Dellara

ABN: 26 131 659 339

Orchard Hills Waste and Resource Management Facility

Cell Design and Groundwater Assessment

Prepared by:

Aquaterra Consulting Pty Ltd

March 2010

Specialist Consultant Studies Compendium Volume 1, Part 2

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Cell Design and Groundwater Assessment

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March 2010

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EXECUTIVE SUMMARY

Detailed geological and hydrogeological investigations have been undertaken on the Site. The geology of the site consists of clay, up to 89 m of shale of the Bringelly formation overlying Hawkesbury Sandstone. Extensive drilling previously undertaken on the site by R W Corkery & Co (2004) and others has shown evidence of occasional and thin carbonaceous lenses of limited extent and connectivity, existing in horizontal planes.

Minor groundwater flow at the Site is expected to move within near surface features, defects, bedding planes and in carbonaceous lenses. These pathways are generally discontinuous over short distances.

The Site's measured horizontal permeability of the shale is very low. Vertical permeability is typically many times lower than horizontal permeability within laminar shale deposits such as those that occur on the Site.

No hydraulic connection could be found between Blaxland Creek and groundwater in the adjacent North West piezometer. Also, the higher horizontal permeability measured in the North East piezometer does not extend across the site to the North West piezometer which confirms that the zones of higher permeability (in the fractures etc) are discontinuous.

The Site's geology naturally offers a high level of protection to prevent the off-site migration of pollutants from the emplacement of general solid (non-putrescible) waste. Additional best practice design, construction, operation, monitoring and rehabilitation features are proposed to be installed and implemented which would meet (and in several cases exceed) the environmental performance requirements for waste disposal in NSW.

Modelling has predicted leachate generation, storage and disposal requirements. Conservative assumptions have been used in the modelling and are expected to result in an over-prediction of leachate generation volumes. The modelling results would be verified with site data to continue to demonstrate that the Site has sufficient leachate storage and evaporative disposal capacity at all times.

The waste emplacement cells will be progressively capped and rehabilitated. It is the Proponent's intention to monitor the waste received and gas generation during the early stages of operations to establish whether sufficient gas is accumulating within each emplacement cell to warrant collection and oxidation from the rehabilitated cells which in turn would reduce the Site's greenhouse footprint.

Imported waste was deposited at the Site before it was purchased by the Proponent. The composition and quantity of this waste has been investigated by Douglas Partners (2009). The existing on-site waste would be managed throughout the Project life to ensure that it does not impact unacceptably on the environment.

Robust procedures would be put in place to ensure that all waste levy obligations are met.

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1 INTRODUCTION

1.1 Background

The Project Site comprises Lot 40, DP 738126, which is located at 123-179 Patons Lane Orchard Hills. The site's location is depicted in **Figure 1.1**.

The Project's focus is the efficient recovery of resources from general solid (non-putrescible) waste. Waste unable to be economically recovered will be emplaced on site in environmentally secure waste emplacement cells.

Only waste classified as general solid (non-putrescible) waste will be emplaced on site. No putrescible, liquid, special, hazardous or restricted wastes would be accepted on site. The site would not be open for waste receipts from the general public thereby providing considerable control over wastes received and emplaced.

The purpose of this report is to document:

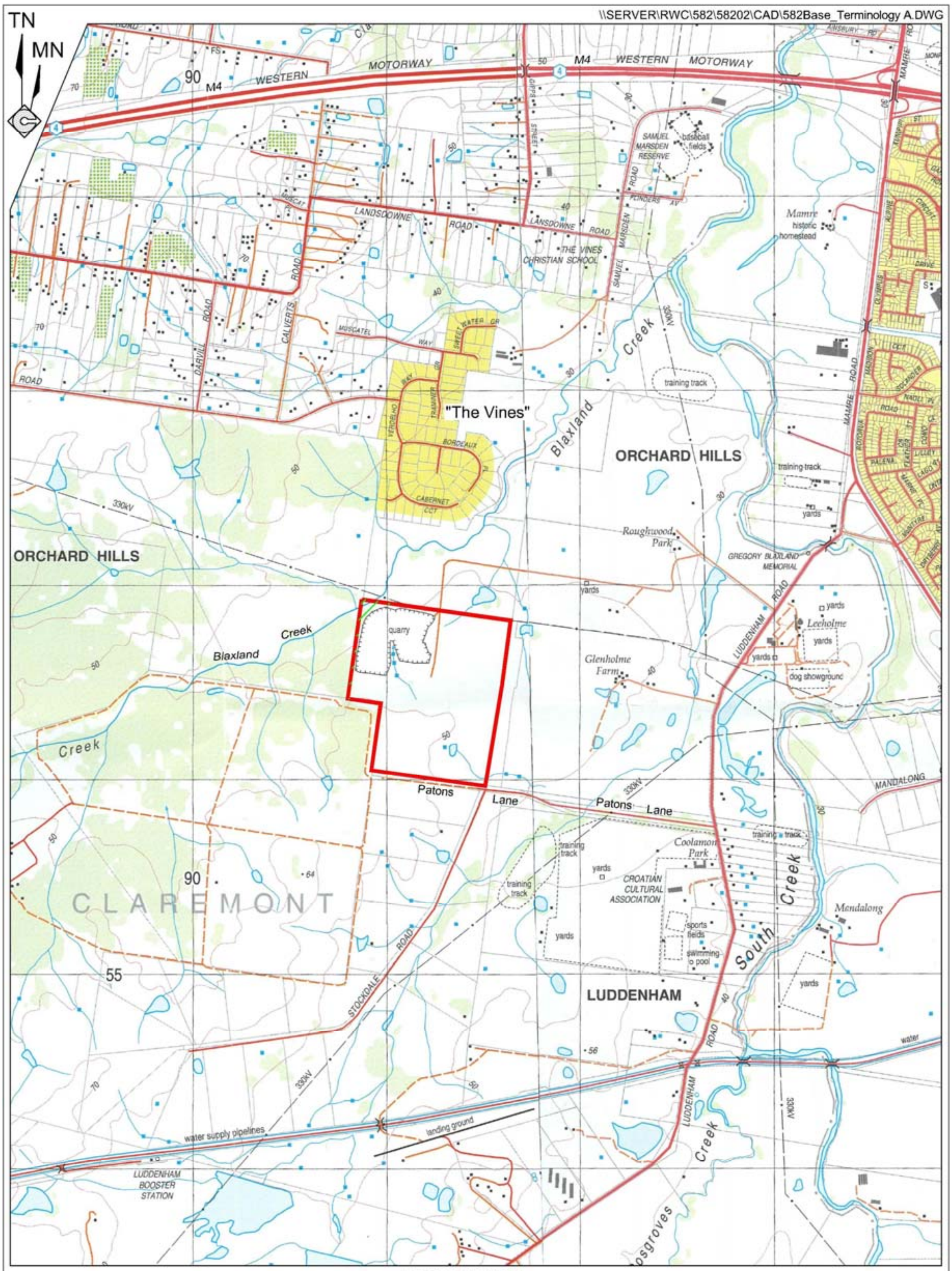
- A groundwater assessment for the Site
- A conceptual design for the emplacement cells; and
- An outline environmental management plan for the emplacement cells.

The detail of the relevant components of the project would be provided to the DECCW when applying for approval for each component to be incorporated within the relevant Environment Protection Licence (EPL).

The design and operation of the emplacement cells reflects an integrated approach. This approach to the emplacement cells' design recognises that the selected environmental controls work in concert to ensure that the site's operation and post-closure period will meet the environmental requirements nominated in:

- The Protection of the Environment Operations Act 1997;
- The Environmental Goals in DECC's Environmental Guidelines: Solid Waste Landfills (1996); and
- The Department of Planning Director-General's Requirements (20 May 2009).

The operation of the waste emplacement component of the Facility would be undertaken by an established and experienced waste management company.



REFERENCE
Project Site Boundary

SCALE 1:30 000

500 0 500 1000 1500 m

Base Map Source: Prospect (2001) and Penrith (2001) 1:25 000 Topographic Maps

Figure 1.1
LOCALITY PLAN

2 GEOLOGICAL DATA AND FIELD INVESTIGATIONS

2.1 General

Six geological studies and one hydrogeological field study have been undertaken at the site.

R.W Corkery & Co Pty Limited undertook a study in early 2004 to determine the location, quality and quantity of clay and shale at the site which was likely to be in high demand by the brick making industry. This study also determined the lithologies at the site by coring and logging boreholes. This work took into account information from five previous drilling programs at the site.

In April 2009, Aquaterra Consulting Pty Ltd installed two groundwater piezometers (DWE Licence number 10BL602962) at the site and measured water levels, sampled and hydraulically tested these in June and July 2009. Also present at the site is an existing groundwater abstraction bore (DWE licence number 10BL161098).

Aquaterra's hydrogeological investigations were undertaken to provide data to underpin the conceptual design for the waste emplacement cells so that leachate and gas will be contained on site. Work carried out as part of this assessment included:

- A detailed review of the previous six geological studies undertaken at the site;
- Installation of two piezometers in the northwestern and northeastern corners of the site;
- Hydraulic testing to determine average horizontal hydraulic conductivity of the clay/shale beneath the site;
- Measurement of the piezometer water levels to determine the depth to the groundwater and direction of groundwater flow;
- Analysis of the quality of the groundwater; and
- Collection of clay samples for testing to determine their re-compacted permeability.

2.2 Previous Geological Studies

R W Corkery & Co Pty Limited in 2004 issued a report titled "Evaluation of Clay/Shale Resources at Erskine Park Quarry". This report is for the identical site as the proposed Orchard Hills Waste and Resource Management Facility.

R W Corkery & Co reviewed the results from five previous drilling programs which involved 35 boreholes, and also installed a further eighteen (18) bores to depths of 17 m AHD.

It is worth noting that of the 18 bores drilled by R W Corkery & Co that 'no noticeable inflows of groundwater were encountered'. R W Corkery & Co also noted that where carbonaceous lenses were encountered they were limited in extent and unable to be correlated between drill holes.

2.3 Licensed Bores

A search of the DWE groundwater database has revealed the presence of three licensed groundwater bores within approximately 3km of the centre of the Project Site. These are depicted on **Figure 2.1**, and detailed in **Appendix 1**.

One of these licensed bores is the Project Site's abstraction bore. Note that the abstraction bore accesses groundwater predominantly in the Hawkesbury Sandstone, as it is cased to 59.5 m and is an open hole to 210 m (bottom of bore at -165 m AHD). This bore is licensed to abstract up to 32 ML/year.

The other two bores within 3km of the Project Site are able to abstract water from the Hawkesbury Sandstone, with one bore extending to 366 m in depth.

Access to the licensed bore nearest the Project Site which is on the "Coolamon Park" property (GW105382) was unable to be obtained. However, it is understood that this bore is currently not being utilised to access groundwater, but when it is used it is pumped at the rate of 60 L/min.

2.4 2009 Investigations

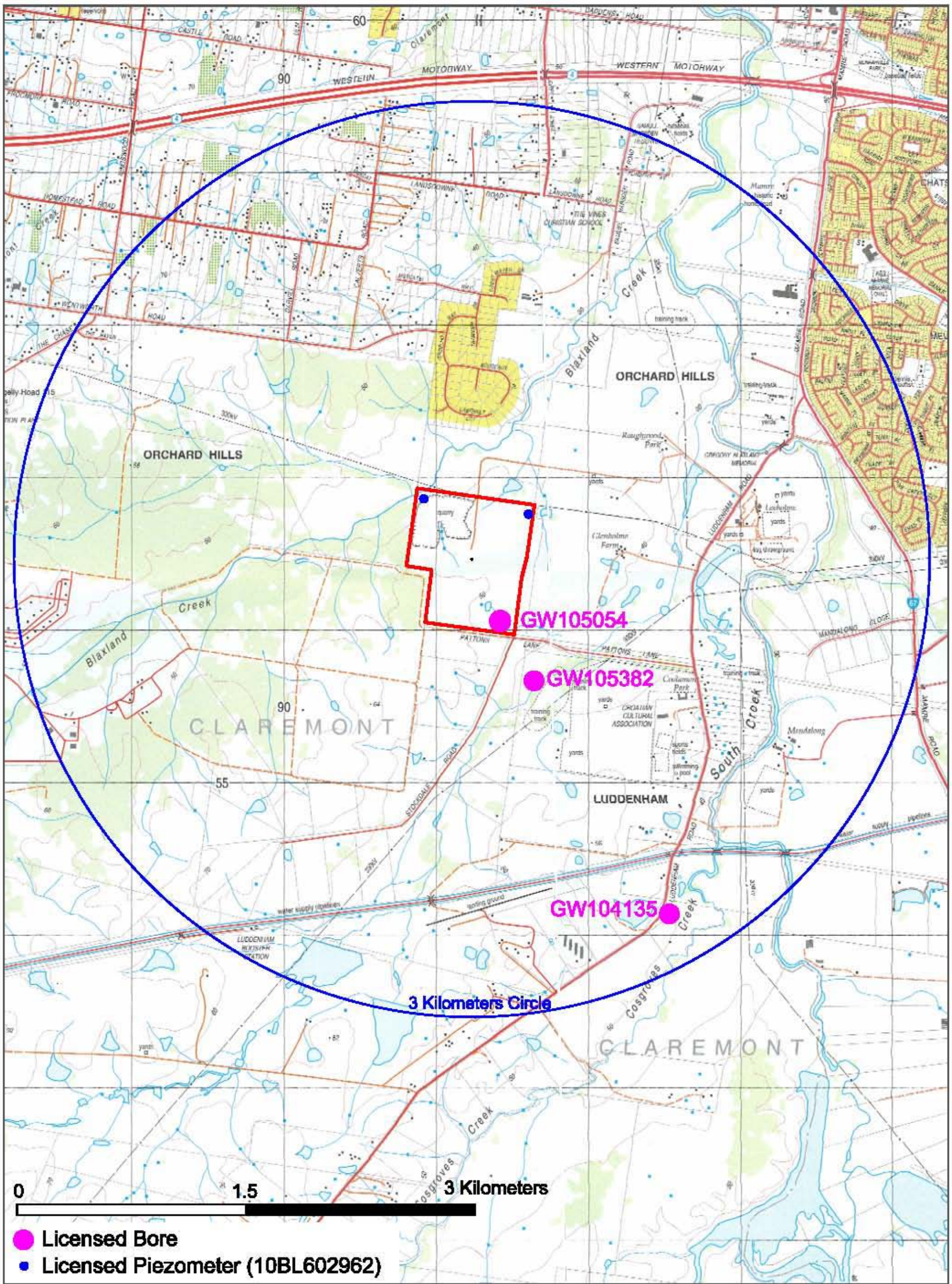
2.4.1 Piezometer Installation

A drilling program was conducted in April 2009. Two dual purpose subsurface gas and groundwater monitoring piezometers were installed in the shale and their location is depicted on **Figure 2.1**. The locations of the piezometers were selected so that they are hydraulically downgradient of the proposed emplacement cells. Groundwater generally follows the topography from high to low locations and the two piezometers are located near the northwest and northeast corners of the site which are topographic low points.

Drilling was undertaken by Intertech Drilling Services Pty Ltd who used conventional down hole (air) hammer techniques. Air hammer drilling uses compressed air, which is used to work the hammer and return drill cuttings to the surface via the borehole annulus, from where they were discharged through a bluey line (**Appendix 1**).

One of the major advantages of conventional air hammer drilling is that water-bearing zones can be identified when formation water is discharged with the cuttings. Airlift yields were estimated using a 90^{o} v-notch weir and field measurements of water quality parameters (EC and pH) were undertaken using calibrated electronic meters.

The two piezometers (known as NW Piezometer and NE Piezometer) were started with 125 mm diameter pre collar casing (class 9 PVC) installed within the upper clay sequence and were then drilled at 120 mm diameter to accommodate 50 mm diameter class 9 machine slotted PVC casing to depths well below the proposed floor of the cells, followed by gravel pack to near surface. The piezometer logs and their construction details are presented in **Appendix 1**.



Date: 1 October 2009	Scale: as shown	**Orchard Hills WMRF**	
Initials: PZ	Job No: S39	**Licensed Bores and Piezometers**	
Drawing No: S39-007	Rev: 0		
aquaterra			**Figure 2.1**

Aquaterra hydrogeologists supervised the drilling and completion of both piezometers. Information collected during drilling included:

- Lithology, based on drill cuttings collected at 1 m intervals.
- Penetration rate, based on time for drilling each rod length.
- Airlift water yield, measured whilst drilling.
- Groundwater temperature, electrical conductivity (EC, mS/cm) and pH, measured during airlift at each rod change and water cut encountered.
- Depth to groundwater, when possible during and after drilling.

2.4.2 Hydraulic Testing

Hydraulic testing of piezometers was carried out in June 2009. Constant rate tests (CRT) were performed on both piezometers in accordance to AS 2368 1990 Test Pumping of Water Wells. The tests undertaken in each piezometer were as follows:

- NW piezometer was subjected to a 300 minute constant rate test at a rate of 13 m^3/day, and recovery.
- NE Piezometer was subjected to 2 x 10 to 15 minute constant tests at a rate of 6 m^3/day and recovery. The short duration of the pumping test for this piezometer was attributed to the very low hydraulic conductivity of the groundwater in the shale and hence rapid dewatering of the piezometer.

A suite of published analytical methods (Kruseman and de Ridder, 1991) have been used to analyse the pumping test data from the piezometers. The following methods have been used in this analysis:

- Jacob's straight-line method for unsteady flow in a confined aquifer. The method is used here to analyse mid-time data, after well storage effects become negligible.
- Theis's Recovery method, which is derived for confined aquifers.
- Hvorslev solution– This solution is derived for slug tests and is suitable for providing 'near well' estimates of hydraulic conductivity for confined aquifers. Here a volume of water ('slug') is either removed (rising head) or introduced (falling head) into a well. This solution was used to analysis the recovery data ('rising head') measured in the NE piezometer after the CRT. This analysis was deemed suitable due to the rapid dewatering of this piezometer during pumping and the very slow subsequent recovery of groundwater levels.

It is important to note that these methods were used even though the groundwater in the shale does not constitute an aquifer. An aquifer is a water bearing permeable rock or sediment from which groundwater can be usefully extracted from a bore. Only very small quantities of highly saline groundwater can be extracted from the shale beneath the Project Site.

A summary of the shale hydraulic parameters (kh) is presented in **Table 2.1** and the graphical solutions and calculations from which these values were derived are included in **Appendix 1**. These tests determine the horizontal hydraulic conductivity of the shale.

Table 2.1
Summary of Hydraulic Testing – Horizontal Hydraulic Conductivity

	Kh (m/d)		**Kh (m/s)**	
Solution	**NE Piezometer**	**NW Piezometer**	**NE Piezometer**	**NW Piezometer**
CRT Drawdown (Jacob)	0.0022	0.09	2.6E-08	1.04E-06
Recovery (Thies)	0.0006	0.14	6.94E-09	1.62E-06
Slug test (Hvorslev)	0.001	-	1.16E-08	-
Geometric mean[1]	0.001	0.11	1.3E-08	1.3E-06

[1] Geometric mean is used to evaluate data covering several orders of magnitude. Geometric mean is a log-transformation of data to enable meaningful statistical evaluations.

2.4.3 Groundwater Levels

Groundwater levels in the shale were measured in the two piezometers on 17 June 2009, 28 July 2009 and 16 November 2009 and were found to be consistent between all dates. This time period was sufficient to ensure that the groundwater levels had stabilised after the piezometers were installed and tested.

The standing water level was also measured in June 2009 in the abstraction bore. The bore log for the abstraction bore indicates that it is an open hole for the lowest 33 m of shale and extends a further 118 m into the underlying Hawkesbury Sandstone.

The groundwater levels are presented in **Table 2.2**.

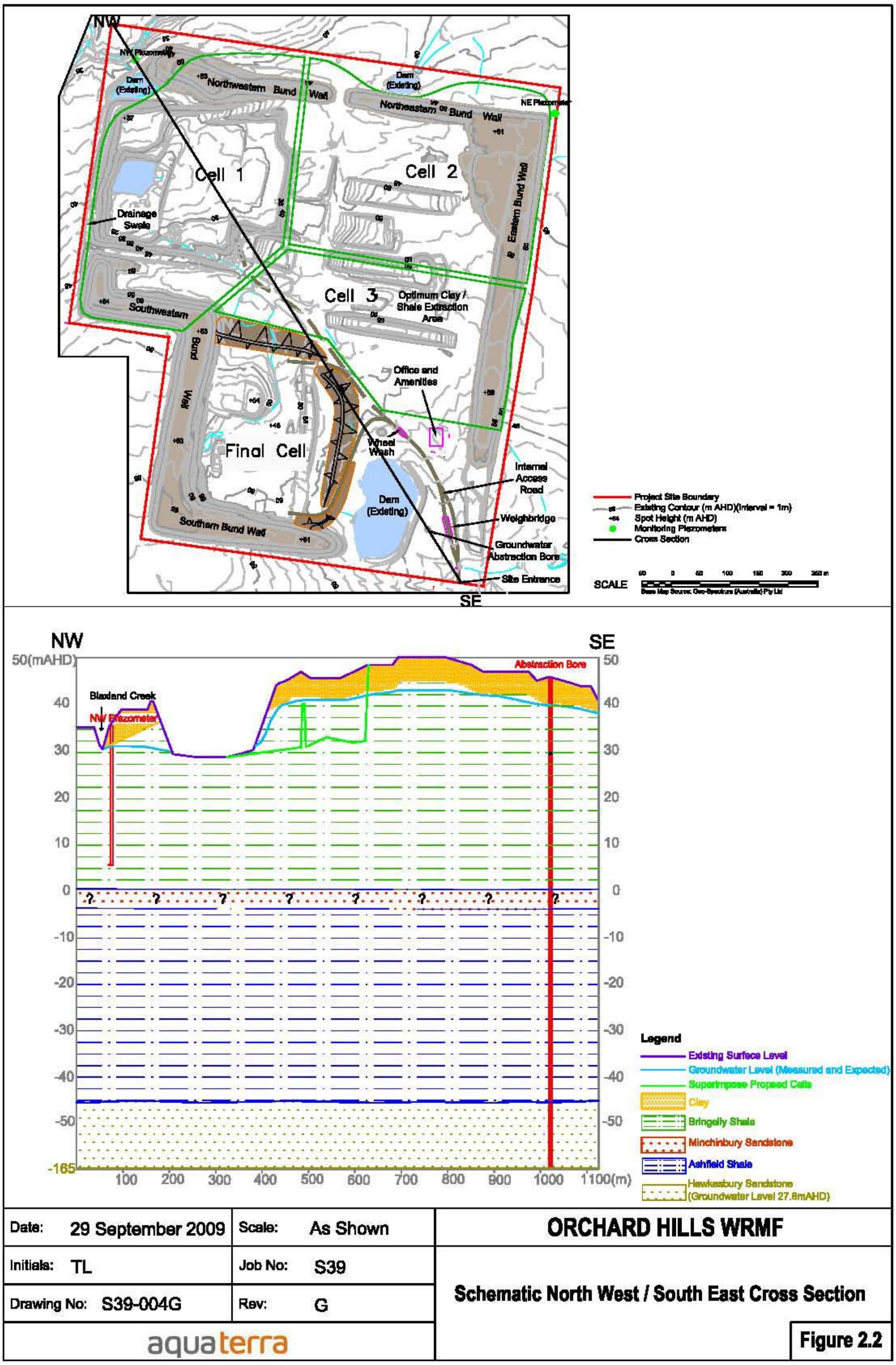
Table 2.2
Standing Water Level

		Ground elevation (mAHD)	**Standpipe height (magl)**	**DTW (mbsp)**	**DTW (mbgl)**	**Groundwater Level (mAHD)**
NW Bore	17/06/2009	35.5	0.92	5.58	4.66	30.8
	28/07/2009	35.5	0.92	5.55	4.63	30.9
	16/11/2009	35.5	0.92	6.06	5.14	30.4
NE Bore	17/06/2009	42.0	0.92	4.9	3.98	38.0
	28/07/2009	42.0	0.92	4.68	3.76	38.2
	16/11/2009	42.0	0.92	5.05	4.13	37.9
Abstraction Bore	17/06/2009	45.0	0.2	17.36	17.16	27.8

magl = metres above ground level / mbsp = metres below standpipe / DTW = metres below ground level (mbgl)

Figure 2.2 is a schematic depicting the Site's geology, groundwater levels in the Bringelly Shale and Hawkesbury Sandstone. The level of the interface between Ashfield Shale and Hawkesbury Sandstone has been inferred from the abstraction bore's log.

Figure 2.2 Schematic North West / South East Cross Section



2.4.4 Groundwater Sampling

During the CRTs for the Site's two piezometers, field measurements of temperature, pH and EC were continuously recorded and a water sample collected once consecutive readings stabilised to within 10% of the previous reading and at least 3 bore volumes had been purged. Also the Site's groundwater abstraction bore was pumped and when temperature, pH and EC stabilised within 10% of the previous reading and at least several bore volumes had been purged a sample was collected. At this time, groundwater samples were collected in laboratory prepared containers, stored on ice and submitted with a chain of custody to ALS Environmental Pty Ltd (ALS) for analysis of the following analytes (ALS is a NATA accredited laboratory for the analyses undertaken):

- General:
- pH, EC, total dissolved solids (TDS) and alkalinity.
- Major ions:
- Sulfate, chloride, calcium, magnesium, sodium, potassium, fluoride, and carbonate (as $CaCO_3$).
- Dissolved metals:
- Aluminium, arsenic, barium, cadmium, chromium, cobalt, copper, lead, manganese, mercury and zinc.
- Nutrients:
- Nitrite (as N), nitrate (as N) and nitrite + nitrate (as N), ammonia, total organic carbon
- Pesticides and Hydrocarbons:
- Organochlorine pesticides (OC), organophosphorus pesticides (OP), polynuclear aromatic hydrocarbons, total petroleum hydrocarbons and BTEX.

The results of field measurements and laboratory testing of the shale groundwater collected from the NW and NW piezometers are presented in **Appendix 1**.

A summary of the Site's groundwater chemistry is presented in **Table 2.3**.

Table 2.3
Summary of Groundwater Chemistry

Compound	Unit	NW	NE	Abstraction Bore
pH Value	pH Unit	6.56	6.28	6.99
Total Dissolved Solids	mg/L	8930	13000	–8300
Total Alkalinity as CaCO3	mg/L	599	353	–897
Total Ammonia as N	mg/L	2.73	0.36	1.02
Organophosphorus Pesticides (OCP)	µg/L	BLD	BLD	BLD
Polynuclear Aromatic Hydrocarbons (PAH)	µg/L	BLD	BLD	BLD
Total Petroleum Hydrocarbons (TPH)	µg/L	BLD	200	BLD

BLD = Below Level of Detection

2.5 Laboratory Testing Of Clay Samples

Eight clay samples were collected from the site at the locations identified in **Appendix 1**. The samples were collected from about 0.3 m below the surface at locations 1, 2, 3, 6, 7 and 8. Samples 4 and 5 were collected from clay stockpiles at the site and these samples are representative of the deeper site clays.

Samples 1, 4, 5 and 7 were tested by Australian Soil Testing Pty Ltd (NATA accredited) to determine the clay's dry density versus moisture content. The results of each of these tests was then utilised to prepare each of the samples by remoulding them to 95% of their maximum dry density at optimum moisture content and subjecting each sample to permeability testing. Both of these tests were undertaken in accordance with the relevant Australian standard. The test results are included in **Appendix 1** and summarised in **Table 2.4**.

Table 2.4
Clay Remoulded Permeability

Clay Sample	Permeability (m/s)
1	6.6×10^{-10}
4	7.3×10^{-10}
5	7.3×10^{-10}
7	4.4×10^{-10}

These results are very good and mean that a thinner clay liner can be installed with the same level of performance at the DECC's benchmark clay liner (0.9 m at $K<1 \times 10^{-9}$ m/s).

3 GEOLOGICAL AND HYDROGEOLOGICAL SITE CONDITIONS

3.1 Geological Settings

The lithologies exposed at the site are sedimentary rocks of the Bringelly Shale, a formation of the Wianamatta Group, a Mid-Triassic sequence of sediments that crop out over most of the central Sydney Basin. The Wianamatta Group is covered by more recent Cainozoic sediments immediately east of the Hawkesbury Nepean River (Herbert, 1979).

Appendix 1 includes a figure which shows the location of the site within the regional geological setting. The Bringelly Shale generally comprises shale, siltstone, claystone, carbonaceous sediments, sandstone, tuff, coal and laminite that is thought to be deposited in a terrestrial alluvial to estuarine intertidal/coastal plain environment. This formation has a maximum thickness of greater than 250 m. The presence of a significant amount of carbonaceous material and thin coal seams in the lithological sequence would place the stratigraphy somewhere in the lower 60m of the Bringelly Shale based on the descriptions of the formation by Herbert (1979).

In the vicinity of the site, the Bringelly Shale dips gently to the south at approximately 5 degrees and has been interpreted to be approximately 50 m to 55 m in thickness. It is underlain generally by a thin layer of Minchinbury Sandstone, Ashfield Shale and by Hawkesbury Sandstone (Jones and Clark 1991). The depth of shale in the southern end of the site as determined from the geological log for the existing licensed abstraction bore is up to 89 m or extends to -47 m AHD (**Appendix 1**).

The sedimentary rocks within the site show strong lateral facies variation, especially in the coarser grained sandstone beds, resulting in difficult lithological correlation of between drill holes. However, it can be clearly seen from R W Corkery & Co 2004 borehole logs for the site that the shale is layered horizontally. Faulting is evident within the existing extraction area but is not thought to significantly constrain the horizontal geological interpretation between drill holes.

Weathering of the rocks in the vicinity of the site is generally intense in the top 3 m to 12 m from the surface. Weathering intensity decreases rapidly with depth below the zone of intense weathering with relatively fresh rock generally encountered within 4 m to 8 m below the natural surface. Clay exists at the surface at the site in those areas not yet extracted.

3.2 Hydrogeology

The shale beneath the site consists of claystone and siltstone, interlayered with thin localised carbonaceous sediments and is not an aquifer as it is highly saline and is not present in sufficient quantities to be beneficially extracted. The shale is an aquitard which has a very low hydraulic conductivity (permeability) and is restricting the recharge of the underlying Hawkesbury Sandstone aquifer.

In the shale, minor groundwater flow may occur in near surface weathering defects, fractures, bedding planes and in the carbonaceous lenses. Extensive drilling previously undertaken on the site by R W Corkery & Co, 2004 and others has shown evidence of occasional and thin carbonaceous lenses of limited extent and connectivity, existing in horizontal planes. The claystone and siltstone are fine grained and formed by compaction and lithification of clay and mud deposits, giving rise to very low hydraulic conductivities (permeability).

Horizontal bulk permeabilities in shales of the Wianamatta Group are usually low (between 10^{-8} and 10^{-9} m/s), with occasional small zones of higher permeabilities in fractures and carbonaceous lenses. Fractures are generally discontinuous over short distances, as are the carbonaceous lenses. Because of the laminar, sedimentary nature of the rock, any permeability that does exist within the rock mass is generally confined to the horizontal direction, with extremely low vertical permeability.

Two piezometers drilled and tested within the shale reported very low horizontal hydraulic conductivities within the range, 10^{-6} and 10^{-9} m/s. The NE piezometer intercepted no groundwater during drilling, however established a groundwater level after completion, following very slow seepage from the saturated zone below the water table. The first evidence of groundwater inflow during drilling of the NW piezometer was a minor water bearing zone (water cut) at 21.5 mbgl (13.5 m AHD) – indicating a small fracture zone or carbonaceous lens within the shale.

The quantity of water "perched" in the shale aquitard above the Hawkesbury Sandstone is invariably limited and when exposed during extraction quickly disappears. Voids created by on-going clay and shale extraction would cause the small quantity of groundwater that is present to seep towards and into the voids. In reality, and based on observations in the existing extraction areas, little if any water would seep into the void (due to the low bulk permeability of the shale) as it would simply evaporate on the exposed side walls and floor of the extraction void, prior to emplacement of waste.

The regional groundwater aquifer exists within the Hawkesbury Sandstone beneath the Site. There is expected to be negligible recharge of groundwater from the shale into the underlying Hawkesbury Sandstone and this is supported by:

- the horizontally layered shale geology with preferential horizontal discontinuous flow paths and very low vertical permeability;
- voids/cells excavated below the shale groundwater table will act as sinks (hydraulic trap) for the surrounding shale groundwater; and
- the groundwater quality analysis detailed below.

3.2.1 Groundwater Levels

Groundwater levels were measured at three locations at the site. Groundwater levels were measured in the NE and NW piezometers and abstraction bore. The piezometers measure the groundwater levels in the shale, whilst the abstraction bore measures the groundwater level predominantly in the underlying Hawkesbury Sandstone.

The groundwater level measured in the shale is about 4-5 m below the undisturbed land's surface, whereas the groundwater level in the underlying Hawkesbury Sandstone is at least 12-13 m lower than in the shale at 27.8 m AHD. It is expected that if the groundwater level were only measure in the Hawkesbury Sandstone, rather than both the lowest section of shale and Hawkesbury Sandstone it would be lower as there would not be a piezometric contribution from the shale.

The site generally slopes towards Blaxland Creek towards the north west.

Within the Bringelly Shale, the groundwater elevations are expected to follow the form of the topography and exist in the shale near the clay interface, and groundwater flow will be in a north westerly direction.

The site's undisturbed topography ranges between 35-57 m AHD. The groundwater elevations in the shale are therefore in the range of 30-53 m AHD with the lower point believed to be in the northwestern corner of the site, which is the site's topographic low.

3.2.2 Hydraulic Properties

The following presents an overview of results of the hydraulic testing undertaken at the NW and NE piezometers.

- The pumping test of the NW piezometer (pumped bore) suggests the groundwater in the shale (at this location) is confined, and has a boundary effect that was encountered after 70 minutes of pumping. Transmissivities calculated during this period range from 2.3 to 3.7 m^2/d (K_{ave} = 1.3 x 10^{-6} m/s). The drawdown response observed is characteristic of a fractured aquifer with little permeability outside of this zone.
- The pumping test of the NE piezometer (pumped bore) suggests the groundwater in the shale (at this location) is also confined. Rapid dewatering of this piezometer and slow recovery indicate very low transmissivity values of 0.02 to 0.09m^2/d (Kh = 7 x 10^{-9} m/s to 1.2 x 10^{-8} m/s).

It is noteworthy that the higher horizontal permeability measured in the NE piezometer does not extend across the site to the NW piezometer which confirms that the zones of higher permeability (in the fractures/carbonaceous lenses) are discontinuous.

The difference in results from the two piezometers indicates that the permeability of layers of relatively undisturbed shale is much less than the occasional discontinuous zones of fracturing or carbonaceous lenses that can be found within the shale on the site.

Vertical permeability is typically many times lower than horizontal permeability within laminar shale deposits such as those that occur on the site. There is up to 64 m of shale between the lowest point in Cell 1 and Hawkesbury Sandstone depicted in **Figure 2.2**. On the bases of low vertical permeability (expected to be less than 1 x 10^{-9} m/s) and the considerable thickness of shale beneath the emplacement cells it is expected that there will be minor hydraulic connection between the groundwater in the shale and the Hawkesbury Sandstone aquifer.

Furthermore, the groundwater around and beneath emplacement Cell 1 (and possibly Cells 2 and 3 if they are extended below the groundwater level) will seep towards the emplacement cells, as the leachate level has been designed to be maintained below the level of groundwater in the shale. This inward seepage of groundwater into the waste emplacement cells will resist leachate migrating outside the emplacement cells to prevent the pollution of groundwater off site. This concept is known as the 'hydraulic trap' principle. Further discussion of the hydraulic trap principle is provided in **Section 4.3.1.**

3.2.3 Groundwater Quality

The groundwater quality varied between the two piezometers in the shale, with Total Dissolved Solids (TDS) ranging from 8,930 mg/L in the NW piezometer to 13,000 mg/L in the NE piezometer. The high TDS encountered is reflective of connate (less mobile water) of long residence time and very low recharge. This variability in salinity is consistent with the groundwater contained in a low porosity rock matrix with occasional discontinuous fractured and carbonaceous lenses. The quality of connate water often reflects the origin of the rocks themselves, which for the Bringelly Shale was an estuarine environment.

The occurrence of localised fractures or thin carbonaceous lenses leads to heterogeneity in the shale, whereby some regions of the shale are more permeable (i.e. NW piezometer) than others. The higher salinity in the NE piezometer may be reflective of different rock mineralogy, and is likely reflective of the less permeable nature of the shales encountered and hence longer residence time for the groundwater in the NE piezometer area.

Leachate quality in comparison typically has salinity concentrations in the order of 11,000 mg/L (Jones-Lee and Lee, 1993).

The quality of the groundwater in the Hawkesbury Sandstone at the Site was measured in water extracted from the Site's abstraction bore. To interpret the results requires consideration of the abstraction bore's construction details.

The abstraction bore's log was sourced from DECCW database and is contained in **Appendix 1**. The log indicates that groundwater from the lowest 33 m of shale is able to enter the bore, together with groundwater from the Hawkesbury Sandstone for a depth of 118 m. Also worth noting is that the bore log provides the salinity of the water which is recorded between 3050 – 4360 and no units are provided. By referencing the data obtained (**Appendix 1**) it deduced that the units are either µS/cm or mg/L. At a worst case the upper concentration is 4360 mg/L as the generally applied conversion factor for µS/cm to mg/L is 0.67. The bore logs for the two nearest bores to the Site which also extend into the Hawkesbury Sandstone also record low salinity concentrations below 3,800 mg/L. The salinity of the Hawkesbury Sandstone groundwater measured in the Site's abstraction bore was 8,300 mg/L and is slightly lower than the salinity of groundwater in the overlying Site's shale. The reason for the elevated salinity can be attributed to the bore's log as water from the shale is entering the bore and this is the likely source of the high salinity. However, the salinity results recorded on the abstraction bore's log are much lower as described above and are approximately half the concentration.

The Site's abstraction bore was pumped for a period of time at 90L/min before the sample was collected. Had this bore been pumped for an extended period of time the salinity concentration in the groundwater is likely to have decreased in the range recorded on the DECCW bore logs as the water would have been sourced predominantly from the Hawkesbury Sandstone aquifer.

The DECCW salinity data provides evidence that the groundwater in the shale is not significantly recharging the underlying Hawkesbury Sandstone aquifer. If it was the case then the groundwater in the Hawkesbury Sandstone would have much higher salinity.

3.2.3.1 Major Ions

Groundwater samples collected from the two shale piezometers show dominance in chloride ions in respect to bicarbonate and calcium ions, which is indicative of old groundwaters, which are not readily recharged and/or are remote from recharge zones.

3.2.3.2 Dissolved Metals

Comparison of the analysis results for dissolved metals against the ANZECC guideline values for Freshwater Ecosystem Protection (ANZECC, 2000) shows a number of exceedances of the guideline values as follows:

- Aluminium was detected in the sample from NE piezometer at a concentration of 0.09 mg/L, which is above the freshwater ecosystem guideline of 0.055 mg/L (ANZECC, 2000)
- Zinc was detected in the NE, NW piezometers and abstraction bore at concentrations of 0.032 mg/L, 0.023 mg/L and 0.017 mg/L respectively, which exceeds the freshwater ecosystem guideline of 0.008 mg/L.
- Copper was detected in the NE, NW piezometers and abstraction bore at concentrations of 0.007 mg/L, 0.005 mg/L and 0.002 mg/L respectively, which exceeds the freshwater ecosystem value of 0.0014 mg/L.
- Cadmium concentration detected in NE piezometer was equal to the freshwater ecosystem guideline of 0.0002 mg/L.

Aluminium, zinc, copper and cadmium at these concentrations are believed to naturally occurring in the groundwater of Bringelly Shale and Hawkesbury Sandstone.

3.2.3.3 Nutrients

The ammonia concentration in NW piezometer (2.73 mg/L) and abstraction bore (1.02 mg/L) was above the freshwater ecosystem protection guidelines of 0.9 mg/L. This is typical for shale groundwater in the Sydney basin which has been found to have ammonia concentrations greater than 10 mg/L (Old, 1942).

Ammonia is an indicator of the presence of leachate in groundwater. However, in this case the ammonia is naturally present within the shales, and if it is again detected in the future its presence will need to be reviewed in light of the fact that it is naturally occurring in the site's groundwater.

Total nitrogen was detected in the NE and NW piezometers and the abstraction bore at concentrations of 0.7 mg/L, 3.1 mg/L and 1.5 mg/L, respectively. These are above the freshwater ecosystem protection guidelines of 0.35 mg/L (Total N). The source of the nitrogen is the shale geology (Old, 1942).

3.2.3.4 Pesticides and Hydrocarbons

No pesticides or polycyclic aromatic hydrocarbons were detected in groundwaters at the site.

Benzene, toluene, ethylbenzene and xylene (BTEX) are the simplest of the C6-C9 aromatic hydrocarbons. A recording of 200 µg/L of C6-C9 was detected in the NE piezometer. The sample was analysed further for BTEX and toluene was 105 µg/L and xylene was 10 µg/L. It is expected that the source of these was residual oil and grease on the drilling rods.

The ANZECC 2000 Water Quality Guidelines provide trigger values which indicate that water containing these substances at these concentrations may not impact on aquatic ecology and as these substances are in a low permeable groundwater environment they present negligible risk. Further testing of groundwater is expected to show that BTEX is not present as there would be no continued source of the compounds.

3.2.3.5 On-site Waste

The NW and NE piezometers are located hydraulically downgradient of the existing on site bunds which contain some general solid (non-putrescible) waste and some minor asbestos. These bunds are mostly comprised of VENM.

Based on an analysis of the groundwater data from these two piezometers there is no evidence that the groundwater has been contaminated by any leachate which may have been generated from the waste in the bunds.

3.2.4 Groundwater/Surface Water Interaction

The NW piezometer was located about 5 m from the southern bank of Blaxland Creek and is screened from above the Creek bed for a depth of 28 m down to 5 m AHD. Blaxland Creek is not considered to be in direct hydraulic connection with the groundwater measured in the NW piezometer. This conclusion has been arrived at based on the following evidence.

- The elevation of the top of the shale is approximately equal to the base of the creek and groundwater within the shale flows very slowly within the shale rock matrix.
- When the NW piezometer was installed, a minor inflow of groundwater (water cut) was identified between 21-23 m below ground level, well below the base of Blaxland Creek.
- Low aquifer hydraulic conductivities were measured in the NW piezometer.
- Groundwater sampled in the NW piezometer has TDS values well above the TDS of the Creek. Furthermore, as water was pumped out of the NW piezometer its TDS actually increased over time. This indicates that water entering the borehole was not sourced from the creek or the groundwater immediately around the creek bed. The Piper Diagram (**Appendix 1**), classifies waters according to their ionic nature, shows that there is some difference between the creek and the groundwater, with the creek showing a more recent, 'bicarbonate' type groundwater within its baseflow.

3.2.5 Groundwater Extraction

Groundwater will be extracted on occasion for operational use on site, with the main use being for dust control. GSS Environmental & BMT WBM (2009) have predicted that in Year 13 up to 26 ML of water would be required to be obtained from the Site's licensed groundwater abstraction bore (DWE licence number 10BL161098). The bore is licensed to abstract up to 32 ML/year of groundwater and therefore can readily meet the predicted demand.

The extraction of groundwater from the Hawkesbury Sandstone is expected to have negligible impact on the groundwater levels in the overlying Bringelly Shale.

3.3 Geotechnical Conditions

3.3.1 Site Clay

The results confirm that on-site clays can be readily compacted to achieve a permeability of less than 7.3×10^{-10} m/s. The DECC clay liner permeability requirement is 1×10^{-9} m/s, or less.

The on-site clays when recompacted will offer a much lower permeability than the DECC liner requirement. This means that they can be installed in a thinner layer and offer as good a hydraulic performance as the DECC liner.

Using Darcy's Law the on-site clays can be installed to a thickness of 37 cm and offer a superior hydraulic performance to the DECC benchmark technique clay liner. This assumes a head of 0.3 m and the remoulded clay achieves a permeability of no more than 7.3×10^{-10} m/s.

In the event the permeability of the on-site recompacted clays is greater than 7.3×10^{-10} m/s but less than 1×10^{-9} m/s, the thickness of the liner may be as great as 90 cm. In effect, the compacted clay used on site may vary in thickness from 40 cm to 90 cm. However in most circumstances during the placement and recompaction of the clay, adaptive controls would be applied (clay source selection, moisture content and compactive effort) to achieve a permeability of less than 7.3×10^{-10} m/s so that the liner's thickness can be set at 40 cm and still exceed the DECC liner hydraulic performance requirements.

4 CELL DESIGN

4.1 Important Site Data

The geological and hydrogeological studies provide important site data for optimising the design, operation and rehabilitation of the emplacement cells. Important site data to take into account with the design for the emplacement cells includes:

- Tight shale geology exists at the site which has discontinuities (fractures and carbonaceous lenses) of limited spatial extent.
- The groundwater level in the shale is expected to be between 30.8 – 52.5 m AHD, as monitoring data has shown it is about 4-5 m below the undisturbed land's surface.
- The site is underlain by low permeability clay/shale geology which will act as a natural barrier to prevent the off-site migration of pollutants and is an aquitard.
- Groundwater quality in the shale is highly saline. This demonstrates low subsurface recharge and flow rates which confirms that the site's geology has a very low permeability.
- There is no measured interconnection between groundwater in the shale beneath the site and Blaxland Creek.
- There is no significant connection between groundwater in the Hawkesbury Sandstone aquifer and groundwater in the shale aquitard.
- There is no evidence of waste in the existing on-site bunds (which are not lined, do not include a leachate collection and extraction system and have a thin soil cover) having caused any contamination of the groundwater at the downgradient end of the Site.
- On-site clays are able to be re-compacted to achieve very low permeabilities.
- A clay/shale resource exists on site which can be further extracted to create a larger void than what currently exists.

Other important factors that need to be taken into account in designing the emplacement cells are:

- Average annual rainfall measured at the nearest weather station is 802 mm and average annual evaporation is 1,807 mm and therefore evaporation far exceeds rainfall.
- The site will emplace on average 200,000 tpa of general solid (non-putrescible) waste and in some years, where a maximum of 600,000 tpa of waste is received, up to 450,000 tpa may be emplaced.
- The minimum design capacity (airspace) that is available to emplace waste on the Project Site (and its associated daily cover and capping) is approximately 4.4 million cubic metres (m^3) based upon the existing void space, the proposed final landform. Additional airspace would be created through ongoing extraction operations and the removal off site of clay and shale to an average elevation of 28 m AHD.

- Subject to the volume of clay and shale extracted and despatched from site, the maximum design capacity could be as much as approximately 7.8 million m^3 i.e. assuming extraction in Cells 1, 2 and 3 is undertaken to an average depth of 28 m AHD. A previous owner of the site has already extracted a portion of Cell 1 below 28 m AHD.

The conceptual design presented below takes into account the design capacity of either 4.4 million m^3 or up to 7.8 million m^3.

4.2 Design Guidance

4.2.1 Previous Study

Studies by P Dupen conclude waste emplacement in clay/shale quarries in Sydney in many cases represents an environmentally sound waste disposal practice for that portion of the waste stream that cannot be economically recovered or recycled. It bases this conclusion on the following:

- The shales around brick quarries in Sydney generally exhibit very low groundwater flows. Polluting leachates are likely to exfiltrate from emplacement cells very slowly.
- The shales around and under Sydney's brick quarries are likely to have very high capacities to attenuate pollutants.
- The groundwaters in the Wianamatta group, in which almost all brick quarries in Sydney are sited are notoriously saline and are low yielding. These groundwaters have never been beneficially used in the past and are unlikely to be exploited in the future.
- Modelled predictions of contaminant migration indicate that releases to the environment would be very limited.

Dupen modelled the release of leachate into groundwater from a hypothetical unlined landfill in a Sydney brick quarry using highly conservative assumptions. Dupen found that the maximum predicted concentration of the modelled contaminant is not expected to travel more than 10 m after 100 years.

4.2.2 DECC Guidelines

The DECCW environmental requirements for waste emplacement cells are detailed in its *Environmental Guidelines: Solid Waste Landfill* (EPA, 1996). This Guideline takes a performance based approach to emplacement cell design, construction, operation, monitoring and rehabilitation. It also offers a number of benchmark techniques which provide the design, operation and rehabilitation criteria for emplacement cells which operators can select and conform to the Guidelines.

Alternatives to the benchmark techniques are permitted provided it can be demonstrated that their performance is as good, or better than the equivalent benchmark technique. This is how the performance based approach is considered by DECCW.

Benchmark technique 1, titled 'leachate barrier system' includes the option for the application of the natural geology to meet the requirements for 'a suitable liner'. This is sensible as the natural geology in many cases is a superior barrier than any thin engineered liner. For example, tens of metres in situ low permeability Wianamatta Shale as exists at the Orchard Hills Site is a superior barrier to protect the underlying Hawkesbury Sandstone aquifer than would a 1.5 mm thick flexible membrane liner.

4.2.3 Director-General's Requirements

The Department of Planning issued on 20 May 2005 the Director-General Requirements (DGRs) which identifies matters to be addressed in the application for the proposed Facility. **Section 7** details the specific matters listed in the DGRs which are addressed by this report.

It is noted that in DECC's input into the DGRs provide a section titled, 'Specific Matters to Address for Waste Disposal Facilities'. Point 5 in this section acknowledges that a proponent may chose to demonstrate that the natural geology is sufficient to protect leachate (and gas) from polluting waters. This position is totally consistent with benchmark technique 1 in the Department's *Environmental Guidelines: Solid Waste Landfills*.

Furthermore, the option of utilising the natural geology as the barrier is also offered in the Department of Planning's *Landfilling EIS Guideline* (DUAP 1996).

However, DECCW advised the Department of Planning on 3 November 2009 and 19 January 2010 that, *inter alia*, it is reviewing its position regarding cell liners and stated that:

- *'the Environmental Assessment should include information for a proposed engineered wall and floor liner, regardless of the groundwater levels and/or hydrogeology of the site'*.

4.3 Design Approach

The above guidance and data has been taken into account to determine the optimal integrated design for the emplacement cells. Two of the main objectives of the design are to achieve the following specific environmental requirements:

- Leachate needs to be contained on site to ensure that groundwater and surface water is not polluted off site; and
- Gas would be contained within the Project Site such that it does not migrate off site through the subsurface. Furthermore, gas generated by the emplaced waste would be managed to ensure that it does not create offensive odour off site, and is subject to oxidation to reduce greenhouse gas emissions.

The site's hydrogeological circumstances, low rainfall/high evaporation and the opportunity to further extract clay and shale are the three main factors which dictate the optimal emplacement cell design for the site. The design needs to take into account the emplacement of waste both above and below the groundwater level.

The emplacement cells would be set-back at least 10 m from the site's perimeter in accordance with the findings of Dupen.

The Proponent has also made the decision to install an engineered liner around the emplaced waste to demonstrate its willingness to comply with the DECCW's revised position on the requirements for engineered liners.

4.3.1 Natural Geological Barrier and Hydraulic Trap

The horizontal hydraulic conductivity (permeability) of the site's shale has been found to be greater than the DECCW's permeability requirement for barriers. Due to this circumstance, the external side walls of all cells should be lined with an engineered liner.

However, the vertical hydraulic conductivity is expected to be at least equivalent to DECCW's permeability requirement and is probably 1-2 orders of magnitude lower. Vertical permeability is typically many times lower than horizontal permeability within laminar shale deposits such as those that occur on the site. This being the case, the use of an engineered liner would provide an additional safeguard in the event:

- groundwater inflow rates (for cells below the shale groundwater level) are greater than the modelled predictions; and/or
- of any localised zones of enhanced vertical permeability within the underlying shale.

Where waste is to be placed below the shale groundwater level, the design approach is also able to make use of the hydraulic trap principle. This is applicable for the emplacement cells excavated below the surrounding shale groundwater level. Provided the level of leachate is maintained below the surrounding groundwater level groundwater would continue to slowly seep into the emplacement cells to retard leachate migrating outside of them. This design and operational circumstance exceeds the engineered liner requirements as specified by DECCW.

The shale groundwater elevation ranges between about 31-38 m AHD along the northern end of the site and is expected to be as high as 52 m AHD in the south west corner of the site. The north-west portion of the site (within Cell 1) already has an area excavated to approximately 17 m AHD and is below the groundwater level. Cells 2 and 3 may be excavated to an average depth of 28 m AHD. At these depths, the floors of Cells 2 and 3 will be below the groundwater level.

Groundwater in the shale around Cell 1 (and possibly Cells 2 and 3 if they are excavated deep enough) will seep from the shale around the cells and into them due to a pressure head gradient created by keeping the leachate pressure head (level) in the cells lower than the surrounding shale pressure head (level). This hydraulic trap design approach has been successfully applied to several waste emplacement facilities and remediated contaminated sites in Sydney and elsewhere. For example, in NSW at the Blacktown Waste and Woodlawn waste emplacement facilities and the Pasminco contaminated soil containment cell.

The key to protecting the groundwater is controlling the head of leachate in the cells and this can clearly be achieved as demonstrated by the leachate modelling in **Appendix 2**.

4.4 Design Components

4.4.1 Emplacement Cell Dimensions

The geological and hydrogeological field studies demonstrate that the site is underlain by a low to very low permeable clay/shale geology. There is a significant clay/shale resource at the site available for making house bricks. Part of this resource has already been extracted, removed or is stockpiled at the site. To access the remaining resource it will need to be extracted from the site resulting in an excavated area at depth.

The dimensions of the proposed emplacement cells are depicted in the figures contained in **Appendix 5**, assuming the maximum design capacity.

The cell areas would not change should the design capacity be less than the maximum. In this case the base of the cells will be at higher elevations.

4.4.2 VENM Placement

Clay/shale materials recovered from on site or virgin excavated natural material (VENM) would be placed on the northern edges of Cells 1 and 2 and between the Final Cell and Cell 3 to enable the site to reach final contours. As VENM would be placed in these locations, it would not be underlain with an engineered liner nor a basal leachate drainage layer.

4.4.3 Barrier

At least 10 m of clay/shale would exist between the emplacement cells and the site's boundary. This natural clay/shale geology will act as the primary barrier to prevent the off-site migration of contaminants as it has a low permeability.

In addition to the natural barriers present, an engineered barrier will also be installed:

- around the outer perimeter walls of all cells up to the elevation of the land's natural surface. At the base of each cell, the liner will be keyed into the engineered barrier on the cell's floor. Where Cells 1, 2 and 3 adjoin the bunds which have been identified (Douglas Partners 2009) to likely contain construction and demolition waste, then the barrier will be extended up the side wall of the bund and be joined in with the capping layer to isolate the waste in the bunds from the emplaced waste; and
- on the entire floor of all cells in accordance with DECCW's current position on liners.

Section 3.3.1 demonstrates that the on-site clays are able to be re-compacted to achieve a permeability of less than 7.3×10^{-10} m/s and that provided it is placed to a thickness of at least 37 cm, it would offer an equivalent hydraulic performance as the DECCW's benchmark clay liner.

The engineered liner at the Site would comprise at least 40 cm of re-compacted clay with a permeability less than 7.3×10^{-10} m/s, or another design which is equivalent. For example, the outer perimeter walls of the cells may instead be lined with a 1.5 mm minimum thickness High Density Polyethylene (HDPE) geomembrane with the engineered re-compacted clay liner on the floor of the cells.

To complement the performance of the perimeter wall liner, a series of gravel chimneys will be installed against it at approximately 50 m intervals. The purpose of these chimneys is to relieve any leachate or gas pressure against the liner and funnel leachate and gas to the extraction points.

Where applicable, the hydraulic trap principle (see **Section 4.3.1**) will also be applied to contain leachate on site.

The walls of the cells would be very steeply sloped which naturally enables leachate to run down them, whereas leachate will pool on the floor of the cells if it is not extracted. It is possible that if a continuous permeable layer were installed around the perimeter walls of the emplacement cells that this would perform as effectively as the engineered liner. If this design option is selected in the future it would be supported by modelling to advise whether leachate or gas can be retained on-site. If the modelling results conclude that this outcome can be achieved by a continuous permeable drainage layer, an application with the supporting information will be made to DECCW seeking approval for its use, in-lieu of the perimeter wall liner.

4.4.3.1 Final Cell

The Final Cell is a shallow cell and it would have a base elevation of approx. 47 m AHD. At this elevation, its base is expected to be above the shale groundwater level.

All available geological data (RW Corkery & Co, 2004) was reviewed to establish a preliminary assessment on the depth of in-situ clay within this cell. Geological interpretations suggests the presence of ‘weathered clay rich material’ overlying the shale, at shallow depth (e.g. <6.5 m deep, 43-47.5 m AHD). Based on the limited number of holes drilled in this area, it appears that the in-situ clay in the southern end of the Final Cell may not extend below 47 m AHD **Figure 4.1**.

An engineered liner would be installed on its floor and walls as depicted in **Figures 3** and **4** (**Appendix 5**). The engineered liner would comprise at least 40 cm of re-compacted clay with a permeability less than 7.3×10^{-10} m/s, or another design which is equivalent.

The Recycling and Re-processing Area is within the footprint of the Final Cell and would be established and operating before the engineered liner is installed and waste emplacement activities commence in the Final Cell. The wood/garden waste stockpile in the Recycling and Re-processing Area would be at the northern end where the clay depth is substantial. Prior to placement of the wood/garden waste stockpile, the clays in this location would be tested to confirm that they have an *in situ* permeability of less than 10^{-7} m/s. This is to demonstrate compliance with DECC’s *Environmental Guidelines: Composting and Related Organics Processing Facilities* (2004).

4.4.3.2 Cells 1, 2 and 3

Cell 1 would be located within the area of an existing clay/shale extraction void which extends to approximately 17 m AHD. An engineered liner would be installed on the outer perimeter walls as depicted in **Figures 5** and **6** (**Appendix 5**) and keyed into the engineered liner to be installed on the cell’s floor. The level of leachate would be maintained below the level of the surrounding shale groundwater level to maintain a hydraulic trap (see **Section 4.3.1**).

Similarly to Cell 1, an engineered liner would be installed on the outer perimeter walls of Cells 2 and 3 and keyed into the engineered floor liner of each cell. The details on the engineered liner on the outer perimeter walls and floor of Cells 2 and 3 are depicted in the figures in **Appendix 5**.

These two cells are likely to extend to an average depth of 28 m AHD following the extraction and removal off-site of clay/shale to the brick making industry. In this case, the level of leachate would also be maintained below the level of the surrounding groundwater level to maintain a hydraulic trap (see **Section 4.3.1**).

Note that an engineered liner (or equivalent) will also be extended up the side walls of the bunds (which will be partially deconstructed) adjacent to Cells 1, 2 and 3 to isolate the construction and demolition waste identified in the bunds (Douglas Partners 2009) from the emplaced waste.

4.4.3.3 Liner Construction

Where the cells are excavated below the shale groundwater level, an assessment of the groundwater inflow seepage rate would be made prior to the placement of the engineered liner to confirm that it would not cause liner upheaval and/or interfere with its performance. In the unlikely event that groundwater inflow seepages could affect liner performance, the inflow area will be locally excavated and a flow reducing barrier (or equivalent works) would be installed, prior to the placement of the engineered liner.

Where extraction depths exceed 15 m, the outer perimeter walls would typically slope at 70 degrees. If the clay liner is installed (in lieu of an equivalent alternative) this would be done progressively with each lift of waste. The liner's installed thickness will be greater than 40 cm to enable the plant to be supported on it. However when waste is emplaced adjacent the liner, it will be trimmed to a thickness of not less than 40 cm.

Prior to the placement of waste against the liner, it will be moisture controlled to prevent it from being desiccated. For example, by spraying a fine mist of water on it, as needed, or it would be covered by plastic. Also before expected rainfall it would be covered by plastic to prevent it from being scoured by rainfall running off the cell walls.

Where a HDPE liner is to be installed on the outer perimeter walls, the design and construction details would be provided for approval by DECCW prior to installation.

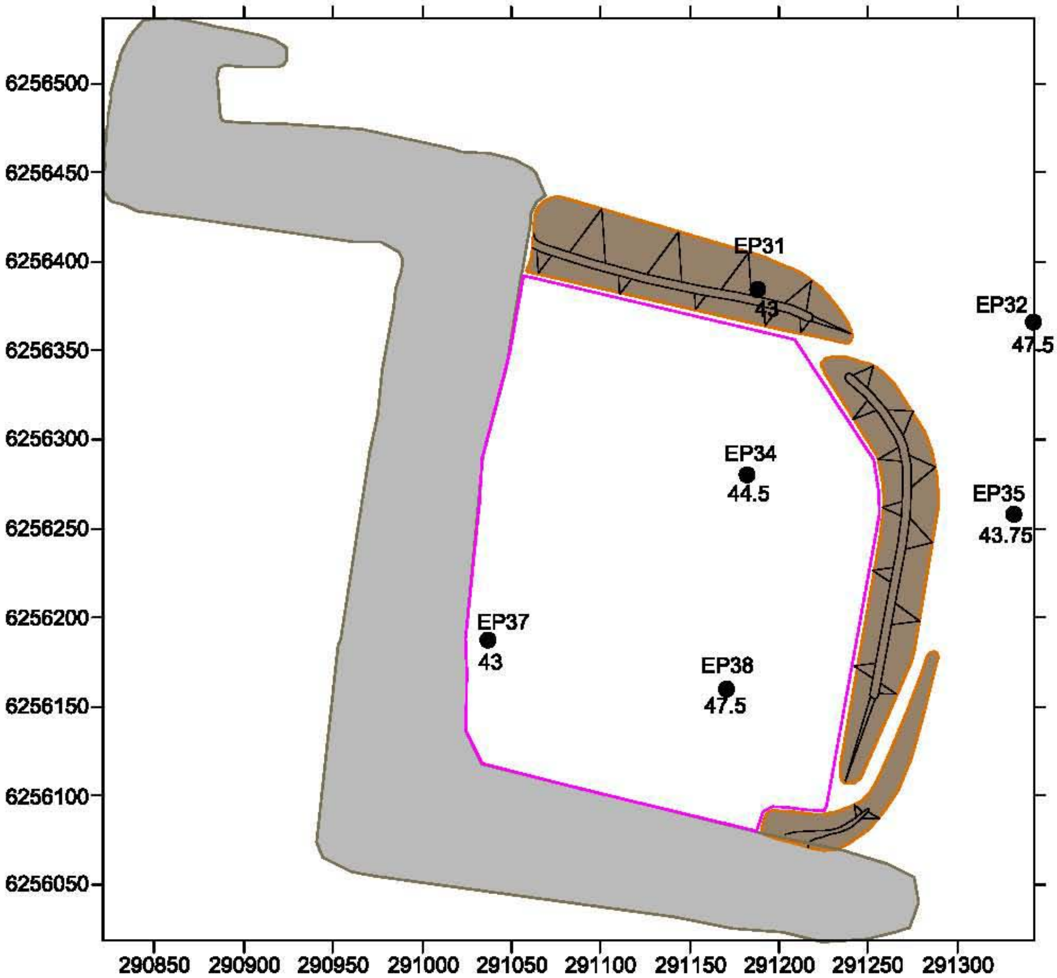
4.4.4 Leachate Generation, Collection, Extraction, Storage and Disposal.

Best practice leachate minimisation would be implemented at the Orchard Hills Facility.

The generation of leachate would be minimised by:

- Preventing stormwater running onto the active emplacement cell;
- Minimising the uncovered area of the daily emplacement cell;
- Minimising the area of the shaping/deconstruction of the existing site perimeter bund walls;
- Diverting stormwater away off areas of daily cover to the stormwater system; and
- Progressively rehabilitating the emplacement cells once they achieve the final elevations.

Figure 4.1 Elevation of Clay in the Final Cell (mAHD)



Summary of Drillhole information

Drill Hole	Easting	Northing	Surface Elevation (mAHD)	Elevation of base of clay (mAHD)
EP31	291188	6256384	48	43
EP32	291343	6256366	49.5	47.5
EP34	291182	6256280	51	44.5
EP35	291332	6256258	50	43.75
EP37	291037	6256187	48	43
EP38	291171	6256160	52.5	47.5

Date: 3 March 2010
Scale: As Shown
Initials: TL
Job No: S39
Drawing No: S39-003d
Rev: D
aquaterra

ORCHARD HILLS WRMF

ELEVATION OF CLAY IN THE FINAL CELL (mAHD)

Figure 4.1

Through the adoption of best practice leachate management, the leachate which is generated at the Site would be able to be appropriately managed on site controlling the risk of pollution of groundwater and/or surface water.

4.4.4.1 Leachate Generation

The sources of leachate from the emplacement of waste and associated activities are:

- Stormwater coming into contact with the emplaced waste before it is covered;
- Stormwater infiltrating through the daily cover, intermediate cover, temporary cap and final rehabilitated surface into the emplaced waste;
- Groundwater infiltrating into the emplaced waste;
- Stormwater falling directly on the leachate evaporation pond; and
- Stormwater coming into contact with waste when the bund walls are being shaped and deconstructed.

DECC in its requirements for the Environmental Assessment provides guidance on the water balance methodology for estimating leachate generation volumes. This methodology has been adopted, with some necessary variations.

Appendix 2 provides the details of the leachate generation modelling and provides the justification for necessary variations of some of the DECC's recommended assumptions. These variations reflect the specific design and operational circumstances for the Site and best practice leachate management.

Mathematically the model is:

Leachate storage = Leachate generation from rainfall infiltration into the emplaced waste + leachate generated from the bund wall shaping/deconstruction + groundwater inflow + rainfall into the leachate evaporation pond – absorptive capacity of the waste – evaporation from the leachate pond.

The model is a conservative estimate (i.e. overestimate) of leachate generation volumes for the following reasons:

- It is has considered eleven 90th percentile rainfall years occurring in a 30 year period. This is improbable as only three are statistically expected;
- All run-off from the exposed waste during the shaping or partial deconstruction of the bunds has been included as a contribution in the leachate model, however it is possible that a lot of this water will be clean and suitable for including in the stormwater system;
- It assumed approximately 0.5% greater rainfall infiltration through the daily cover than predicted by HELP for both the average and 90th percentile wet rainfall years; and
- It assumes more than 80 times greater rainfall infiltration than the HELP modelled quantity for the final cap and rehabilitated surface.

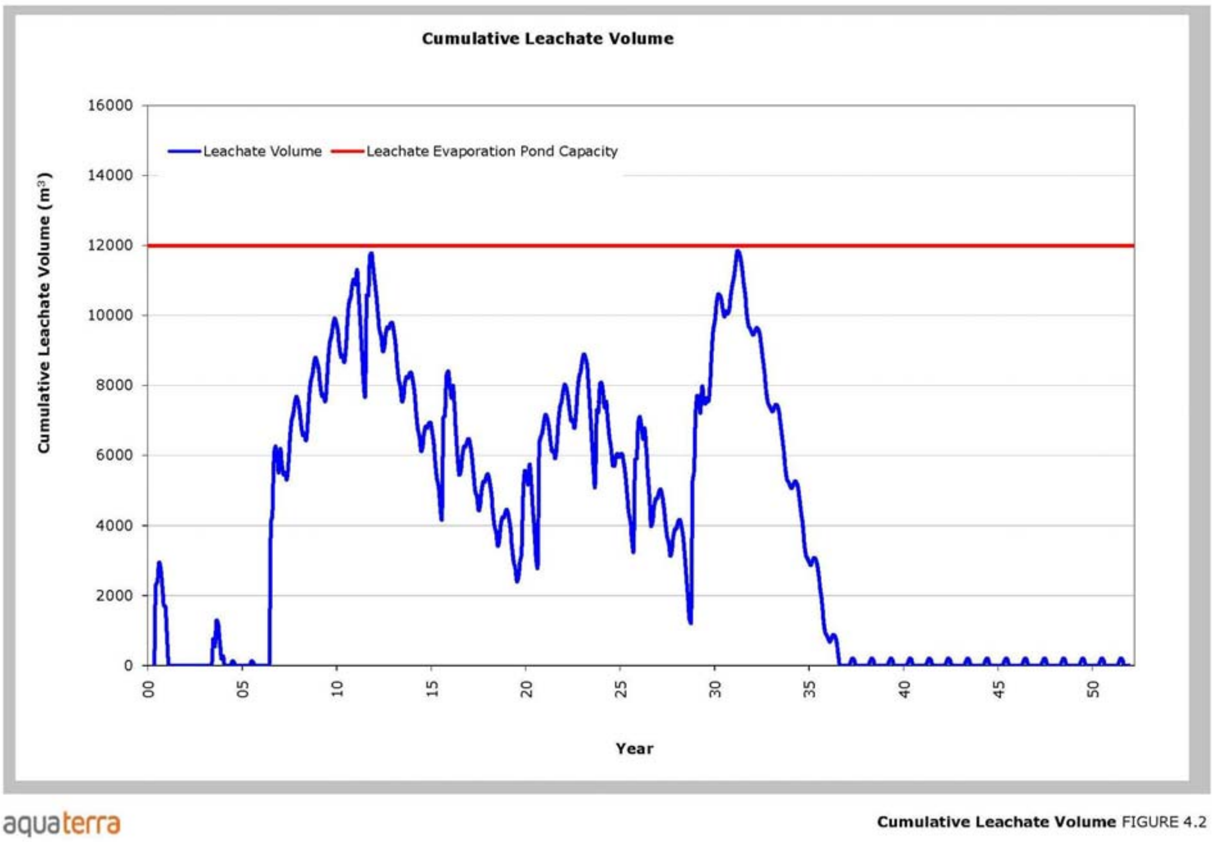
The results of the leachate prediction modelling are presented in **Figure 4.2**. The following can be deduced from this figure:

- The predicted maximum leachate storage requirement is just under 12 ML (plus a 0.5 m freeboard);
- At the end of 30 years when all the cells are capped and rehabilitated the leachate generation volumes are predicted to be relatively small (2.74 ML/year including groundwater inflow); and
- By the end of year 30 the evaporative loss from the leachate evaporation pond are greater than the volume of leachate which is generated, hence why the leachate storage volume trends to zero.

It is predicted that the leachate evaporation pond's capacity (12 ML plus a 0.5 m freeboard) would not be exceeded at any time during the operational and post closure period for the Site. Nevertheless monitoring data should be continuously gathered to measure the actual volumes of leachate generation versus the model predictions. As the modelling is believed to be a conservative estimate of leachate generation and disposal rates it is sensible to assess the site data. This would be done to continuously be able to demonstrate that the model predictions are a conservative estimate of leachate storage requirements.

It is important to note that there will be periods when leachate will need to be reinjected back into the waste when cells are operational to utilise the waste's ability to act as a sponge. See **Section 4.4.5** for further details.

Figure 4.2 Cumulative Leachate Volume



Occasional monitoring would be undertaken to confirm that the daily cover permeability (less than 2 x 10^{-8} m/s) can be maintained for up to 30 days, before intermediate cover or further waste would be applied over it. This is possible as demonstrated by the clay test results in **Section 2.5** and unconsolidated clays typically exhibit such permeabilities (Fetter 2001). The ripped and compacted site shales are also expected to be able to achieve this permeability.

The DECC's *Environmental Guidelines: Composting and Related Organics Processing Facilities* (2004) require the management of stormwater run-off from wood and garden waste stockpiles (pre and post processing), rather than discharged directly into the environment. Specifically the Guidelines state:

- The dam needs to be sized to contain leachate without overflowing for up to a 1:10 year ARI storm event of 24 hours duration.

The modelling detailed in **Appendix 2** concludes that the dam to contain this runoff would have a surface area of 2,000 m^2 and a depth of 0.95 m (which includes a 0.5m freeboard) to service a wood/garden waste stockpile area of 4,000 m^2.

This dam would initially be located in the area of Cell 3 and would be later relocated to the southeast section of the site. The specifications for both dams would be identical and at any point in time one of these dams would be available to contain the runoff from the wood/garden waste stockpile.

4.4.4.2 Leachate Collection, Extraction, Storage and Disposal

The purpose of the leachate drainage layer is to direct leachate to the riser from where it would be automatically extracted to control the head of leachate on the floor of each cell. This would ensure that Cells 1, 2 and 3 can be maintained as hydraulic traps (see **Section 4.3.1**).

The leachate drainage layer would be placed over the entire base of all of the emplacement cells as depicted in **Figure 2** (**Appendix 5**). Above the drainage layer, a separation geotextile would be placed to prevent fines entering and clogging the leachate drainage layer. The leachate drainage layer would be constructed to slope at 1% horizontally and 3% in the transverse direction.

The maximum height of material above the leachate drainage layer is 37 m. The expected density of waste is 1.2 tonnes/m^3 (including cover and capping material). This equates to a maximum pressure exerted on the leachate drainage layer of less than 450 kPa.

The basal leachate drainage layer would comprise one of the materials described in **Table 4.1**, or a material with equivalent hydraulic properties.

Table 4.1
Possible Basal Leachate Drainage Layers

Page 1 of 2

Material Description	Specification
Basalt Gravel	Transmissivity > 3x10^{-4} m^2/s, rounded (< 30% misshapen), < 10% passing the 10mm sieve, <3% passing the 0.075 mm sieve
Triplanar Geonet	Transmissivity greater than 4.05x10^{-4} m^2/s at 500 kPa (**Appendix 3**)

Table 4.1 (Cont'd)
Possible Basal Leachate Drainage Layers

Page 2 of 2

Material Description	Specification
Basalt Gravel with concrete	Transmissivity > $3x10^{-4}$ m^2/s, rounded (<30% misshapen), < 10% passing the 10mm sieve, <3% passing the 0.075 mm sieve, < 20% by mass concrete*, <0.5% foreign matter (anything other than concrete or gravel) – at 500 kPa
Geotextile**	Non-woven, mass > $270g/m^2$, O95 < 0.21mm, Grab Strength N > 900, Trapezoidal Tear N > 350, Puncture Strength N > 350, Burst Strength kPa > 1700

* From Holznolner 1995. **Design from Rowe et al.

Transmissivity is equal to permeability multiplied by the thickness of the drainage layer.

The leachate drainage layer would incorporate HDPE collection pipes spaced at 50m intervals selected to withstand the weight of the overlying waste without buckling (**Appendix 3**). The leachate drainage pipes would report to a riser from which leachate would be automatically extracted out of each cell once a pre-determined level is reached and pumped to the evaporation pond.

A portion of the floor of Cell 1 was excavated by the previous site's owner down to approximately 17 m AHD. The leachate drainage layer and horizontal leachate collection pipes would be included in the area which slopes from 28 m AHD down to 17 m AHD, but not the transverse leachate drainage pipes. The transverse leachate drainage pipes are not necessary as the slope is greater than 3%.

Leachate would be disposed of via evaporation from the evaporation pond.

The leachate evaporation pond (Initial and Long-Term) would each have a volume of 12 ML plus a 0.5 m freeboard and would be lined with 1.0 mm (nominal) HDPE on a rolled subgrade of clay free of protrusions. This composite liner would be installed with strict quality control and accordingly it would leak less than 1150 L/ha/day, as required by DECC (Giroud 1997).

The Initial Leachate Evaporation Pond would be placed in the area of Cell 3 and would be operated until Cell 3B is being constructed. At this point in time the Long-Term Leachate Evaporation Pond would be available to store and dispose of leachate. The surface area, capacity and liner for both the Initial and Long-Term Leachate Evaporation Ponds would be identical.

4.4.4.3 Automated Leachate Controls

The leachate riser in each cell would have a pump installed which would automatically extract leachate from the cell once the level of leachate around the riser reaches a pre-determined level. The level at which leachate would be automatically extracted would be:

- 0.3 m above the floor of each cell where the floor is above the surrounding groundwater level (Final, and possibly Cells 2 and 3); and
- 2 m below the groundwater level for Cell 1 (and possibly Cells 2 and 3), to ensure the inward flow of groundwater into these cells to maintain the hydraulic trap (see **Section 4.3.1**). In the case of Cells 2 and 3, this is applicable if they are excavated at least 2 metres below the level of the surrounding groundwater in the shale.

When the set leachate extraction level is exceeded, leachate would be automatically pumped to the evaporation pond, however, should the level of leachate in the evaporation pond reach the pond's freeboard then a signal would be sent back to the pumps preventing them from pumping leachate and thereby preventing leachate overflowing from the evaporation pond and entering the stormwater system.

A visual alarm would be installed at a prominent location and it would be triggered if the level of leachate in the riser in any cell exceeds the automated pumping level by about 0.1 m. The visual alarm would be configured to identify which cell has had its leachate level exceeded.

The pumps and level indicators installed in each riser will be selected to be intrinsically safe. This is to ensure that they are unable to trigger a fire as the gas in the risers will contain methane which at certain concentrations is explosive.

The pipeline from the risers to the leachate evaporation pond would also have pressure controls included to prevent leachate being pumped out of the cells if the transfer pipeline has ruptured, again to prevent leachate entering the stormwater system.

4.4.5 Leachate reinjection

The Project's Director-General's requirements recommend that the water absorptive capacity of the waste is 0.03 m^3/tonne. The average monthly waste emplacement rate is 16,667 tonnes which would have a 500 m^3 leachate absorptive capacity.

In some months, the rainfall infiltration rate into the emplaced waste is less than 500 m^3. During months when the absorptive capacity of the emplaced waste is not exceeded by infiltrating rainfall, leachate from the evaporation pond can be transferred across into these cells and injected. The waste then absorbs the leachate.

Leachate would be reinjected back into the waste by scraping back the daily cover and injecting small quantities of leachate into the emplaced waste and then reinstating the daily cover.

Leachate re-injection would be practiced if the proceeding month's rainfall results in less infiltration than 500 m^3. This is defined by the following algorithm (**Appendix 2**).

If there is leachate in the evaporation pond, consider the injection of leachate into the active cell if: the area (m^2) of daily cover for the previous month multiplied by 0.24 multiplied by the previous month's rainfall (m) equals less than 500 m^3.

4.4.6 Daily Cover

Daily cover will comprise 150 mm of VENM (ripped shale or clay). Before the emplacement of waste, daily cover will be scraped back and recovered for re-use.

The application of a waterproof biodegradable film may also be applied to the batters of the active emplacement face to conserve airspace. By only applying it to the batters the issue of having to seal the film sheets is not critical due to the near vertical slope providing almost total stormwater run-off.

Daily cover would be placed by the compactor with the finished surface completed with divots from the compactor's sheep foot blades. These divots can hold rainwater increasing infiltration, therefore increasing the potential for leachate generation. It is proposed to compact, grade and roll the surface of the daily cover at the end of each day's emplacement activities. This would minimise the generation of leachate.

Run-off from daily cover would be directed to the stormwater system (provided it has not come into contact with uncovered waste or leachate).

The uncovered daily emplacement area would be bunded when rainfall in likely or when leachate is being applied to it to ensure leachate does not enter the stormwater system. The uncovered daily emplacement area would also be either totally covered or reduced in size when rainfall in occurring.

During the Project's emplacement activities, the Proponent may seek from time to time approval from DECCW to use alternative daily covers.

4.4.6.1 Bund Wall Shaping and Deconstruction

Waste was illegally deposited on the site prior to the Proponent purchasing the property. The location of the perimeter bund walls is depicted in **Figure 4.3**. The composition of material in the bunds was investigated and reported by Douglas Partners (2009).

The plan of management for these bund walls is detailed in **Section 5** of this Report.

4.4.7 Emplacement Cell Capping and Rehabilitation

The design of the final cap and rehabilitated surface for all cells is depicted in **Figure 12** (**Appendix 5**). The role of the capping works is to:

- Minimise rainfall infiltration and hence minimise the generation of leachate;
- Create a stable landform;
- Enable vegetation to grow;
- Enable surface run-off from the vegetated surface to be released directly off-site, without entraining unacceptable concentrations of suspended solids; and
- Control and oxidise the emission of methane gas.

Figure 4.3
EXISTING SITE LAYOUT

The design of the final cap and rehabilitated surface above the emplacement cells has the following layers starting from the bottom to the surface.

- Gas collection layer at set intervals comprising selected C&D waste aggregates, overlaid with a geotextile;
- A seal-bearing layer of up to 100 mm of shale;
- A sealing layer of up to 0.3 m of clay with a permeability of less than 1x 10^{-8} m/s;
- A clay moisture regulating layer of up to 200 mm of shale; and
- A soil vegetation layer (also referred to as topsoil/subsoil layers) of at least 1000 mm, part of which may be manufactured from incoming waste. Also included in this layer would be a gas distribution layer which would comprise selected C&D waste aggregates and a perforated HDPE pipe.

The final cap and rehabilitated surface was subject to modelling using the US EPA's HELP model (**Appendix 2**). The model results conclude that there will be negligible rainfall infiltration through the cap which would generate leachate. However, a rainfall infiltration rate of 0.25% was assumed to model the leachate generation rates. The higher assumed infiltrated rate provides conservative predictions of the generated volumes of leachate.

Due to the site being progressively capped and rehabilitated, ongoing leachate monitoring of generation rates should be undertaken to confirm the modelled performance of the cap. In the unlikely event that a capped and rehabilitated area was generating more leachate than the modelled predictions, then the design of the cap for future cells would be amended, if necessary.

A research project underway in Australia is the Australian Alternative Capping and Assessment Program. This and other capping studies would be reviewed and may result in changes to the design of the capping works. Any changes to the design of the capping works would be agreed with DECCW, before the works are constructed.

4.4.8 Gas Generation, Collection and Oxidation

The Federal Government's planned Carbon Pollution Reduction Scheme, if made law, will put a price on the emission of methane from emplaced waste if the emission is above the trigger tonnage. At present, the trigger is flagged at 25,000 tonnes per annum of CO_{2-e} or 10,000 tonnes per annum CO_{2-e} for sites within a certain distance of other landfills.

Regardless of whether the scheme becomes law, gas emissions from the Orchard Hills Ancillary Waste Emplacement Facility will be collected and a large portion of the generated methane will be oxidised to reduce the site's greenhouse impact. The potential gas generation, collection and oxidation is discussed in the following sections.

4.4.8.1 Gas Generation

The Proponent would not receive or emplace any putrescibles waste on the Project Site. However, the Proponent recognises it is likely that a very small component of the emplaced waste will contain biodegradable material and accordingly small quantities of gas (methane) will be generated by the anaerobic decomposition of the waste after it is emplaced.

One of the Project's aims is to achieve the State's waste reduction targets. A significant proportion of the incoming wood and garden waste (and other biodegradable waste) will be processed and removed off site for re-use and recycling and possibly used to generate energy.

The rate of generation of methane from the emplaced waste has been predicted using one of the Federal Government's calculation methodologies (Technical Guidelines 2009). Method 1 was utilised as it does not require any field data and is the only option available as waste is yet to be emplaced at the Facility. Method 1 is believed to overestimate methane emissions from emplaced waste from general solid (non-putrescible) waste emplacement facilities (Hudson and Cook 2009) such as the Orchard Hills Ancillary Waste Emplacement Facility.

In the future when the Facility commences operations, methane emissions would be re-calculated using one of the other available methods which rely on actual emission measurements. It is the Proponent's preference to review the re-calculated emissions to establish the feasibility of collecting the gas generated (see Section 4.4.8.2).

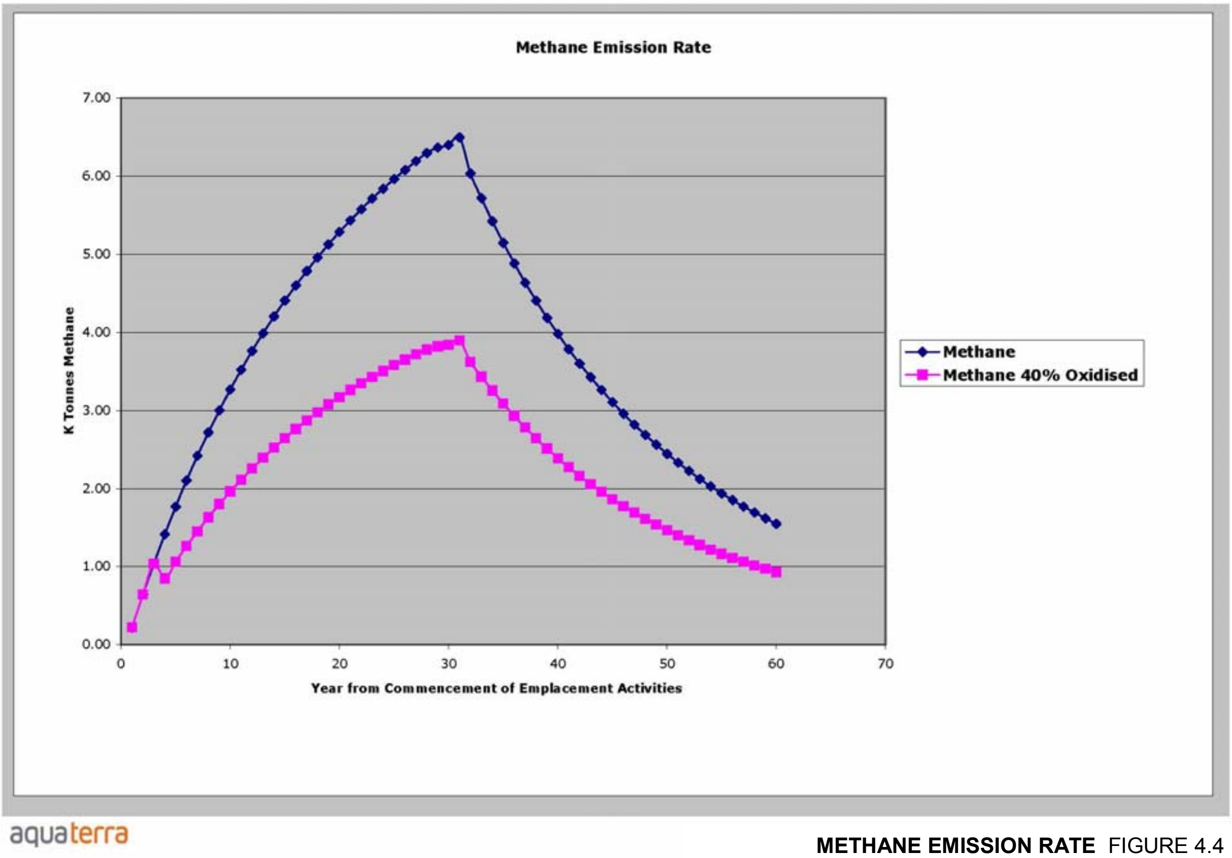
General solid (non-putrescible) waste comprises commercial & industrial (C&I) and construction & demolition waste (C&D). The C&I waste stream can contain putrescible waste, however only that portion of the C&I waste stream that did not contain food waste would be received and emplaced at the Facility. In accordance with Method 1, the waste composition for the C&I waste stream was adjusted to account for the fact that no food waste would be received or emplaced at the Facility and the adjusted compositions for this waste stream are listed in **Table 4.2**. The C&D waste composition data does not contain putrescibles waste and accordingly the default compositions were applied.

Table 4.2
C&I Waste Composition

	C&I %	C&I Adjusted for Non-Putrescible
Food	21.5	0.0
Paper	15.5	19.7
Garden	4.0	5.1
Wood	12.5	15.9
Textiles	4.0	5.1
Sludge	1.5	1.9
Nappies	0.0	0.0
Rubber	3.5	4.5
Inert	37.5	47.8

The model was run assuming an annual waste emplacement rate of 200,000 tonnes of General Solid (non-putrescible) Waste for 30 years and a post closure period of another 30 years. The data is contained in **Appendix 4**.

It can be seen from **Figure 4.4** that methane generation peaks in Year 31 at 6.5 kt and thereafter emission rates quickly decline as no more waste is emplaced.



METHANE EMISSION RATE FIGURE 4.4

4.4.8.2 Gas Collection

The purpose of the gas collection layer is to ensure that gas that is in sufficient quantities to collect can be collected in a controlled manner from the emplaced waste, post capping and rehabilitation. Cells would be progressively capped and rehabilitated throughout the operation of the Facility.

If a gas collection system is required, it would typically comprise the following:

- Gravel chimneys at regular intervals placed around the perimeter walls of the cells;
- Gravel strips at regular intervals beneath the seal bearing layer of the cap for each cell; and
- A series of pipes within the gravel layers which will exit the cap and transfer the gas out of the emplaced cells for management.

The gravel may be derived from construction and demolition waste with 95% by weight greater than the 40 mm sieve and less than 5% passing the 0.5 mm sieve to ensure a suitably high permeability of the gravel (*Passive Drainage and Biofiltration of Landfill Gas Using Recycled Materials, DEC 2006*). The gravel will be covered with a non-woven geotextile to prevent the intrusion of fines which could otherwise clog the gravel.

The conceptual design details for the gas collection system are depicted in **Figure 12** (**Appendix 5**). The application for the Environment Protection Authority will include the details for the gas collection system.

4.4.8.3 Gas Oxidation

Studies have demonstrated that methane generated from emplaced waste can be effectively oxidised by naturally occurring bacteria in soils *(Passive Drainage and Biofiltration of Landfill Gas Using Recycled Materials, DEC 2006*). Based on this study the methane oxidation efficiency has been correlated to methane loading rates in soils. A methane loading rate of 10 g $CH_4/m^2/hr$ is expected to achieve an oxidation efficiency of approximately 40%.

At a 40% oxidation rate the peak methane emission would be reduced by 2,600 tonnes in year 31 (**Figure 4.4**). That is, the emission rate of methane in year 31 is 3.9 kt (6.5 kt minus 2.6 kt) and as detailed in **Section 4.4.8.1** is likely to be an overestimate of the emission of methane from the Site.

Post capping and vegetation of Cells 1A, 1B, 1C, 2A, 2B, 3A, 3B, 3C and the Final Cell, gas would be passively extracted from beneath the cap's seal-bearing layer and directed into the gas distribution layer within the vegetation layer (or sometimes referred to as the topsoil/subsoil layers) and is depicted in **Figure 12** (**Appendix 5**). The methane component of the gas would then be subject to oxidation by naturally occurring bacteria in the vegetation layer converting it to carbon dioxide and thereby reducing the site's greenhouse impact. The oxidised methane is proposed not to be counted as a greenhouse gas emission by the Federal Government as the source of carbon is not from fossil hydrocarbons.

The gas distribution layer within the vegetation layer of the final cap and rehabilitated surface will cover an area of at least 4,700 m^2. This area is smaller than the area suggested to achieve 40% methane oxidation, however it has been selected as methane emissions are expected to be significantly less than predicted by Method 1 (Hudson and Cook 2009).

Monitoring of surface emissions of methane above the final cap and revegetated surface will be undertaken in accordance with benchmark technique 17 of the DECC's *Environmental Guidelines: Solid Waste Landfills*. In the unlikely circumstances where surface methane concentrations exceed 500 ppm, the following action will be taken:

- Methane extracted from the emplaced waste would be throttled into the gas distribution layer in order to optimise the rate of methane oxidation by the bacteria in the vegetation layer and the remaining portion of the gas may be directed to a flaring system and oxidised, or
- The area of the gas distribution layer will be increased to enable a greater mass of methane to be oxidised by the bacteria in the vegetation layer. This is readily possible as the cells will be progressively capped and rehabilitated. The area of the gas distribution layer can be increased and installed at the same time as capping and rehabilitating the future cells.

The conceptual design details for the gas oxidation system are depicted in **Figure 12** (**Appendix 5**).

4.4.9 Construction Quality Assurance

A construction quality assurance plan (CQAP) would be provided with the relevant application(s) for an Environment Protection Licence for the emplacement cells. The CQAP would contain the following information:

- Drawings for construction for Cell 1A and associated infrastructure. The drawings for construction for Cells 1B, 1C, 2A, 2B, 3A, 3B and the Final Cell would be provided progressively to DECCW in advance of works commencing in these cells; and
- A construction quality assurance testing programme to be implemented which would provide evidence that the cells and associated infrastructure were constructed in accordance with their design specifications. A draft construction quality assurance testing programme is contained in **Table 4.3**.

Table 4.3
Draft Construction Quality Assurance Testing Programme

Cell Component	Test	Minimum Frequency	Method
Cell Floor and Perimeter Walls	Confirm inflow groundwater seepage would not impact on liner performance	Floor and Walls of Cells 1, 2,3 and Final Cell	Visual
Clay liner and cap sealing layer^	Compaction and Moisture Content	Every 1000 m^3 placed	0%-3% (wet) of standard optimum moisture content and minimum dry density ratio of at least 95% (AS 1289.5.8.1).
Daily Cover	Permeability (if required)	1 test for every bench	AS1289.6.7.3 (undisturbed)
Leachate and gas drainage layers*	Particle size distribution	1 per 2500 tonnes and at least 1 per source and per cell	AS 1289.3.6.1 or AS 1141.11
	Permeability	1 per 2500 tonnes and at least 1 per source and per cell	AS 1289.6.7.1
HDPE liner	Seam pressure test and visual	All seams and whole surface	In accordance with manufacturers recommendation

^ Testing to be confirmed taking into account AS3798-2007. * If required

Note: In-situ clay permeability testing for the wood/garden waste stockpile area would also be undertaken (2 tests using AS1289.6.7.3 (undisturbed)).

The following information will also be documented and recorded after each cell is constructed:

- As constructed drawings prepared from field surveys which detail:
  - A plan view of the perimeter of each cell and its finished surface contours of the cell's floor;
  - A plan view of perimeter of each cell and the surface contours of the upper surface of the engineered liner, before placement of the leachate drainage layer;

  - A plan view of perimeter of each cell and the surface contours of the installed geotextile covering the leachate drainage layer (for all Cells);
  - The installed alignments and grades of the leachate collection pipes and the installed leachate risers in all cells;
  - Cross sections of the basal features of each cell and the level in the riser which will trigger leachate extraction and trigger the alarm system in the event that the level of leachate within the cell rises to a level more than 0.1 m above the leachate extraction level, or less than 2 m below the surrounding groundwater level.
- Tests to confirm that the leachate and gravel drainage layers met the design specifications; and
- A letter for each cell and its associated infrastructure from a suitably qualified person that advises whether the works were constructed in accordance with their design specifications.

4.4.10 Concept Design Drawings

The concept design drawings for the ancillary waste emplacement cells are contained in **Appendix 5**.

5 OUTLINE ENVIRONMENTAL MANAGEMENT PLAN

5.1 General

This section documents an outline Environmental Management Plan (EMP) for the operation and closure of the emplacement cells and the waste and VENM contained in the bunds around the perimeter of the site. An EMP would be prepared to accompany the initial application of an Environment Protection Licence. The document would be progressively modified throughout the life of the project as further cells are developed and prior to the commencement of approved activities.

5.2 Classification of Emplaced Waste and Design Capacity

Waste classified as general solid (non-putrescible) received from off site would be emplaced. A small quantity of special waste (asbestos) has been identified in one location within the eastern bund wall. The asbestos waste would be emplaced on site in accordance with the requirements of the Protection of the Environment Operations (Waste) Regulation 2005.

The minimum design capacity (airspace) that is available to emplace waste on the Project Site (and its associated daily cover and capping) is approximately 4.4 million cubic metres (m^3) based upon the existing void space and the proposed final landform. Additional airspace would be created through ongoing extraction of on-site clay and shale and its sale and removal off-site.

Subject to the volume of clay and shale extracted and despatched from site, the maximum design capacity could be as much as approximately 7.8 million m^3 i.e. assuming extraction in Cells 1, 2 and 3 is undertaken to an average depth of 28 m AHD. Based upon approximately 50% (average 150,000 tpa) of received material being suitable for re-processing and recycling, of which approximately 35% (50,000 tpa) would constitute residual waste, approximately 200,000 tpa of material on average would be emplaced each year. However, in some years, when waste receipts approach 600 000 tpa, principally due to large quantities of material that cannot be reprocessed or recycled (eg. low level contaminated soil) are received, emplaced tonnages may increase up to 450,000 tpa.

Waste and VENM was placed in bunds around the perimeter of the site by others, prior to the Proponent purchasing the site. The expected quantities and waste types have been investigated by Douglas Partners (2009).

Waste Receipts and Placement

The site would not be open for waste receipts from the general public thereby providing considerable control over waste received and emplaced.

Waste received from off site would be screened at the weighbridge as a first check to ensure that it meets the classification of general solid (non-putrescible). Some loads would be directed to the recycling and re-processing plant for the recovery of materials where a second stage of screening would take place. All other waste received at the site, after initial screening at the weighbridge, would be directed to the active emplacement cell and subjected to secondary screening as it is deposited/unloaded from the vehicle.

Any vehicle entering the site which contains waste which does not meet the classification of general solid waste (non-putrescible) would be directed back off site. In the event that waste not meeting the classification of general solid waste (non-putrescible) is deposited on site and the vehicle has departed the site, the waste would be collected and stored in a covered skip bin until it can be taken off site to a facility which can lawfully receive it. This would be acted on as a priority.

The emplacement and progressive cell rehabilitation is outlined in **Table 5.1**.

Table 5.1
Emplacement and Cell Rehabilitation Staging

Year#	Activity*
Yr 1	Cell 1A prepared to receive waste and filling to commence. Deconstruction of the section of the Eastern Bund located over the clay/shale extraction area within Cell 2 would be commenced and all wastes placed in Cell 1A.
Yr5	Cell 1B has been constructed and is available to commence waste emplacement and about the same time Cell 1A would have been capped and rehabilitated.
Yr 8	Cell 1C has been constructed and is available to commence waste emplacement and about the same time Cell 1B would have been capped and rehabilitated.
Yr 13	Cell 2A has been constructed and is available to commence waste emplacement and about the same time Cell 1C would have been capped and rehabilitated
Yr 17	Cell 2B has been constructed and is available to commence waste emplacement and about the same time Cell 2A would have been capped and rehabilitated
Yr 22	Cell 3A has been constructed and is available to commence waste emplacement and about the same time Cell 2B would have been capped and rehabilitated
Yr 25	Cell 3B has been constructed and is available to commence waste emplacement and about the same time Cell 3A would have been capped and rehabilitated
Yr 27	Cell 3C has been constructed and is available to commence waste emplacement and about the same time Cell 3B would have been capped and rehabilitated
Yr 30	The Final Cell would be filled to finished levels, capped and rehabilitated.

Indicative Only

* Assumes and average waste emplacement rate of 200,000 tpa

5.3 Bund Wall Shaping/Deconstruction

5.3.1 Classification and Timetable

A substantial quantity of clay and shale from the area now referred to as Cell 1 and a quantity of imported waste was illegally deposited in bund walls around parts of the perimeter of the site prior to the Proponent purchasing the property. The location of the bund walls is depicted in **Figure 4.3**. The composition of material and quantities in the bunds was investigated and reported by Douglas Partners (2009).

The imported waste component was found by Douglas Partners to be classified as VENM or general solid waste (non-putrescible), with asbestos waste (special waste) identified in a small section at one location. The waste is typically originating from the building construction and demolition industry.

The bund walls adjacent to Cells 1A, 1B, 2A, 2B, 3A and between Cell 1C and the Final Cell will be shaped and incorporated into the final landform. These are depicted on **Figure 2** (**Appendix 5**) and they would be shaped to ensure that they are stable and achieve the final landform contours. The bund walls adjacent to all other cells will be partially deconstructed with the VENM and a substantial proportion of the construction and demolition waste left in situ and its outer surface covered with clay (where appropriate) and shaped to blend with the final landform.

The sequence for shaping and partial deconstruction the on-site perimeter bunds relative to the emplacement cell preparation and rehabilitation is outlined in **Table 5.2**.

Table 5.2
Bund Shaping and Partial Deconstruction Sequence

Cell	Bund
Recycling & Reprocessing Area	Eastern
1A	Northwestern
1B	Northwestern
1C	Southwestern
2A	Northeastern
2B	Northeastern & Eastern
3A	Eastern
3B	-
3C	-
Final	Southwestern & Southern

5.3.2 Screening

Waste materials to be recovered during shaping/partially deconstructing the on-site bund walls would be screened during deconstruction to confirm that it meets the classification of general solid waste (non-putrescible). At that stage, all waste to be removed would be assessed to establish whether it can be recycled or re-processed on site. In the event the waste cannot be recycled or re-processed on site, it would be transported to the active waste emplacement cell for emplacement.

5.3.3 Management of Waste Containing Asbestos

A fine misting spray of water would be applied over the area of the bund wall, where wastes are being removed as a safeguard to prevent the airborne emission of any asbestos fibres, should they be present.

Any asbestos waste (special waste) identified when the bunds are shaped or partially deconstructed will be wetted down and transported in a covered and leak proof vehicle to the active waste emplacement cell. It will then be disposed of in a manner to prevent the generation of dust. It will be placed at the toe of the active cell's batter and covered initially with 0.15 m and by at least 0.5 m of waste or cover at the end of the day. By disposing of the asbestos at the toe of the active cell's batter, asbestos will not be exposed when the daily cover is scraped back from the top of the emplacement bench in the future.

Clause 42 of the Protection of the Environment (Waste) Regulation 2005 stipulates the depth of final cover above emplaced asbestos waste. Douglas Partners (2009) identified small concentrations of asbestos in a bonded matrix and the soil within some areas of the bunds. The bunds which will not be fully deconstructed and contain materials with low concentrations of asbestos will have a final capping and rehabilitation layer placed over them with a depth greater than 1 m. This would ensure compliance with Clause 42.

Any waste identified in the bund walls not meeting the classification of General solid waste (non-putrescible) would be managed in accordance with the requirements of the *Protection of the Environment Operations Act 1997* and removed off site to a facility which can lawfully receive it.

5.3.4 Management of Leachate (from the Bunds)

The three stages in the lifecycle of the bunds around the perimeter of the site have been considered in terms of the management of leachate. The aim is to ensure than any leachate generated by the material in the bunds does not pollute waters. The three stages are:

- Preshaping / pre-deconstruction;
- During shaping and deconstruction; and
- Post shaping / post deconstruction.

5.3.4.1 Preshaping or Pre-deconstruction

The bunds around the perimeter of the site have been in existence for a number of years. The bunds on the northern and western side of Cell 1 have been in place for over 25 years (and contain no asbestos material). The remaining bunds have been in place for about 4 to 6 years. In April 2009 Douglas Partners drilled 20 bores through the bunds. The bunds are located on the natural ground level which is clay and Douglas Partners noted '*free groundwater was not encountered in any of the bores during drilling'*. Also visual inspections of the bunds failed to identify any seeps from the batters of the bunds.

This means that there has been very little rainfall infiltration through the bunds, otherwise leachate would likely have been encountered. This further suggests that the waste located in the bunds presents a very low risk of leachate being generated and seeping into the underlying groundwater. Should any leachate be generated from the materials within the bunds, there is about 4 m – 8 m of natural clay beneath them which provides a natural barrier to the groundwater in the shale.

If any leachate did seep into the underlying groundwater in the shale, the hydrogeological evidence is that the pollutants would be unable to migrate any significant distance. This view is confirmed by the fact that no evidence of leachate contamination could be found in the two piezometers which are downgradient of the bunds.

Furthermore, groundwater in the shale will generally migrate towards the leachate drainage layers in the Cell 1 (and possibly Cells 2 and 3) which are below the groundwater level, and any pollutants would likely be retained on-site.

Nevertheless, erring on the side of caution, the existing groundwater monitoring piezometer network will be expanded as depicted on the figure in **Appendix 1** (**Annexure 5**). Monitoring of the groundwater in these piezometers will provide continued assessment to confirm the bunds (and emplaced waste) continue not to pollute groundwater.

5.3.4.2 During Shaping or Partial Deconstruction

It is possible during the bund shaping or partial deconstruction that rainfall coming into contact with the exposed waste could contaminate stormwater at concentrations above the ANZECC 2000 95th percentile values for fresh water. Should this be the case, this water would be managed in the same manner as leachate.

During the bund shaping or partial deconstruction process, the exposed waste would be bunded to contain the run-off water from rainfall. All earthworks on those bunds containing waste materials would be undertaken such that the upper surface of the bund slopes inwards at all times to allow any runoff to flow onto the site for management. At any point in time, no more than 5,000 m^2 of waste (other than VENM) will be exposed during the bund shaping/partial deconstruction process.

Erring on the side of caution all of the rainfall coming into contact with the exposed surfaces during the shaping or deconstruction of the bunds has been considered as a contributing source of leachate in the leachate model. This means that the all of the run-off water would be able to be managed as leachate, if necessary.

In practice, it is expected that a significant quantity of run-off from any exposed bund will be of a suitable quality to be released to the stormwater system. Where the exposed waste is clearly only VENM then the run-off from shaping/deconstructing the bunds will be directed to the stormwater system. However, where the exposed waste is another waste type (eg general solid non-putrescible) the stormwater will be subject to testing and if it meets the ANZECC 2000 95th percentile limits it will be introduced into the site's stormwater system.

If the stormwater run-off data for at least six sample events for the bunds which Douglas Partners concluded contained general solid (non-putrescible) waste is found to have concentrations of contaminants below the ANZECC 2000 95th percentile limits, approval will be sought from DECCW to manage all future run-off water in the stormwater system.

5.3.4.3 Post Shaping or Post Partial Deconstruction

The bunds that would be partially deconstructed would be shaped, capped and rehabilitated to form the final land surface. Modelling of leachate generation rates through this final land surface concludes that no more than 0.003% of rainfall will become leachate. This is a very small infiltration rate and is equivalent to generating 0.92 L/ha/Day of leachate for the 90th wet year (1990).

According to Darcy's Law the rate of leakage of leachate through the DECCW's benchmark clay liner is less than 1,152 L/ha/Day with a head of leachate of 0.3 metres. Therefore the volume of any leachate leaking from the bunds into the clays underlying the bunds would be significantly less than that from a DECCW accepted clay liner.

The safeguards described above for the preshaping or predeconstruction phase of the bunds would apply even when the bunds are capped and rehabilitated. Therefore the retained bunds present a very low risk of generating leachate which could pollute off-site groundwater.

5.4 Leachate Management

Leachate management is discussed in **Sections 4.4.4** and **5.3.4**.

- Leachate modelling (Appendix 2) concluded that at no time will the Site's leachate storage capacity (12 ML plus a 0.5 m freeboard) be exceeded. This modelling is very conservative and monitoring should be undertaken of the actual leachate generation, storage and disposal volumes to demonstrate that the Site would always have sufficient leachate storage and evaporative disposal capacity.
- It is possible that the monitoring of leachate generation volumes concludes that lower rainfall infiltration rates are occurring for daily cover than what was modelled. In this event the Proponent will vary its daily cover practices (eg by not compacting, grading, rolling cover), in consultation with DECCW.

5.5 Amenity Controls for Odour, Dust, Litter and Tracking of Mud

A number of controls and management approaches would be put in place to prevent the Facility impacting on local amenity. These controls and management approaches are outlined below.

5.5.1 Odour

General solid (putrescible) waste would not be received at the Facility and as such the odour potential from the activities on site would be low.

To minimise odour emissions from the premises and to ensure that no offensive odour is emitted beyond the Site boundary, the following controls would need to be adopted:

- Operating a small active tipping face to minimise the area of uncovered waste in the emplacement area;

- Covering all waste at the end of each day's emplacement activities in accordance with DECCW requirements;
- Collecting and oxidising gas from the rehabilitated cells;
- Controlling the pH of the leachate that is evaporated to minimise its odour, if necessary;
- Managing stockpiles to ensure that anaerobic conditions don't develop in the stockpiled wood waste;
- Airtight fittings to be included on the surface of the leachate risers; and
- Operating an aerator on the leachate evaporation pond.

5.5.2 Dust

Dust emissions would be minimised by:

- Sealing of Patons Lane;
- The progressive rehabilitation of the emplacement cells;
- Regular watering of exposed surfaces and highly trafficked areas (with the on-site water truck);
- A fine misting spray of water applied to the areas of the perimeter bund walls which are being shaped or deconstructed; and
- The suspension of clay/shale extraction and dispatching of clay/shale products on days predicted and/or observed to experience high temperatures and wind speeds.

5.5.3 Litter

Litter would be controlled at the Facility by regular clean-up campaigns during windy conditions and through the application of mobile litter fences, trash racks on stormwater flow lines and the collection of all litter on a regular basis.

5.5.4 Tracking of Mud

A vehicle wheel wash would be installed at the Facility. All heavy vehicles departing the site will be directed through the wheel wash to have their wheels cleaned, if necessary.

Patons Lane will be sealed which will further limit the tracking of mud from Patons Lane onto Luddenham Road.

5.6 Fire Management

The most effective way of preventing fire is by the application of daily cover.

Other fire prevention measures include:

- Controlling the entry to the Facility;
- Maintaining a perimeter access track around the Facility.

Staff will be trained in basic fire fighting procedures. In the event of a fire on-site which is unable to be readily extinguished by site staff, the NSW Fire Brigade will be contacted to extinguish the fire.

5.7 Monitoring – Groundwater, Surface Water and Gas

Monitoring of groundwater, surface water and surface and subsurface gas should be undertaken at the Facility.

A monitoring quality control plan will be prepared and submitted with each application for an Environment Protection Licence.

All monitoring of waters should be undertaken in accordance with DECCW's *Approved Methods for Sampling and Analysis of Water Pollutants in NSW* (March 2004).

5.7.1 Groundwater

Groundwater monitoring should be undertaken at the existing and proposed piezometers depicted in the figure in **Appendix 1** (**Annexure 5**). The parameters and frequency of monitoring are detailed in **Table 5.3**.

The results of the groundwater monitoring programme should be reviewed annually to ensure only meaningful data is being collected.

Table 5.3
Parameters and Frequency of Groundwater Monitoring

Page 1 of 2

Parameter	Frequency
Total dissolved solids	Quarterly
pH	Quarterly
Standing water level	Quarterly
Nitrogen – Ammonia	Quarterly
Calcium	Quarterly
Magnesium	Quarterly
Potassium	Quarterly

Table 5.3 (Cont'd)
Parameters and Frequency of Groundwater Monitoring

Page 2 of 2

Parameter	Frequency
Sodium	Quarterly
Chloride	Quarterly
Sulfate	Quarterly
Alkalinity (as HCO_3 and CO_3^{2-})	Quarterly
Total Organic Carbon	Quarterly
Nitrogen – Nitrate	Annually
Nitrogen – Nitrite	Annually
Aluminium	Annually
Arsenic	Annually
Barium	Annually
Cadmium	Annually
Chromium (total)	Annually
Chromium (hexavalent)	Annually
Cobalt	Annually
Copper	Annually
Mercury	Annually
Manganese	Annually
Lead	Annually
Zinc	Annually
Fluoride	Annually
Benzene	Annually
Toluene	Annually
Ethylbenzene	Annually
Xylene	Annually
Total Phenolics	Annually
Total Petroleum Hydrocarbons	Annually
Organochlorine Pesticides	Annually
Organophosphate Pesticides	Annually
Polycyclic Aromatic Hydrocarbons	Annually

5.7.2 Surface Water

Surface water samples should be collected quarterly from the dams which will discharge stormwater off site and upstream and downstream of Blaxland Creek. The parameters which will be monitored are detailed in **Table 5.4**.

Table 5.4
Indicator and Parameter Limits for Surface Water Monitoring

Parameter	Frequency
pH	Quarterly
Dissolved Oxygen	Quarterly
Total Suspended Solids	Quarterly
Nitrogen – Ammonia	Quarterly
Total Organic Carbon	Quarterly

The results of the surface water monitoring programme should be reviewed annually to ensure only meaningful data is collected.

5.7.3 Gas

The existing piezometers have been screened over their full length and have been constructed to enable subsurface gas monitoring. Any new piezometers will be constructed in the same manner.

The location of the existing and proposed piezometers is depicted in the figure in **Appendix 1** (**Annexure 5**). Monitoring of the concentration of methane in these piezometers should be conducted at a quarterly frequency.

Monitoring of methane above the final capped and rehabilitated surface of the cells will be conducted on a quarterly basis in accordance with benchmark technique 17 of DECCW's *Environmental Guidelines: Solid Waste Landfills*.

5.8 Action Criteria

The criteria detailed in **Table 5.5** should be considered when assessing the performance of the emplacement cells with respect to groundwater, surface water and gas emissions.

Table 5.5
Action Criteria

Medium	Criteria
Groundwater	Ammonia Concentration greater than 15mg/L
Surface Water	Ammonia concentration greater than 1 mg/L
Surface Gas Emission	Methane Concentration greater than 500 ppm v/v
Subsurface Gas Emission	Methane concentration greater than 1.25 % v/v

If any of these criteria are exceeded, at least another round of monitoring should be undertaken to confirm the exceedance. If the criteria are exceeded again in the 2nd monitoring event, a Response Plan should then be prepared and submitted to DECCW for their consideration before it is implemented.

5.9 Site Closure

Six months prior to the Facility ceasing to emplace waste, a Closure Plan should be prepared and submitted to DECCW in accordance with the requirements of Section 76 of the Protection of the Environment Operations Act 1997. This Plan should detail the post closure management and monitoring procedures.

5.10 Financial Assurance

A financial assurance will be provided to DECCW before waste is received from off site and emplaced at the Facility. The quantum of this financial assurance will be agreed with DECCW and is expected to be less than that of nearby general solid (non-putrescible) waste emplacement facilities. This would reflect the fact that the Orchard Hills Facility would present a lower environmental risk than nearby waste emplacement facilities. The Orchard Hills Facility is conceptually designed and would be constructed and operated in accordance with a number of best practices (eg automated leachate level and transfer controls on all cells and gas extraction and oxidation).

5.11 Levy Integrity

Robust procedures would be put in place to ensure that the Facility meets its levy obligations under the Protection of the Environment Operations Act 1997.

All waste received at the Facility from off-site would be weighed and recorded. Waste received from off-site and emplaced would be subject to the levy.

All waste relocated from the perimeter bunds would be weighed and recorded before being emplacement in a cell. The existing waste on site would not be subject to the levy.

Volumetric surveys of the volume of airspace consumed would be undertaken as required by DECCW and the data would be reconciled against the quantity of waste received from off site and emplaced.

6 DESIGN AND OPERATIONAL SAFEGUARDS AND IMPACTS

6.1 Summary of Design and Operational Safeguards for Protecting Groundwater

The *Environmental Guidelines: Solid Waste Landfills (1996)* (and DECC's input in the DGRs) provides for operators of waste emplacement facilities the option of selecting proven benchmark techniques which if selected work in concert to meet the environmental requirements for protecting groundwater. The key benchmark techniques are:

- A leachate barrier, including the application of the natural geology as a barrier (Number 1);
- A leachate collection, extraction and disposal system and surface water controls (Numbers 2 and 3);
- Covering of waste (Number 33);
- Gas containment system (Numbers 10 and 11);
- Capping and rehabilitation (Number 28).

Each of the benchmark techniques has been proposed to be adopted at the Project Site, with the exception of:

- the final capping and rehabilitated surface.

In the case of the final cap, modelling is contained in **Appendix 2** which demonstrates that the proposed cap will meet the environmental performance requirements of the benchmark technique cap.

6.2 Assessment of Impacts

6.2.1 Introduction

An integrated approach has been taken to the design, construction, operation and rehabilitation of the emplacement cells to achieve the objectives of:

- Leachate needs to be contained on site to ensure that groundwater and surface water is not polluted off site; and
- Gas would be contained within the Project Site such that it does not migrate off site through the subsurface. Furthermore, gas generated by the emplaced waste would be managed to ensure that it does not create offensive odour off site, and is subject to oxidation to reduce greenhouse gas emissions.

An assessment of potential impacts from the emplacement of waste on groundwater and surface water (with respect to leachate) are discussed below. The potential impacts from odour, dust and methane emissions have been addressed by PAE-Holmes (2010).

6.2.2 Groundwater

Groundwater beneath the Project Site exists in the Wianamatta Shale and at depth in the Hawkesbury Sandstone. Groundwater quality could potentially be impacted upon by leachate and possibly by high gas pressures in the emplacement cells forcing leachate laterally out of the cells.

However, the risk of leachate impacting on groundwater quality in the Hawkesbury Sandstone beneath or surrounding the Site is considered to be negligible for the following reasons.

- Up to 64 m of shale exists beneath the base of the lowest emplacement cell (approx.17 m AHD) and the Hawkesbury Sandstone;
- The vertical permeability of the shale is confidently expected to be very low (less than 1×10^{-9} m/s). This natural barrier offers a greater level of protection than the DECCW's recommended 900 mm of compacted clay;
- Cell 1 and possibly Cells 2 and 3 will act as a hydraulic trap with groundwater in the Shale surrounding the emplacement cells seeping into these cells due to the leachate level being maintained below the groundwater level;
- An engineered liner will be installed on the floor and perimeter walls of all cells; and
- The salinity of the groundwater in the Hawkesbury Sandstone is approximately an order of magnitude lower than the salinity in the overlaying shale. This provides evidence that the shale is not significantly recharging groundwater within the Hawkesbury Sandstone. If on the other hand the water was flowing from the shale into the underlying sandstone then the shale's salinity would be lower (from being flushed) and the salinity of the Hawkesbury Sandstone's groundwater would be higher.

Furthermore, a search of DWE registered bores within a 3 km radius of the Site found three bores, one of which is on site. The two off site bores are cased through the upper shale and are able to extract groundwater from the underlying Hawkesbury Sandstone. As there is a negligible risk of the emplaced waste impacting on the groundwater in the Hawkesbury Sandstone there is consequently a negligible risk of the emplaced waste impacting on the groundwater quality able to be extracted from the two nearby registered groundwater bores (i.e., there would be no change to the groundwater's beneficial use status).

Overall, it can be concluded that the risk of leachate contaminating groundwater in the shale surrounding the site is very low for the following reasons.

- The horizontal permeability of the shale is low (between 1×10^{-6} to 1×10^{-9} m/s) and the higher horizontal permeability measured in the North East piezometer does not extend across the site to the North West piezometer which confirms that the zones of higher permeability (in the fractures etc) are discontinuous;
- There is no evidence of there being a hydraulic connection between groundwater in the shale and Blaxland Creek;
- R W Corkery and Co (2004) found the carbonaceous lenses (which are groundwater flow paths in the shale) are discontinuous across the site;

- Modelling by Dupen (1993) suggest that the natural clay/shale geology as is present at the Site is an excellent barrier to prevent the migration of leachate into groundwater;
- The base of Cell 1 and possibly Cells 2 and 3 would be below the level of the groundwater in the surrounding shale. The level of leachate will be maintained below the groundwater level to ensure the inward seepage of groundwater thereby arresting any outward flow of leachate and hence these cells would act as a hydraulic trap (see **Section 4.3.1**);
- The floor and outer perimeter walls of all cells will be lined with an engineered liner with a permeability of less than 7.3×10^{-10} m/s and a thickness of at least 400 mm (or equivalent);
- Gravel chimneys will be placed at approximately 50 m intervals around the outer perimeter of the emplacement cells to relieve any leachate and gas pressure on the engineered liner on the emplacement cell walls;
- A leachate drainage layer will extend across the entire floor of all cells where general solid (non-putrescible) waste will be emplaced;
- Automated controls will be in installed to control the level of leachate below a set level in all cells. This will ensure that groundwater continues to seep into Cell 1 and possibly Cells 2 and 3 and there is no more than 300 mm of leachate on the floor of the Final Cell (or Cells 2 and 3 if they are not excavated below the groundwater level in the shale);
- Best practice controls will be implemented to minimise the generation of leachate (eg, diversion of stormwater away from waste, daily cover and progressive capping and rehabilitation of the cells with a low infiltration cap);
- Modelling has demonstrated that by the application of daily cover and by progressive capping and rehabilitation of the cells that the leachate generated at the site can be continuously extracted from the cells and disposed of via evaporation at the Site;
- There is general solid (non-putrescible) waste and some minor asbestos contained with the existing on site bunds, placed there before the Proponent purchased the Site. There are no engineered controls installed around these bunds (eg liner, leachate collection and extraction or engineered cap). Nevertheless there is no evidence of leachate having contaminated the groundwater downgradient of these two bunds. This provides evidence that the in situ clays and shales are able to contain any pollutants on site;
- Both the Initial and Long-term Leachate Evaporation Ponds and initial and final stormwater leachate dams (if required) will be lined; and
- The floor of Cell 1 has already been excavated below the level of groundwater in the shale by the Site's previous owner. Groundwater in the shale around this Cell will continue to seep into it and this will assist with arresting the off-site migration of leachate from all of the emplacement cells placed above the groundwater level, ie. it will act as a hydraulic trap.

6.2.3 Surface Water

Leachate generated from the emplaced waste will be prevented from entering the surface water system and potentially polluting surface water by the application of the following design, operation and monitoring measures:

- The diversion of surface water away from the emplaced waste;
- The application of daily cover which would be compacted and rolled (if required) to shed stormwater;
- The reduction in the size of the daily cover area when rain is forecast and whilst it is raining;
- Deconstructing the bunds so the upper surface of the exposed waste slopes inwards and the exposed general solid (non-putrescible) waste is bunded when rainfall is forecast or occurring;
- Leachate extraction from the emplacement cells would be automated. Leachate will be unable to be extracted out of the emplacement cells if the level of leachate in the leachate evaporation pond exceeds its freeboard. Furthermore, leachate would not be able to be extracted out of the emplacement cells if the transfer pipeline has been ruptured; and
- Daily monitoring will be undertaken of the level of leachate in the leachate evaporation pond. Should the level exceed the pond's freeboard the leachate will be pumped back and reinjected into one of the emplacement cells to be absorbed by the waste, or temporarily stored within the waste until dry conditions prevail when it will be extracted and evaporated.

Leachate generated from the wood/garden waste stockpile on the Recycling Facility will be contained within the Site's stormwater leachate dam depicted on **Figure 2** in **Appendix 5**. This dam has been sized in accordance with the DECC's requirement to contain up to the 1:10 year ARI rainfall event of 24 hours duration.

7 COVERAGE OF DIRECTOR-GENERAL'S REQUIREMENTS

The Director-General's requirements (DGRs) and requirements from other government agencies for the Project were provided in correspondence from the Department of Planning (DoP) on 20 May 2009. **Table 7.1** provides a summary of the requirements relating to groundwater and the design, construction, operation, monitoring and rehabilitation of the emplacement cells.

Table 7.1
Summary of DGRs relevant to Groundwater Assessment

Page 1 of 7

Agency	Details of Requirements	Where addressed in this document
Department of Environment & Climate Change (15/04/09)	Identify any potential impacts on quality or quantity of groundwater describing their source.	Section 4.3
	Specific Matters to Address for the Waste Disposal Facility: 1. An awareness of the application of the waste levy as required under section 88 of the Protection of the Environment Operations Act 1997 (POEO Act).	Section 5.11
	2. The Proponent's report in support of the Proposal, Preliminary Environmental Assessment for the Orchard Hills Waste Recycling and Management Facility, indicates that amenity bund walls ("the bund walls") are in situ on the premises. The bund walls are partly comprised of waste material. The Proponent must undertake thorough investigations into the composition of the bund walls on the premises and prepare a plan of management for the waste, which must cover at least the following matters:	
	1. The amount of waste in the bund walls	Douglas & Partners 2009
	2. The classification of that waste according to the Waste Classification Guidelines (DECC, 2008);	Douglas & Partners 2009
	3. How the waste is to be disposed of, and a timetable for the disposal of that waste;	Section 5.3.1
	4. How the environmental impacts relating to the excavation of the bund walls (particularly dust, odour and leachate generation) will be mitigated;	Section 5.3.4, 5.5.1, 5.5.2
	5. A contingency plan for management of any waste which is classified as restricted solid waste or hazardous waste or is otherwise unsuitable for disposal at the premises	Section 5.3.3
	6. Management of leachate generated in this waste.	Section 5.3.4
	3. A commitment to provide a soil and management plan at the time of submitting an application for an environmental protection licence for a waste recycling and disposal facility under the POEO Act (should consent be granted). This commitment must also confirm that the soil and water management plan will be prepared in accordance with *Managing Urban Stormwater: Soils and Construction* (Landcom, 2004) and all sediment control dams will be sized to contain up to the 90^{th} percentile 5 day duration rainfall event and that all pumped discharges will contain less than 50 mg/L of TSS and all discharges will contain less than 0.9 mg/L of total ammonia.	Surface Water Assessment

Table 7.1 (Cont'd)
Summary of DGRs relevant to Groundwater Assessment

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<table>
<tr><th>Agency</th><th>Details of Requirements</th><th>Where addressed in this document</th></tr>
<tr><td rowspan="4">Department of Environment & Climate Change (15/04/09) (Cont'd)</td><td>4. A plan with cross sections at a suitable scale depicting the dimensions of the i.e. proposed landfill cell(s) i.e. its length, width and depth, as well as details of the landfill cell(s) floor and wall gradients. The floor of the cell should have a transverse gradient of greater than three percent and a longitude gradient greater than one percent. All levels should be relative to AHD. The plan diagram must also depict the boundary of the premises subject to the development application and the lot and DP numbers of this land.</td><td>Appendix 5</td></tr>
<tr><td>5. If the Proponent does not propose to install an engineered barrier and leachate collection drainage layer in the landfill cells, then a detailed surface water and hydrogeological assessment must be included in the EA, including details on the location of all surface water samples, groundwater bores (including the location of existing and proposed landfilled waste), their construction details, depths relative to AHD and geological bore logs, the chemical composition of the groundwater and its standing water level, groundwater gradient and the hydraulic conductivity of each layer of the geology. Depth of the existing waste at the site should also be provided. Issues of slippage if the waste becomes saturated and batter seeps must also be addressed.</td><td>Sections 2, 3, 4 and 6,
GSS Environmental 2010</td></tr>
<tr><td>6. Specifications for the proposed leachate collection drainage layer. The specifications must be in accordance with those specifications detailed in Benchmark Technique ("BT") 2 of the EPA's Environmental Guidelines; Solid Waste Landfills (unless an alternative is proposed). If the BT is selected it must:
have in situ permeability of greater than 10-3 metres per second; and
be placed over the entire floor of the new cell at a depth greater than 300 mm.
Further the drainage layer may consist of gravel or comparable material that is:
rounded (or less than 30% misshapen);
of grain size greater than 20 mm (that is by demonstrating that not greater than 10% is smaller than 10mrn in size and that not greater than 3% is smaller than 0.075mm in size - under the anticipated weight of waste and other material);
smooth-surfaced;
non-reactive in mildly acidic conditions;
relatively uniform in grain size; and
free of carbonates.</td><td>Section 4.4.4.2</td></tr>
<tr><td>7. Advice on whether a geotextile will be placed on the lower and upper surface of the leachate collection drainage layer and if so the material's specifications and justification for its selection.</td><td>Section 4.4.4.2</td></tr>
</table>

Table 7.1 (Cont'd)
Summary of DGRs relevant to Groundwater Assessment

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Agency	Details of Requirements	Where addressed in this document
Department of Environment & Climate Change (15/04/09) (Cont'd)	8. Details of the layout and specification of the proposed leachate collection pipes. The pipes must: • be a minimum 150mm in diameter • placed within the drainage layer at intervals not more than 50 metres; and • be of sufficient strength to ensure their performance is not diminished due to the weight the overlying waste (assume 2 tonne per m3) - taking into account AS2566 and the drilled holes - this information can be provided at the licence application stage, should consent be granted.	Section 4.4.4.2
	9. Concept details of the proposed leachate risers and leachate extraction and pumping system for the landfill. Drawings with sufficient details and specifications to enable construction should be provided at the license application stage, should consent be granted.	Section 4.4.4.2 and Figure 11 or Appendix 5
	10. Details of the design, construction and operation of a leachate management system. The system must allow for the level of leachate within the cell to be maintained no greater than 300mm above the upper surface of the engineered barrier (liner) or at least two metres below the lowest level of the surrounding groundwater level if the cell's base is below the standing groundwater level. The system should be automated and include: • an alarm system that is activated if the leachate level within the cell rises to a level that is more than 300mm or less than 2 metres from the lowest standing groundwater level; • interlocks to prevent leachate being pumped from the landfill in the event that any receiving dams freeboard is exceeded; and • leachate transfer pipe work leak detection and interlocks to prevent pumping if the pipe work has ruptured.	Section 4.4.4.3
	10. A commitment to provide a construction quality assurance (CQA) plan at the licence application stage (should consent be granted) which details: a) As constructed drawings prepared from field surveys depicted at a suitable scale: • a plan view of the perimeter of the cell and finished surface contours of the finished cell floor; • a plan view of the perimeter of the cell and the surface contours of the upper surface of the engineered liner (if proposed/ required), before placement of the leachate drainage material; • a plan view of the perimeter of the cell and the surface contours of the installed geotextile covering the leachate drainage layer, if any, or the finished contours of the leachate drainage layer; • the installed alignments and grades of the leachate collection pipes and the installed leachate risers; and • cross sections of the basal features of the cell and the leachate levels within the riser/s which will trigger leachate extraction and triggering of the alarm system in the event that the level of leachate within the cell rises to a level that is more than 300mm, or less than two metres below the surrounding groundwater level;	Section 4.4.9

Table 7.1 (Cont'd)
Summary of DGRs relevant to Groundwater Assessment

Page 4 of 7

Agency	Details of Requirements	Where addressed in this document
Department of Environment & Climate Change (15/04/09) (Cont'd)	b) A sampling and testing for the leachate drainage material, utilising an appropriate Australian Standard (AS) to: I. validate that the installed material has a permeability greater than 10^{-3} metres per second; II. validate that the installed material has a granular size greater than 20mm (that is by demonstrating that not greater than 10% is smaller than 20mm in size and that not greater than 3% is smaller than 0.075mm in size, using an appropriate AS); III. Shape analysis - AS1141.1.4 - with % of misshapen particles less than 30%; IV. establish the reactivity of the leachate drainage material from each source; and V. depending of the material, other tests may be required.	Section 4.4.9
	Note: The DECC will accept one set of the above tests per source and no less than one set of tests per 2500 tonnes of material from any particular source. Reactivity tests are not required for river gravel.	Section 4.4.9
	c). the provision of a report with documentary evidence that the works and testing required by the above parts have been completed, with the report approved by a suitable qualified person (for example a chartered professional engineer with the Institution of Engineers Australia).	Section 4.4.9
	11. A report detailing the leachate storage and disposal needs and location and size of the proposed leachate storage dam/s. The size of the leachate storage dam must take the form of a water balance run using monthly time steps and using the following assumptions. • The rainfall data should be taken from the nearest Bureau of Meteorology station which has at least 50 years of data. • Average monthly rainfall data, 90th percentile wettest monthly rainfall data, and average monthly evaporation data should be collated.. • The percentage of rainfall which becomes leachate should be taken as 50% of daily and intermediate cover areas and 10% for final capping. However when the level of fill in a cell is below the surrounding natural ground level (1.e. in a void) the % of rainfall assumed to become leachate should be taken as 90% for daily and intermediate cover areas. • The evaporation rate from dams should be 70% of the average monthly evaporation rate. • The absorptive capacity of solid waste (both putrescibles and non-putrescibles) can be taken as 0.03kL/tonne of waste disposed (i.e. the waste acts like a sponge). • The average monthly tonnage of waste disposed of to landfill needs to be estimated and this should be used to both determine the absorptive capacity of the waste arid the time taken to fill each cell before capping can be applied. • The flow rate of groundwater into the cell needs to be estimated, justified and taken into account in cases where the groundwater level is above the base of the cell. • The volume and area of the leachate storage dam needs to be assumed.	Section 4.4.4 and Appendix 2

Table 7.1 (Cont'd)
Summary of DGRs relevant to Groundwater Assessment

Page 5 of 7

Agency	Details of Requirements	Where addressed in this document
Department of Environment & Climate Change (15/04/09) (Cont'd)	• The volumetric disposal rate to sewer, if available needs to be factored into the water balance model. • The model should be run for each cell for 20 years after the site assuming in the 1st year of operation of each cell 90th percentile wet months and thereafter average monthly rainfall. • Where leachate is irrigated on the active tipping face the evaporative volume per month should be determined using 70% of the pan evaporation, 30% infiltration into the waste and average monthly evaporation and only possible on dry days which are the average number of dry days per month. Mathematically the water balance is: Leachate Storage = Leachate generated from rainfall infiltrating into the waste + groundwater inflow- the absorptive capacity of the waste - evaporation from leachate storage dams - any other leachate disposal means (eg. sewer). The report must include details of the proposed leachate disposal methods and predicted volumes disposed of by each of those methods.	Section 4.4.4 and Appendix 2
	12. Information to demonstrate that any dam's proposed liner for leachate storage will have a leakage rate less than 1150 litres/hectare/day.	Sections 4.4.4.1 and 4.4.4.2
	13. The design specifications for the engineered barrier (liner) if proposed to be installed on the base and walls of all cells; and a commitment should be made in the EA that CQA details and drawings for construction will be provided at the licence application stage for the liner and cells and other infrastructure, should consent be granted.	Sections 4.4.3 and 4.4.9
	14. An assessment of the proposal's greenhouse gas emissions and a commitment to install and operate landfill gas collection and oxidation works, if required by the environment protection licence (should consent be granted).	Section 4.4.8
Department of Water and Energy (31/03/09)	Sufficient detail needs to be provided for DWE to assess any water licencing requirements under the Water Act 1912, the EA needs to provide details on: • The water supply source(s) for the proposal.	Section 2.3 and Surface Water Study
	• Any proposed surface water extraction for the proposal, including purpose, location of any existing and proposed pumps, dams.	Surface Water Study
	• Any proposed groundwater extraction related to the project.	Section 3.2.5, Appendix 2 and Surface Water Study
	• Volumes of water to be used.	Section 3.2.5 and Surface Water Study
	• The function and location of all existing and proposed storages / ponds on the site.	Surface Water Study and Appendix 5

Table 7.1 (Cont'd)

Summary of DGRs relevant to Groundwater Assessment

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Agency	Details of Requirements	Where addressed in this document
Department of Water and Energy (31/03/09) (Cont'd)	• The design, layout, pumping and storage capacities, all associated earthworks and infrastructure works must be clearly shown and explained.	Appendix 5
	Protect groundwater resources in accordance with NSW State groundwater policy, enhance groundwater quality and protect groundwater dependent ecosystems (GDEs).	Sections 4, 5 and 6
	Identify groundwater issues and potential degradation to the groundwater source: The predicted highest groundwater table at the site.	Sections 2.4.3
	• Any works likely to intercept, connect with or infiltrate the groundwater sources.	Sections 3.2.5 and 4.3.1
	• Any proposed groundwater extraction, including purpose, location and construction details of all proposed bores and expected annual extraction volumes.	Section 3.2.5 and Appendix 2
	• A description of the flow directions and rates and physical and chemical characteristics of the groundwater source.	Section 2.4.2, 2.4.4 and 3.2.1
	• The predicted impacts of any final landform on the groundwater regime.	Section 6
	• The existing groundwater users within the area (including the environment), any potential impacts on these users and safeguard measures to mitigate impacts.	Sections 2.3 and 6
	• An assessment of the quality of the groundwater for the local groundwater catchment.	Section 2.4.4
	• How the proposed development will not potentially diminish the current quality of groundwater, both in the short and long term.	Section 6
	• Measures for preventing groundwater pollution so that remediation is not required.	Section 6
	• Protective measures for any groundwater dependent ecosystems (GDEs).	Section 6
	• Proposed methods of the disposal of waste water and approval from the relevant authority.	Sections 4.4.4.1 and 4.4.4.2
	• The results of any models or predictive tools used.	Appendix 2
	Identify limits to the level of impact and contingency measures that would remediate, reduce or manage potential impacts to the existing groundwater resource and any dependant groundwater environment or water user, including information on: • Any proposed monitoring programs, including water levels and quality data.	Sections 5.7.1 and 6
	• Reporting procedures for any monitoring program including mechanism for transfer of information.	Section 5.7

Table 7.1 (Cont'd)
Summary of DGRs relevant to Groundwater Assessment

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Agency	Details of Requirements	Where addressed in this document
Department of Water and Energy (31/03/09) (Cont'd)	• An assessment of any groundwater source/aquifer that my be sterilised from future use as a water supply as a consequence of the proposal.	Section 6
	• Identification of any nominal thresholds as to the level of impact beyond which remedial measures or contingency plans would be initiated (this may entail water level triggers of a beneficial use category).	Section 5.8
	• Description of the remedial measures or contingency plans proposed.	Section 5.8
	• Any funding assurance covering the anticipated post development maintenance cost, for example on-going groundwater monitoring for the nominated period.	Section 5.10
	The EA needs to provide details if the volume of groundwater that is to be extracted is to increase from the volume authorised by the existing bore licence (referred to in Section 3.8 of the PEA).	Section 3.2.5 and Section 3.3 of Appendix 2

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APPENDICES

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