Elevation 8m

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9 am Jan
337 Total Observations

Calm 8%



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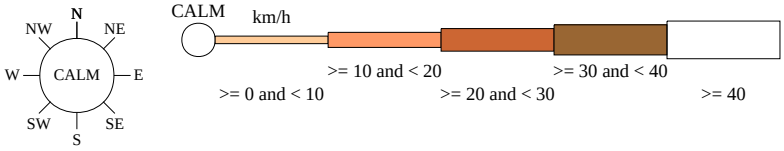
Rose of Wind direction versus Wind speed in km/h (05 Jun 1999 to 30 Sep 2010)

Custom times selected, refer to attached note for details

ALBION PARK (WOLLONGONG AIRPORT)

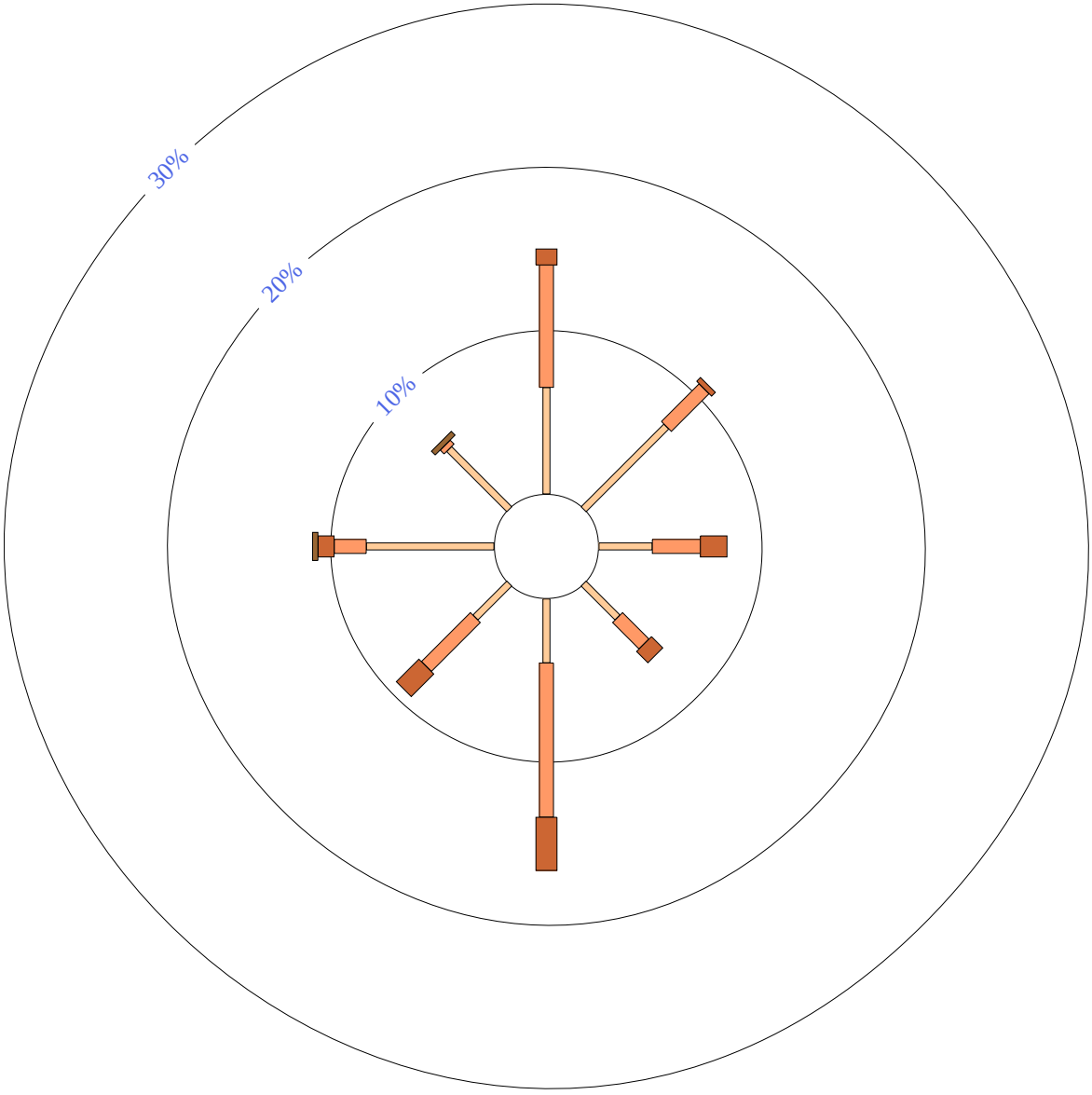
Site No: 068241 • Opened Jun 1999 • Still Open • Latitude: -34.5638° • Longitude: 150.79° • Elevation 8m

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9 am Feb
302 Total Observations

Calm 16%



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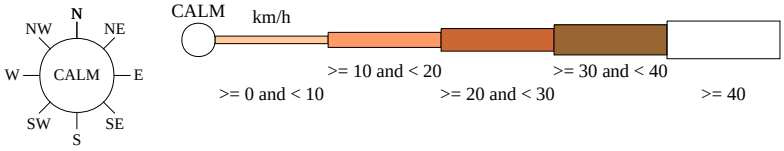
Rose of Wind direction versus Wind speed in km/h (05 Jun 1999 to 30 Sep 2010)

Custom times selected, refer to attached note for details

ALBION PARK (WOLLONGONG AIRPORT)

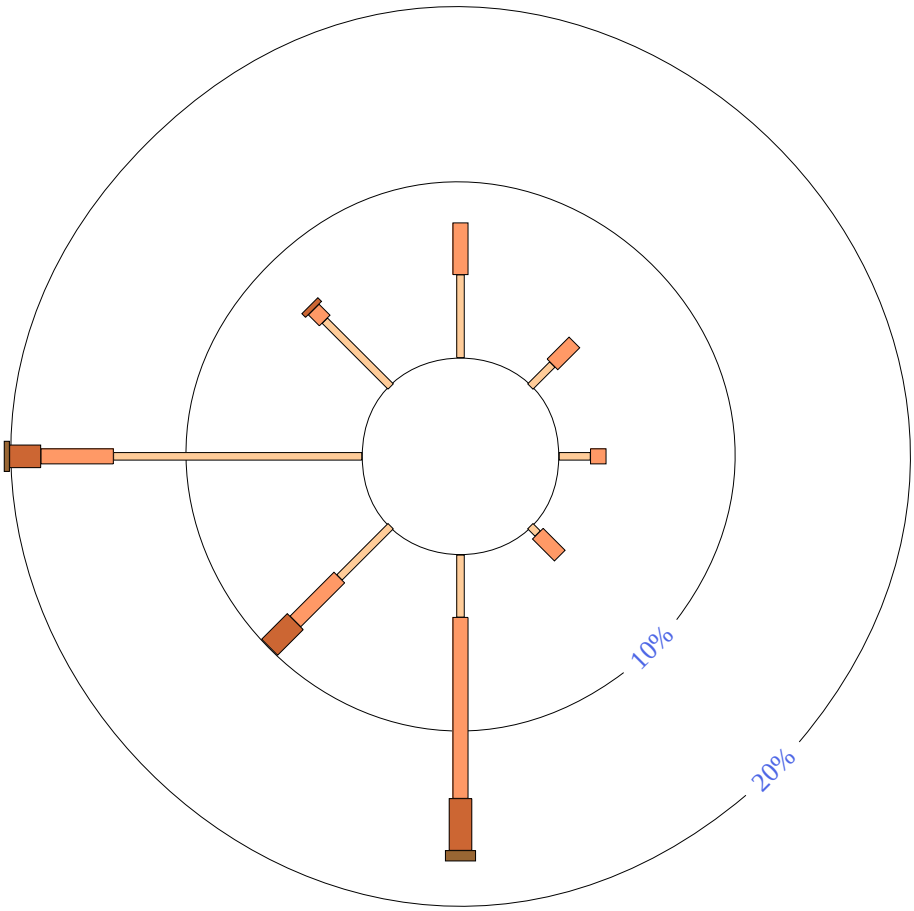
Site No: 068241 • Opened Jun 1999 • Still Open • Latitude: -34.5638° • Longitude: 150.79° • Elevation 8m

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9 am Mar
333 Total Observations

Calm 29%



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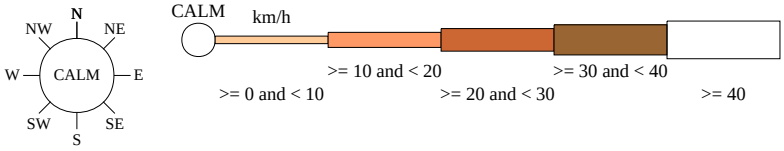
Rose of Wind direction versus Wind speed in km/h (05 Jun 1999 to 30 Sep 2010)

Custom times selected, refer to attached note for details

ALBION PARK (WOLLONGONG AIRPORT)

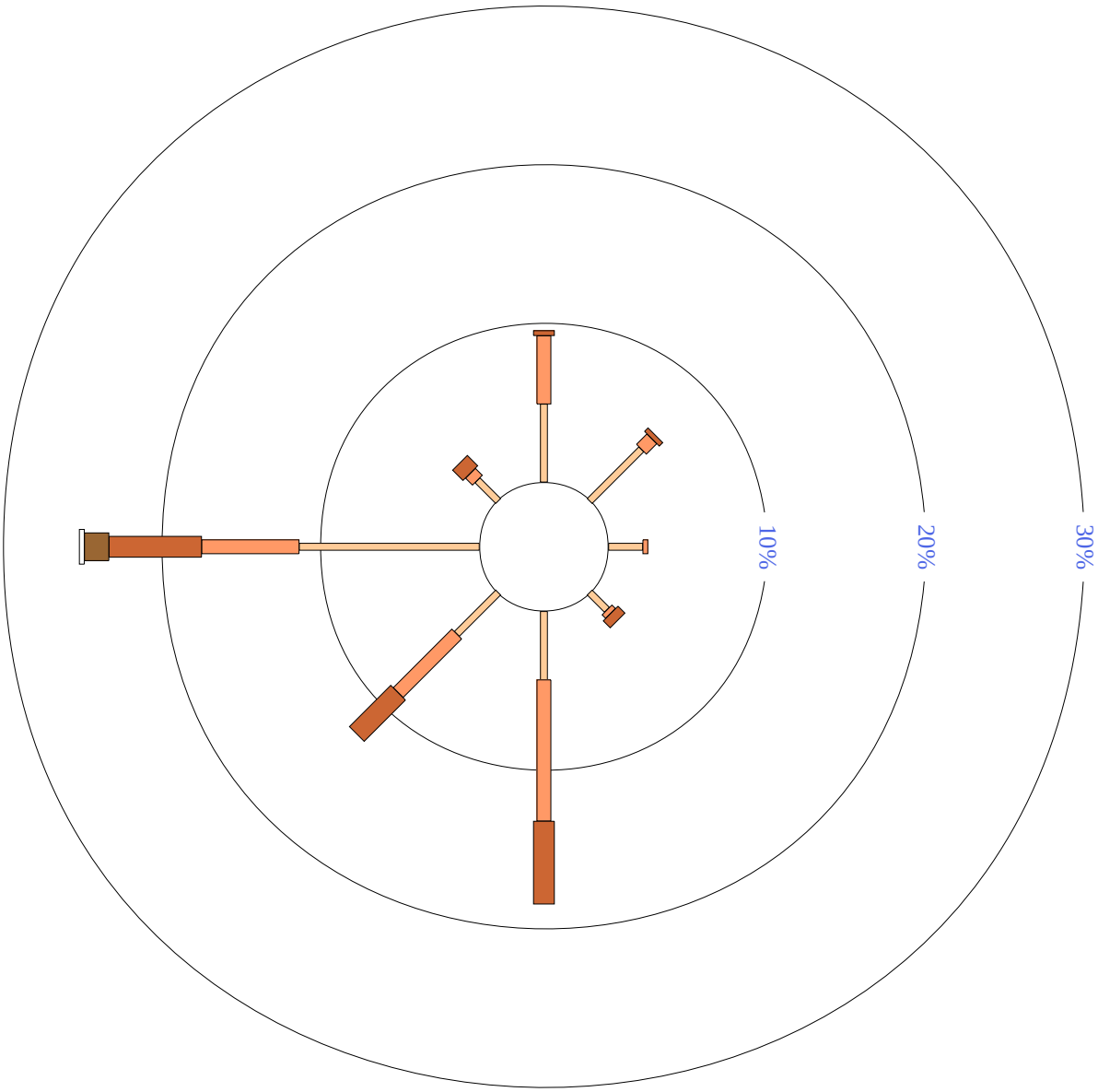
Site No: 068241 • Opened Jun 1999 • Still Open • Latitude: -34.5638° • Longitude: 150.79° • Elevation 8m

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9 am Apr
326 Total Observations

Calm 20%



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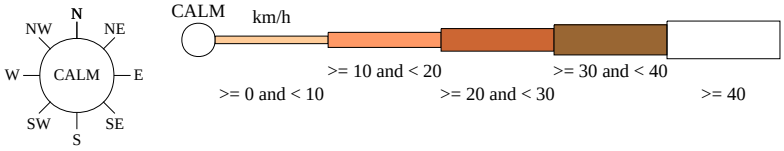
Rose of Wind direction versus Wind speed in km/h (05 Jun 1999 to 30 Sep 2010)

Custom times selected, refer to attached note for details

ALBION PARK (WOLLONGONG AIRPORT)

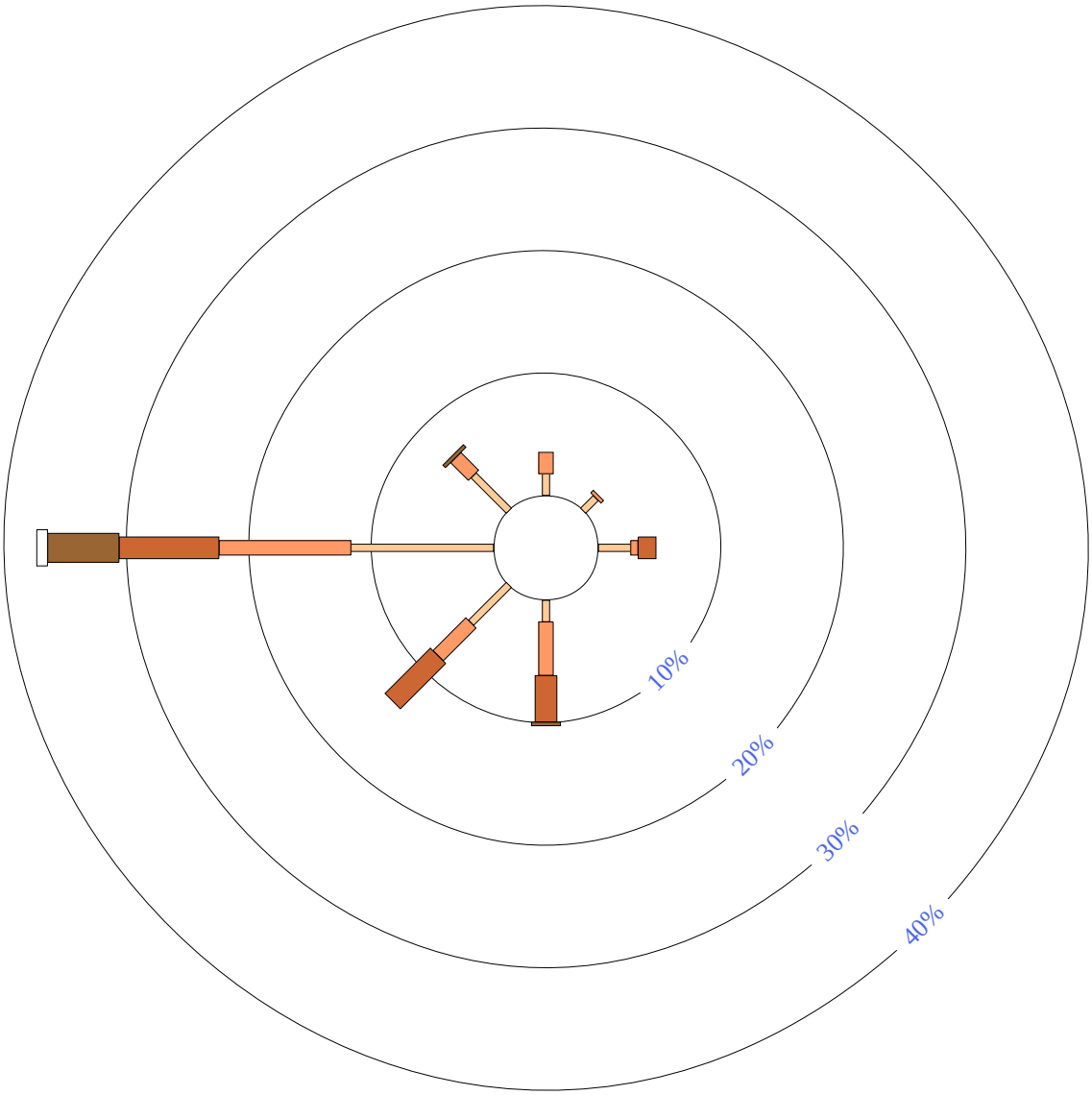
Site No: 068241 • Opened Jun 1999 • Still Open • Latitude: -34.5638° • Longitude: 150.79° • Elevation 8m

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9 am May
338 Total Observations

Calm 22%



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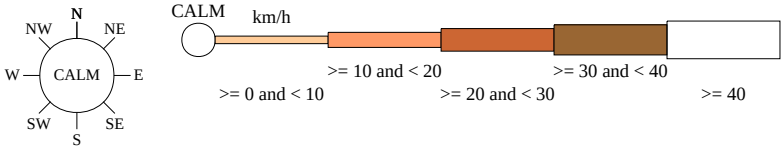
Rose of Wind direction versus Wind speed in km/h (05 Jun 1999 to 30 Sep 2010)

Custom times selected, refer to attached note for details

ALBION PARK (WOLLONGONG AIRPORT)

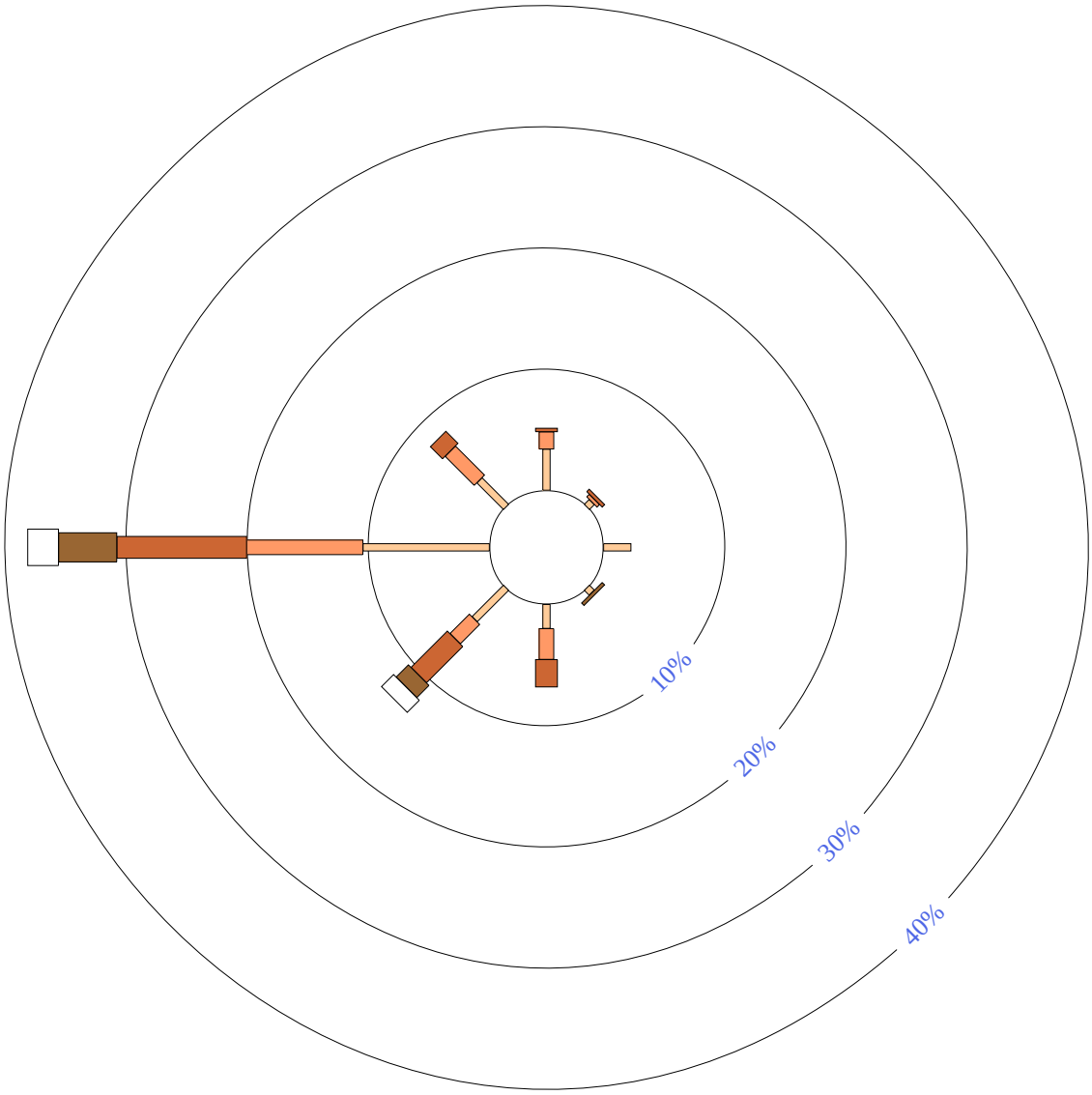
Site No: 068241 • Opened Jun 1999 • Still Open • Latitude: -34.5638° • Longitude: 150.79° • Elevation 8m

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9 am Jun
349 Total Observations

Calm 24%



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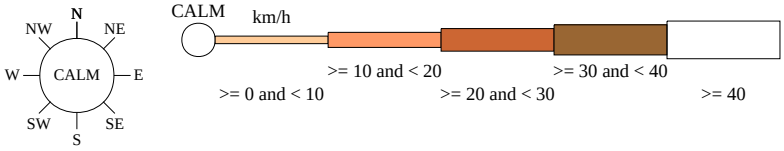
Rose of Wind direction versus Wind speed in km/h (05 Jun 1999 to 30 Sep 2010)

Custom times selected, refer to attached note for details

ALBION PARK (WOLLONGONG AIRPORT)

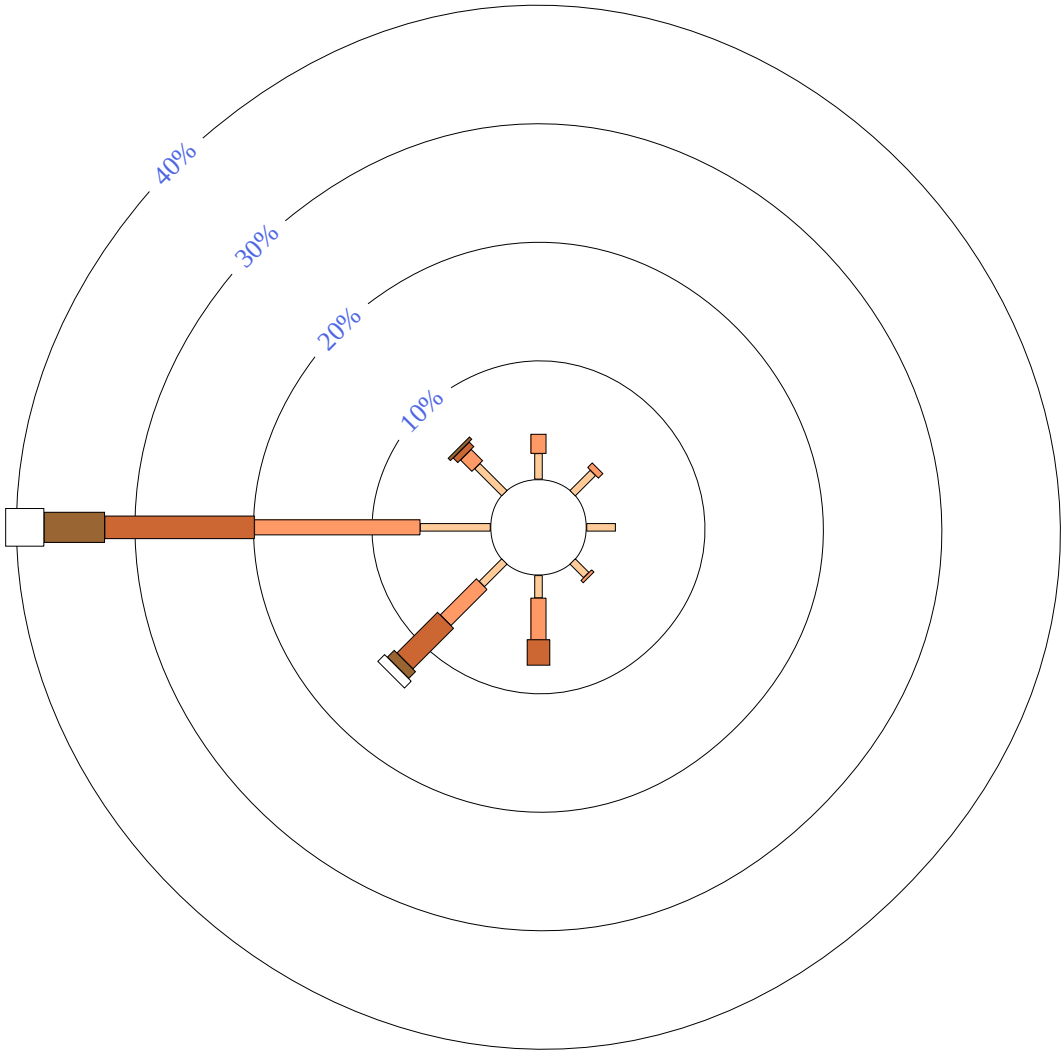
Site No: 068241 • Opened Jun 1999 • Still Open • Latitude: -34.5638° • Longitude: 150.79° • Elevation 8m

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9 am Jul
366 Total Observations

Calm 20%



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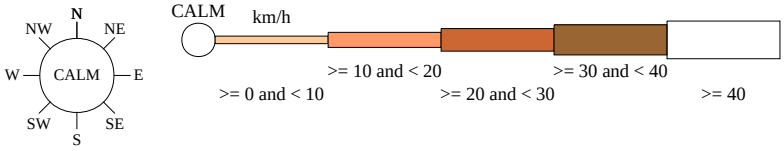
Rose of Wind direction versus Wind speed in km/h (05 Jun 1999 to 30 Sep 2010)

Custom times selected, refer to attached note for details

ALBION PARK (WOLLONGONG AIRPORT)

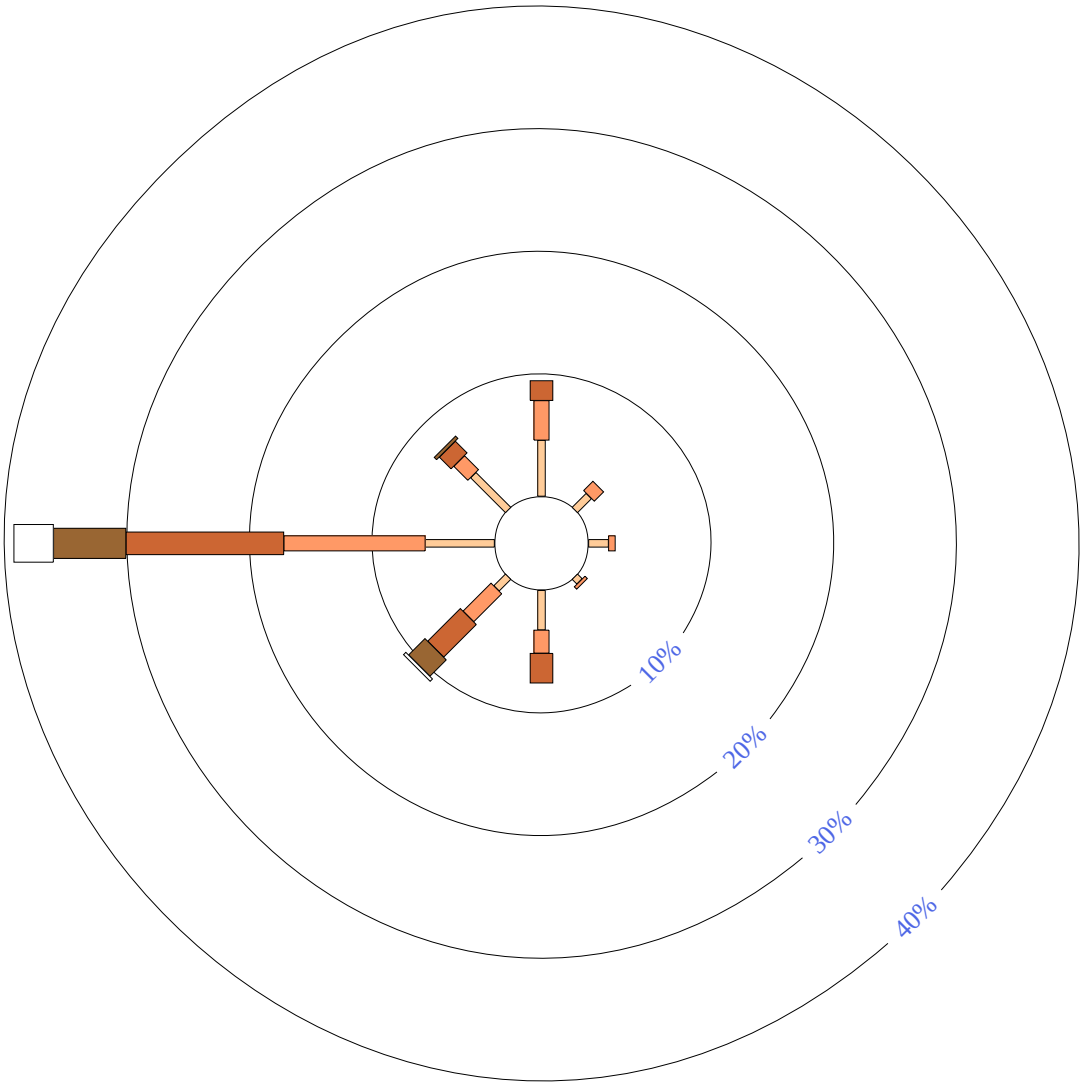
Site No: 068241 • Opened Jun 1999 • Still Open • Latitude: -34.5638° • Longitude: 150.79° • Elevation 8m

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9 am Aug
367 Total Observations

Calm 19%



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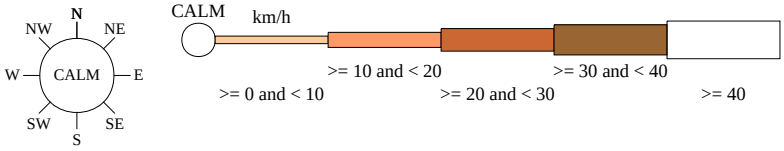
Rose of Wind direction versus Wind speed in km/h (05 Jun 1999 to 30 Sep 2010)

Custom times selected, refer to attached note for details

ALBION PARK (WOLLONGONG AIRPORT)

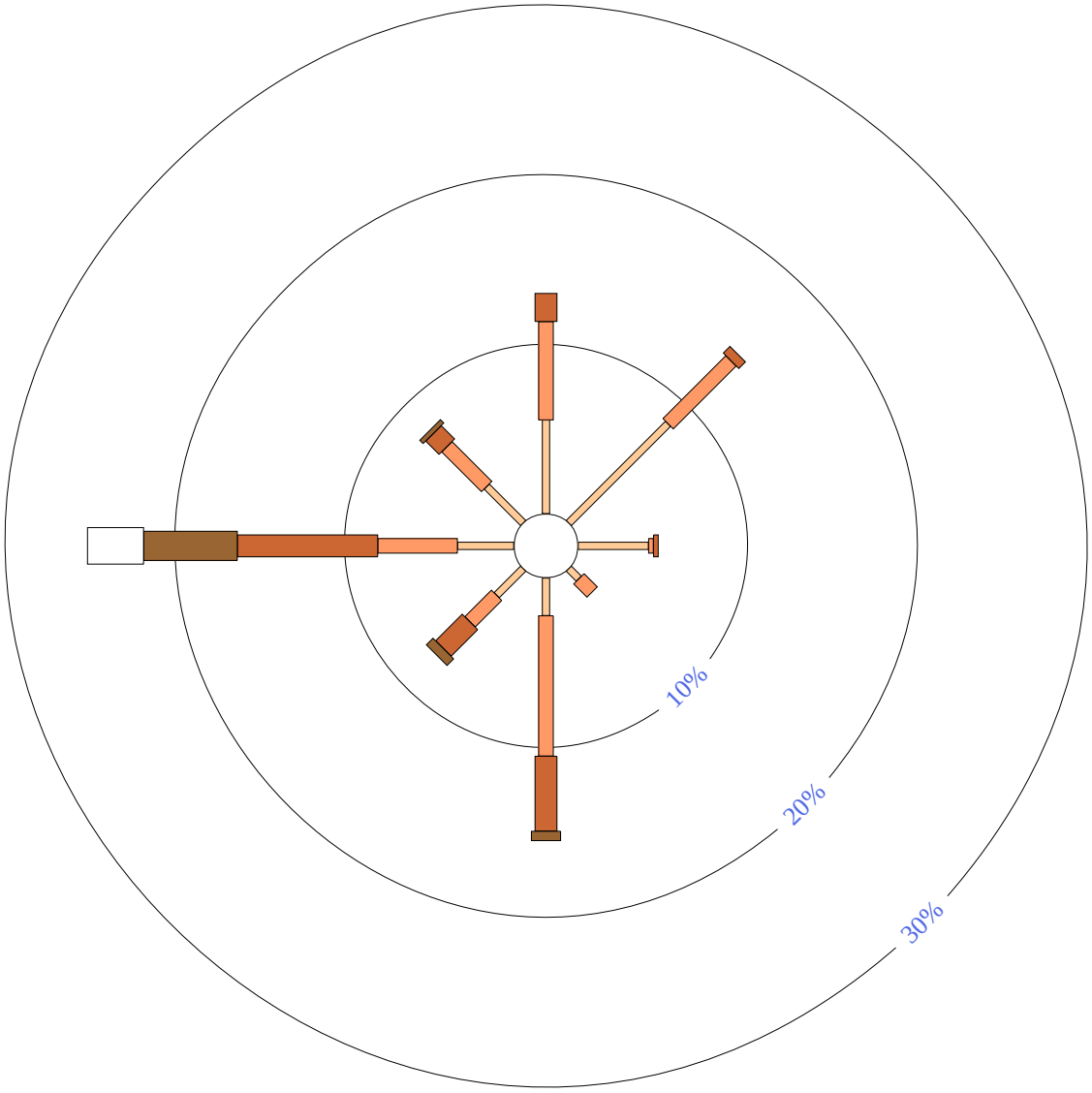
Site No: 068241 • Opened Jun 1999 • Still Open • Latitude: -34.5638° • Longitude: 150.79° • Elevation 8m

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9 am Sep
357 Total Observations

Calm 10%



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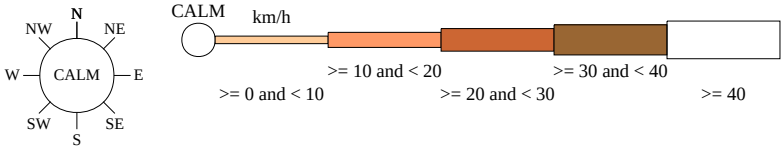
Rose of Wind direction versus Wind speed in km/h (05 Jun 1999 to 30 Sep 2010)

Custom times selected, refer to attached note for details

ALBION PARK (WOLLONGONG AIRPORT)

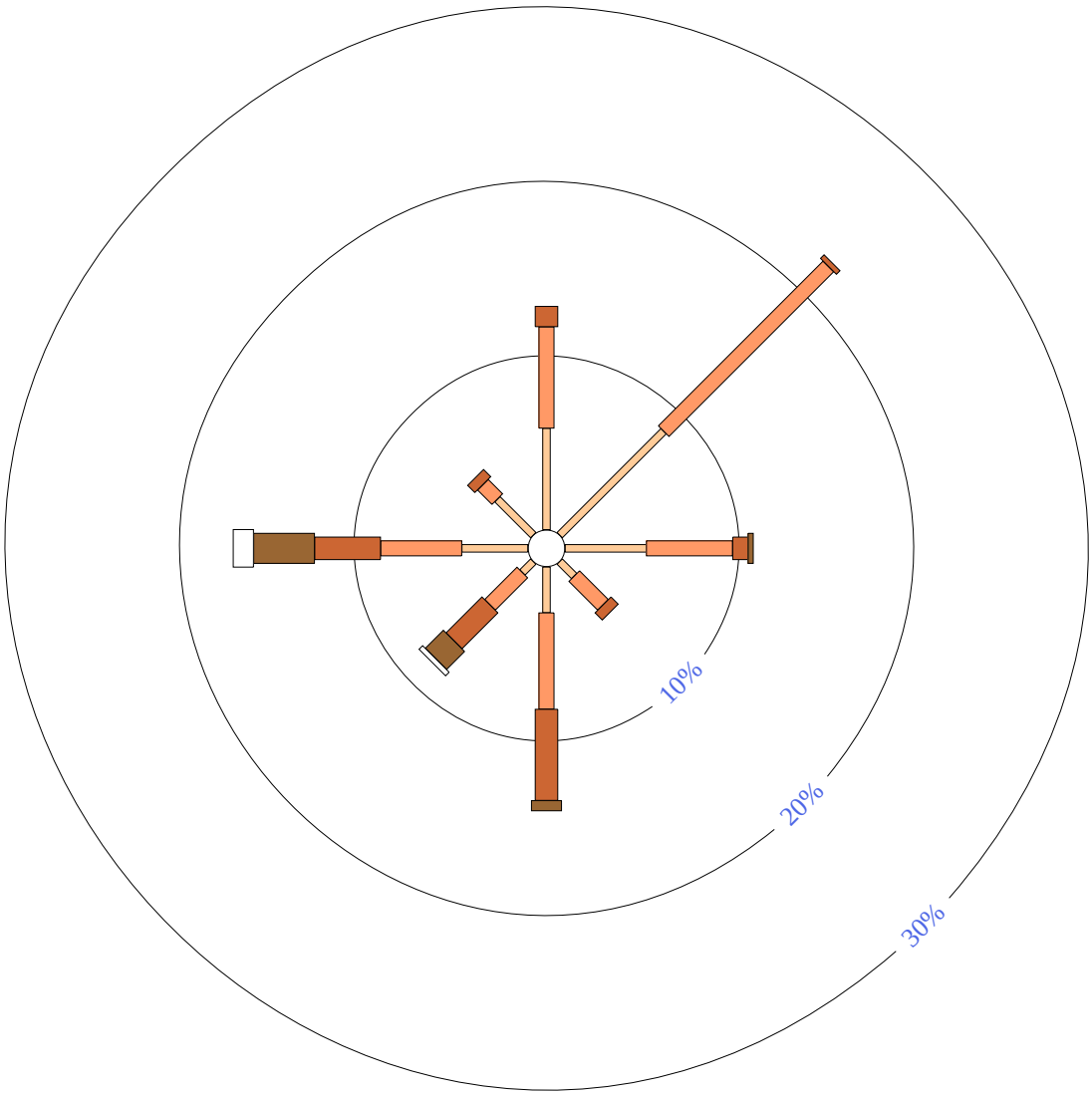
Site No: 068241 • Opened Jun 1999 • Still Open • Latitude: -34.5638° • Longitude: 150.79° • Elevation 8m

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9 am Oct
339 Total Observations

Calm 5%



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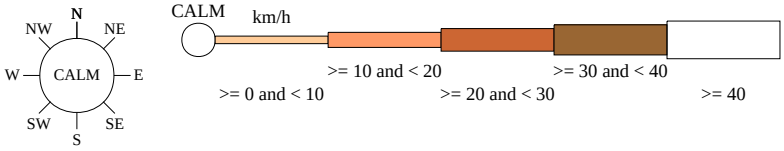
Rose of Wind direction versus Wind speed in km/h (05 Jun 1999 to 30 Sep 2010)

Custom times selected, refer to attached note for details

ALBION PARK (WOLLONGONG AIRPORT)

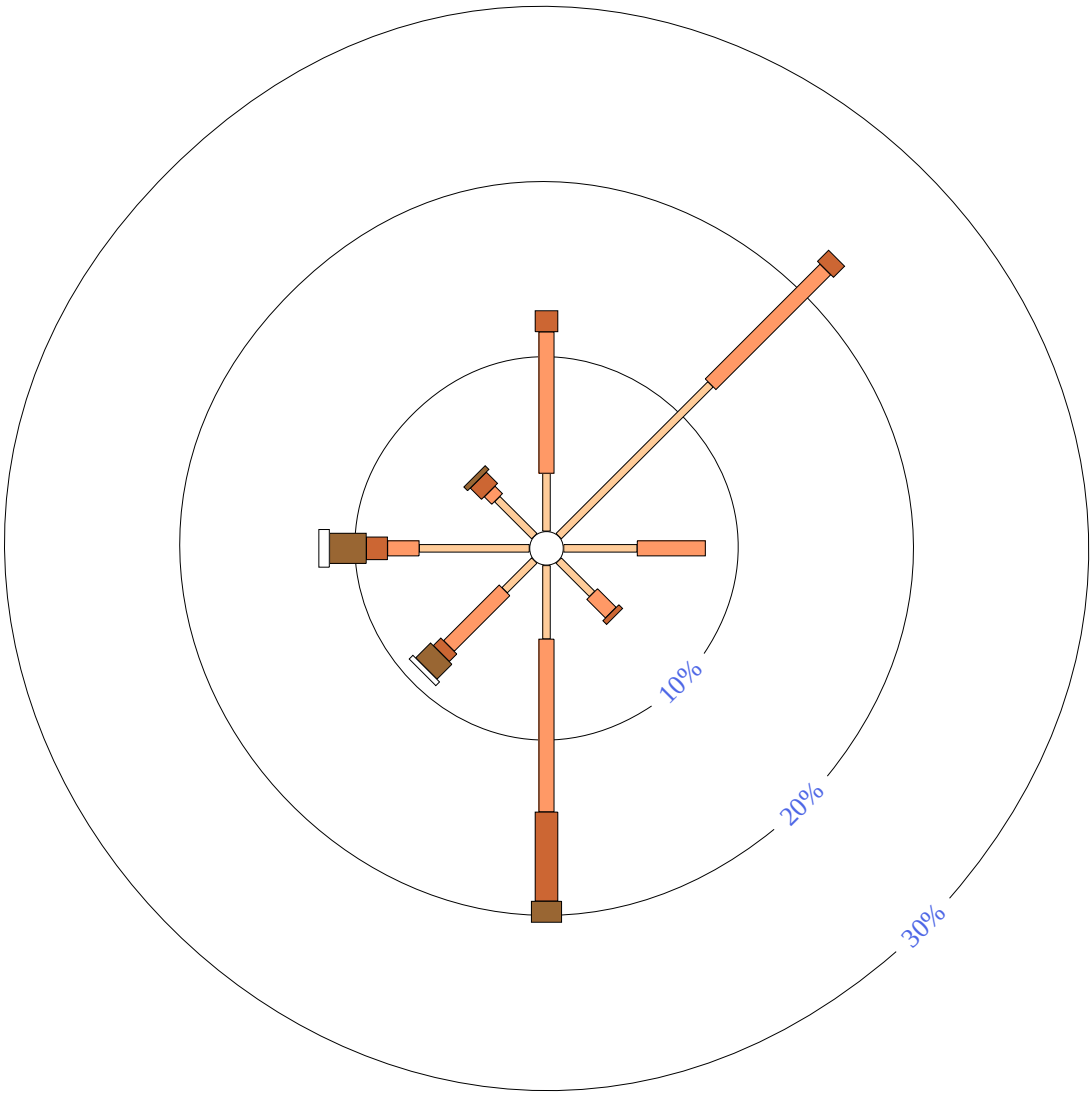
Site No: 068241 • Opened Jun 1999 • Still Open • Latitude: -34.5638° • Longitude: 150.79° • Elevation 8m

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9 am Nov
329 Total Observations

Calm 5%



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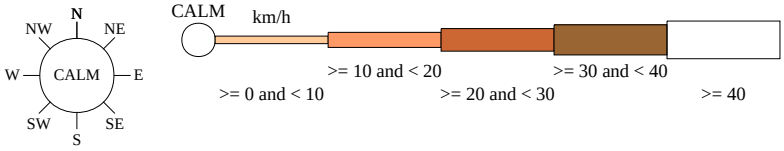
Rose of Wind direction versus Wind speed in km/h (05 Jun 1999 to 30 Sep 2010)

Custom times selected, refer to attached note for details

ALBION PARK (WOLLONGONG AIRPORT)

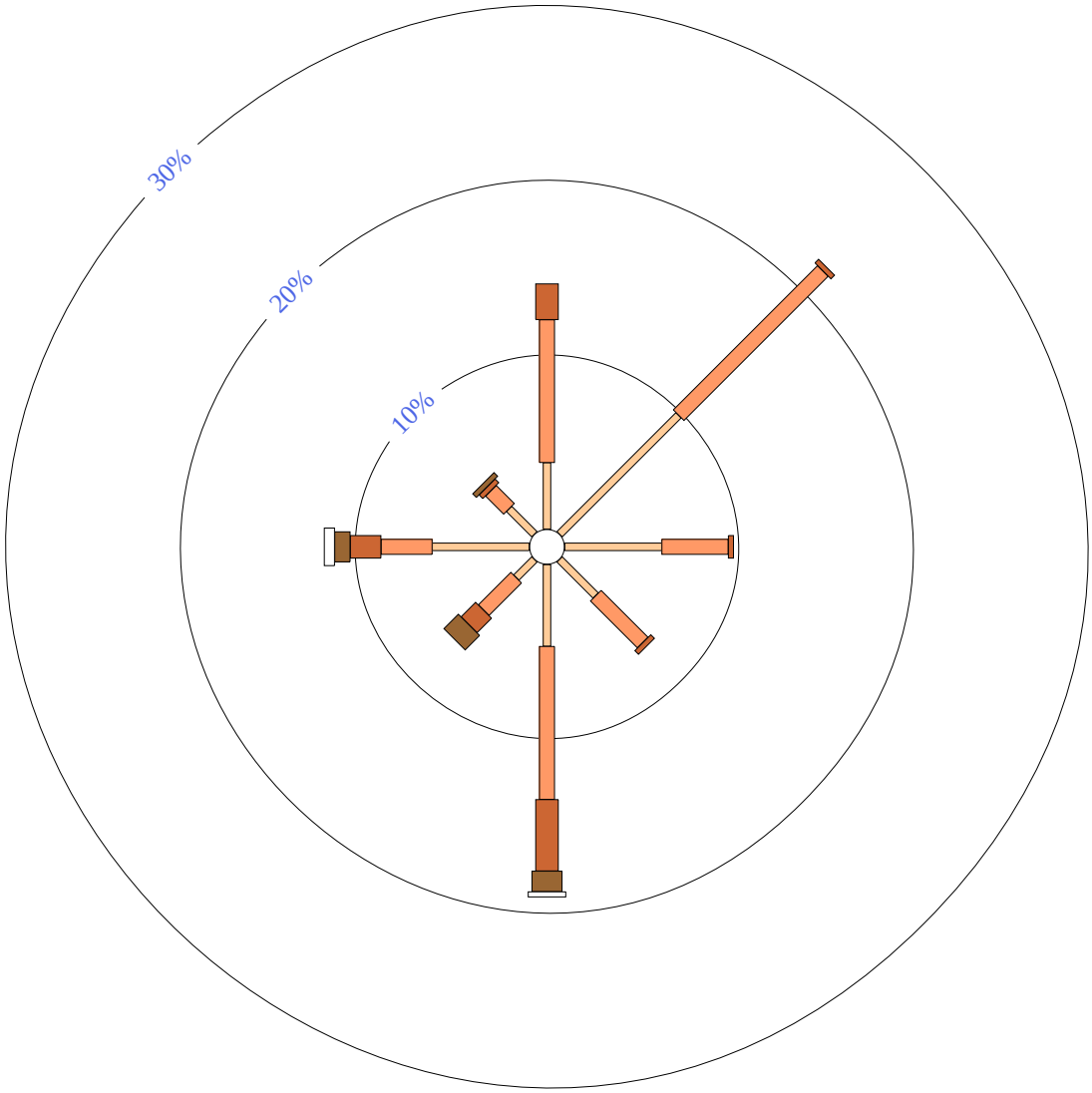
Site No: 068241 • Opened Jun 1999 • Still Open • Latitude: -34.5638° • Longitude: 150.79° • Elevation 8m

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9 am Dec
337 Total Observations

Calm 5%



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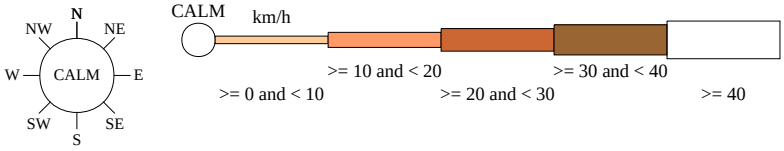
Rose of Wind direction versus Wind speed in km/h (05 Jun 1999 to 27 Feb 2010)

Custom times selected, refer to attached note for details

ALBION PARK (WOLLONGONG AIRPORT)

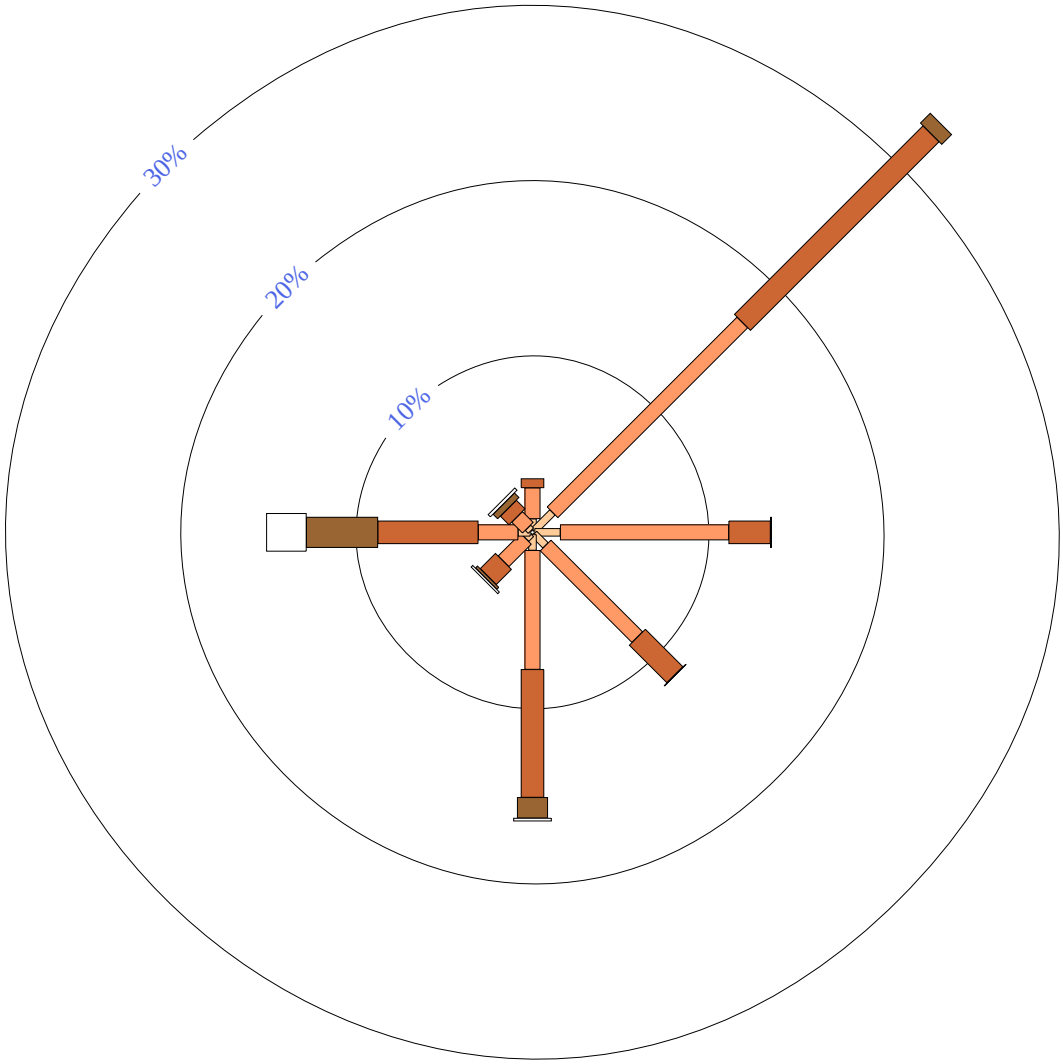
Site No: 068241 • Opened Jun 1999 • Still Open • Latitude: -34.5638° • Longitude: 150.79° • Elevation 8m

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3 pm
3869 Total Observations

Calm 1%



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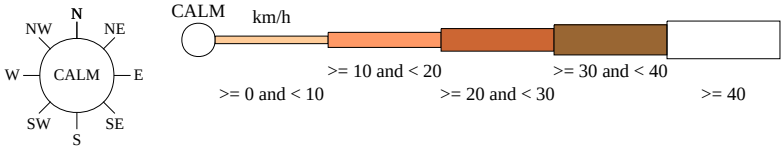
Rose of Wind direction versus Wind speed in km/h (05 Jun 1999 to 30 Sep 2010)

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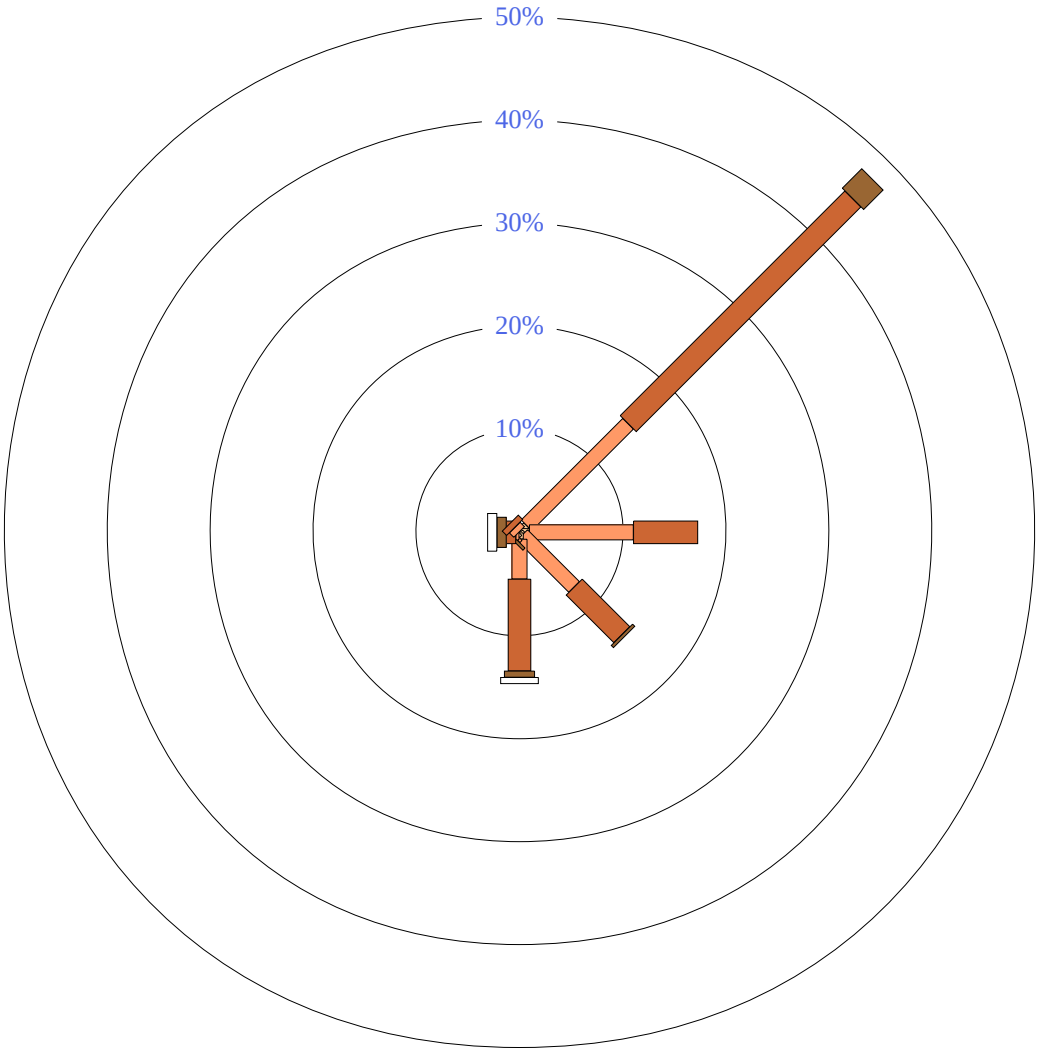
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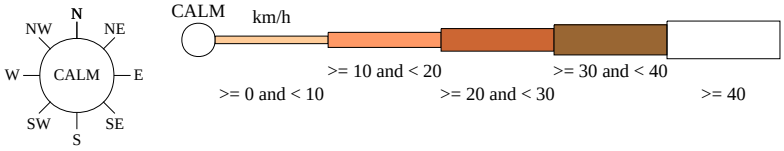
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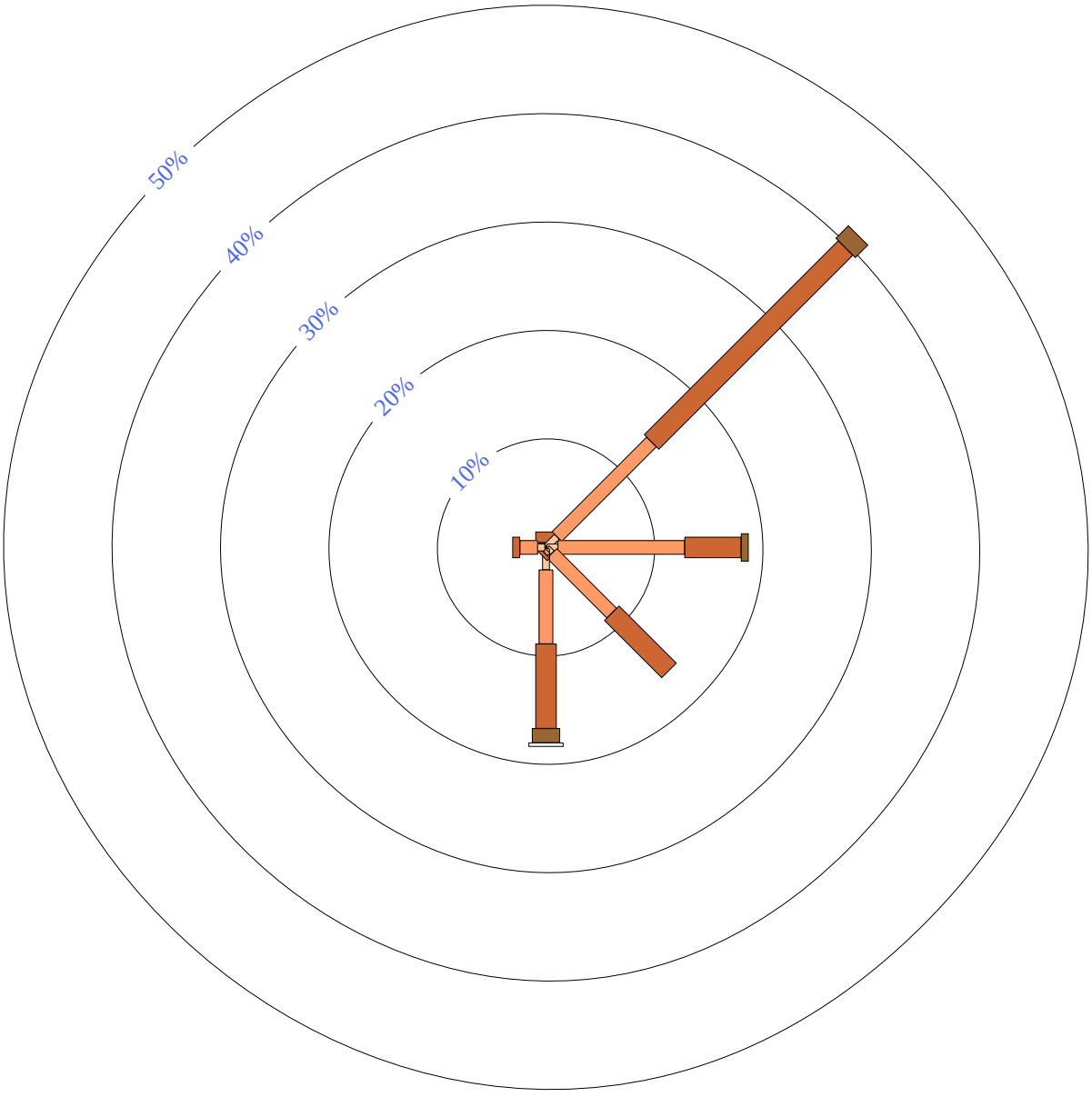
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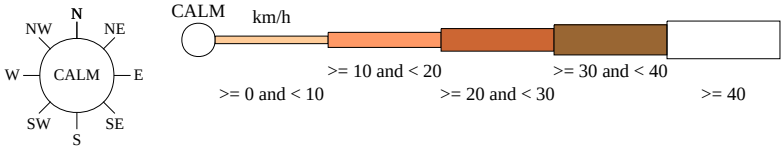
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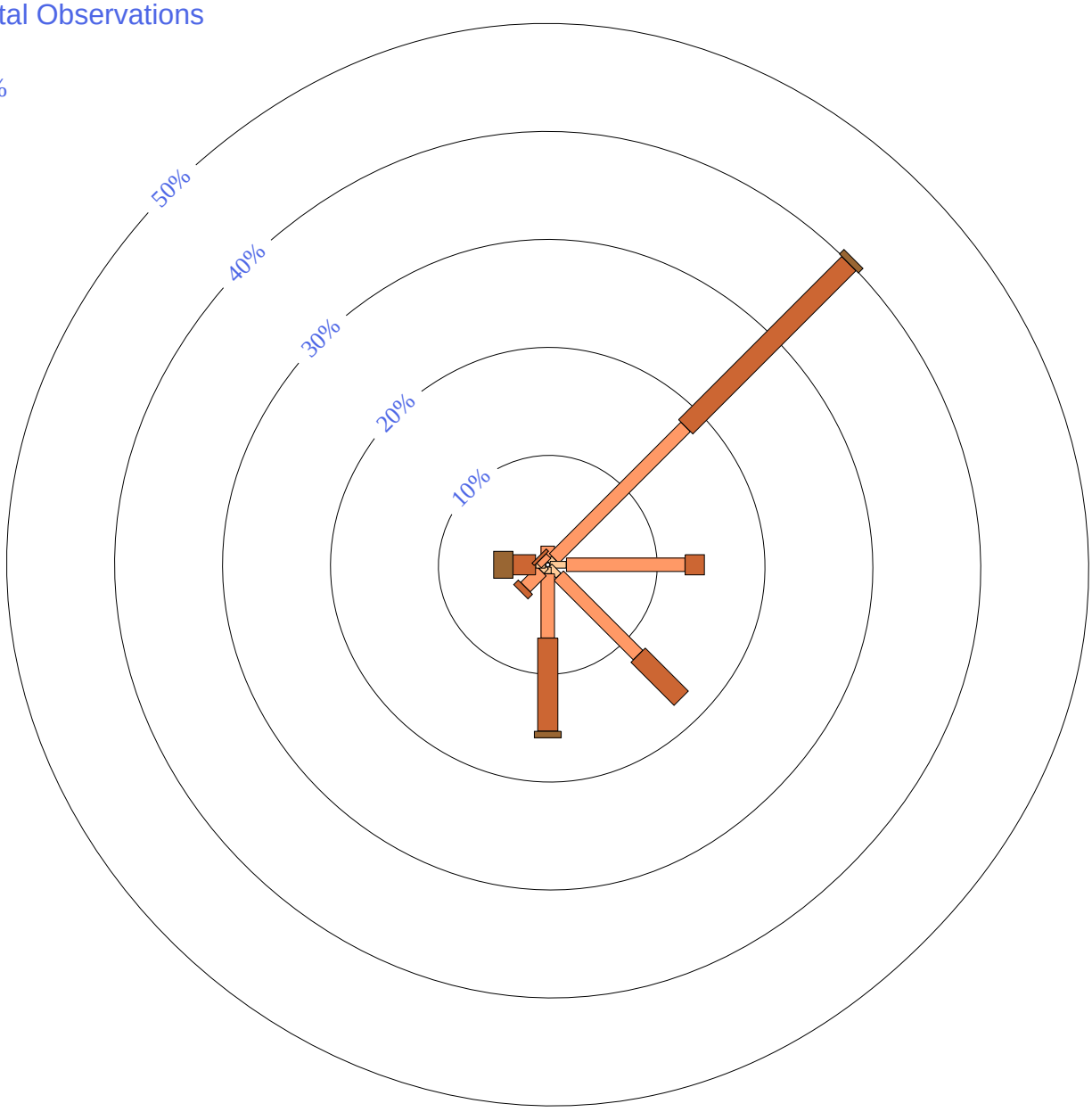
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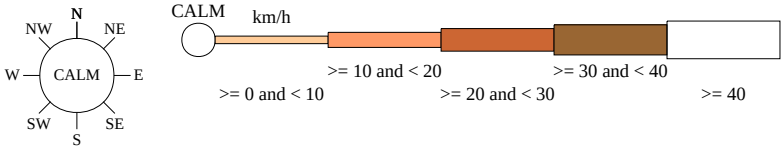
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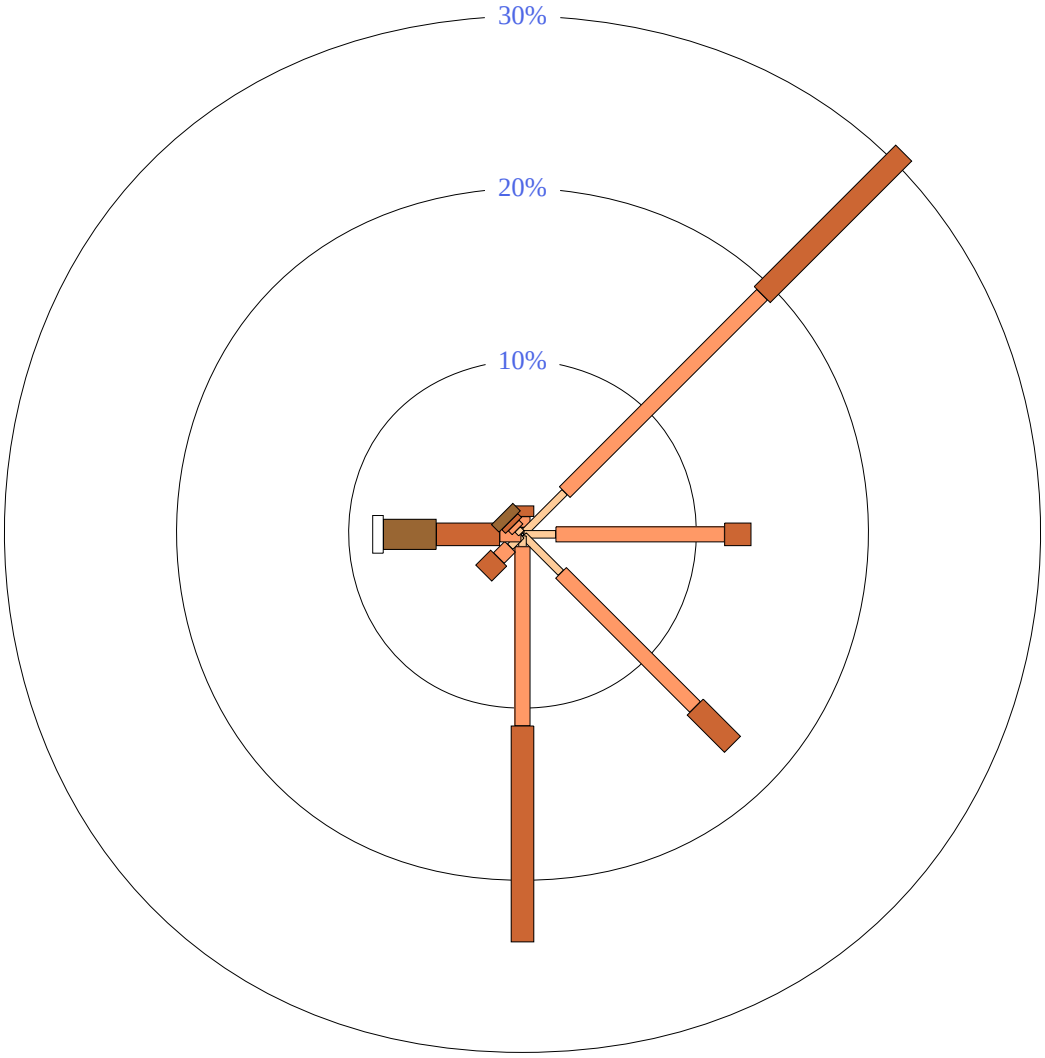
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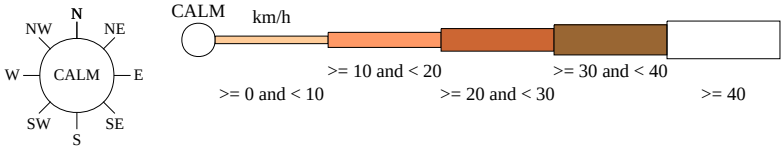
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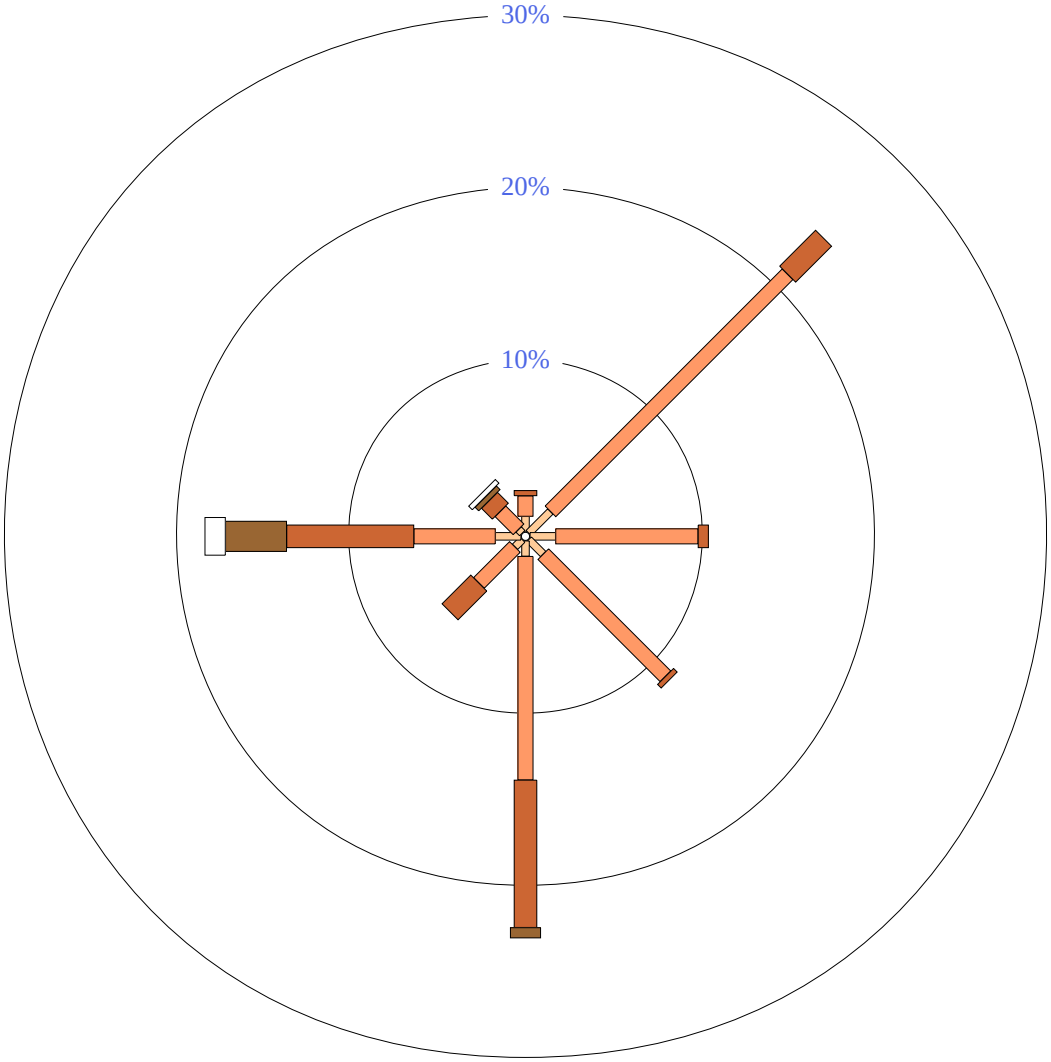
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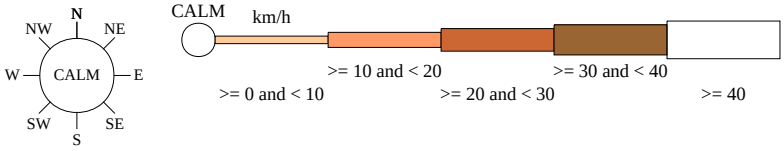
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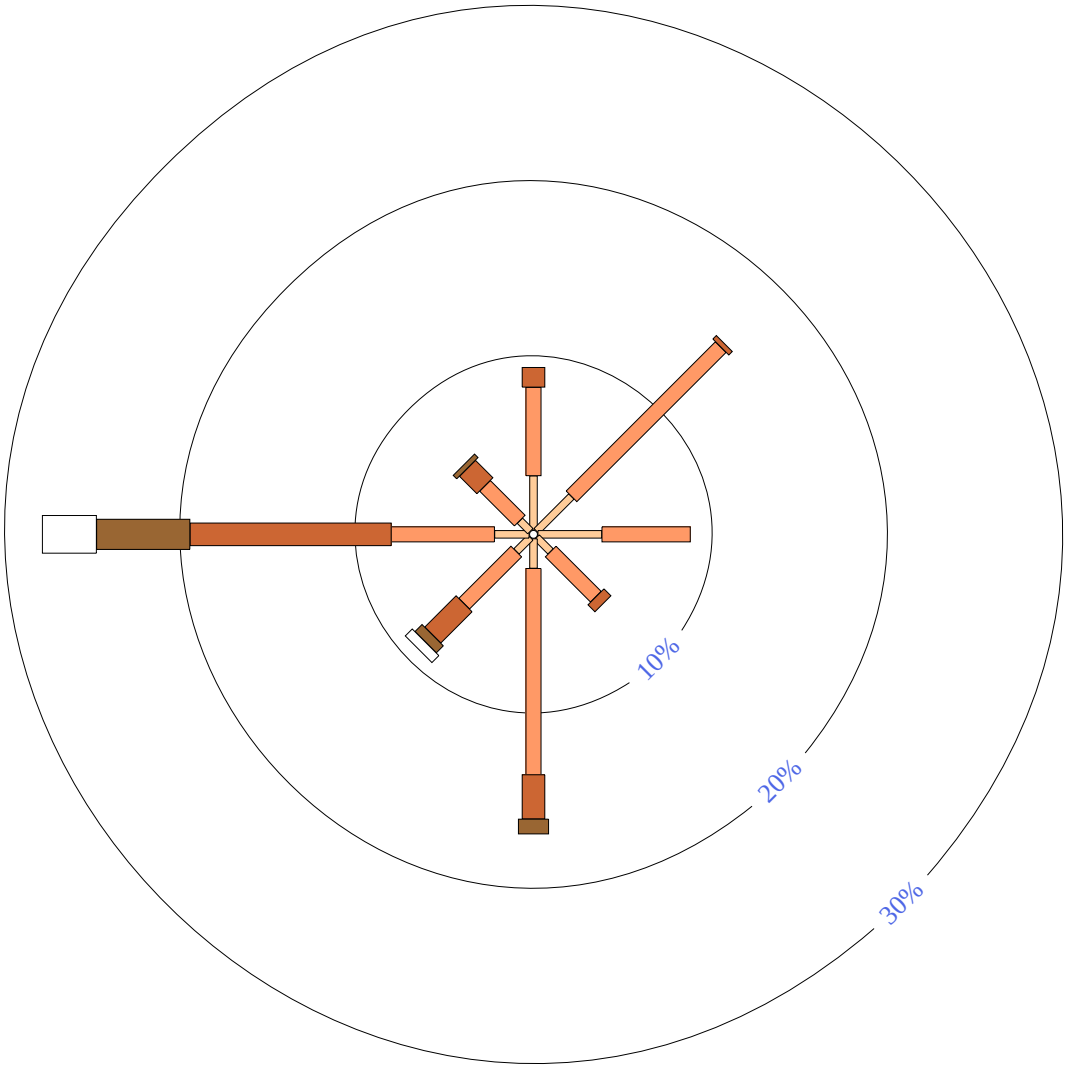
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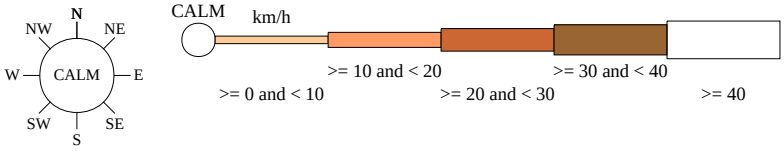
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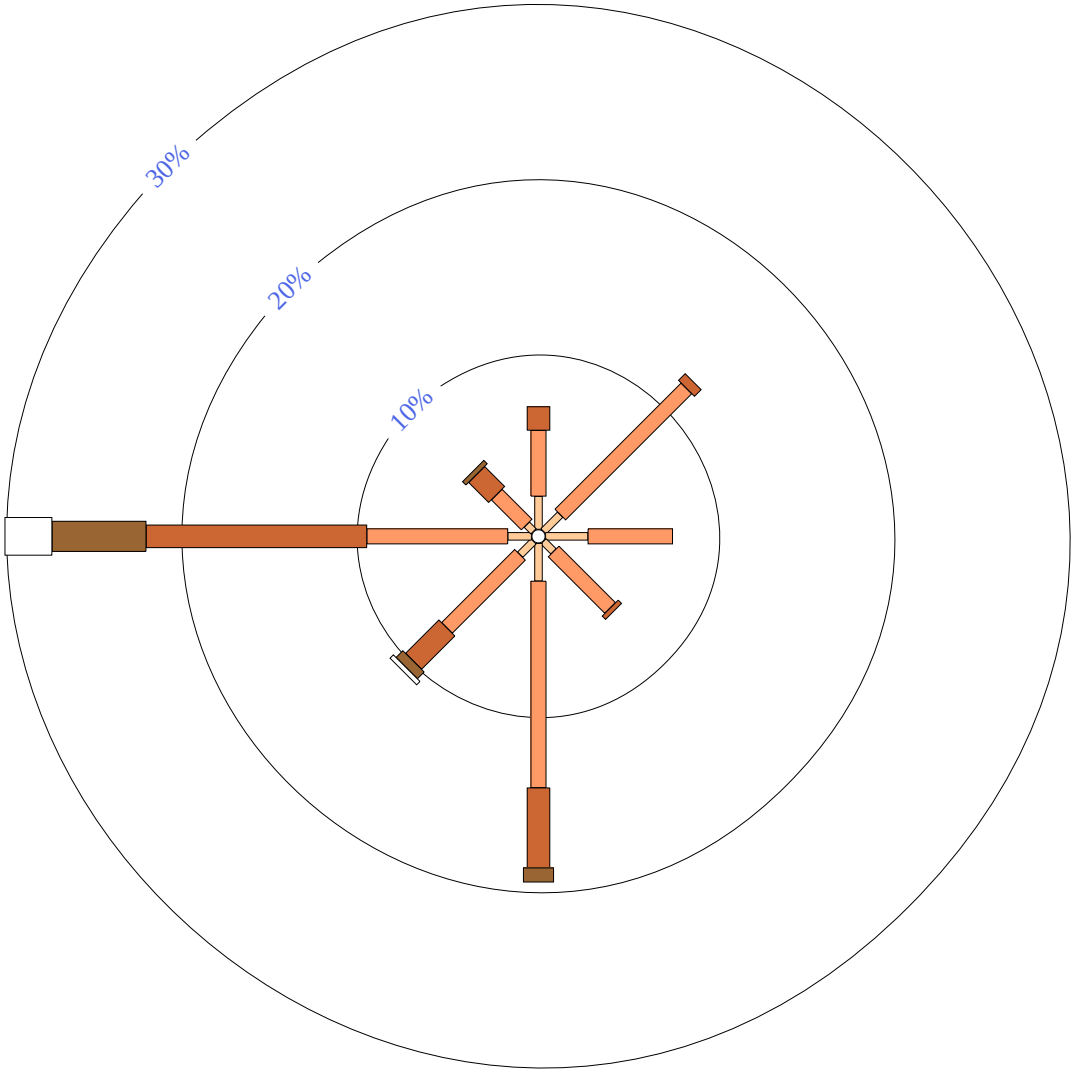
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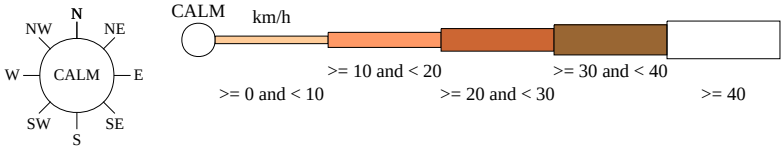
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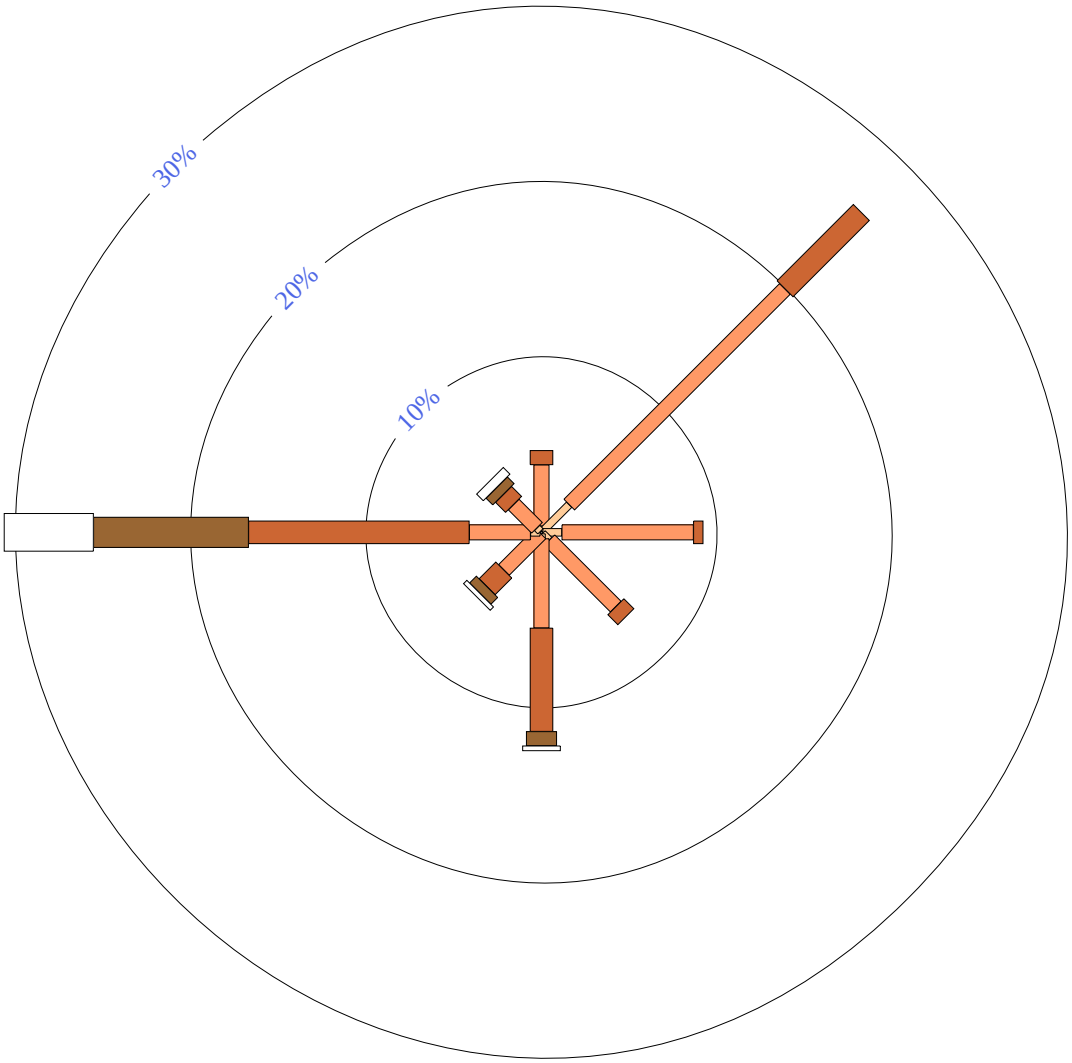
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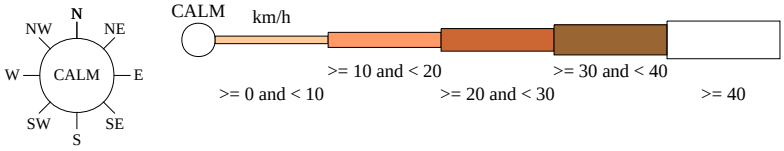
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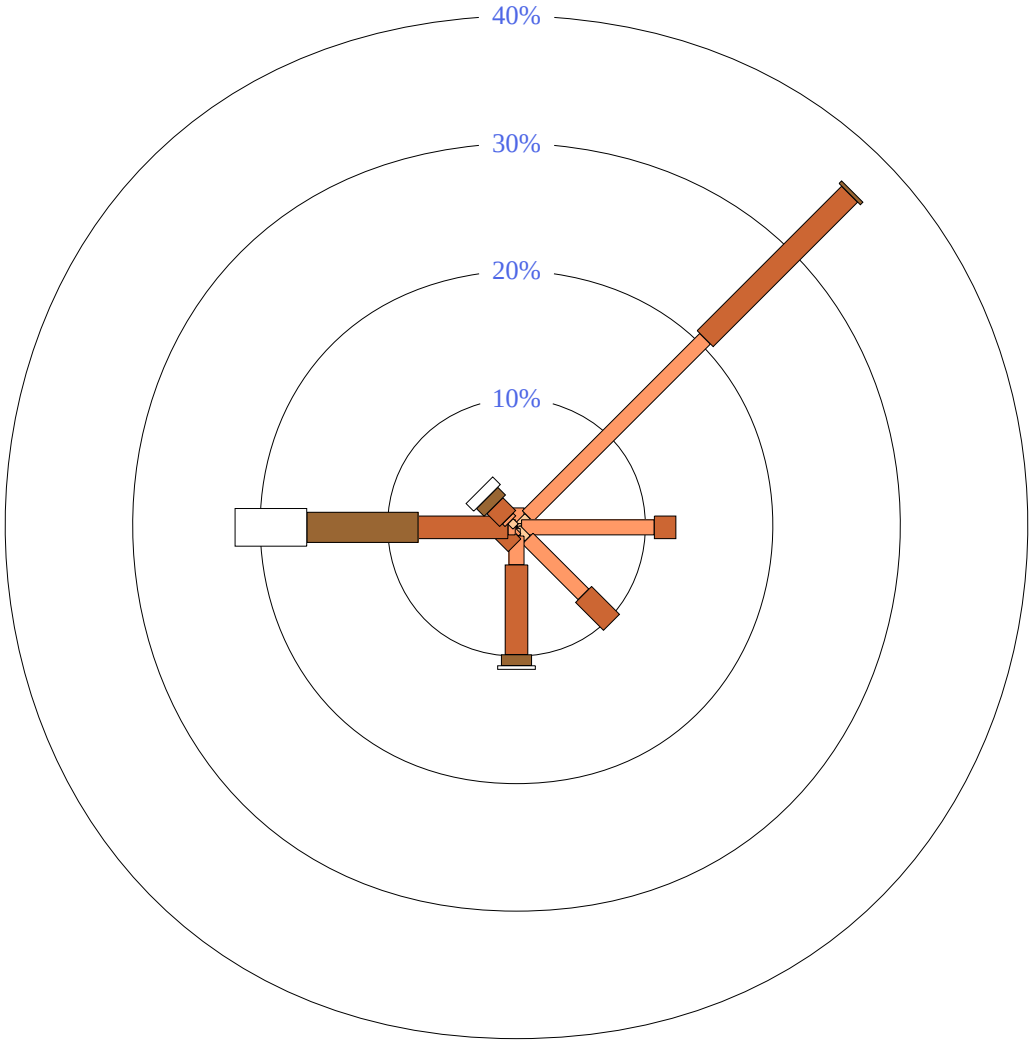
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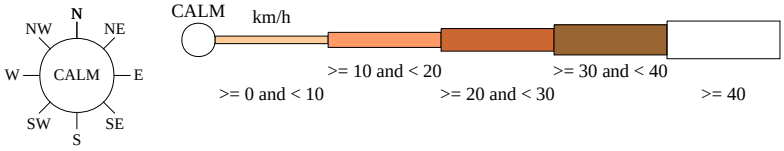
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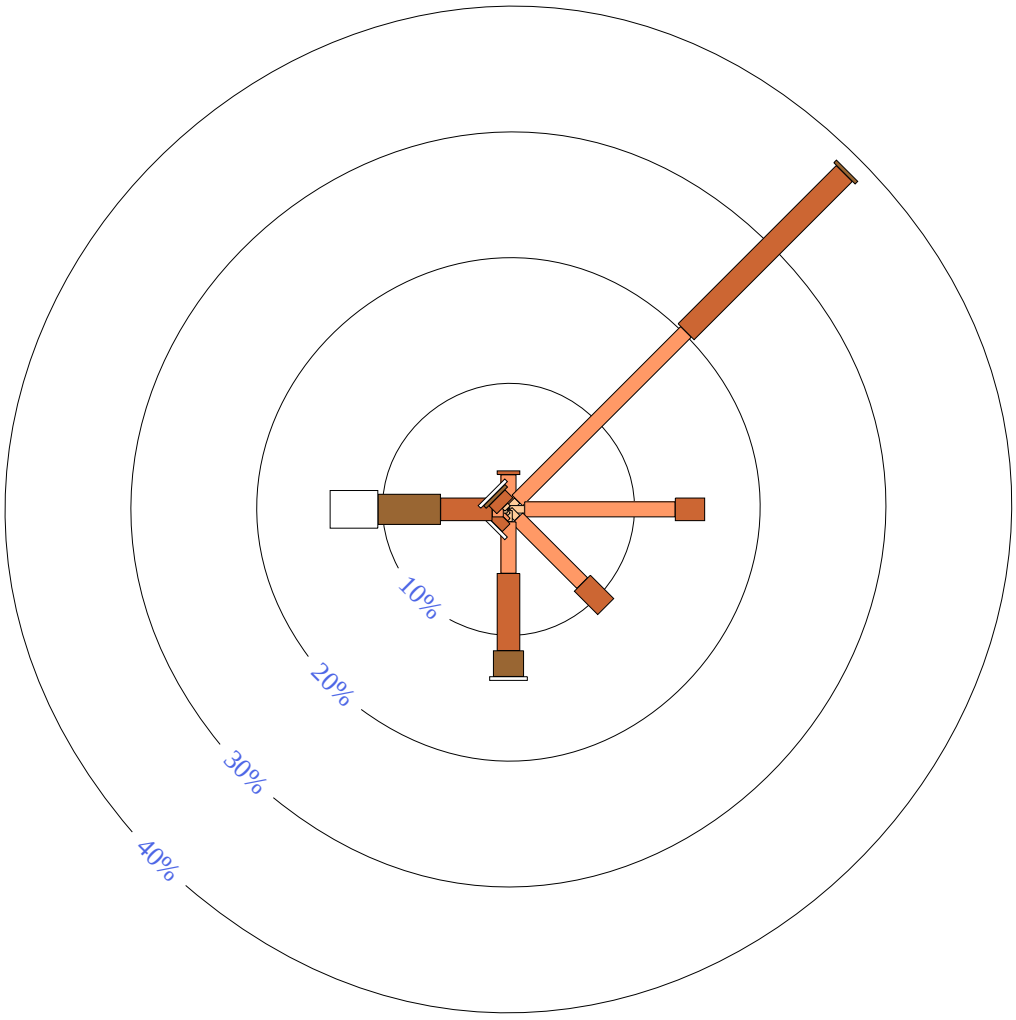
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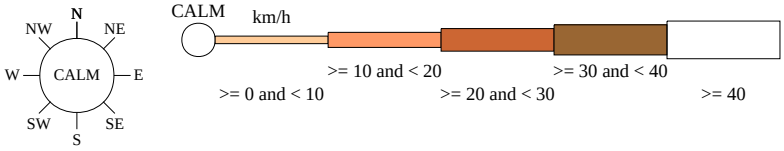
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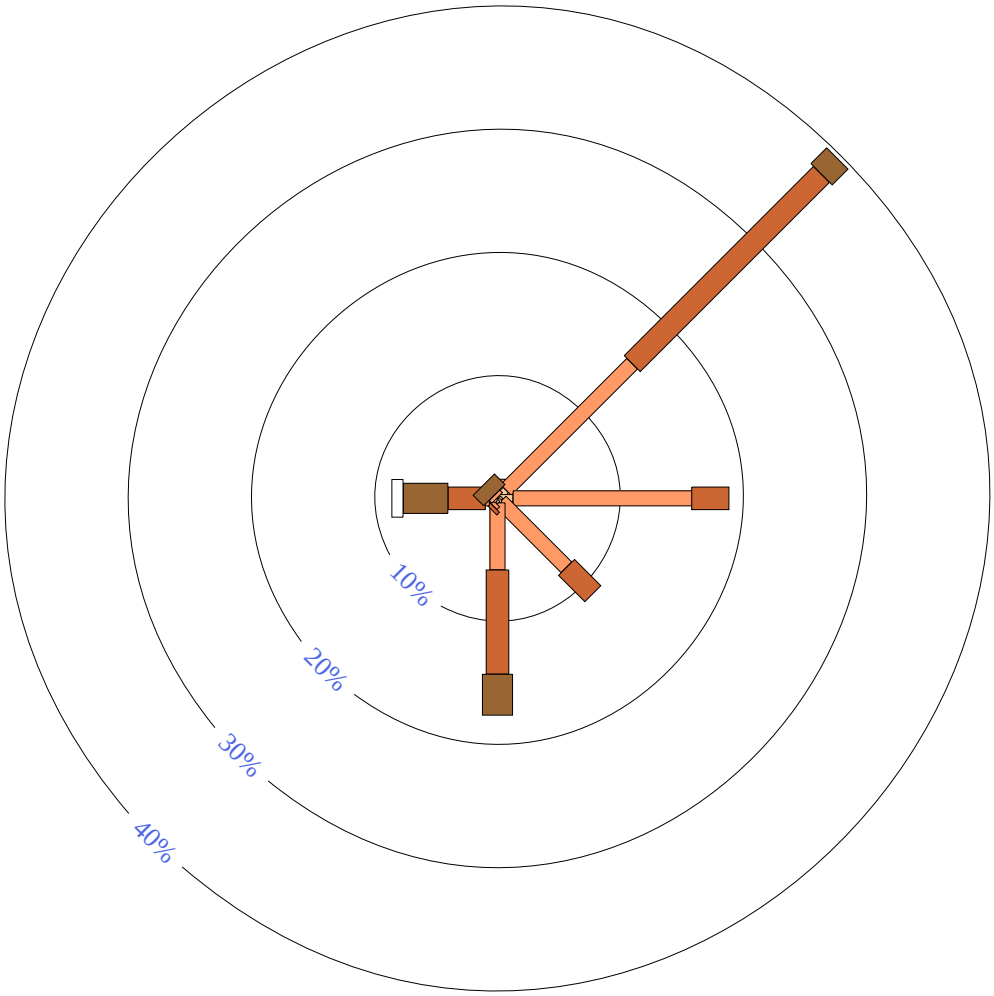
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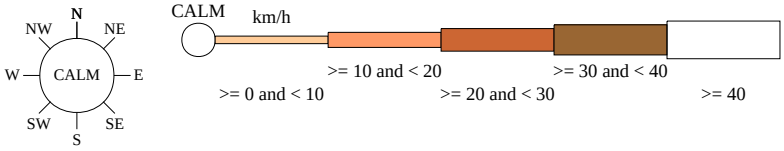
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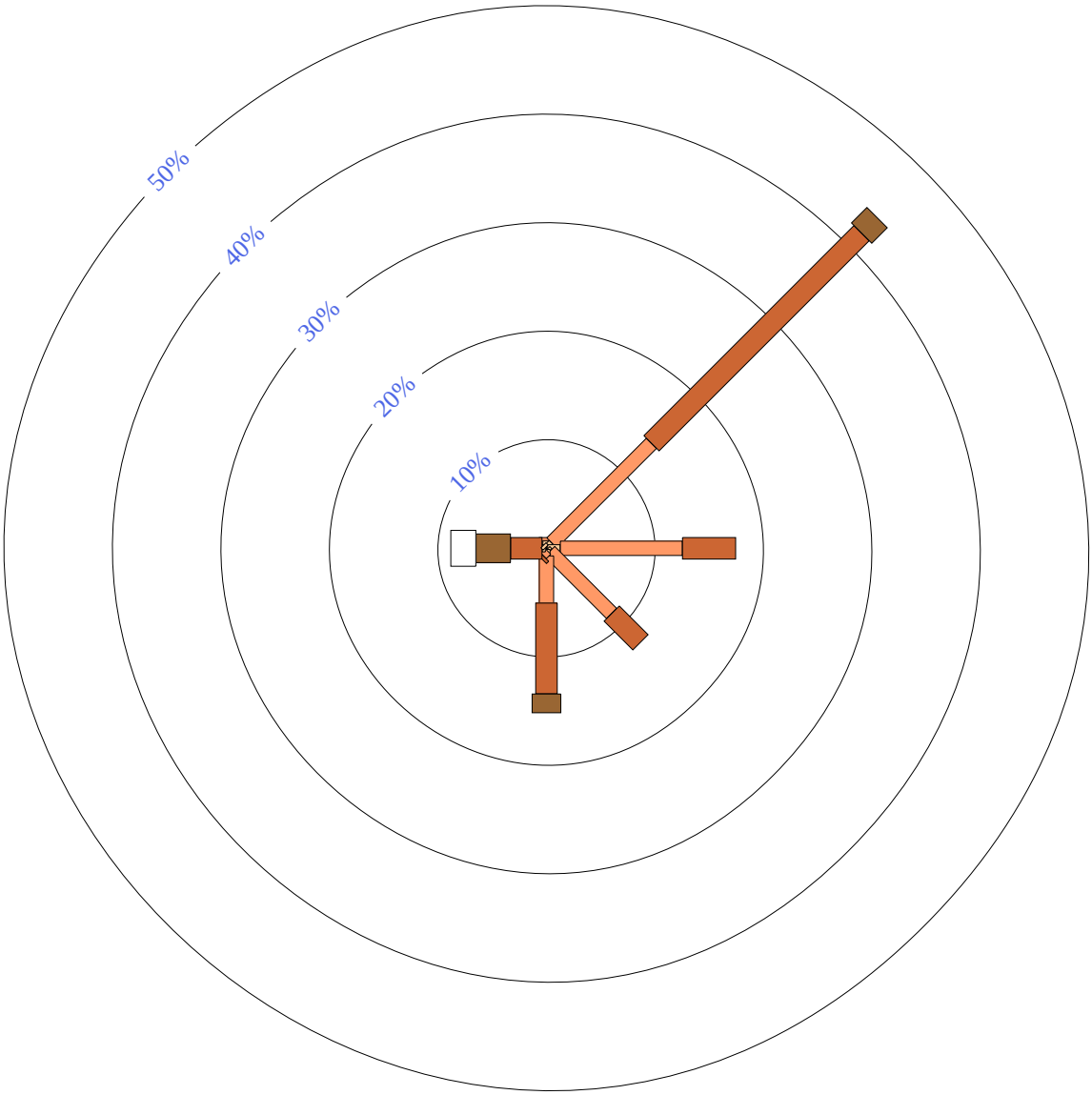
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APPENDIX C

As built drawings

Provided on DVD

APPENDIX D

Landfill Master Plan

March 2012

REPORT

Whytes Gully New Landfill Cell Landfill Master Plan

Submitted to:
Wollongong City Council

Report Number. 117625003-143-R-Rev0

REPORT

Golder Associates

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APPENDICES

APPENDIX A

Whytes Gully New Landfill Cell Staging Plans

1.0 INTRODUCTION

Golder Associates Pty Ltd (Golder) has been engaged by Wollongong City Council to prepare documentation to support the Whytes Gully New Landfill Cell Project (the Project).

Located at the existing Whytes Gully Resource Recovery Park (Whytes Gully RRP), the Project would create approximately 6 million m^3 of additional landfill capacity in addition to associated infrastructure. The new landfill cell would be constructed on top of, and integrated with, existing landfill cells on the site, in a 'piggyback' formation.

This Landfill Master Plan presents an overview of the development of the Whytes Gully New Landfill Cell, and provides information on the planned stage-by-stage development.

Detail on the design is provided in the Preliminary Design Report (Golder 2012d) Reference 117625003_058_R_Rev0

2.0 PROJECT OVERVIEW

2.1 Project Elements

The Project would consist of the following key components:

- New Landfill Cell Construction (Stage 1, 2A, 2B, 3 and 4)
- New Landfill Cell Operation (Stage 1, 2A, 2B, 3 and 4)
- Progressive Landfill Rehabilitation and Revegetation of the finished Landform
- Surface Water Drains and Surface Water Ponds
- Leachate Ponds
- Leachate Treatment Plant Upgrade
- Landfill Gas Extraction
- Ancillary – demolition of existing buildings, construction of temporary and permanent roads.

A Project Footprint Plan is provided in Figure 1 and Final Landform Plan is presented on Figure 2.

2.2 New Landfill Cell Capacity and Life

The term "airspace" refers to the available volume for landfill material placement between an upper and lower surface, with the upper surface typically corresponding to the design levels for the top of a planned landfill. The New Landfill Cell project is designed to provide for 40 years or more of landfill operations at an airspace consumption rate of 140,000 m^3/yr. The project is planned to be developed in a number of workable stages with each stage providing at least two years of landfill airspace.

3.0 OVERALL PROJECT STAGING

3.1 New Landfill Cell Staging

The proposed landfill would be constructed in five stages (Stage 1, Stage 2A, Stage 2B, Stage 3, Stage 4), including eleven cells (Cells 1, 2, 2A, 2B, 3, 4, 4A and Piggy Back Cells 1, 2A, 2B, 3), to enable the gradual development of the landfill site. A gradual development approach is beneficial in reducing the active footprint of the landfill and consequently reducing potential impacts upon the environment and allowing progressive rehabilitation throughout the life of the proposed landfill. The main stages of the development are presented in Figure 3. The cell locations are presented in Figure 4. Table 1 outlines the approximate airspace, life and timeline for the development of each stage of the Project's new landfill cell.

Table 1: Approximate Stage Volumes and Timelines of the Project New Landfill Cell

Stage	Cells	Piggy Back Cells	Area (m^2)	Airspace (cum)	Life of Cell (Years)	Operation Period	Proposed Capping Construction Period *	Proposed Liner Construction Period *
1	1	1	82,000	912,000	4.4	2013 - 2018	2016 - 2019	2013 - 2016
2A	2A	2A	22,500	343,000	2.4	2018 - 2020	2020 - 2021	2017 – 2018
2B	2, 2B	2B	81,200	2,134,000	15.2	2020 - 2035	2023 - 2036	2019 – 2031
3	3	3	67,200	1,589,000	11.3	2035 - 2046	2038 - 2047	2035 – 2041
4	4, 4A	none	69,000	1,007,000	7.2	2046 - 2054	2048 - 2055	2046 – 2050
TOTAL			**321,900**	**5,985,000**	**40.5**			

* Not continuous during period

Staging plans including temporary access roads are presented in Appendix A, Figures 1 to 11.

The overall staging sequence is summarised as follows:

- Stage 1 covers the Eastern Gully landfill, a section of the Western Gully landfill and a non-landfilled area at the foot of the Eastern Gully landfill that is occupied by roads and stormwater infrastructure.

  In order to divert stormwater from the northern side of the Eastern Gully landfill to the southern side, waste will have to be removed from the eastern most portion of the Eastern Gully landfill. This waste (approximately 300,000 cu.m.) would be placed in Stage 1 of the newly constructed landfill.

- Stage 2 covers part of the Western Gully landfill, a non-landfilled area at the toe of the Western Gully landfill that is occupied by roads and stormwater infrastructure and a non-landfilled ridge line between the eastern and western gully landfills.

- Stage 3 covers part of the Western Gully landfill and a non-landfilled area at the toe of the Western Gully that is occupied by roads, the green waste process area and stockpiling areas.

- Stage 4 covers a non-landfilled area to the west of the Western Gully landfill as well a non-landfilled area at the toe of the Western Gully landfill that is currently occupied by roads and the Primary and Secondary Leachate Ponds.

While one stage is providing for waste filling, the liner for the succeeding stage is proposed to be constructed. In addition, at the completion of waste filling in each stage, that stage would be capped and rehabilitated whilst waste is being landfilled in subsequent cells.

3.2 Staging of Stormwater Infrastructure

The surface water management controls would be progressively developed as the landfilling areas are developed. A drainage philosophy has been designed based on the construction staging of the proposed new landfill cell and offsite discharge constraints. The following summarises the staged approach. Figure 5 presents the staged approach to surface water management. Figure 1 presents the surface water pond down sizing.

Stage 1 and Stage 2A:

The drainage philosophy up to the completion of Stage 2A is to discharge the whole 50 ha catchment to the existing sediment pond. A minor existing discharge offsite from the Western Ridge would be maintained.

Stage 2B:

After completion of Stage 2B the Eastern Gully would become fully capped and therefore surface runoff would become 'clean' runoff. During Stage 2B a new 'clean' drain can be constructed to bypass the sediment pond and discharge directly to the Dapto creek outfall. This drain would be constructed between the existing leachate treatment plant and the surface water ponds. On completion of stage 2B, approximately 24 ha will discharge directly to Dapto Creek and 26 ha to the existing sediment pond.

Stage 3:

On completion of Stage 3, approximately 30 ha will be discharged directly to Dapto Creek and 20 ha to the existing sediment pond. Due to the extent of the Stage 4 works the existing leachate ponds will require relocating towards the end of Stage 3. At this stage it is proposed that the leachate pond is relocated to the footprint of the two reed bed ponds and downsize the existing surface water pond. The downsizing of the surface water pond at this stage is possible due to approximately 60 percent of the original 50 ha catchment now discharging directly to the Dapto Creek outfall.

Stage 4:

The downsized surface water pond is designed for a 20 ha catchment. The clean 30 ha catchment would discharge unrestricted to the Dapto Creek outfall. The surface water pond would be made up of sediment pond and onsite surface water detention pond. The outflow from the pond to the Dapto Creek outfall would be restricted to meet discharge constraints and the resultant attenuated runoff detained within the surface water pond.

3.3 Staging of Other Associated Infrastructure

The staging for associated infrastructure is presented in Table 3 below.

Table 2: Construction and Operation Staging for Other Concept Master Plan Elements

Infrastructure	Commence Construction	Commence Operation
Amenities relocate to Old SWERF building (to make way for Stage 1 landfill construction)	late 2012	2013
Landfill Gas to Flare and/or Energy Facility	mid 2012	2012
Leachate Pond Construction	End of Stage 3 Landfilling (2045)	2045
Surface Water Pond Downsize	End of Stage 3 Landfilling (2045)	2045

3.4 Staging of Easements and Services Relocation

The location of easements and other development constraints on the site are shown on Figure 6. These are summarised as follows:

- An easement for the 132 kV overhead power transmission line which runs east to west across the site, situated south of the Eastern Gully landfill and north of Reddalls Road.
- Power lines as well as a Telstra line run along Old Reddalls Road.
- Power supply easement for the leachate treatment plant runs along the northern edge of the MRF boundary.
- A private power line easement exists in the northern part of the site and crosses the Western Gully landfill. It is understood this line is de-energised and due for decommissioning.
- A sewer line exists between the leachate treatment plant and Reddalls Road.

Service and easements along Old Reddalls Road should be relocated and removed before 2020 prior to construction of Cell 2 (assuming no decommission work is required for any powerlines/substation located within Cell 1 footprint).

Private easement power lines should be removed prior to 2041 for the construction of the upper portion of Piggy Back Cell 3.

All other easements would not be impacted by the Project.

4.0 CELL CONSTRUCTION

Three distinct types of ground conditions can be identified for proposed new landfill areas of the Project :

1) Non-landfilled areas primarily occupied by infrastructure such as roads, soil fill placement, and ponds,. (south of existing landfill Footprint) and would include Cells 1 to 4.

2) Non-landfilled areas that have remained largely undisturbed (Western Ridge and Central Ridge) including Cells 2A, 2B and 4A.

3) The Eastern Gully and Western Gully landfill (Existing Waste) including Piggy Back 1, 2A, 2B, 3.

The cell design varies depending on the ground conditions. Main activities of the construction and landfilling of each cell types are summarised as below. Cell locations are presented in Figure 4.

Cells 1 to 4

1) Construction of temporary stormwater diversion system and erosion and control measures prior the construction of each cell;

2) Excavation of excess material to form the subgrade in accordance to the design and stockpiling materials for cover material;

3) Excavation of unsuitable materials and backfilling with imported materials to prepare subgrade;

4) Construction of perimeter bund and internal bunds;

5) Construction of base liner system;

6) Construction of leachate collection system, leachate sump and connecting to the leachate drainage system; this includes a leachate collection blanket comprising a layer of drainage aggregate;

7) Filling waste in the cell;

8) Placement of intermediate cover to temporary and permanent batters of the cell and progressive vegetation of batters;

9) Construction of passive and active gas collection systems and capping system in each area.

Cells 2A, 2B and 4A

The main activities in these cells are generally similar to those described in the construction of Cell 1 to 4 above with the exception of:

1) The natural materials in these areas are to be excavated to approximately 5.0 m below ground level. These materials may be used in the cell construction or may be used as daily cover. These materials could be excavated and stockpiled or progressively excavated as required to reduce double handling. The excavation is to be finished prior to the construction of the cell base liner;

2) Excavation on subgrade surface to create cross-slope benches, providing platform for cross-slope leachate collection pipes;

3) A geocomposite drainage net will be used in leachate collection system rather than drainage aggregate along with a 300 mm thick protection layer above the liner system.

Piggy Back Cells 1, 2A, 2B, 3

1) Cut to fill to form subgrade surface on the existing landfill areas and stockpiling excess materials for use as daily cover;
2) Excavation of subgrade surface to create cross-slope benches, providing platform for cross-slope leachate collection pipes;
3) Construction of perimeter bund and internal bunds;
4) Construction of piggy back liner system including passive gas collection system underneath liner
5) Construction of leachate collection system connecting with the existing leachate collection system;
6) Placement of 300 mm protection layer;
7) Filling waste in the cell;
8) Placement of intermediate cover to temporary and permanent batters of the cell and progressive vegetation of batters;
9) Construction of passive and active gas collection systems and capping system in each area.

5.0 LANDFILL STAGING PLAN

Staging plans for the Whytes Gully New landfill Cell are presented in Appendix A, Figures 1 – 11. These staging plans include temporary and permanent access roads, areas of cell construction and lining, landfilling and capping. Surface Water Staging is presented in Figure 5. The following table summarises the works to be undertaken in each Stage.

Table 3: New Landfill Cell Works Staging

Stage 1-1: Approximately 2012 – 2013 (Appendix A Figure 1)	
Cell Construction	Stage 1-1 (Cell 1 and lower portion PB 1)
Landfilling	Complete filling on Eastern Gully Landfill Platform.
Capping and Rehabilitation	Not required.
Access Road	Construction of new access road A - B, going across the existing Green Waste Processing Centre prior to the construction of liner in Cell 1. Construction of temporary access road C - D on Western Gully Landfill along western side of Stage 1.
Permanent Surface Water	Construction of diversion channel for surface water drainage from Central Ridge (C-D) connected with existing drainage system to discharge to surface water pond.
Excavation	Excavation of existing material on Eastern Gully Landfill to average 1.5 m depth to form subgrade surface; for use as daily cover material.
Other	Relocation of existing amenities to Old SWERT building. Demolishing of existing infrastructure and removal of services with Cell 1 footprint. Construction of new leachate drainage system for the existing leachate collection systems in the existing Western and Eastern Gully Landfill (beneath the Cell 1 liner system). Construction of active landfill gas extraction on existing Western and Eastern Gully landfill areas in 2012.
Stage 1-1 and 1-2: Approx 2013 – 2015 (Appendix A Figure 2)	
Cell Construction	Stage 1-2 (upper portion PB 1)
Landfilling	Stage 1-1 (Cell 1 and lower portion PB 1)
Capping and Rehabilitation	Not required
Access Road	Construction of permanent access road E – E1. Forming access road E1 - F on waste during the filling of Stage 1-1.
Permanent Surface Water	Not required
Excavation	Complete excavation of material in Cell 2A prior to the construction of Stage 2A.

Staging 1-2 and 2A: Approximately 2015 – 2018 (Appendix A Figure 3)	
Cell Construction	Stage 2A (Cell 2A and PB 2A)
Landfilling	Stage 1-2 (Cell 1 and PB 1) Waste Cutback on Eastern Gully Landfill (Waste relocation to Stage 1-1)
Capping and Rehabilitation	not required
Access Roads	Construction of temporary access road D - D1 during filling of Stage 1-2. Removal of access road within Stage 2A footprint (refer Appendix A Figure 2 for location). Construction access road E1 - F during capping Stage 1-1.
Permanent Surface Water	Construction of swale drain along eastern boundary of the waste cutback and perimeter drain along southern edge of Cell 1, to discharge into the existing surface stormwater pond.
Excavation	Not required
Other	Progressive construction of active landfill gas extraction in new waste.
Stage 2A and 2B-1: Approximately 2018 – 2021 (Appendix A Figure 4)	
Cell Construction	Stage 2B-1 (Cell 2 and PB2B)
Landfilling	Stage 2A (PB 2A and Cell 2A)
Capping and Rehabilitation	Progressive Stage 1
Access Road	Construction access road G - H - I for filling of Stage 2A. Construction of access road I – J on waste during the filling of Stage 2A. Removal of access roads B - C and C - C1 located within Stage 2B-1 footprint.
Permanent Surface Water Drain	Construction drainage channel to discharge clean stormwater from northern site catchment and Stage 1 cap area off site.
Excavation of On-Site Materials	Not required
Other	Relocation of services (Telstra and Power) to along old Reddalls Road. Progressive construction of active landfill gas extraction in new waste.

Stage 2B-1 and 2B-2: 2021 – 2026 (Appendix A Figure 5)	
Cell Construction	Stage 2B-2 (PB2B)
Landfilling	Stage 2B-1 (Cell2 and PB2B)
Capping and Rehabilitation	Progressive Stage 1, Stage 2A
Access Road	Construction of permanent landfill access road I - J, during capping Stage 2A. Construction of temporary access road B - K adjacent to Stage 2B. Forming access road F – B on waste during the filling of Stage 2B-1. Road surface to be constructed during/after capping.
Permanent Surface Water	Construction of perimeter drain along the edge of Stage 2A, discharged to the clean water drain along eastern cell boundary. Construction of clean drainage channel along north western and western boundary of the site.
Excavation of On-Site Materials	Complete excavation of Cell 2B prior to the construction of Stage 2B-3.
Other	Progressive construction of active landfill gas extraction in new waste.
Stage 2B-2 and 2B-3: Approximately 2026 – 2031 (Appendix A Figure 6)	
Cell Construction	Stage 2B-3 (Cell 2B and PB2B)
Landfilling	Stage 2B-2 (PB2B)
Capping and Rehabilitation	Progressive Stage 1, Stage 2A, Stage 2B-1
Access Road	Removal of access road K - D located within Stage 2B-3 footprint. Construction of access road F – B for Stage 2B-3 during capping Stage 2B-1.
Permanent Surface Water	Not required
Other	Progressive construction of active landfill gas extraction in new waste.

Stage 2B-3 and 3-1: Approximately 2031 – 2035 (Appendix A Figure 7)	
Cell Construction	Stage 3-1 (Cell3 and PB3)
Landfilling	Stage 2B3
Capping and Rehabilitation	Progressive Stage 1, Stage 2A, Stage 2B-1, Stage 2B-2
Access Road	Removal of access road A - B - B1 located within Stage 3-1 footprint (refer Figure 6 for location of access road). Construction of temporary access road H – H1 during the filling of Stage 2B-3. Removal of access road B – N at end of Stage 2B-3.
Permanent Surface Water Drain	Not required
Excavation	Excavation of borrow materials within PB3-1 footprint completed prior to the construction of Stage 3–1.
Other	Progressive construction of active landfill gas extraction in new waste. Removal of private powerlines prior to construction of Stage 3-2.
Stage 3-1 and 3-2: Approximately 2035 – 2041 (Appendix A Figure 8)	
Cell Construction	Stage 3-2 (PB3)
Landfilling	Stage 3-2 (Cell3 and PB3)
Capping and Rehabilitation	Progressive Stage 1, Stage 2A, Stage 2B-1, Stage 2B-2, Stage 2B-3
Access Road	Construction of access roads A - M - N on waste during the filling of Stage 3-1 and access road G - L - H for the filling of Stage 3-2. Removal of access roads G - H and G - K located within Stage 3-2 footprint.(refer Figure 7 for location)
Permanent Surface Water	Connecting perimeter drain along Cell 2 boundary to the clean water channel discharged off site.
Excavation of On-Site Materials	Excavation of borrow materials within Stage 4-1 footprint completed prior to Stage 4-1 cell construction.
Others	Progressive construction of active landfill gas extraction in new waste. Relocation of leachate pond(s) prior to Cell 4 construction 2045. Downsizing of surface water pond(s) prior to leachate pond relocation.

Stage 3-2 and 4-1: Approximately 2041 – 2047 (Appendix A Figure 9)	
Cell Construction	Stage 4-1 (Cell 4)
Landfilling	Stage 3-2 (PB3)
Capping and Rehabilitation	Progressive Stage 1, Stage 2A, Stage 2B-1, Stage 2B-2, Stage 2B-3, Stage 3-1, Stage 3- 2
Access Road	Construction of temporary access road Z – Z1 during the filling of Stage 3-2.
Permanent Surface Water	Construction of perimeter drain along Cell 3 and Cell 2B boundary, discharged to the existing stormwater ponds.
Excavation of On-Site Materials	Excavation of Cell 4A completed prior to Stage 4-2.
Other	Progressive construction of active landfill gas extraction in new waste.
Stage 4-1 and 4-2: Approximately 2047 – 2050 (Appendix A Figure 10)	
Cell Construction	Stage 4-2 (Cell 4A)
Landfilling	Stage 4-1 (Cell 4)
Capping and Rehabilitation	Progressive Stage 1, Stage 2A, Stage 2B-1, Stage 2B-2, Stage 2B-3, Stage 3-1, Stage 3- 2
Access Road	Removal of access road (M-N-G-L) located within Stage 4-2 footprint during Cell 4A construction.
Permanent Surface Water Drain	Connecting perimeter drain along Cell 3 boundary to the clean water channel discharged off site.
Excavation of On-Site Materials	Not required
Others	Progressive construction of active landfill gas extraction in new waste.

Stage 4-2 : Approximately 2050 – 2054 (Appendix A Figure 11)	
Cell Construction	None
Landfilling	Stage 4-2
Capping and Rehabilitation	Stage 4
Access Road	Forming access road M – O and P – Q on waste during the filling of Stage 4-2. Construction of access road O – P for the filling of Stage 4-2. Completing the permanent access road for final landform during capping of Stage 4-2.
Permanent Surface Water Drain	Completing the perimeter drain around the final landform.
Excavation of On-Site Materials	Not required
Others	Not required Progressive construction of active landfill gas extraction in new waste.

Report Signature Page

Ryan Huynh
Civil Engineer

Jacinta McMahon
Principal Environmental Engineer

JM/GRS/rh

A.B.N. 64 006 107 857

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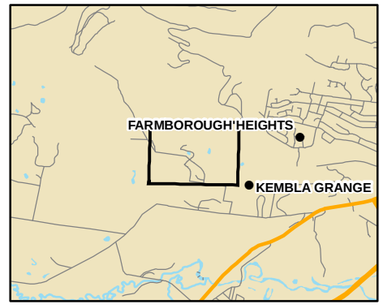
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WHYTES GULLY NEW LANDFILL CELL LANDFILL MASTER PLAN

WOLLONGONG CITY COUNCIL

PROJECT FOOTPRINT



LEGEND

- Contours of Final Landform (5 m interval)
- Site Boundary
- Approximate Extent of Waste
- Extent of Landfill Works
- Indicative New Leachate Pond Footprint
  New Leachate Pond to be established prior to commencement of Stage 4 construction
- Indicative New Surface Water Pond Footprint
  Surface Water Pond to be reduced in size prior to commencement of Stage 4 construction
- Indicative, augmented LTP footprint.
  LTP footprint will be assessed at the end of 2014.
- Existing Leachate Treatment Plant (LTP) Footprint

NOTES

Extent of waste based on site observations and information provided by Council.

Aerial Ortho-Photograph provided by AAM Pty. Ltd. taken on 16 May 2011, Reference 18763A. Image Georeferenced.

Extent of landfill works as per Golder Design Report.

0 25 50 100 150 metres

SCALE (at A3) **1:3,800**

Coordinate System: GDA 1994 MGA Zone 56

PROJECT: **117625003**
DATE: **22/02/2012**
DRAWN: **FA**
CHECKED: **JMc**

FIGURE 1

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REDDALL'S ROAD

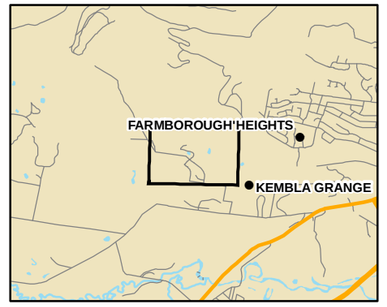
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WHYTES GULLY NEW LANDFILL CELL LANDFILL MASTER PLAN

WOLLONGONG CITY COUNCIL

FINAL LANDFORM



LEGEND

- Contours of Final Landform (5 m interval)
- Site Boundary
- Extent of Landfill Works

NOTES

Aerial Ortho-Photograph provided by AAM Pty. Ltd. taken on 16 May 2011, Reference 18763A. Image Georeferenced.

Extent of landfill works and final contours as per Golder Design Report.

0 25 50 100 150 metres

SCALE (at A3) 1:3,800

Coordinate System: GDA 1994 MGA Zone 56

PROJECT: 117625003
DATE: 5/03/2012
DRAWN: FA
CHECKED: JMc

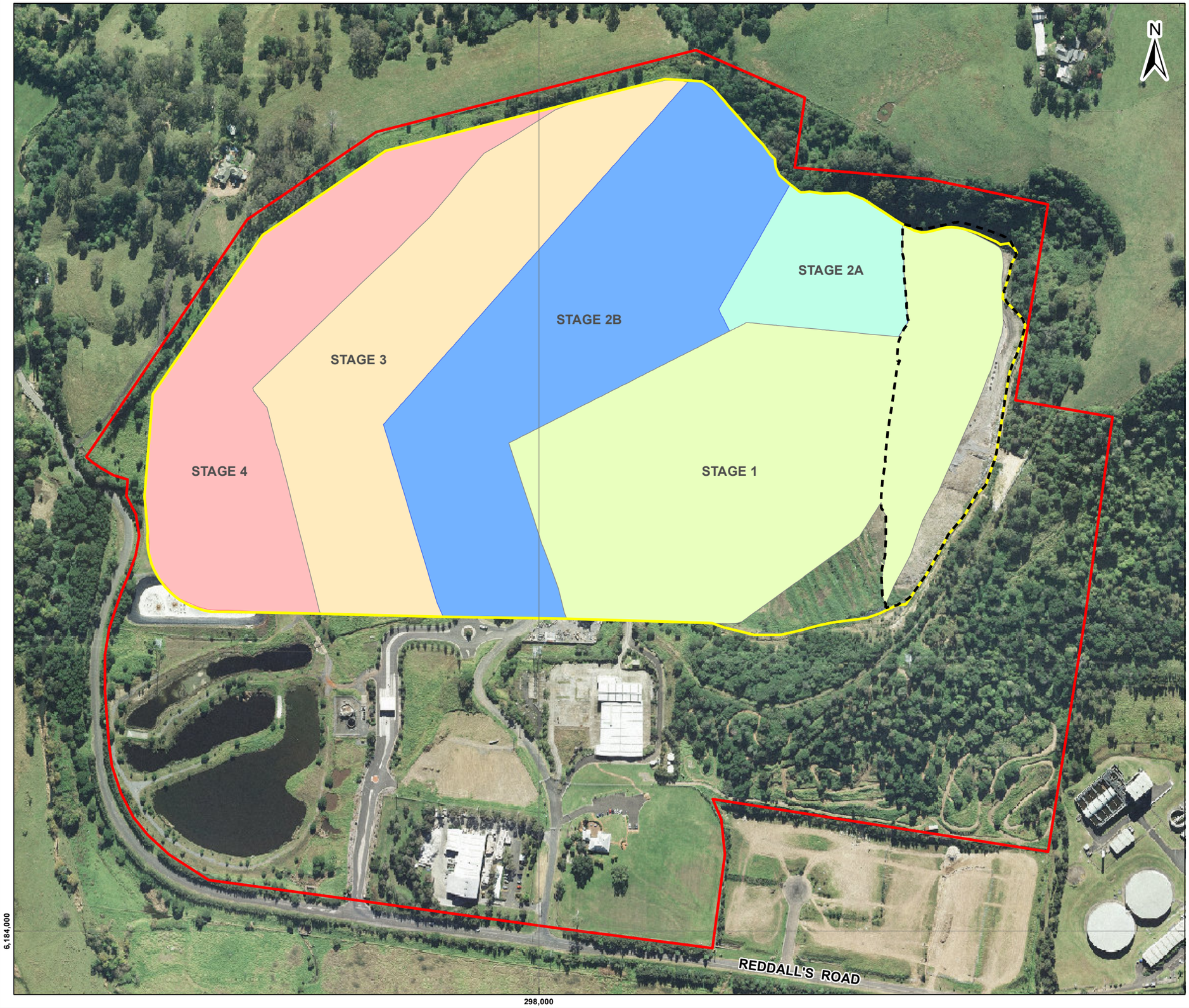
FIGURE 2

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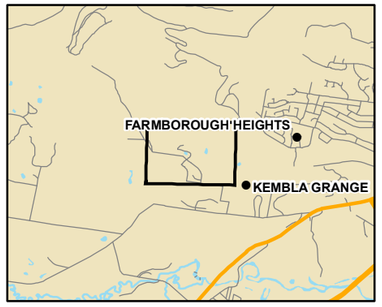
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WHYTES GULLY NEW LANDFILL CELL LANDFILL MASTER PLAN

WOLLONGONG CITY COUNCIL

PROJECT STAGING



LEGEND

- Site Boundary
- Extent of Landfill Works
- Proposed Area of Waste Cut
- Stage1
- Stage2a
- Stage2b
- Stage3
- Stage4

NOTES

Extent of waste based on site observations and information provided by Council.

Aerial Ortho-Photograph provided by AAM Pty. Ltd. taken on 16 May 2011, Reference 18763A. Image Georeferenced.

Extent of landfill works as per Golder Design Report.

0 25 50 100 150 metres

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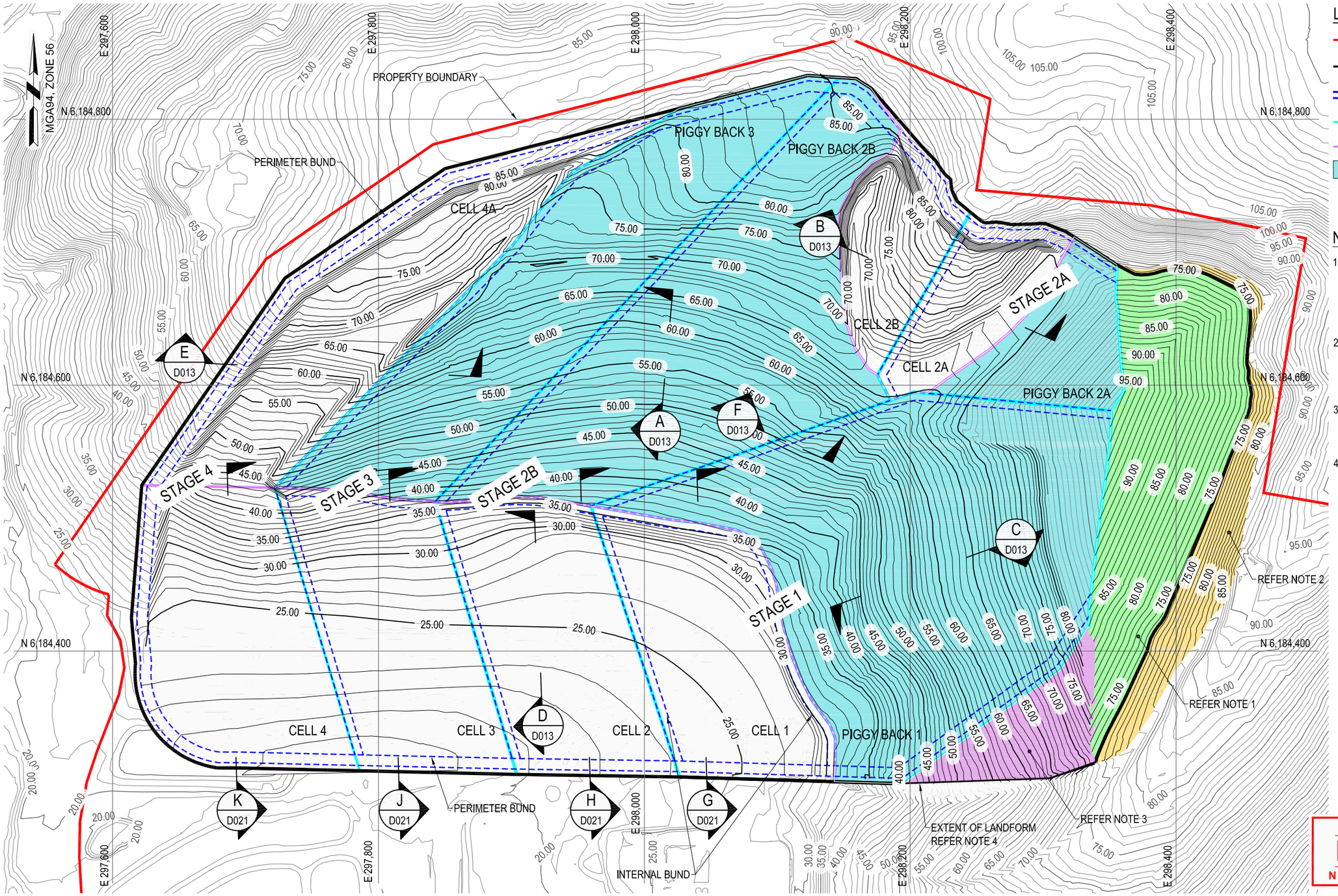
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DATE: **26/03/2012**
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FIGURE 3

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LEGEND

- PROPERTY BOUNDARY
- EXTENT OF LANDFORM
- PROPOSED BUNDS
- STAGING BOUNDARY
- CELL BOUNDARY
- PIGGY BACK AREA

NOTES:

1. SHADED AREA INDICATES PORTION OF WASTE CUTBACK WHERE A WASTE BATTER WILL REMAIN AFTER THE CUTBACK IS COMPLETE. CONTOUR LEVELS INDICATE THE WASTE BATTER SURFACE.
2. SHADED AREA INDICATES PORTION OF WASTE CUTBACK WHERE ALL WASTE WILL BE REMOVED. CONTOUR LEVELS INDICATE NATURAL GROUND AFTER WASTE REMOVAL.
3. SHADED AREA INDICATES AREA WHERE FINAL CAP WILL BE INSTALLED WITH NO ADDITIONAL WASTE PLACEMENT.
4. ADDITIONAL WASTE PLACEMENT TO OCCUR WITHIN THE EXTENT OF LANDFORM, EXCEPT WITHIN SHADED AREAS IDENTIFIED IN NOTE 1 AND NOTE 3.

ISSUED FOR
PRELIMINARY
NOT FOR CONSTRUCTION

1:3,000

0 60 120 180m

BASE DRAWING TAKEN FROM K F WILLIAMS AND ASSOCIATES DRG.WHYTES PHOTOGRAMMETRY AND GROUND SURVEY 20-07-11.dxf DATED 20 JULY 2011.

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
B	ISSUED FOR PRELIMINARY	EJ JEET	R HUYNH	R HUYNH	G SCHMERTMANN	G SCHMERTMANN	
A	DRAFT - ISSUED FOR CLIENT REVIEW	H CAMPBELL	R HUYNH	R HUYNH	G SCHMERTMANN	G SCHMERTMANN	23.01.2012

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LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE
EJ JEET	J McMAHON	1:3,000	A3

CLIENT: WOLLONGONG CITY COUNCIL

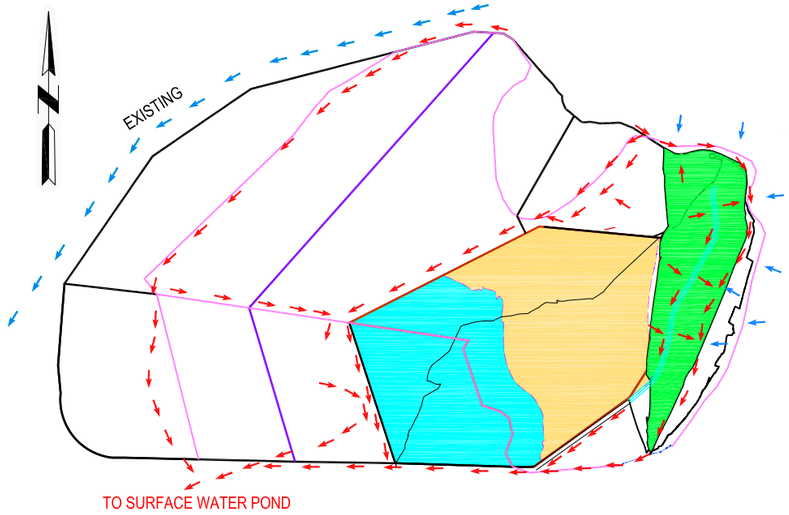
PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: STAGING AND SUBGRADE PREPARATION PLAN

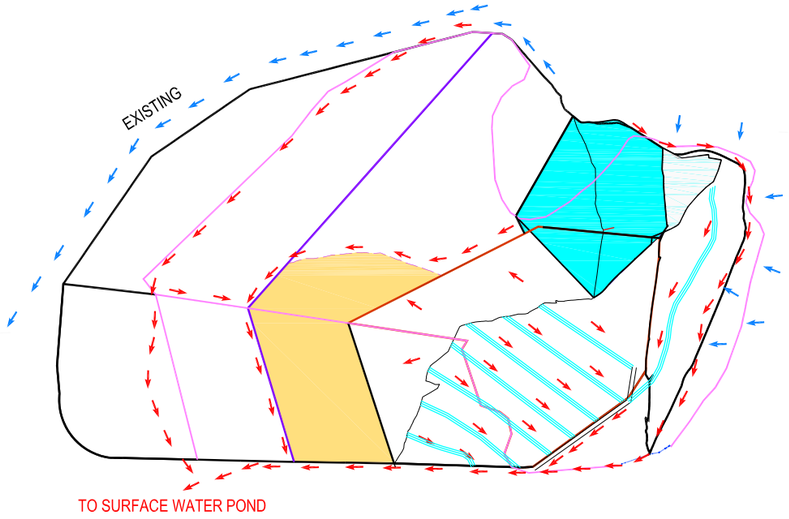
PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
117625003	143	S	FIGURE 4	B

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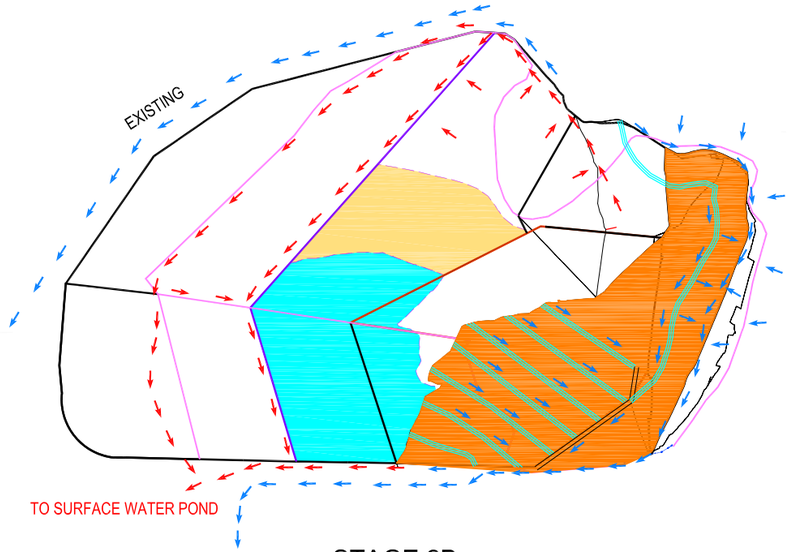
NOTE: DRAWINGS SHOW REPRESENTATIVE CONDITIONS AT AN INTERMEDIATE TIME DURING LINING AND FILLING OF EACH STAGE



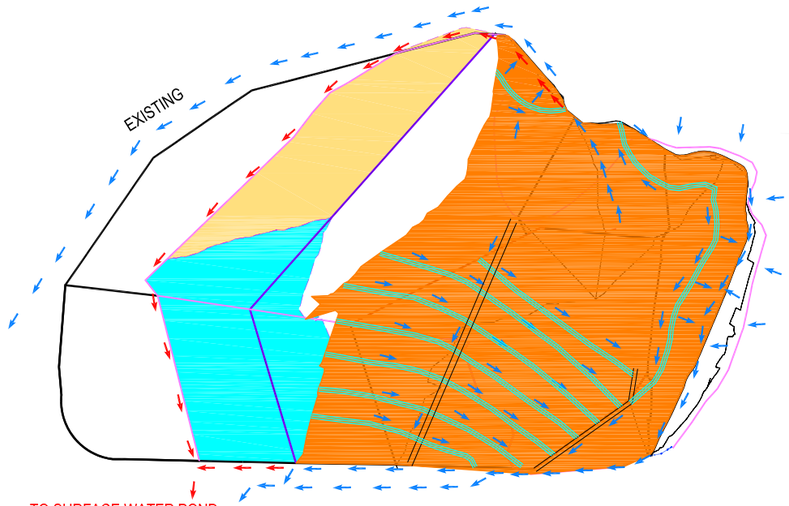
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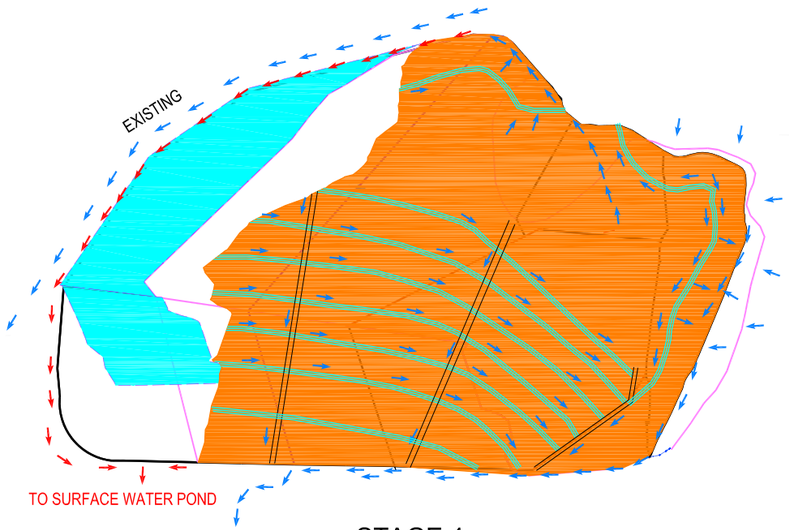
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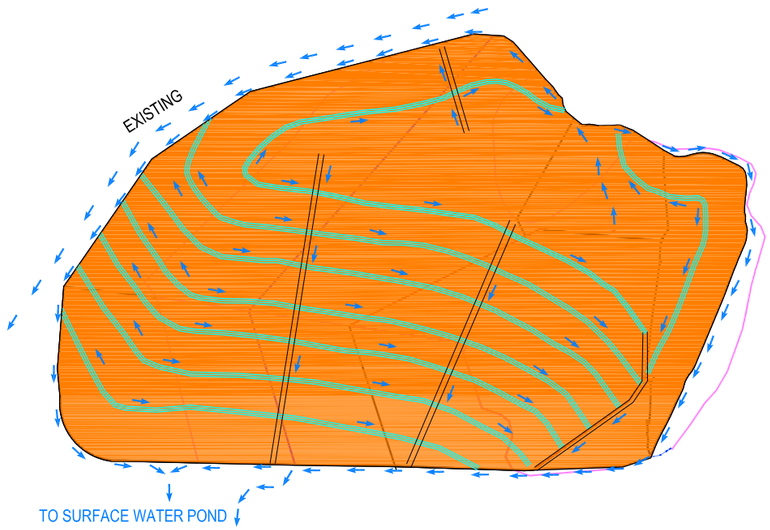
STAGE 2B
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STAGE 3
SCALE 1:7,500



STAGE 4
SCALE 1:7,500



STAGE FINAL
SCALE 1:7,500

LEGEND

- CLEAN WATER
- DIRTY WATER
- WASTE CUTBACK AREA
- ACTIVE FILLING AREA
- LINING AREA
- CAPPED AREA
- PROPOSED BENCHES
- PROPOSED DROP STRUCTURE

ISSUED FOR
PRELIMINARY
NOT FOR CONSTRUCTION

1:7,500 0 150 300 450m

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
	ISSUED FOR PRELIMINARY	E J JEET	R HUYNH	R HUYNH	G SCHMERTMANN	G SCHMERTMANN	
A	DRAFT - ISSUED FOR CLIENT REVIEW	C GIBCUS	R HUYNH	R HUYNH	G SCHMERTMANN	G SCHMERTMANN	23.01.2012

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LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE
EJ JEET	J McMAHON	1:7,500	A3

CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: SURFACE WATER MANAGEMENT SYSTEM CONCEPT PLAN

PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
117625003	143	S	FIGURE 5	B

Plot Date: 1 March 2012 Time:10:49:14 AM By: Jeet, Elvin Path: K:\Des\2011\117625003 WHYTES GULLY\DRAWINGS - File Name:117625003-145-S-D051-REVB.dwg
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7/12/2011

PAH
8/09/2011

Open Site
52-2-3867

ASF
8/09/2011

90

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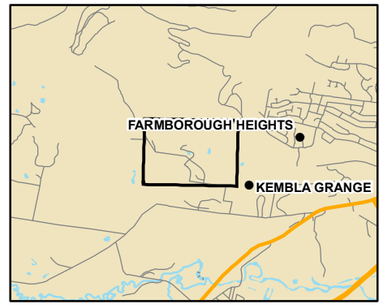
6,184,000

298,000

WHYTES GULLY NEW LANDFILL CELL LANDFILL MASTER PLAN

WOLLONGONG CITY COUNCIL

DEVELOPMENT CONSTRAINTS



LEGEND

- Site Boundary
- Cadastre
- Easement
- Flood Planning Area (West Dapto LEP)
- Interpreted Flood Planning Area (50 cm Freeboard)
- Heritage
- Aboriginal Archaeological Sites (12/01/2012)
- AHIMS Results in Study Area (12/01/2012)
- Extent of Landfill Works

NOTES

Historic locations digitised by Golder from reports supplied by Wollongong City Council

Aerial Ortho-Photograph provided by AAM Pty. Ltd. taken on 16 May 2011, Reference 18763A. Image Georeferenced.

Site contours based on survey by KFW Williams, dated 20/07/2011

0 12.5 25 50 75 100 125 150 metres

SCALE (at A3) 1:4,000

Coordinate System: GDA 1994 MGA Zone 56

PROJECT: **117625003**
DATE: **26/03/2012**
DRAWN: **FA**
CHECKED: **JMc**

FIGURE 6

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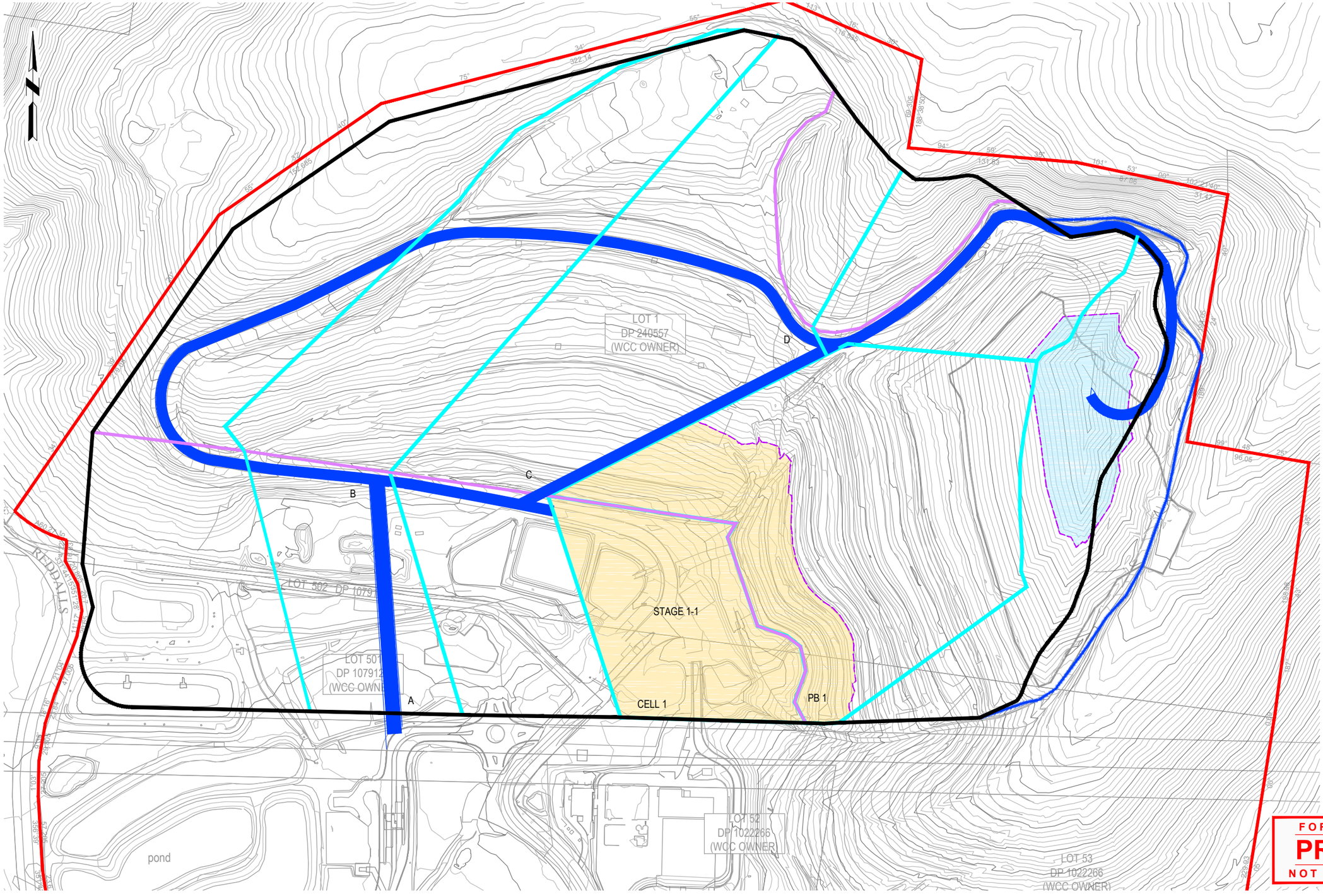
File Location: J:\GIS\Jobs\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Workspaces\117625003_115_R_F0001_DevelopmentConstraints_Rev_1.mxd

APPENDIX A

Whytes Gully New Landfill Cell Staging Plans

March 2012
Report No. 117625003-143-R-Rev0

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LEGEND

- FILLING
- LINING
- TEMPORARY ROAD
- PERMANENT ROAD
- PROPERTY BOUNDARY
- EXTENT OF LANDFORM
- STAGING BOUNDARY
- CELL BOUNDARY
- EXISTING CONTOURS

FOR DISCUSSION ONLY
PRELIMINARY
NOT FOR CONSTRUCTION

1:3,000

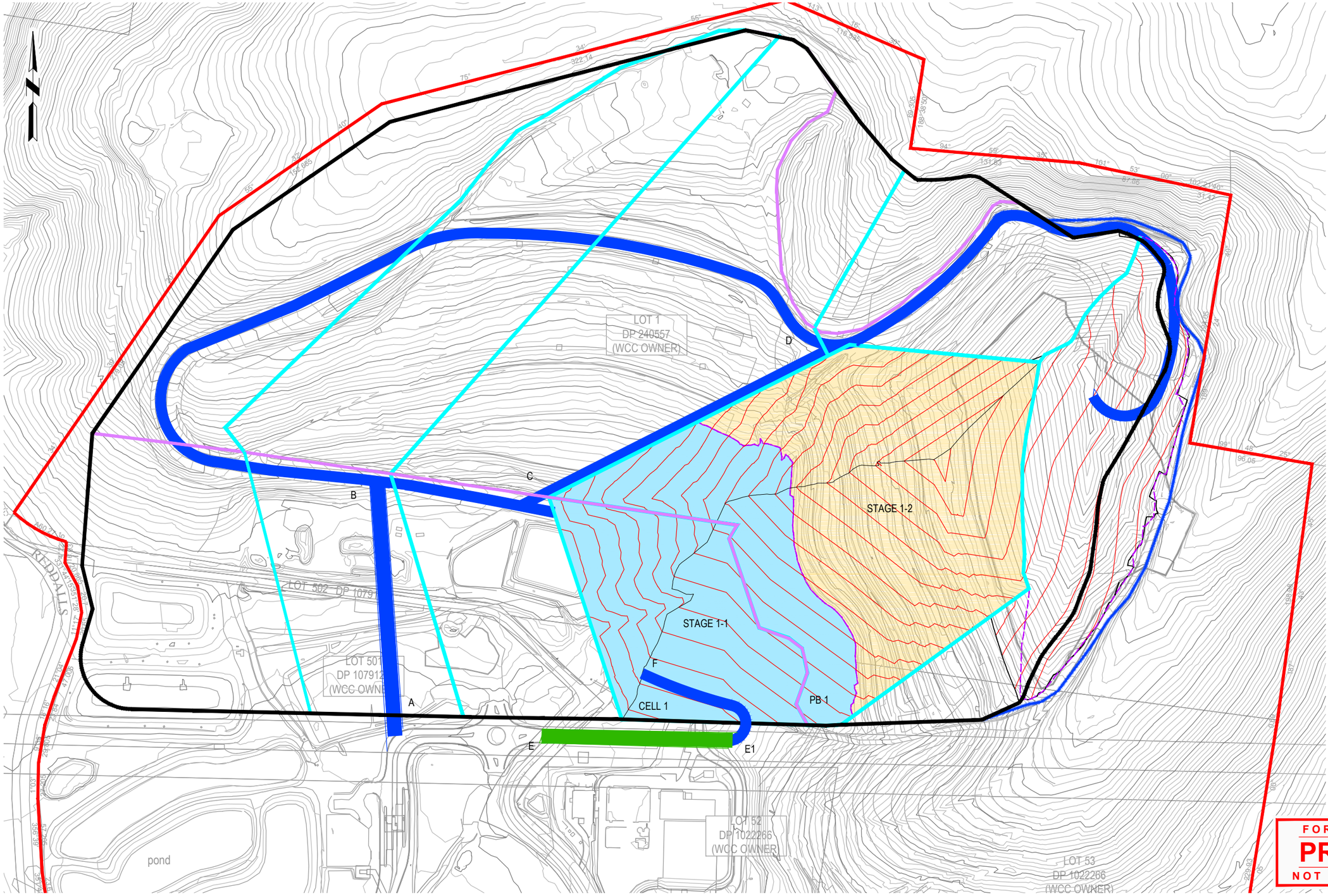
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CLIENT: WOLLONGONG CITY COUNCIL		PROJECT: PRELIMINARY CONCEPT - WHYTES GULLY LANDFILL	
DRAWN BY: EJ JEET	DATE: 21 MARCH 2012	DRAWING TITLE: FIRST STAGE	
CHECKED BY: R HUYNH	DATE: 21 MARCH 2012		
SCALE: 1:3,000	SHEET SIZE: A3	PROJECT No: 117625003	DOC No: 143 / DOC TYPE: R / FIGURE No: F007 / REVISION: 0 — FIGURE 1

Plot Date: 26 March 2012 Time:12:01:09 PM By: Jeet, Elvin Path: K:\Des\2011\117625003 WHYTES GULLY\FIGURES - File Name:117625003-143-R-F007-REV0.dwg
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LEGEND

- FILLING
- LINING
- TEMPORARY ROAD
- PERMANENT ROAD
- END OF STAGE CONTOUR (CURRENT STAGE)
- PROPERTY BOUNDARY
- EXTENT OF LANDFORM
- STAGING BOUNDARY
- CELL BOUNDARY
- EXISTING CONTOURS

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PRELIMINARY
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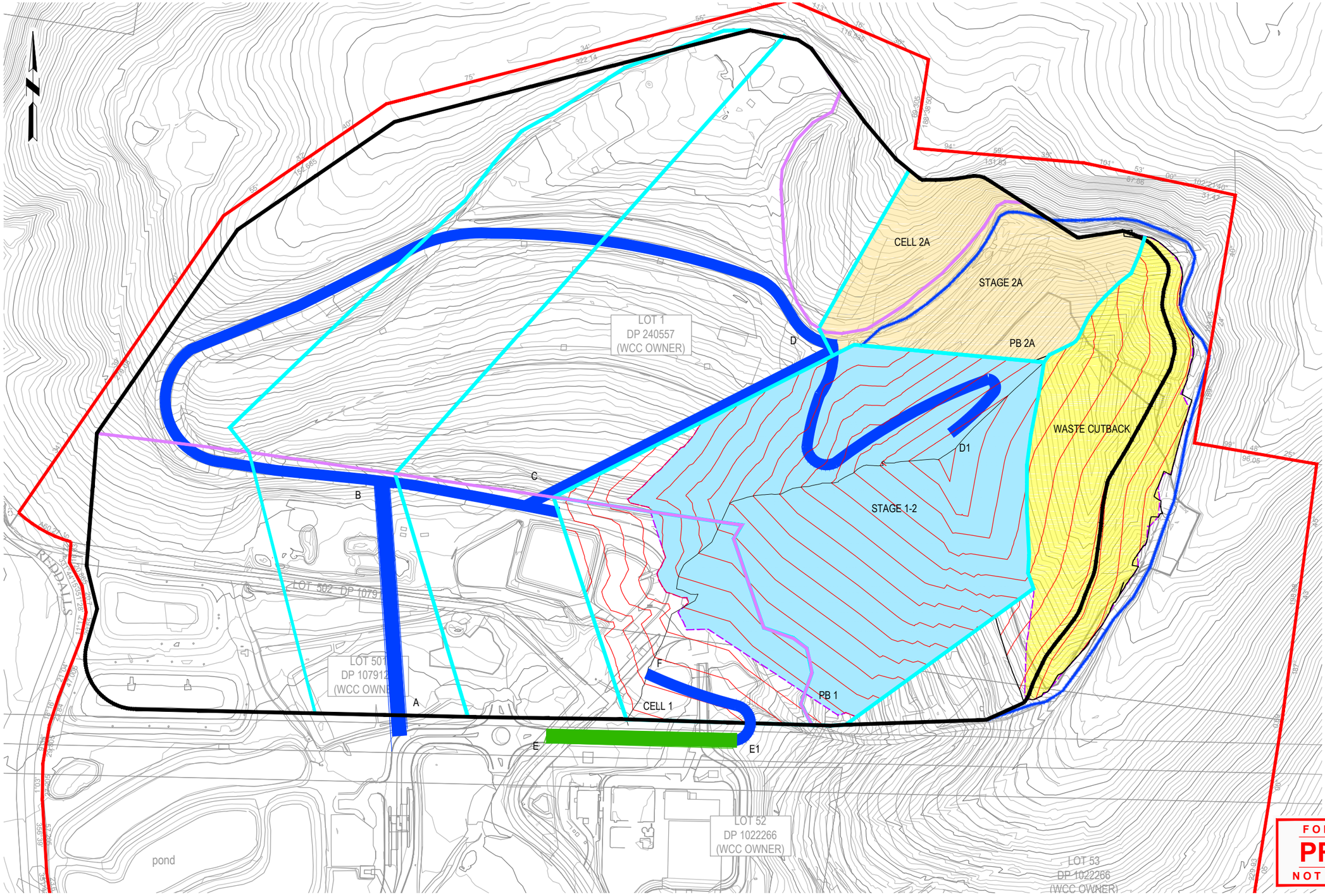
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CLIENT: WOLLONGONG CITY COUNCIL		PROJECT: PRELIMINARY CONCEPT - WHYTES GULLY LANDFILL	
DRAWN BY: EJ JEET	DATE: 21 MARCH 2012	DRAWING TITLE: STAGE 1-1 AND STAGE 1-2	
CHECKED BY: R HUYNH	DATE: 21 MARCH 2012		
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LEGEND

- FILLING
- LINING
- TEMPORARY ROAD
- PERMANENT ROAD
- WASTE CUTBACK
- END OF STAGE CONTOUR (CURRENT STAGE)
- PROPERTY BOUNDARY
- EXTENT OF LANDFORM
- STAGING BOUNDARY
- CELL BOUNDARY
- EXISTING CONTOURS

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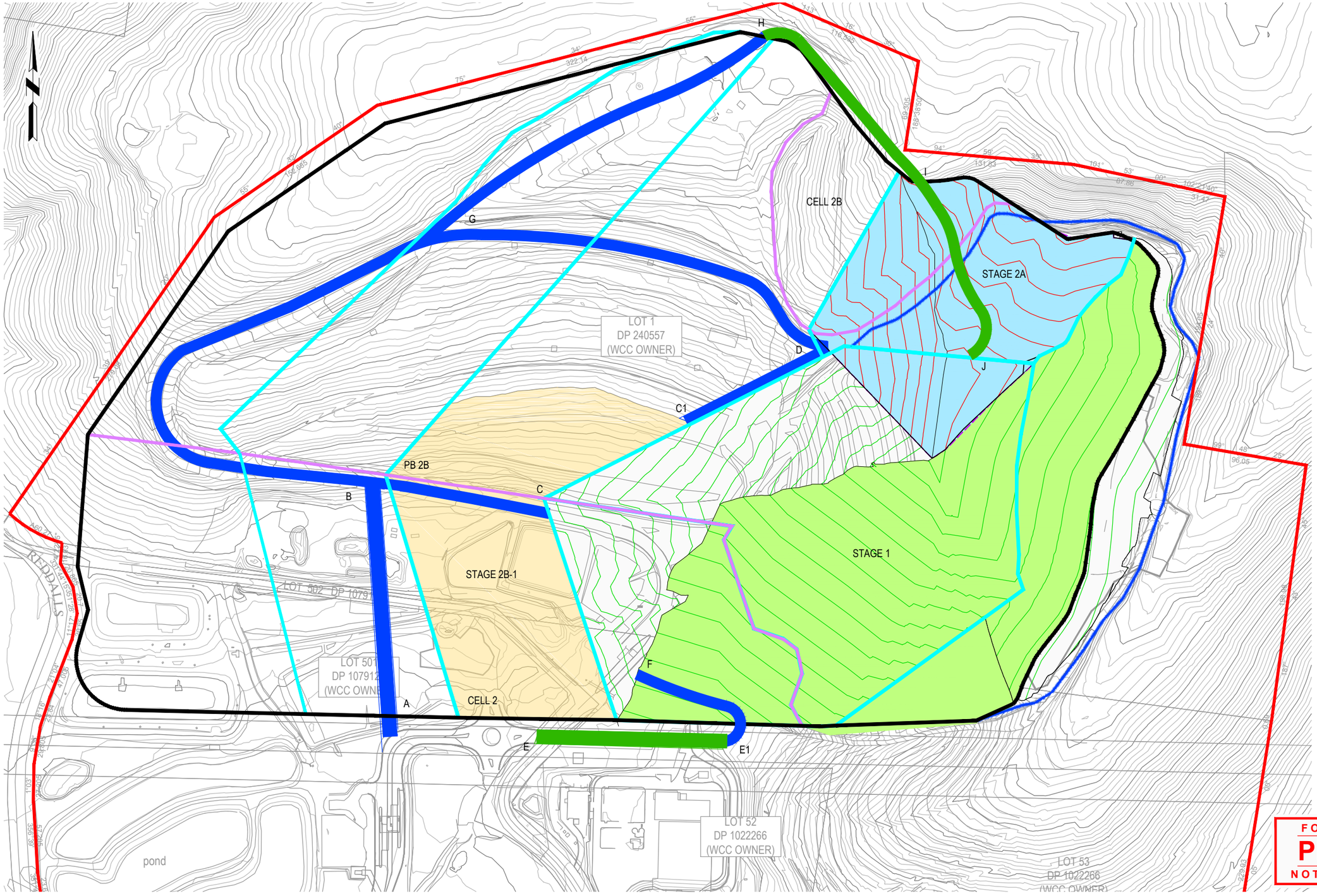
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DRAWN BY: EJ JEET	DATE: 21 MARCH 2012	DRAWING TITLE: STAGE 1-2 AND STAGE 2A	
CHECKED BY: R HUYNH	DATE: 21 MARCH 2012		
SCALE: 1:3,000	SHEET SIZE: A3	PROJECT No: 117625003	DOC No: 143 / DOC TYPE: R / FIGURE No: F009 / REVISION: 0 — FIGURE 3

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LEGEND

- FILLING
- LINING
- TEMPORARY ROAD
- PERMANENT ROAD
- CAPPING
- END OF STAGE CONTOUR (CURRENT STAGE)
- END OF STAGE CONTOUR (FINISHED STAGES)
- PROPERTY BOUNDARY
- EXTENT OF LANDFORM
- STAGING BOUNDARY
- CELL BOUNDARY
- EXISTING CONTOURS

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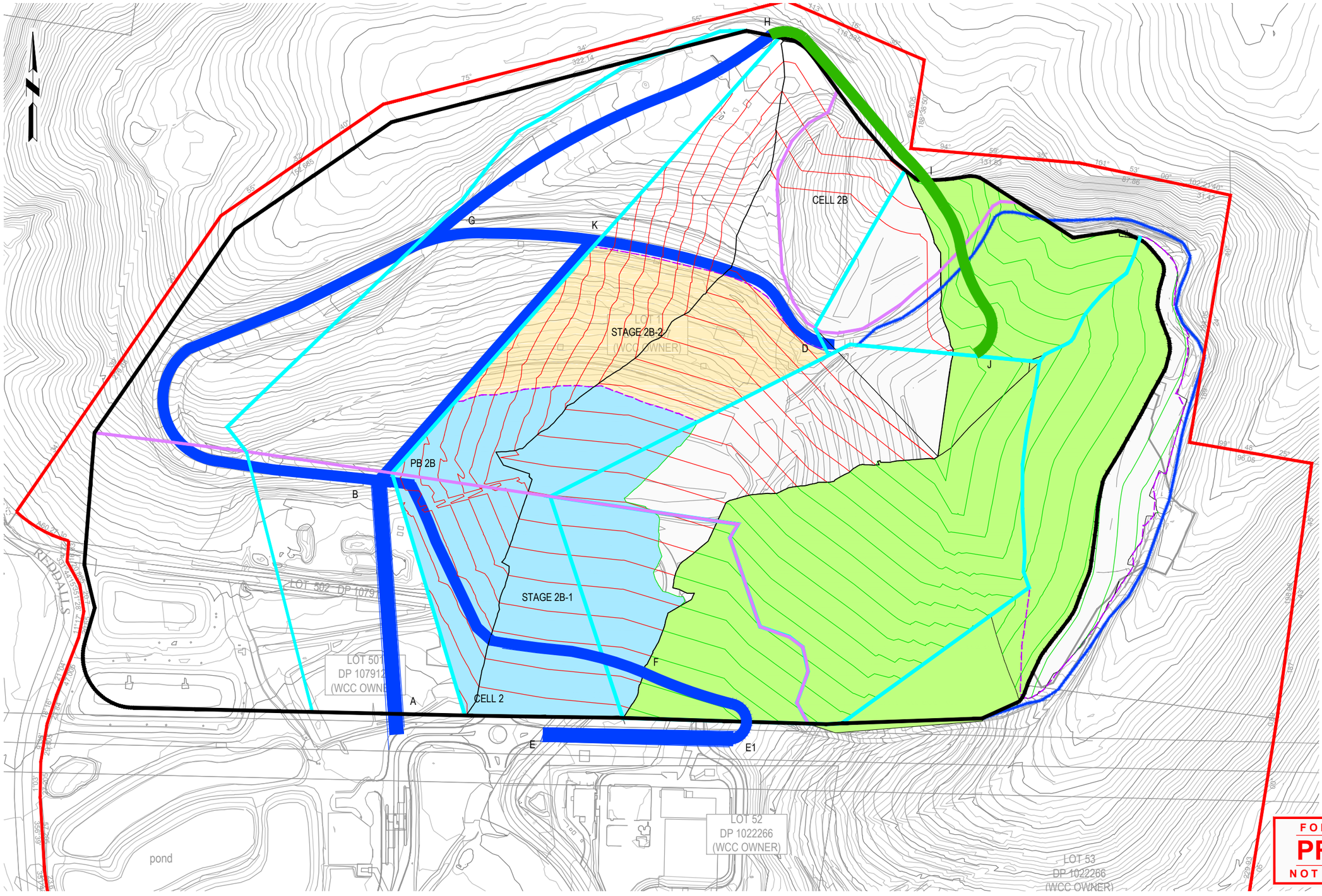
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CHECKED BY: R HUYNH	DATE: 21 MARCH 2012							
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LEGEND

- FILLING
- LINING
- TEMPORARY ROAD
- PERMANENT ROAD
- CAPPING
- END OF STAGE CONTOUR (CURRENT STAGE)
- END OF STAGE CONTOUR (FINISHED STAGES)
- PROPERTY BOUNDARY
- EXTENT OF LANDFORM
- STAGING BOUNDARY
- CELL BOUNDARY
- EXISTING CONTOURS

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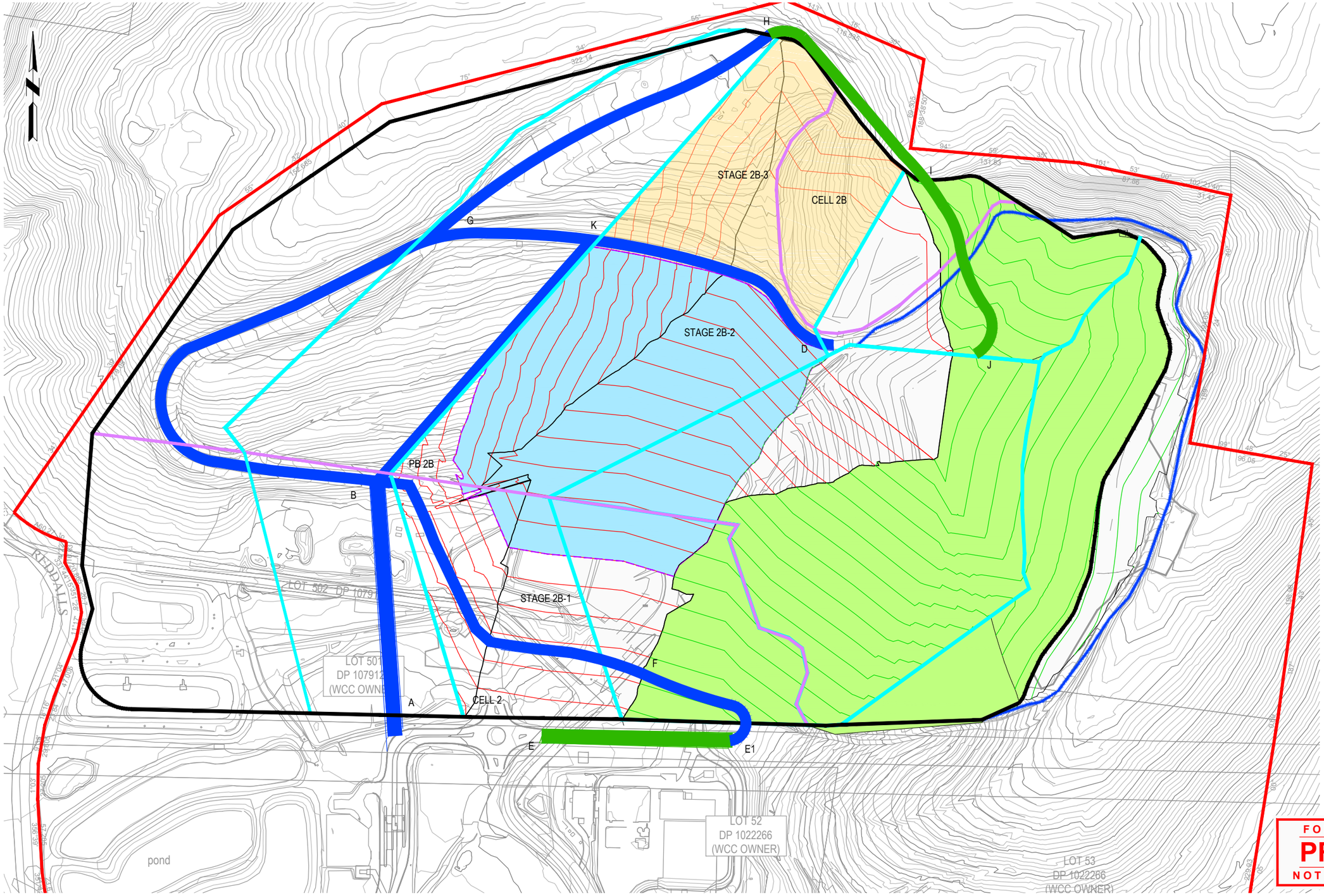
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CHECKED BY: R HUYNH	DATE: 21 MARCH 2012		
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FIGURE 5

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LEGEND

- FILLING
- LINING
- TEMPORARY ROAD
- PERMANENT ROAD
- CAPPING
- END OF STAGE CONTOUR (CURRENT STAGE)
- END OF STAGE CONTOUR (FINISHED STAGES)
- PROPERTY BOUNDARY
- EXTENT OF LANDFORM
- STAGING BOUNDARY
- CELL BOUNDARY
- EXISTING CONTOURS

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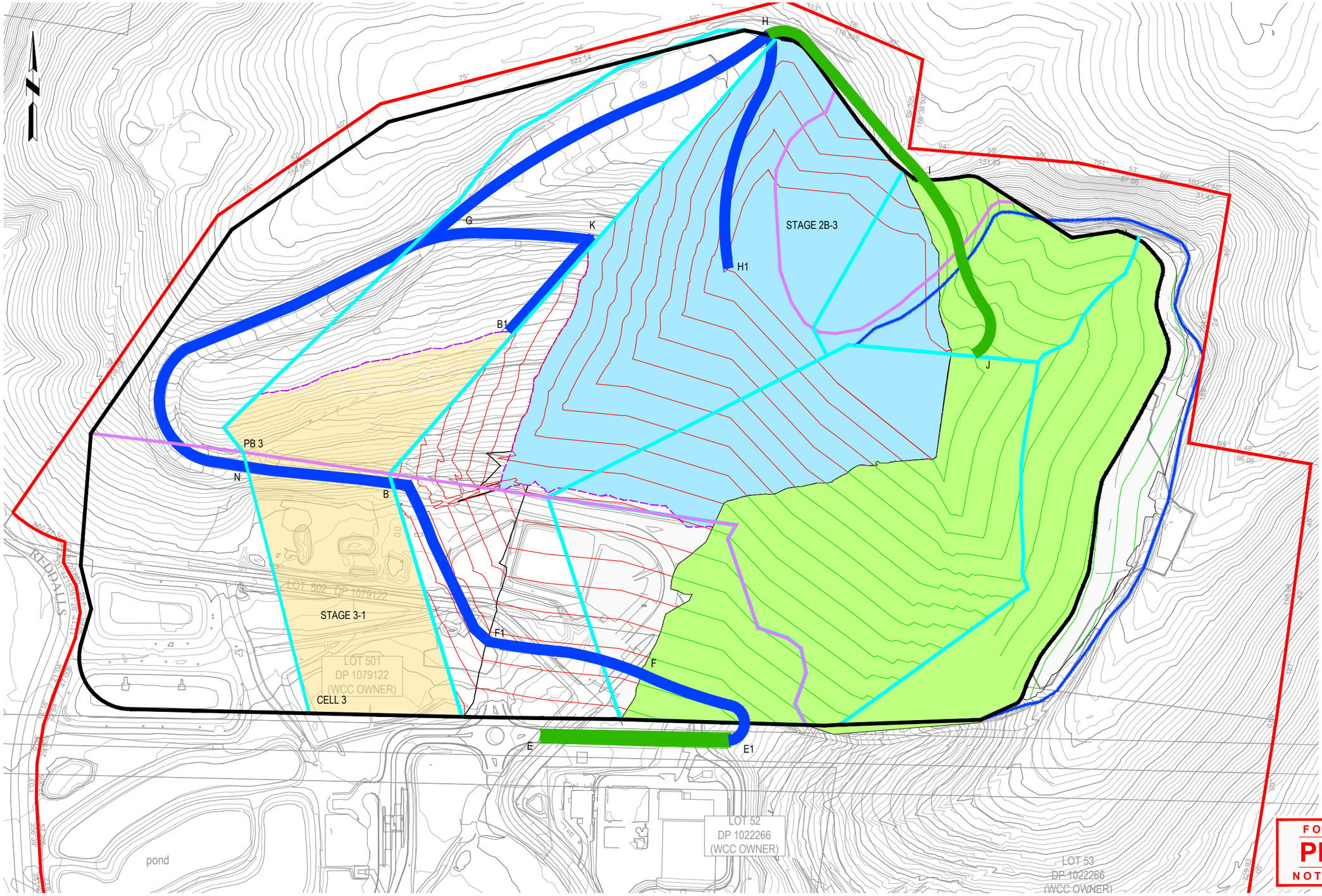
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CHECKED BY: R HUYNH	DATE: 21 MARCH 2012		
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LEGEND

- FILLING
- LINING
- TEMPORARY ROAD
- PERMANENT ROAD
- CAPPING
- END OF STAGE CONTOUR (CURRENT STAGE)
- END OF STAGE CONTOUR (FINISHED STAGES)
- PROPERTY BOUNDARY
- EXTENT OF LANDFORM
- STAGING BOUNDARY
- CELL BOUNDARY
- EXISTING CONTOURS

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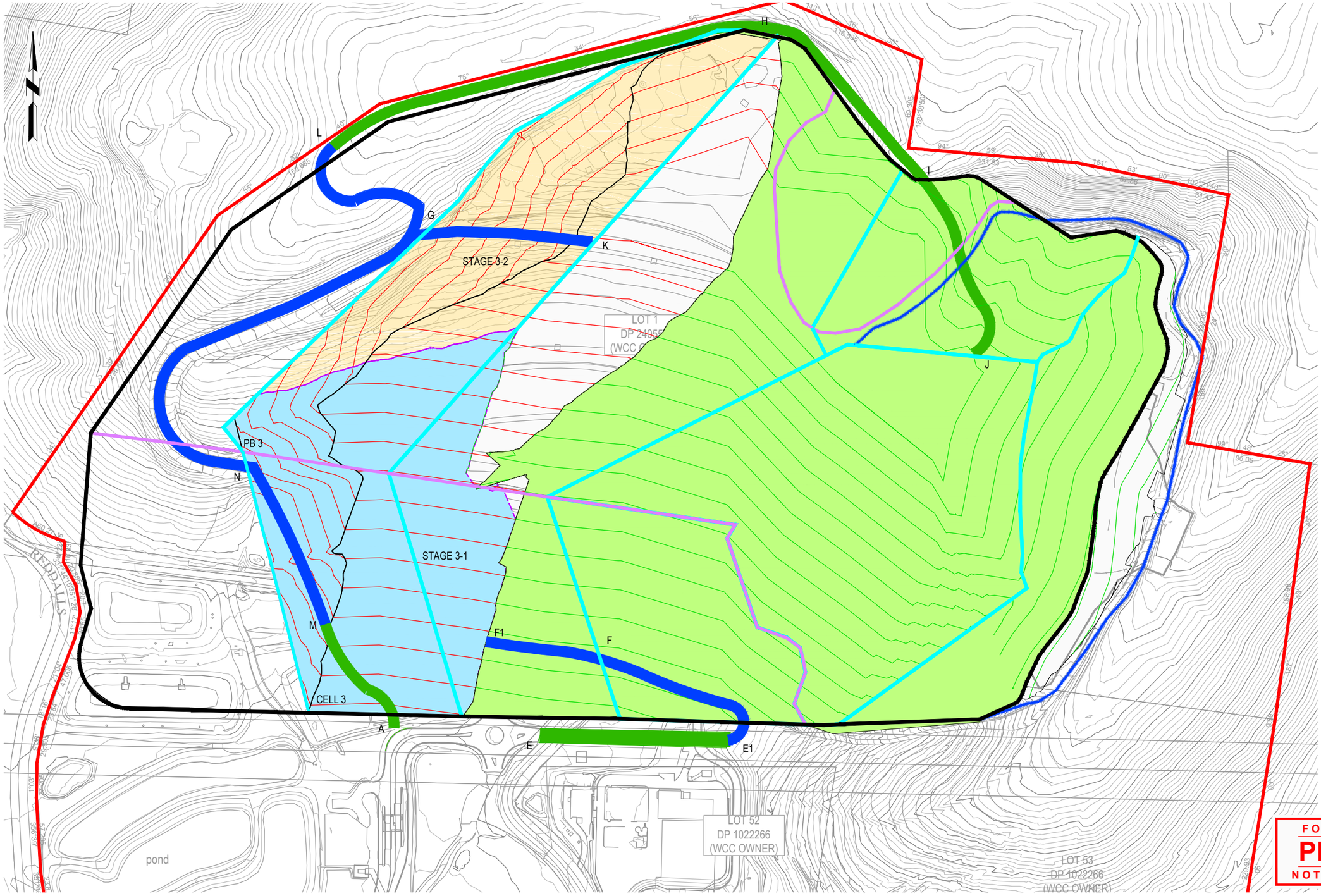
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CLIENT: WOLLONGONG CITY COUNCIL		PROJECT: PRELIMINARY CONCEPT - WHYTES GULLY LANDFILL	
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CHECKED BY: R HUYNH	DATE: 21 MARCH 2012		
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LEGEND

- FILLING
- LINING
- TEMPORARY ROAD
- PERMANENT ROAD
- CAPPING
- END OF STAGE CONTOUR (CURRENT STAGE)
- END OF STAGE CONTOUR (FINISHED STAGES)
- PROPERTY BOUNDARY
- EXTENT OF LANDFORM
- STAGING BOUNDARY
- CELL BOUNDARY
- EXISTING CONTOURS

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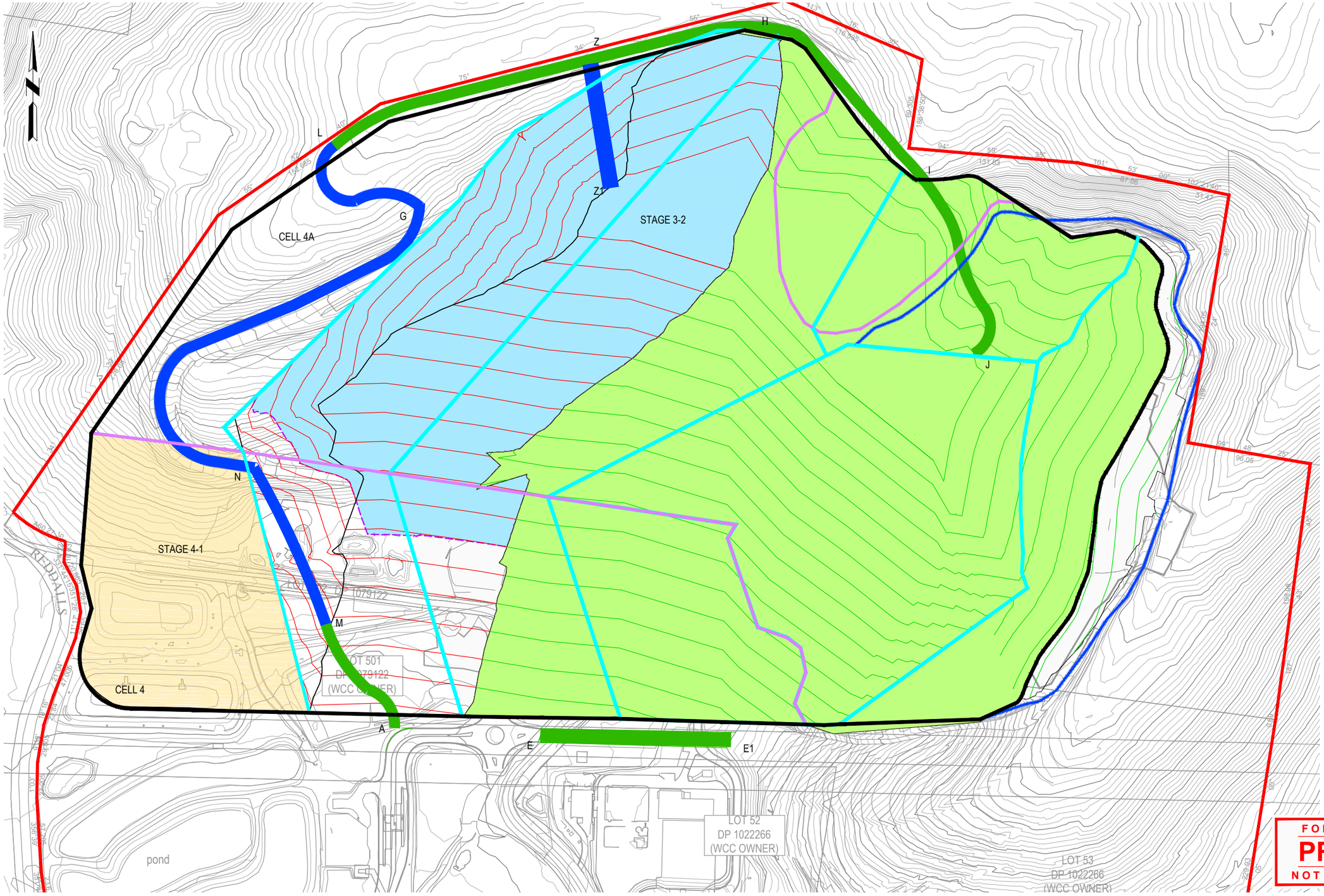
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CLIENT: WOLLONGONG CITY COUNCIL		PROJECT: PRELIMINARY CONCEPT - WHYTES GULLY LANDFILL	
DRAWN BY: EJ JEET	DATE: 21 MARCH 2012	DRAWING TITLE: STAGE 3-1 AND STAGE 3-2	
CHECKED BY: R HUYNH	DATE: 21 MARCH 2012		
SCALE: 1:3,000	SHEET SIZE: A3	PROJECT No: 117625003	DOC No: 143 / DOC TYPE: R / FIGURE No: F014 / REVISION: 0 — FIGURE 8

Plot Date: 27 March 2012 Time:10:30:05 AM By: Jeet, Elvin Path: K:\Des\2011\117625003 WHYTES GULLY\FIGURES - File Name:117625003-143-R-F014-REV0.dwg
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LEGEND

- FILLING
- LINING
- TEMPORARY ROAD
- PERMANENT ROAD
- CAPPING
- END OF STAGE CONTOUR (CURRENT STAGE)
- END OF STAGE CONTOUR (FINISHED STAGES)
- PROPERTY BOUNDARY
- EXTENT OF LANDFORM
- STAGING BOUNDARY
- CELL BOUNDARY
- EXISTING CONTOURS

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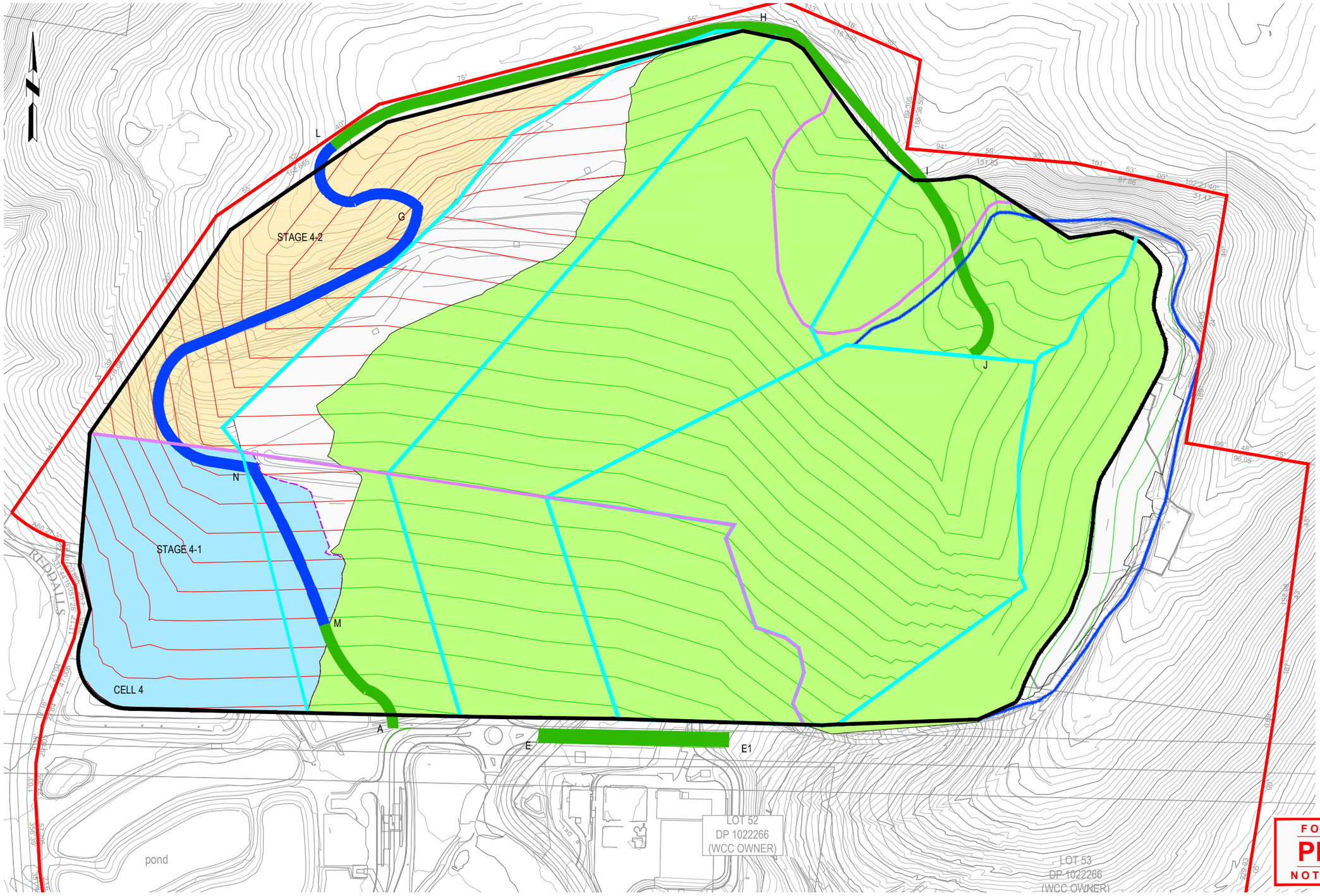
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CLIENT: WOLLONGONG CITY COUNCIL		PROJECT: PRELIMINARY CONCEPT - WHYTES GULLY LANDFILL	
DRAWN BY: EJ JEET	DATE: 21 MARCH 2012	DRAWING TITLE: STAGE 3-2 AND STAGE 4-1	
CHECKED BY: R HUYNH	DATE: 21 MARCH 2012		
SCALE: 1:3,000	SHEET SIZE: A3	PROJECT No: 117625003	DOC No: 143 / DOC TYPE: R / FIGURE No: F015 / REVISION: 0 — FIGURE 9

Plot Date: 27 March 2012 Time:10:32:35 AM By: Jeet, Elvin Path: K:\Des\2011\117625003 WHYTES GULLY\FIGURES - File Name:117625003-143-R-F015-REV0.dwg
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LEGEND

- FILLING
- LINING
- TEMPORARY ROAD
- PERMANENT ROAD
- CAPPING
- END OF STAGE CONTOUR (CURRENT STAGE)
- END OF STAGE CONTOUR (FINISHED STAGES)
- PROPERTY BOUNDARY
- EXTENT OF LANDFORM
- STAGING BOUNDARY
- CELL BOUNDARY
- EXISTING CONTOURS

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PRELIMINARY

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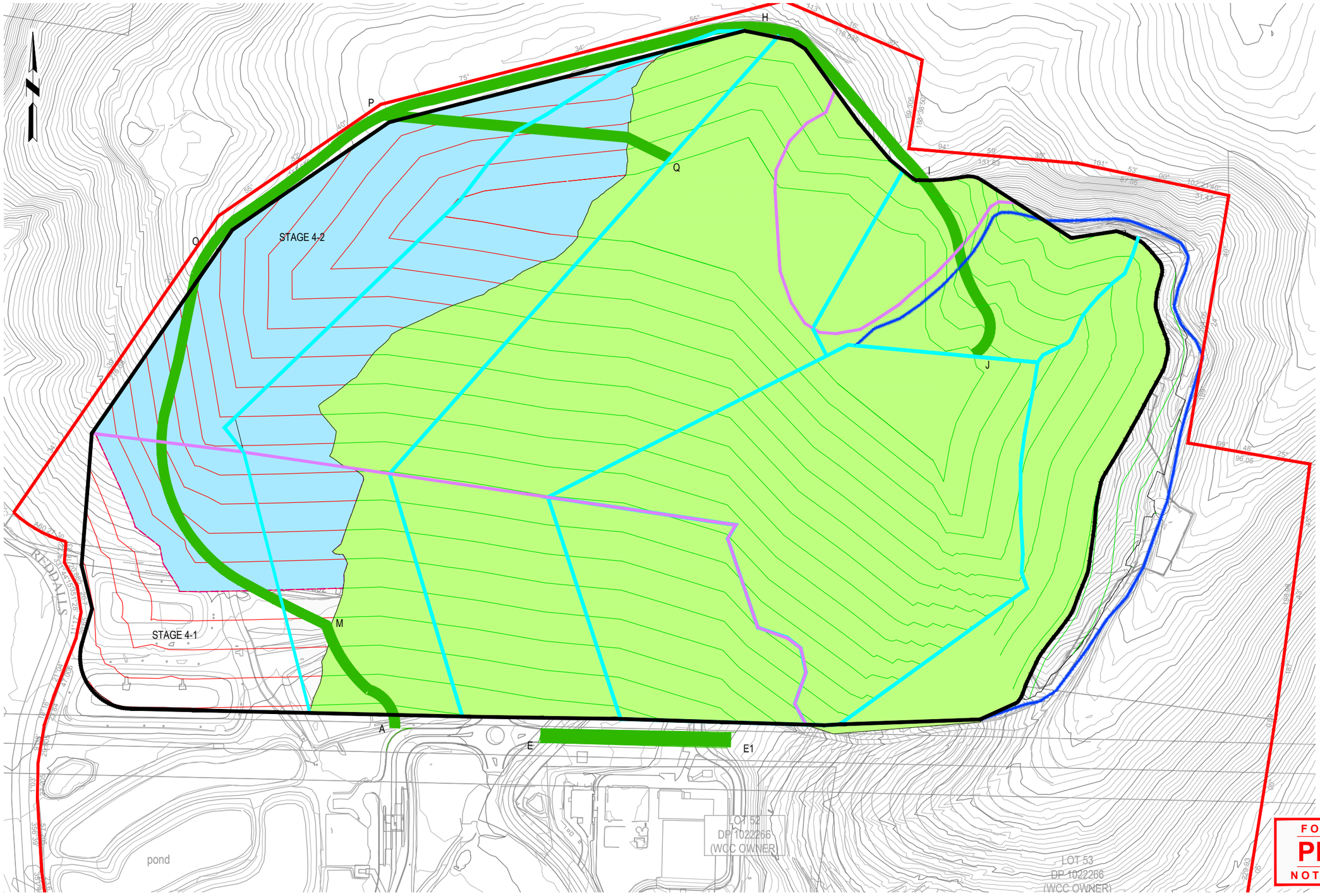
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CLIENT: WOLLONGONG CITY COUNCIL				PROJECT: PRELIMINARY CONCEPT - WHYTES GULLY LANDFILL				
DRAWN BY: EJ JEET	DATE: 21 MARCH 2012			DRAWING TITLE: STAGE 4-1 AND STAGE 4-2				
CHECKED BY: R HUYNH	DATE: 21 MARCH 2012							
SCALE: 1:3,000	SHEET SIZE: A3	PROJECT No: 117625003	DOC No: 143	DOC TYPE: R	FIGURE No: F016	REVISION: 0	FIGURE 10	

Plot Date: 27 March 2012 Time:10:31:46 AM By: Jeet, Elvin Path: K:\Des\2011\117625003 WHYTES GULLY\FIGURES - File Name:117625003-143-R-F016-REV0.dwg
Xref: 117625003-XREF-EXISTING BREAKLINES.dwg; GAP_LOGO-A3.dwg;

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LEGEND

- FILLING
- LINING
- TEMPORARY ROAD
- PERMANENT ROAD
- CAPPING
- END OF STAGE CONTOUR (CURRENT STAGE)
- END OF STAGE CONTOUR (FINISHED STAGES)
- PROPERTY BOUNDARY
- EXTENT OF LANDFORM
- STAGING BOUNDARY
- CELL BOUNDARY
- EXISTING CONTOURS

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0 60 120 180m

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CLIENT: WOLLONGONG CITY COUNCIL				PROJECT: PRELIMINARY CONCEPT - WHYTES GULLY LANDFILL				
DRAWN BY: EJ JEET	DATE: 21 MARCH 2012			DRAWING TITLE: STAGE 4-2				
CHECKED BY: R HUYNH	DATE: 21 MARCH 2012							
SCALE: 1:3,000	SHEET SIZE: A3	PROJECT No: 117625003	DOC No: 143	DOC TYPE: R	FIGURE No: F017	REVISION: 0	FIGURE 11	

Plot Date: 22 March 2012 Time:10:36:02 AM By: Jeet, Elvin Path: K:\Des\2011\117625003 WHYTES GULLY\FIGURES - File Name:117625003-143-R-F017-REV0.dwg
Xref: 117625003-XREF-EXISTING BREAKLINES.dwg; 117625003-XREF-PROPOSED ROADS.dwg; GAP_LOGO-A3.dwg;

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www.golder.com

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St. Leonards, New South Wales 2065
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T: +61 2 9478 3900

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APPENDIX E

Complaints Register Form

WHYTES GULLY RESOURCE RECOVERY PARK

COMPLAINTS REGISTER

MONTH ……

SUPERVISOR ……..

DATE ……

DATE	TIME	COMPLAINT	DESCRIPTION	ACTION	RESPONSIBILITY FOR ACTION	DATE FOR ACTION	SIGNATURE	COMMENTS

form number:
date:

WHYTES GULLY RESOURCE RECOVERY PARK

INCIDENTS REGISTER

MONTH ……

SUPERVISOR ……..

DATE ……

DATE	TIME	INCIDENT	DESCRIPTION	ACTION	RESPONSIBILITY FOR ACTION	DATE FOR ACTION	SIGNATURE	COMMENTS

form number:
date:

APPENDIX F

Standard Operating Procedures

Provided on DVD

APPENDIX G

Whytes Gully New Landfill Cell Preliminary Design Report

Please see Appendix O - EA Volume IV

APPENDIX H

Bore Logs and Monitoring Well Construction Logs

Provided on DVD

APPENDIX I

Landscape Strategy

Please see Appendix N - EA Volume III

APPENDIX J

Limitations

LIMITATIONS

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