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Report on
Soil, Water & Leachate Management Plant

Light Horse Business Centre
Eastern Creek

Prepared for
Alexandria Landfill Pty Ltd

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The undersigned, on behalf of Douglas Partners Pty Ltd, confirm that this document and all attached drawings, logs and test results have been checked and reviewed for errors, omissions and inaccuracies.

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Light Horse Business Centre, Eastern Creek

1. Introduction

ACN 114 843 453 Pty Ltd (also referred to as the Light Horse Business Centre or LHBC) proposes to operate a Resource Recovery/Materials Processing Centre and a solid waste landfill site at the former Pioneer Quarry located off Old Wallgrove Road at Eastern Creek ("The Site").

The landfill will be located within a former breccia quarry and its geological and hydraulic characteristics are described in, amongst others, the following reports:

- Archbold Road, Eastern Creek: Groundwater and Salinity Assessment for Proposed Quarry Rehabilitation Project and Developable Land, Ian Grey Groundwater Consulting May 2007,
- Report on Preliminary Contamination Assessment Stockpiled Material and General Land Quality, Douglas Partners, April 2006.

A water balance and a Soil, Water and Leachate Management Plan (SWLMP) for the site is required for the construction phase of the project and for the operation of the site, based in part on the surface water report modelled by Martens Consulting Engineers and on the projected filling plan. The information has been compiled herein and the relevant reports on which the SWLMP is based are appended.

This SWLMP is required under the following planning conditions issued by the Department of Planning associated with their Major Project Assessment dated 22 November 2009:

"The Proponent shall prepare and implement a Soil, Water and Leachate Management Plan for the site to the satisfaction of the Director-General. This plan must:

a) be submitted to the Director-General for approval prior to construction;

b) be prepared by a suitably qualified and experienced expert;

c) be prepared in consultation with the DECC and Council; and

d) include:

   - o a site water balance;
   - o an erosion and sediment control plan;
   - o a stormwater management scheme;
   - o a surface water, groundwater and leachate monitoring programme; and
   - o a surface water, groundwater and leachate response plan."

The structure of this report reflects the respective planning conditions associated with the SWLMP. In addition, background information is provided on the planning condition relating to the Leachate Management System given its relation to the SWLMP. This SWLMP draws from a number of reports prepared by various consultants relating to specific facets of the overall SWLMP. Appended reports prepared by others have been summarised in this report. Technical review and endorsement by DP of calculations, designs and recommendations presented in referenced or appended reports prepared by others was not part of DP's scope of work. DP had no input to these reports and takes no responsibility for their content.

The report has been prepared with reference to the following published guidance:

- EPA, 1996. Environmental Guidelines: Solid Waste Landfills.
- Landcom, 2004. Managing Urban Stormwater: Soils and Construction ("Blue Book"). Fourth Edition.
- DEC, 1997. Draft Managing Urban Stormwater: Council Handbook.

The site layout is shown on Drawing 1, Appendix A.

2. Operational Areas

In order to establish a background to the proposed site operations, the "operational areas" are described as follows.

Sector A – Processing Area approximately 194,000 m^2
Area 1 - Clean collection area in Sector A comprises the Materials Processing Centre (MPC) shed and the stockpile areas including the internal roads, the workshop, office, weighbridge area and car parks.

Area 2 – Leachate area comprising green waste storage, green waste processing activities and MPC work floor areas (exposed).

The separation of Areas 1 and 2 will be ensured through:

- Delineation of the green waste areas;
- Preventing leachate from escaping the green waste areas;
- Preventing clean operational waters from entering the green waste areas;
- By the use of appropriate bunding and grading of Sector A.

Note: The processing area (Sector A) including the MPC, administration, workshop weighbridge buildings and car parks drains in the manner and direction described in GMW Drawings (7328_006 to 7328_0010) presented in Appendix A. Further details are also shown on Jones Nicholson Drawing 090669 H01 presented in Appendix A.

Sector B – Landfill Area
The total catchment over the landfill is approximately 280,000 m^2.

Area 1 – Clean operational area. This is defined as an area having no exposed waste and that has been capped with intermediate cover material (300 mm of suitable cover material or as required by the

Environmental Protection Licence for the site). The clean operational area of the landfill is expected to be graded towards a sump or pond. Water collected therein will be pumped for appropriate reuse (mostly dust suppression around the site) or to stormwater as required.

Area 2 – Leachate area. This is an area where water comes into contact with exposed waste or daily cover. All surface water run off from that area will be treated as leachate and collected in a sump. Following treatment of leachate waters it will then be discharged through to sewer. The daily tipping area is expected to be approximately 450 m^2 – 1000 m^2 with a working landfill face of approximately 4,000 m^2.

Sector B is the area to be filled progressively in a cellular manner as set out in chapter 3.4.6 (Figure 3.5) of the EA (ERM, 2008). The filling plan is summarised as follows:

Filling Plan

Initial filling will commence in the south-western corner of the quarry base at the shallowest point and proceed north and west in a series of landfill cells towards the north-western corner. Working in cells, benching and vehicle movements will be accommodated around the active tipping area. The initial lift is expected to be incremented to a height of 10 m. Once the north-western corner is reached, the filling area will proceed east and continue back to the southern side of the pit. This will constitute a 'windscreen wiper' formation. This process will be repeated until filling reaches the eastern end of the quarry at which time the total lift throughout the base of the quarry is expected to reach the initial 10 m. Filling will then occur in the same manner in the opposite direction and with subsequent lifts to be approximately 10 m (ERM, 2008).

In accordance with Benchmark Technique No. 33 (BT33) (EPA, 1996), the active tipping area will be covered at the end of each working day with 150mm of cover material or other type of landfill daily cover as approved by the Office of Environment and Heritage (OEH). Cover material will be either VENM or Alternative Daily Cover material approved by the OEH. Daily cover will be scraped off everyday prior to filling starting and will be topped up as required to allow that recycled daily cover material will diminish with each scrape-off event. Concept landfill plans have been prepared based on the maximum fill rate of 700,000 tonnes per annum.

Landfill Capping Schedule

Sector B

Daily and Intermediate Cover

The active tipping area of approximately 450 m^2 – 1000 m^2 in Sector B is the only part of the site in which waste is open to the environment. The active tipping face is to be covered at the end of every day with approved covers or with 150 mm of cover material as per BT33 (EPA, 1996). This is to be scraped back daily prior to tipping re-commencing on each subsequent day.

Once tipping is complete in any area of Sector B (i.e. no further tipping will occur for at least 90 days) intermediate cover is to be laid and compacted. The capping material shall comprise 300mm of VENM as per BT33 or other suitable engineering material approved by the OEH for that purpose.

Final Capping

Benchmark Technique No. 28 (BT28) (EPA, 1996) seeks to addresses site capping and revegetation as follows:

- prevention of pollution of water by leachate;
- prevention of landfill gas emissions;
- assurance of the quality of design, construction and operation
- minimisation of landfill space;
- prevention of degradation of local amenity.

LHBC has taken the above as a guide for provision of a suitable containment system designed to prevent the spread of contaminants from the landfill. LHBC may however amend this plan in line with any updates or changes of policy concerning landfill capping at the time it is required.

This provides a barrier to the migration of water and gas, promotes sound land management and conservation, and prevents hazards whilst protecting local amenity. Further, LHBC will ensure that capping remains effective through long term monitoring of groundwater (as described in this SWLMP) and landfill gas.

3. Site Water Balance

The planning condition for the site water balance states the site water balance must:

- include details of all water extracted, transferred, used and/or discharged by the development;
- identify the source of all water collected or stored on the site, including rainfall, stormwater and groundwater; and
- describe the measures that would be implemented to minimise water use on site.

The following subsections of the report seek to address the above planning condition. The information provided derives from reports prepared previously by others. DP has not completed detailed checks of calculations, designs and recommendations reported by others and summarised herein.

Water extracted, transferred, used and/or discharged by the development is summarised in the following table.

Table 1: Summary of Site Water Balance

Water	Usage / Storage	Anticipated Volume
Sector A – Processing Area		
Water demands	Toilets, irrigation, dust suppression, wheel wash	33,900kL per year^
Runoff	Runoff (mean rainfall year)	193,900kL per year**
Roof runoff	Total storage 1,580kL	meets 100% of demands
On-site detention basins (OSD)	Two basins to handle runoff, Basin One, Basin Two	One 3,400kL capacity to outlet weir Two 3,100kL capacity to outlet weir
Dust suppression	OSD water for dust suppression	meets 100% of demand
Sector B – Landfill Area		
Groundwater ingress	Generated by groundwater inflow	<3m^3 per day*
Leachate generation / pumping rates	Leachate pumping rates are likely to vary throughout the life of the landfill	estimated maximum required 500kL per day^^
Leachate storage tanks	Sequencing batch reactors (SBR) for leachate treatment	550kL per day based on 7 to 9 hour treatment time
Sediment basin	Sediment basin for "clean water" in quarry	4,362kL capacity^
Leachate disposal	Four sequencing batch reactors (SBR) for leachate treatment prior to discharge to sewer	320kL decanting capacity for each sequence
Leachate disposal	Sewer Discharge under Trade Wastewater Consent	Max Discharge – TBC

Source: ^Martens (2011)
**DADI (2011)
*IGGC, (2009)
^^ERM, (2008)

3.1 Site Water Balance

This section presents the results of the site water balance using actual monthly rainfall and estimated leachate production rates for average and 90th percentile conditions. The information summarised herein is based largely on Martens (2011), ERM (2008) and IGGC (2009).

Calculation of a leachate water balance for a landfill site involves estimation of the various inputs and outputs to and from the waste mass, and allows the potential leachate production rate to be assessed. Water balances are commonly used in landfill site design, particularly in the sizing of cells to minimise leachate production.

In the case of LHBC, the site is not yet in operation and potential leachate production rates can only be estimated.

The leachate water balance for the site for any given time period is described by the following equation:

Output (pumped leachate) = Input – Change in Storage

Inputs
The liquid inputs to the landfill site are as follows:

- infiltration of rainfall directly into waste;
- infiltration of rainfall through the landfill cap;
- infiltration of stormwater runoff from off-site and on-site areas;
- groundwater ingress (breccia fractures);
- liquid waste inputs; and
- miscellaneous other sources, such as infiltration of dust suppression water etc.

Liquid waste inputs are assumed to be negligible for the site given that no liquid waste will be received.

Miscellaneous other sources of liquid and moisture in the waste stream are also assumed to be negligible. This includes water used for dust suppression. Spraying for dust suppression only occurs during dry weather to prevent dust generation from dry surfaces, and infiltration of spray waters is expected to be negligible. Stormwater inflows into the landfill site from offsite sources are also expected to be minor.

The site wheel wash will be a sealed, recirculating design, and does not contribute any water to the landfill area. Direct infiltration of rainfall into the waste mass is considered to be the most important input, because of the limited potential for evaporation and the large active area.

Groundwater ingress from fractures in the Breccia is thought to be minor. A proportion of the groundwater inflow will be intercepted and pumped to stormwater via two systems as per the EA (ERM, 2008).

Outputs

Losses of water from the waste are as follows:

- Direct evaporation from waste surface;
- Direct evaporation from hard-surfaced areas;
- Run-off and discharge to stormwater from hard-surfaced areas;

- Evapo-transpiration from capped areas;
- Absorption by received waste; and
- Leachate disposal to treatment plant and or sewer.

Leakage
Leakage into underlying strata is expected to be negligible at Eastern Creek because of the inward hydraulic gradient in the perched and fractured rock aquifers.

Absorptive Capacity
Absorptive capacity of the waste received is estimated at 50 litres per cubic metre, approximately two-thirds of that typical for compacted domestic waste. The expected waste input rate is 30,000 tonnes per month, equivalent to 450,000 m^3 per year (excluding daily cover material).

3.1.1 Water Balance Methodology & Concept

A daily water balance analysis modified after Storm (2008) (DADI pers. comm. Oct 2011) was used to determine the feasibility of the proposed rain and stormwater harvesting scheme and in particular the effects of various storage sizes for stormwater harvesting along with changes to demand. The water balance utilised flows generated using a simple runoff calculation using historical rainfall data, analysed for various rainfall patterns including dry, mean and wet rainfall years.

The purpose for modelling dry, mean and wet years was to assess the performance of various tank sizes given the changes to rainfall patterns. It is noted that with the potential effects of climate change and the current trend of dry rainfall patterns, the need to consider lower annual rainfalls for rain and stormwater harvesting reuse schemes is becoming more and more necessary. In addition, any excess stormwater produced (especially during wet season periods) need to be considered for the management of on-site surface waters.

A concept diagram for the proposed re-use scheme on site is shown in Figure 1 below.

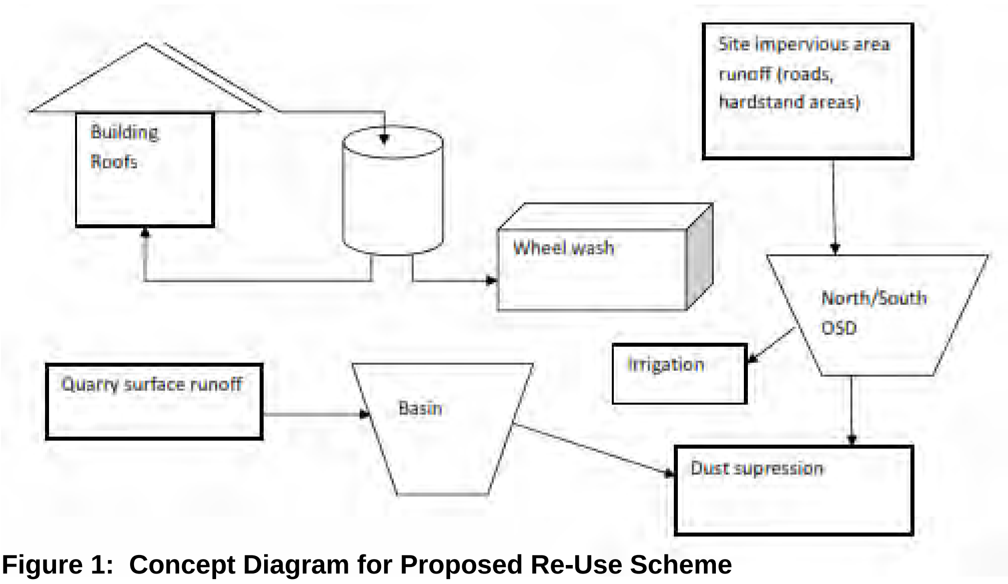

Figure 1: Concept Diagram for Proposed Re-Use Scheme

Modelling Inputs

Rainfall

Data from St Clair (BOM station #67102) was used. Seventeen years of daily rainfall data (1985 – 2002) was assessed to determine a dry, median and wet rainfall sequence for use in the water balance model.

Table 2: Modelled Rainfall

	Modelled Average rainfall and years (mm)	Prospect (long term average) (mm)
Dry	553 (1994/1995/2001/2002)	562
Median	851 (1987/1989/1991)	831
Wet	1104 (1986/1987/1988/1989/1990)	1183

Harvestable areas

The proposed roof and stormwater reuse scheme can harvest runoff from the operational area catchment. This is conservative (under-estimates area available) and excludes the proposed green waste area.

Table 3: Harvestable Areas

Precinct	Area (ha)	Initial loss (mm)
Building roofs	0.85	1
Catchment runoff	21	5
Quarry	26.5	10

Pre-Water demands

The demands for harvested water for reuse includes toilet flushing, dust suppression, sprinklers (irrigation) and the wheel wash.

Table 4: Water Demands

Annual Demand (Ml/yr)				Modelling assumptions
	Dry years	Mean years	Wet years	
Toilet	0.4	0.4	0.4	34 staff on site x 6 flushes/day x 4.5L
Dust suppression	25.8	24.1	24.0	Average application = 80kL/day (assumes no application if daily rainfall exceeds 2mm)
Sprinklers	9.7	9.1	9.0	Average application = 30kL/day (assumes no application if daily rainfall exceeds 2mm)
Wheel wash	0.3	0.3	0.3	Water use = 25kL/month
Total	36.2	33.9	33.7	

Results - Catchment runoff

The actual runoff that can be harvested for reuse will not be the entire volume generated due to losses from the system, and is dependent on storage behaviour (i.e. if the storage volume reaches 100% capacity, overflows will occur rather than further collection).

Table 5: Runoff Summary

Rainfall Scenario	Potential Runoff Generated (ML/yr)		
	Dry	Median	Wet
Building roof	4.25	6.6	8.7
Quarry	44.9	73.2	236.8
Catchment runoff	62.7	114.1	200.2
Total	111.8	193.9	445.7

Rain tanks and building roofs

Overall tank storage volumes of up to 1,580kL would meet all of the site's toilet flushing and wheel wash demands for the dry, median and wet rainfall scenarios.

Surface runoff from clean operational area of the RRF

Surface runoff from the internal roads/hardstand areas and remaining site operational area will be collected. Runoff from these areas will be directed towards the OSD basins which will include a storage component and be drawn down for reuse on site following storm events.

An additional five tanks with a capacity of 50kL each have been provided for, to specifically pump water from the OSDs for storage and re-use to prevent overflow.

A water balance was prepared for the water demand scenario of:

- Dust suppression for watering carts + truck on-board reservoirs (80kL/day) and spray mists/sprinkler system for irrigation or dust suppression (30kL/day).
    - Note: it is assumed that the water quality will be of adequate standard for reuse and will not pose a risk to human or environmental health.
- It was also assumed that on days where daily rainfall exceeds 2mm there is no demand for dust suppression.

Current indicative basin size in the site drawings (Appendix B of the Martens Report) allows for approximately 5,000kL from Basins 1 and 2 combined, which should meet all of the assumed water demand for dust suppression and irrigation combined.

Surface Runoff from Quarry – Sector B

Captured runoff in the quarry basin will be used for dust suppression via water carts. The available water volume for reuse from the basin will vary depending on rainfall and the stage of landfill operation, as the basin size is intended to increase in proportion to the capped landfill catchment area and runoff from quarry walls as required.

In practice the basin size may vary in relation to the area of capped landfill that is its catchment (at a rate of 165 m^3/ha). For this reason it was modelled separately to the storage options within the OSD basin.

Runoff collected from these areas will be suitable for reuse such as dust suppression if it has not come into contact with waste.

Summary of Storage Volumes

Each building should have its own rainwater tank (minimum 10kL volume) to harvest roof water runoff for reuse including toilet flushing and wheel wash top up. Tank storage capacity totalling approximately 1.5 million litres has been provided for on site.

The OSD storage proposed for the operational area is of sufficient volume to contain the 1 in 2 year storm event, 1 in 10 year storm event, and 1 in 100 year storm event with storm durations between 25 and 540 minutes. By use of additional depth in the basin (nominal 0.5m in indicative basin sizes supplied) to act as storage for reuse on-site. It is anticipated that drawdown will occur regularly for dust suppression (water carts and sprinkler) and irrigation.

The proposed sediment basin in the quarry has been sized using the Blue Book (approximately 165 m^3/ha) and can be drawn down following storm events for dust suppression (water carts).

Evaporation and Runoff

Evaporation has been simulated by applying a factor to the total rainfall depending on the type of surface.

In the case of Sector A and the clean pond in Sector B the factor applied represents both evaporation and runoff, because these areas drain to stormwater collection and disposal systems.

Low infiltration rates for Sector A which will be concrete or bitumen surfaces graded to fall towards gross pollutant traps (GPTs).

This is a highly simplified approach to evaporation, and will result in overestimated evaporation during the winter months and during wet years, and underestimated evaporation during the summer (although annual values should be accurate as long as the calibration is reliable). However, a more sophisticated approach would require detailed analysis of daily rainfall and evaporation data, and possibly disaggregation of rainfall events into hourly rates. Information would also be needed on cap/daily cover thickness & construction and other factors.

Given the uncertainties involved in the type of analysis and the heterogeneous nature of landfilled waste, a more sophisticated approach is not justified, even if sufficient data were available. Calibration using actual data for rainfall and leachate generation provides confidence that the overall approach is robust.

Leachate Storage *In Situ*
The waste mass within LHBC site provides a potential storage for leachate. The base of the pit is at around minus 150 mAHD, and the current area of the base of the quarry is approximately 13,000 m^2. The total volume in storage has no direct bearing on the water balance calculations; however the change in storage volume over the period under consideration is significant.

Leachate levels can only be measured at the sump, and there is a high degree of uncertainty with estimated changes in storage because conditions within the waste mass are poorly understood (including performance of the drainage system, leachate levels away from the sump, effective porosity etc).

3.1.2 Groundwater Ingress and Capture & Leachate Generation

Estimating the groundwater ingress into the quarry void has been considered by previous reports (ERM, 2008; IGGC, 2009; and Red Earth Geosciences, 2009) in the context of the water balance. This section outlines the previous studies and evaluates the significance of groundwater ingress on the water balance.

Groundwater ingress into the site from apparent fractures in the Breccia as have been identified in the report of Jeffrey & Katauskas (ref: Appendix K of the EA) occurs primarily along the west / Northern boundary of the site, at a level of between 0 and minus 6 mAHD.

The rate of ingress has previously been estimated as 125 kL/day (ref: Page 17, Report by IGGC Pty Ltd, Appendix C of the EA).

Recent assessment by IGGC Pty Ltd using a water logger produced the following report Groundwater Inflow Assessment, Former Hanson Quarry (IGGC, 2009). The findings of the report are summarised in the subsequent report entitled Proposed Light Horse Landfill Site, Eastern Creek: Detailed Hydrogeological Investigation and Assessment (IGGC, 2009). The latter report is presented in Appendix D. The findings of the report are summarised herein.

Data Collection
The quarry is in the process of being dewatered by pumping of water from the pond located in the quarry base. Pumping was routinely undertaken during quarry operation with anecdotal information from quarry staff indicating an average accumulation rate of around 125kL/day or 125m^3/day (IGGC,

2006). A substantial proportion of this accumulation is expected to result from rainfall and this is also supported by anecdotal information.

Quarrying ceased in 2006 at which time pumping also ceased for a period of around 18 months. Hanson Construction Materials Pty Ltd re-commenced pumping in late 2008 for use in dust suppression for its crushing and stockpiling activities. The quarry pond is almost completely dewatered. The pumping rate during dewatering is estimated at 30L/s.

Pumping was suspended between the 5th February and the 11th February 2009 to allow monitoring of the rate of water level rise. Prior to suspension, two pressure transducers with data loggers (referred to hereafter as “loggers”) were placed in a length of well screen for protection and lowering into a sump hole in the quarry floor. A barometric pressure logger was left in the site office to allow correction of data for barometric variations. On 11 February 2009, the loggers were retrieved and the data downloaded.

Data collected by the loggers were corrected for barometric variations and graphed to allow analysis. A graph by IGGC showing the full record from both loggers is shown below in Figure 2.

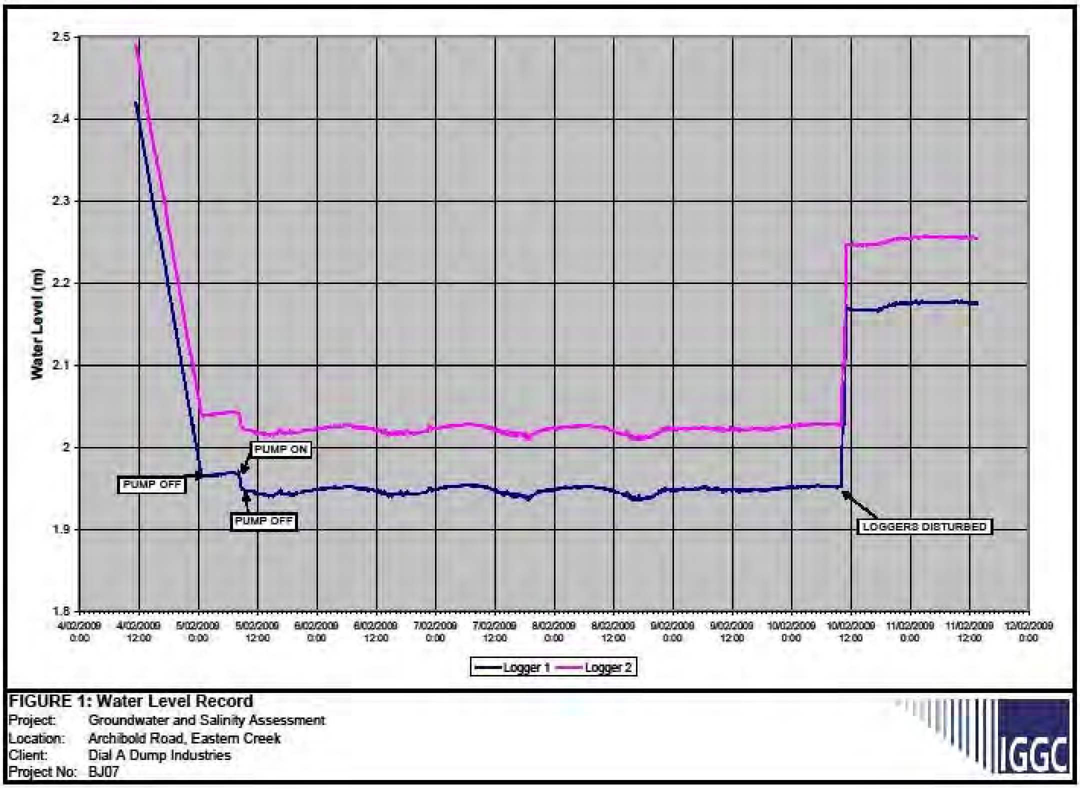

Figure 2: Graphed Data-logger Level Data

The following conclusions were made by IGGC :

- Consistent water levels between the two loggers with a small difference of around 0.07m due to their relative positions;
- Declining water levels due to pumping in the early part of the graph;
- Steady or slightly rising water levels after initial pump switch off followed by a further decline when the pump was switched on again for an additional 1 hour and 20 minutes;
- Steady or slowing rising water levels for the last six days of the recording period with evidence of tidal variation of up to 0.012m; and
- An apparent sharp water level rise of 0.2m near the end of the record due to disturbance of the loggers during relocation of the pump.

The data from Logger 1 were then used for further analysis. The rise at the end of the record was removed by correcting the subsequent data to provide a consistent record. The rate of groundwater inflow to the quarry pond was then estimated by comparing the observed water level change with that expected based on rainfall and evaporation alone. Rainfall and evaporation data were obtained for Bureau of Meteorology station 067019 located at Prospect Reservoir, approximately 7km east of the quarry. These data are summarised in Table 6.

Table 6: Summary of Climate Data (to 9am on date given)

Date	Day	Rain to 9am (mm)	Evaporation to 9am (mm)	Net Gain (mm)
5/02/2009	Thurs	0	5	-5
6/02/2009	Fri	0	7.6	-7.6
7/02/2009	Sat	0	8.8	-8.8
8/02/2009	Sun	0	9.4	-9.4
9/02/2009	Mon	0	9.4	-9.4
10/02/2009	Tues	3.2	1.6	1.6
11/02/2009	Weds	5.6	1.1	4.5
	TOTAL	8.8	42.9	-34.1

Starting with the water level on 5 February 2009, the predicted water level based on rainfall and evaporation alone has been projected. This assumes that both rainfall and evaporation are only applied to the pond surface area: this is realistic for evaporation but will underestimate the effect of rainfall as some runoff from higher levels of the quarry will have occurred. Insufficient information is available to estimate the effective catchment area which in any case will vary depending on the size and duration of rainfall events. This approach will under-estimate the rainfall contribution and lead to some over-estimation of the groundwater inflow rate and will therefore be conservative for the purposes of this assessment.

The quarry pond was estimated to have a surface area of around 3,600m^2 during the monitoring period (pers. comm., DADI). A check calculation was performed using the estimated pump rate (30L/s) and the observed rate of decline during pumping (0.8m/day).

This indicates an effective pond area of 3,240m^2, and the estimate of 3,600m^2 will therefore give a slightly conservative results. The IGGC calculations presented herein assume that the surface area remains constant during the monitoring period, i.e. the pond has vertical sides. Some change in surface area will result from the observed water level rise but this only occurs on one side of the pond (the others having near-vertical faces) and is considered to be negligible compared to the overall area.

Comparison of the projected water level changed based on rainfall and evaporation only with that observed shows an effective rise of 0.049m over 6 days, equivalent to 0.008m/d. Based on the estimated pond area of 3,600m^2 this indicates a net volume gain of 29.4m^3/d.

According to IGGC this is likely to represent an over-estimate of groundwater inflow due to the factors described previously but is consistent with the anecdotal average inflow rate of 125m^3/d comprising both groundwater inflow and rainfall contributions, and with anecdotal information that water level rises are very small except during rainfall.

Previous assessment of the hydraulic conductivity of the deep shale strata surrounding the quarry derived from slug tests indicated values of 1.75×10^{-6} m/d to 8.7×10^{-6} m/d with a calculated inflow of around $2m^3$/day (ERM, 2008). This is around an order of magnitude below the observed inflow probably due to a combination of the conservatism noted previously and localised higher hydraulic conductivity zones associated with fracturing.

In the long term operation of the proposed landfill IGGC advocates allowing the leachate level to rise as waste is placed, with a final level maintained at an appropriate margin below the regional groundwater level (RL 50mAHD) to ensure an inward hydraulic gradient. This will reduce the hydraulic gradient by at least an order of magnitude and will therefore result in an equivalent reduction in groundwater inflow. The long-term groundwater inflow rate is therefore estimated to be below $3m^3$/day.

Recommendations
Analysis of pond water level data collected during a period without dewatering indicates a maximum groundwater inflow rate to the quarry pond of $29.4m^3$/d (IGGC, 2009). This is consistent with previous assessments, confirms that the groundwater contribution is very low, and comprises a small proportion of the total water input, the majority being due to rainfall.

The hydraulic conductivity of the deep formation has been estimated to be 1.01×10^{-10}m/s and 2.03×10^{-11}m/s based on slug test calculations at BH01 and BH03 (Red Earth Geosciences, 2009). Packer testing has indicated the hydraulic conductivity to be 1.5×10^{-8}m/s for BH10d and 8.1×10^{-9}m/s for BH12d based on the geometric mean of packer tests conducted whilst drilling (IGGC, 2009). The packer tests showed some indication of a general decrease in hydraulic conductivity with depth (refer to Figure 6.3 in IGGC, 2009). Based on these results an engineered compacted clay liner with a design hydraulic conductivity of 1×10^{-9}m/s will not reduce groundwater inflow significantly. Localised grouting of active fracture zones should be considered if a reduction in the groundwater inflow rate is required to assist in leachate management, and experience with grouting of fractures for tunnelling projects in the Sydney basin shows this approach to be effective.

The long-term groundwater inflow rate is expected to reduce over time due to the reduced hydraulic gradient as the leachate levels build up in the pit. On this basis and subject to further investigations and data to be obtained as recommended by Red Earth Geosciences (2009), it appears that groundwater inflow is likely to be a negligible factor in water balance calculations.

Leachate Water Balance (ERM, 2008)
The leachate water balance was presented in Appendix D of the EA (ERM, 2008). The leachate water balance is summarised herein. It was anticipated that the 'best case' infilling rate of the landfill was approximately 400,000 tonnes/year (estimated to be 235,000 m^3/year), however, under 'worst case' conditions the infilling rate is likely to approximate 700,000 tonnes/year (estimated to be 413,000 m^3/year). Under best case conditions it is anticipated that the pit cavity will be infilled within 65 years, this will shorten to approximately 26 years under worst case infilling conditions.

DECC requested that a spreadsheet based model be developed by ERM to assess the required discharge rates for leachate; the likely leachate water elevations in the landfill; the required leachate surface storage; and the anticipated discharge rate to sewer. A spreadsheet-based model was developed by ERM in accordance with the Draft Environmental Guidelines: Landfilling (DECC, 2008) as per DECC recommendations and included the following parameters:

- Monthly time steps over a period of 100 years;
- The incorporation of 90th percentile wet years at year 1 and at 10 year intervals. Average rainfall conditions were used for the remaining years;
- Groundwater inflow to the pit of $2m^3$/day;
- A surface area of the landfill base of $12,000m^2$ and a maximum surface area of $265,000m^2$;
- In accordance with the Draft Environmental Guidelines: Landfilling (DECC, 2008) there has been an assumption that 50% of rain falling on the temporary capping at the surface of the landfill becomes leachate while the remaining rainfall runs off as surface water. Following this it is assumed that 10% of rain falling on the landfill cap after closure becomes leachate; and
- The spreadsheet model was also designed to incorporate the infilling procedure outlined above.

The key ERM data relevant to this document are summarised follows:

- The design of the infilling system will allow separation of surface water run-off from the sides of the landfill from the rain falling directly onto the landfill waste and infiltrating to become leachate. This will significantly reduce the volume of leachate generated;
- Table 7 below summarises the conservatively estimated volumes of surface water and leachate generated within the landfill. Based on this, leachate generated was anticipated to range between 45 and $872m^3$/day, with and average of $241m^3$/day;
- In order to maintain groundwater elevations at acceptable levels within the landfill pumping rates from the landfill will be required to range between $250m^3$/day and $500m^3$/day;
- Providing that pumping rates do not fall below $241m^3$/day, the landfill will be able to be used as a storage facility during times of high rainfall. This will allow a constant flow rate to be achieved from the leachate collection system and will negate the need for surface storage capacity for leachate pumped from the landfill;
- At the completion of the landfill and subsequent capping, leachate generation is likely to fall below $90m^3$/day. Due to the potentially poor ability of the regional groundwater system to absorb this volume of leachate there is potential for leachate elevations to eventually rise above the regional groundwater elevation and begin recharging the shallow perched groundwater system. Post landfill monitoring will help to quantify this process, however, there is potential for ongoing pumping to be required to prevent impact to receptors in potential hydraulic contact with the landfill.

The results presented in Table 7 represent the results for a ‘best case’ landfill filling rate. These results were found not to change significantly under worst case conditions.

Table 7: Surface Water & Leachate Generation Estimates (ERM, 2008)

	Surface Water Inflow (m^3/day)	Leachate Generation (m^3/day)	Total Inflow (m^3/day)
Minimum	209	45	254
10th Percentile	238	119	357
Average	385	241	626
90th Percentile	507	374	881
Maximum	1,003	872	1,875

Peak Leachate Generation

The leachate storage/injection trench for the new tipping area should provide sufficient storage capacity to deal with a 1 in 20 year ARI 24-hour storm. The potential volume of leachate or contaminated run off volume generated during such an event is given in Table 8.

Table 8: Peak Leachate Generation, Active Tipping Face (4,000 m^2)

	1:20 year ARI (m^3 /day)	1:20 year ARI (L/s)
Rainfall Intensity	9.27 mm/hr	9.27 mm/hr
Volume Generated – Active Tipping Area	890	10.3

This indicates leachate generation of 890m^3 during a 1 in 20 year 24-hour storm event, with a flow rate of 10.3 L/s. A leachate collection trench should be designed with a capacity of 890m^3 minus the effective infiltration rate.

Should the capacity of Leachate collection system become inadequate, a longer trench lengths will be constructed to aid in infiltration.

3.1.3 Uncertainty in the Water Balance Calculations

The recalibrated water balance for LHBC is considered to be reliable, and the similarity in results between the current version and the previous calibration gives an additional degree of confidence. There is inevitably a degree of uncertainty in such assessments, and the main areas of uncertainty for this site are:

- Groundwater inflow;
- Leachate storage (note that this does not apply to the long term average leachate generation estimates); and
- Proportion of infiltration.

Recalculation of the water balance on an annual basis has been suggested, and this approach should be adopted to allow regular refinement of the process and to allow changes in site conditions to be taken into account.

3.1.4 Haul Road Stormwater Collection System

As indicated previously, it is proposed that the Haul road from the lip of the Quarry to its base will be graded with a fall towards the perimeter quarry wall at the base of which will be formed a dish drain. Further details are outlined on page 69 of the EA (ERM, 2008).

The stormwater pond will receive stormwater runoff from the dish drain on the haul road.

The volume flowing from the dish drain to the stormwater pond will be estimated using a "V" notch weir and water level logger and total potable water use is also measured, but the groundwater component will only be able to be measured during dry weather.

Aspects of the monitoring programme are aimed at verification of base data for the SWLMP and quantification of leachate that will be required to be discharged from site (a requirement of the site development approval).

4. Erosion & Sediment Control Plan

The planning condition for the erosion and sediment control plan states:

The erosion and sediment control plan must:

- be consistent with the requirements in the latest version of Managing Urban Stormwater: Soils and Construction (Landcom);
- identify the activities on site that could cause soil erosion and generate sediment; and
- describe what measures would be implemented to:
    - minimise soil erosion and the transport of sediment to downstream waters, including the location, function and capacity of any erosion and sediment control structures; and
    - maintain these structures over time.

The following subsections of the report seek to address the above planning condition. The information primarily derives from reports prepared previously by others and from information in Managing Urban Stormwater: Soils and Construction 4th Ed. (Landcom, 2004) – the Blue Book.

Activities on the site that could cause soil erosion and generate sediment during the construction have been identified in the Consolidated Stormwater Management Plan (Martens, 2011) presented in Appendix C. The report outlines the measures to be implemented to minimise soil erosion and the transport of sediment to downstream waters, including the location, function and capacity of any erosion and sediment control structures and to maintain these structures over time.

Furthermore, erosion and sediment control measures are inextricably linked to the general Surface Water Management Plan presented in Section 5. The erosion and sediment control plan is therefore primarily covered under the Surface Water Management Plan in Section 5.

4.1 Construction Phase

In summary, during the construction phase of the project the following sediment and soil erosion management measures will be implemented:

- Prior to major surface disturbance graded contour drains, diversion channels, catch drains, sediment traps and basins will be constructed in order to allow water flows to pass through the disturbed areas without mixing with unfiltered run off from the disturbed areas;
- Silt fences and hay bales will be installed where required downstream of disturbed areas, base of embankments, existing drainage lines, earthworks stockpiles;
- All vehicles exiting the site will, if required, travel through a wash down area to limit tracking of dirt;
- Exposed construction areas will undergo regular wet downs to limit sediment erosion and aid in dust suppression. Construction areas include but are not limited to embankment and excavation areas, stockpile areas, site facility and storage areas and temporary work areas;
- On going earthworks will be protected by temporary berms and drains to prevent the scouring of unconsolidated earthworks;
- Where prompt revegetation cannot be completed, implement erosion control measures including silt fencing until revegetation is completed;
- Sediment loaded water may be treated (flocculation) at stormwater sumps before discharge to detention basins.
- Velocities in drainage system will be limited by implementing sediment barriers in order to minimise possible scouring and to encourage precipitation of particulates in run off;
- Access track will be provided where practicable, along the toe of embankments to allow access for maintenance;
- Vegetation will be maintained in and adjacent to drainage lines;
- Pits and sumps will be cleared of silt build up following large storm events;
- Sedimentation basins will be kept in a drawn down state by preferential use of the water quality if required; and
- Wash out concrete delivery vehicles and wash down plant items a minimum of 20m from stormwater drainage systems and natural water course.

Other management measures:

- A detailed site inspection will be conducted after a significant rain event to confirm that erosion control safeguards are working effectively;
- Monitoring and testing of water quality if required.
- Inspection of silt fences regularly to confirm that they are not partially buried and still in good condition
- Conducting regular inspection of water management safeguards and complete checklist; and
- Fuelling and servicing all plant and equipment on a safe area away from any water course.

The proposed sediment and erosion management measures during the construction phase are depicted Drawing 2, Appendix A. Temporary drains attaching to specific areas of construction are not shown as it will be assessed on a task basis and will change according to area of work. Blue Book (Landcom) diagrams are presented on Drawing 1, Appendix B and shows the construction methodology for proposed sediment and erosion management measures.

5. Surface Water Management Plan

The planning condition for the stormwater management scheme (surface water management plan) states:

The stormwater management scheme must:

- Be consistent with the guidance in the latest version of Managing Urban Stormwater: Council Handbook (DEC, 1997); and
- Include the detailed plans for the proposed surface water management system.

The following subsections of the report seek to address the above planning condition. The information primarily derives from reports prepared previously by others and from information in draft Managing Urban Stormwater: Council Handbook (DEC, 1997) and Managing Urban Stormwater: Soils and Construction 4th Ed. (Landcom, 2004).

5.1 Background

The Consolidated Stormwater Management Plan (Martens, 2011) is presented in Appendix C. The report outlines plans for the proposed surface water management system. Key aspects of the report are reproduced herein.

Part of the analysis required for successful development of the Resource Recovery Facility (RRF) and Landfill Facility includes planning of surface water management for the site. As water is both an input and output (waste product) of site activities, site planning needs to adopt an integrated approach to water management.

The key issues concerning site surface water (stormwater) management comprise:

- Segregation and management of ‘clean water’ (water from operational areas) and ‘dirty water’ runoff (i.e. leachate), or
- Water that has come into contact with mixed wastes, green and timber wastes and uncovered landfilled wastes);
- Erosion and sediment control including protection of the drainage system from sediment influx;
- Quarry pit/haul road water management;
- Water quality control; and
- Provision of adequate on-site detention for the proposed operations.

Additionally, the Precinct Plan and Engineering Guide to Development require that pipe sizes be based on a 20 year ARI design flow and that the major drainage system be designed to safely convey the critical 100 year event under normal operating conditions.

Surface runoff generated on-site will fall into two categories:

- 'clean water' (not leachate) – available for reuse (following roof water collection in rainwater tanks or runoff from clean operational areas which may require treatment for sediment only), and
- 'dirty water' (leachate) – generated from the base of the landfill, green waste areas and run off that has come into contact with mixed wastes, green and timber wastes and uncovered landfilled wastes.

Given the recent and impending changes to climate (including pronounced drought conditions), it is intended that the site remains as independent as possible of external water sources, and that the potential for off-site impacts to local receiving waters is minimised.

5.2 Delineation of Surface Water Catchments

Surface water management of the site is based on the principle of separation of the site into different areas, according to the activities undertaken in each area and the treatment/disposal requirements for surface water runoff arising from these. Table 9 describes the proposed land uses and water management requirements for the Sectors nominated by LHBC.

Table 9: Land Use and Water Management Requirements

Land Use	Water Management Requirements
Sector A: Area 1 - Clean operational areas (hard fill sorting/processing) including roads, car parks aprons and building surrounds	Discharge to stormwater with sediment control and monitoring
Area 2 – Green waste areas / MPC work floor	Grading for surface water towards sump for either reuse in recirculation of green waste or to treatment plant prior to discharge to sewer
Sector B: Area 1 – Areas subject to intermediate cover and other inactive areas	Temporary capping or final capping Reuse for dust suppression or discharge through to stormwater
Area 2 – Active tipping area – consisting of daily active face and movement of work face with daily cover (leachate generation)	Treatment and/or discharge to trade waste system

At commencement of operations there will be only two main areas: the clean operational areas draining to the stormwater system, and the "dirty" area comprising the active tipping area.

During the first stage and first lift of waste (10m) there will be insufficient depth for creation of a clean stormwater pond in Sector B and all water collected in the base of the pit during this period will be treated as leachate (reference EA section 3.4.6 (ERM, 2008)).

After the first ten metres of lift there is expected to be a sufficient depth of landfilled material in order to create the Storm Water Pond.

Site Area Separation
The division of the site into Sectors with clearly defined water control systems aims to achieve the following:

- Minimise leachate generation by preventing clean water entering the active tipping area (Sector B, Area 2); and
- Prevents pollution of stormwater by ensuring that run off from the processing area, roads and car parks (Sector A, Area 1), and the inactive parts of Sector B, are differentiated by clear physical barriers and that the water are appropriately managed so as to meet compliance with stormwater standards.

Where appropriate, particularly in Sector B earth banks or drainage gullies used for delineation of clean and dirty areas, will be constructed with maximum batter grades of 2(H):1(V), and a minimum height or depth of 300mm.

Earth banks at the perimeter or lip of the Quarry are to be created by the placement of compacted road base placement of a geotextile, stabilised by compaction and followed by establishment of grass cover.

Earth bank construction is shown in an excerpt from the “Blue Book” (Landcom, 2004) presented in Appendix B.

5.3 Soil and Water Management

5.3.1 General

Site soil and water management will be required throughout the life of the project. The SWLMP will adhere to the following principles:

- It is proposed to direct all operational area (hardstand clean) surface runoff (excluding water managed within the quarry pit) towards the “Quarry” catchment (note this reference is a Blacktown City Council (“BCC”) designation and does not refer to the Pit);
- Sediment-laden stormwater from the materials stockpile area will be directed through permanent sediment capture sumps or mini-basins along surface drainage to intercept sediment prior to reduce sediment ‘slugs’ reaching the GPT. Site grading is to be used to direct sediment-laden drainage away from hardstand areas;
- The MPC work floor and green waste areas will be diverted to sewer;
- Truck access to and from the unsealed areas are to be stable and designed to prevent influx of run-on and escape of untreated flows where possible;
- Runoff from site operational areas of the RRF is to be directed through treatment devices (sediment traps and low-flow wetland treatment) and OSD for reuse prior to release to the site’s

drainage network. Overland flow paths for flows in excess of the design event are to follow natural drainage lines to the west of the site;

- Treatment devices around the site would provide sediment capture, gross pollutants where necessary, and must also be capable of capturing oil and fuel spills. Proprietary devices such as CDS, Humeceptor or similar can be selected and designed in consultation with the manufacturer to accommodate the required treatment;

The treatment devices proposed for soil and water management are:

- Small sediment sumps or mini-basins along swales to trap sediment 'slugs' if entrained in stormwater flow;
- Sediment traps, e.g. proprietary gross pollutant trap (GPT) (i.e. CDS) or baffled settlement tank capable of retaining gross pollutants, sediment, oils and grease;
- Within OSD basin: allowance for wet storage component, as a low-flow wetland for low-flow water quality treatment to remove fine suspended sediments as well as nutrients; and
- Energy dissipation in the OSD basin settling basin for pre-treatment before entry to the OSD basin will provide further attenuation and capture of sediment that may reach the detention basin.

5.3.2 Stockpile and Green Waste Area

Sediment controls installed within the materials stockpile area will be maintained to prevent clogging and to prevent excessive sediment and nutrients entering the drainage system. These controls are to include:

- Small sediment sumps or mini-basins along swales to trap sediment 'slugs' if entrained in stormwater flow. Treatment through a GPT or baffled sediment settlement underground tank at the drainage outlet of these two areas,
- Protection of drains within these areas using:
- Vehicle exclusion areas;
- Stabilisation or lining of drains;
- Check-devices such as sediment sumps or mini-basins approximately every 50 metres to attenuate flows and encourage sediment dropout;

Regular maintenance of drains and sediment traps will be undertaken to reduce loads within the system. Runoff within the MPC work floor / green waste collection area is to be managed as leachate.

5.3.3 Resource Recovery Facility

Surface runoff from the operational areas of the (Resource Recovery Facility) RRF at surface will be managed separately from runoff generated in the quarry pit and haul road.

Sources of stormwater runoff from the operational area include:

- Building roofs – workshop, MPC/ WTS, administration building and weighbridge shed – clean;
- Roads, car parks and other hardstand areas – clean, containing sediment;

- MPC work floor/green waste stockpiles – dirty (to be directed to sewer);
- Materials stockpiles/drop off zones– clean, containing sediment.

Vehicle entry points for MPC work floor, green waste and materials stockpile / drop-off areas are to be located to minimise uncontrolled runoff and sediment release outside these areas. Overland flow paths around the site are to remain stable in 100 year critical flows.

Runoff collected from the clean or sediment-only areas will be reused on site, for uses including building internal uses (toilet flushing), wheel wash facility, dust suppression (via water carts) and irrigation/dust suppression from sprinkler systems around the site.

Run off from areas (other than the green waste areas and the MPC floor) of the RRF and stockpile/drop-off zones is considered to be “clean operational waters” but runoff from these areas will be subject to treatment (sediment removal) prior to reuse.

Clean runoff from roofs will be primarily collected in rainwater tanks for reuse on-site.

Runoff from other parts of the operational area (e.g. roads, open areas away from stockpiles and buildings) will also be considered clean runoff and suitable for treatment and reuse on-site. This water will be directed to the OSD basin.

Stormwater runoff will be conveyed by a combination of major and minor drainage systems, as shown in Appendix B, including:

- An underground piped system with provision for overland flow in swales and along roads;
- Stormwater detention and pollution control structures, and
- The natural drainage systems including creeks and overland flow.

Blacktown City Council requirements are that piped networks are designed to convey 1 in 20 year flows without surcharge. Drainage overflows (greater than 1 in 100yr flows) from both these areas will be discharged away from the quarry pit via overland flow paths.

5.4 Stormwater Discharge Arrangements

Stormwater discharge arrangements proposed by LHBC are as follows:

If required water retained in OSD1 and OSD2, it may be pumped back to the 250KL tank holding capacity for use around the site in dust suppression measures.

The quality of the water released (if any) should be in accordance with the site’s Environment Protection Licence. Typically the licence will only permit discharge once the water in storage has been tested to ensure it complies with specified water quality standards for discharge.

Water quality monitoring from OSD1 and OSD2 is proposed to be carried out after a rain event or at intervals required by OEH and to ensure Compliance with Council’s policy for a suite of indicator parameters (including ammonia). The monitoring requirements are discussed in Section 6 of this report.

5.5 Peak Stormwater Generation

The stormwater management system for the site will be designed to deal with runoff generated under a range of rainfall conditions.

Volume 2B of the 'Blue Book' for Waste Landfills recommends that stormwater drains and storages be designed to ensure separation of clean stormwater from water that has come into contact with waste, and that surface water collected from cleared, non-vegetated areas be treated in accordance with stormwater guidelines.

Council guidelines require post-development peak flows to match pre-development peak flows up to the 100yr storm events. The model was run for the 2 year, 10 year and 100 year ARI storm events for 25 to 540 minutes to derive the required OSD volumes.

DRAINS software modelling allows the user to optimise OSD volume requirements. A 1 in 2, 10 and 100 year ARI storm with durations of 25 minutes to 9 hours were modelled by Martens (2011) to check discharge calculations for peak flow hydrographs.

Assumptions

The operational area (including berms) was modelled in DRAINS and incorporated an area of 19.44 ha. The operational area was divided into two separate catchments to reduce the total anticipated basin size.

OSD 1 catchment is the northern section of the operational area with a modelled area of 10.34 ha.

OSD 2 catchment occupies the southern section of the operational area with a modelled area of 9.10 ha.

The catchments were considered to be 100% pervious in the pre-development model and 13.80 ha was considered 100% impervious post-development.

These assumptions would result in conservative estimates for flow and OSD storage requirements.

Results

Peak flows from the site operational areas were calculated by Martens using DRAINS for the pre-development and post-development scenarios.

This was used to calculate the required OSD storage volume to prevent downstream hydraulic impacts as a result of site development and allow matching of pre- and post-development flows off site. Table 2 and 3 (Martens, 2011 (page 13)) shows the results of peak flow modelling.

5.6 On-Site Detention Basin (OSD) Storage Volume

Based on the OSD modelling results presented in Martens Report (Appendix B), the OSD basin storage volume of 6,000m^3 is sufficient for the proposed operational area.

5.7 Dam Safety Committee Requirements

The New South Wales Dam Safety Committee (DSC) *Risk Management Policy Framework for Dam Safety* (2006) has been reviewed for requirements and criteria for risk assessment. Among other goals, the DSC states that its mission is to develop and implement effective policies and procedures for regulation of dam safety. In general, dam safety is initially determined through a risk assessment that uses the probability of failure per dam in one year (with probabilities ranging from 10^{-7} to 10^{-3}) and the number of fatalities that would occur as a result of dam failure.

For this site, the proposed OSD basin sizes are 3,400m^3 and 2,600m^3, which is smaller than several of the existing dams at the Eastern Creek Precinct. Generally basins will be constructed so that maximum water levels will be at most one metre above existing downstream ground levels, overland flow travels across rural land towards Ropes Creek.

Flows from either basin could be classed as “slow and shallow” in relation to overland flow paths, non-defined drainage lines allowing flow dispersion, and relatively long overland flow paths over un-occupied land to the nearest defined drainage line.

In a Probable Maximum Flood the dam will have already overtopped from a smaller 1:100 event as part of its design. In a PMF event, the volume of catchment flows from further up the Ropes Creek catchment, beyond the site, are likely to be having a greater impact at this point in the catchment, in which the contribution of any (unlikely) dam failure would be negligible.

As a result, these factors contribute to a negligible risk and the Dam Safety Committee has confirmed that the OSDs do not need to be prescribed.

5.8 Groundwater and Stormwater Reuse

Primary dust suppression will be carried out by the operator using a network of:

- Spray mists and sprinkler systems for crushing, grinding and chipping operations;
- Spray mists on all material stockpiles;
- Spray mists and sprinkler systems on the perimeter berms
- Wetting of vehicles with potentially dusty loads, prior to unloading
- Wheel wash for all vehicles travelling off site
- Water carts operated as required;
- Use of onboard reservoirs on site dump trucks to allow wetting whilst in motion

The spray and sprinkler systems are supplied with potable water via five storage tanks each of 450kL capacity located next to the green waste area.

Captured clean groundwater and stormwater are stored in these storage tanks, and reused on site for manual dust suppression (using water trucks) and materials processing. During dry periods the system will be topped up with mains water.

5.9 Stormwater Drainage and Sediment Control

Effective stormwater drainage of all areas is required to minimise flow into the quarry pit and thereby reduce the potential for infiltration through the landfill cap into the waste mass, and to prevent ponding of stormwater, which could impact on landfilling operations.

To meet these requirements, capping and drainage measures have been implemented as outlined below.

Sector A
The processing area will be provided with a compacted surface, or concrete/tarmac or a bitumen concrete mix as appropriate. In addition, the surface will be laid with adequate falls to ensure effective shedding of stormwater. A minimum target fall of 1% has been applied.

Stormwater runoff from this area drains to one of two drainage systems:

- Perimeter drains and sumps will be constructed to convey stormwater from the clean operational area;
- These will comprise concrete dish drains along the north-south section, leading to sumps and from there an underground pipe directing stormwater to GPT1 for transfer to storage tanks or discharge to OSD1 (north);
- Overflow from the sump at GPT flows westward into an overland swale which will be constructed with a target fall of 1% to 5% and which is lined with geofabric, clay and rocks to limit infiltration;
- Sedimentation ponds and check dams will be constructed at intervals to control flow and encourage settlement of suspended solids, in accordance with Blue Book guidelines (Landcom, 2004);
- Sediment control measures will also been constructed around the stormwater discharge point, and will comprise a check dam and a double layer of geotextile-wrapped filter bales;

Excerpts from the Blue Book showing construction details of drainage and pollution control measures are provided in Appendix B.

Monitoring of stormwater quality at OSD1 (north) and OSD2 (south) is recommended to be undertaken during rainfall events, with a target of four monitoring events per year for the first year of operation, to ensure that sediment control is adequate.

Sector B

Inactive areas of Sector B are to be capped (temporary capping), and runoff directed to the stormwater pond in Sector B. The active tipping area and the inactive capped areas are to be separated by compacted earth banks.

After the first lift of 10 metres in which all water into the base of the pit will be treated as leachate the site will normally operated with an active tipping face area of approximately 450 - 1000 m^2, which is to be capped each day.

Until the first ten metres depth of filling is completed the area taken to leachate generating is treated as being 4,000 m^2. Thereafter the ‘open’ or exposed active filling area prone to generation of leachate will be not more than 4,000 m^2 per month.

Sector B is to be contoured to prevent ponding of stormwater in the ‘dirty’ tipping areas and to direct surface runoff to the stormwater pond at the north-eastern end of the Sector or as changed over time based on landfilling direction.

The surface of filled areas in Sector B which is not to be active for more than three months will be capped with compacted clean fill material to minimise infiltration and allow all-weather vehicular access.

Stormwater is to be collected in the stormwater pond, which also acts as a sedimentation pond. Stormwater from the pond will be pumped to the stormwater drainage system in Sector A for disposal and/or storage for on-site reuse as required.

Due to the proposed landfill location being within the existing quarry pit, sediment control per se of the landfill area is not essential as the risk of environmental damage from sedimentation is low within the quarry pit itself for those areas where water reuse does not take place. Rather, the primary aim of a collection basin within the quarry pit is to assist in controlling the volume of stormwater runoff that comes into contact with waste or the active landfill area (hence minimising leachate generation). Reuse of this water was also reviewed in a water balance model for its ability to meet demand for dust suppression, to maximise reuse potential.

Volume 2B of the ‘Blue Book’ for Waste Landfills states that sediment basins and water storages should not be located on landfilled areas. However, the unavoidable constraint of being within the quarry pit, and the need to manage runoff effectively within the pit, necessitates the use of temporary stormwater controls and storage within the quarry pit.

The use of suitable grading and bunding and inclusion of a leachate trench to separate leachate from stormwater from capped areas within the landfill is also necessary to minimise surface water flows into active landfill areas. Erosion across capped areas and sediment influx into any temporary storage at capped areas must also be accommodated.

Forward planning for the location and size of the basin is important for effective runoff and sediment control. Its location should be determined at the development of each landfill lift, taking into account that a sealed basin area is necessary to prevent infiltration, and that it is not possible to excavate through capping and back into landfilled materials.

Initial shaping or grading of capped / covered areas is necessary to allow for a suitable placement for the basin to create a catchment with a low point designed into the intermediate capped areas, to drain away from the active tip face / daily cover areas and allows placement of a liner for a basin without disturbing existing capped material.

Basin Sizing

Basin calculations were undertaken in accordance with the Blue Book for the quarry pit (26.5 ha). The maximum total basin volume based on the total quarry pit footprint (including settling zone and sediment zone) that may be required is approximately 4,362.5 m^3 which equates to 165 m^3 per hectare of catchment area, which may include quarry walls that drain into the pit.

Assumptions and spreadsheets used for sediment basin sizing including rainfall percentiles are presented in Appendix B of the Storm Report (Appendix C) and include the use of 5-day, 80th percentile rainfall and 2-month sediment accumulation.

Sediment influx can be reduced by including a controlled, stabilised inlet to the basin and installing and maintaining effective erosion controls around the haul road outlet and around the boundary of the basin.

A series of basins may be installed to capture flows from sub-catchments of the quarry depending on available space within the quarry. The sub-basins will need to meet minimum storage requirements of 165 m3/ha of catchment draining to each basin.

Based on the basin sizing assumptions used, drawdown of water within the basin would need to occur within 5 days of a storm event occurring, to follow the basin design requirements and also to minimise the time that water is stored at the landfill area.

Water collected in the basin should be used initially for in-pit dust control or other uses requiring water in the pit area. Basin(s) may be drawn down by the water carts for dust suppression purposes or used in dump truck on-board reservoirs.

Guidelines for the construction of the stormwater basin within the landfill area

The designated area covers approximately 4362.5m^3. The proposed outline design comprises wet earth basins: a relatively small first pond to allow preliminary settlement and/or filtration of coarse sediments; followed by a full-size main pond to allow full settlement.

The main objective of the preliminary settlement pond is to reduce clean-out requirements for the main pond. The typical design and construction of a wet earth basin is shown on the excerpt from the “Blue Book” presented in Appendix B.

The basin will be lined using a seam welded HDPE membrane to prevent infiltration of stormwater into the subgrade and underlying waste mass. Discharge of water from the basin is to be by pumping from a floating pump intake after field testing to confirm acceptable water quality.

The sizing of the preliminary basin is considered not critical, but should be as large as is practicable. Construction of any HDPE lined basins should be undertaken as follows:

- Design of the appropriate geometry and dimensions;

- Placement of a protection layer comprising uniform compacted fill, with the need for a geotextile protective layer considered depending on detailed ground conditions;
- Placement of the HDPE liner and welding of the sheets, with appropriate post construction inspection and quality assurance to ensure suitability of the final liner; and
- Placement of a protective layer as required, such as a sacrificial coarse sand layer and/or a geotextile. This layer is designed to minimise the risk of damage to the HDPE membrane during sediment removal, and is particularly important for the preliminary pond.

Construction of any compacted clay lined basins should be undertaken as follows:

- Design of the appropriate geometry and dimensions;
- Sourcing of clay suitable for engineered compacted clay liner;
- A maximum 300mm thick, loose lift is recommended. A minimum of 95% standard compaction is recommended. Soil placement with a density of less than 95% of standard compaction should be rejected. No more than 5% of density values can be below 95% as long as these failures are not concentrated in one lift or in one area. Moisture content should be maintained at -1% to +3% of optimum moisture content (OMC).
- The liner shall be placed with a scraper-pan or trucks and then distributed with a dozer or grader or equivalent.
- The successive lifts shall be compacted with a sheepsfoot roller. The sheepsfoot roller studs shall be sufficiently long to fully penetrated the loose layer and knead successive lifts. Compaction equipment weighing 17 tonne or more is recommended.
- Appropriate post construction inspection and quality assurance is recommended to ensure suitability of the final basin liner.

Basin Operation

The main stormwater basin is designed to provide containment of storm events, and as such should be maintained empty or with a low water level. Stormwater should therefore be pumped to the discharge point after each storm event or reused on site, after sufficient time has passed to allow settlement and testing.

Regular cleaning-out of sediment is required to prevent excessive build-up, and gauges should be installed to allow monitoring of sediment accumulation and to allow ready identification of the top of the sediment storage zone. The effectiveness of the sedimentation pond system at achieving the required water quality is depended on a number of factors, including the flow rate, sediment size distribution and dispersibility of sediments.

Use of flocculants may be considered should sediment settlement be inadequate or unacceptably slow. These include gypsum, which is relatively insoluble and must be dosed across the entire water surface to be effective, polyaluminium chloride, and proprietary block flocculants.

Occasions are likely to arise where the pond becomes full prior to adequate settlement being obtained. Under these conditions, excess stormwater will need to be discharged to the leachate drainage system until conditions are suitable for the stormwater pond to be emptied. Adequate buffer storage capacity should be maintained in the leachate drainage systems and waste mass to allow for this eventuality.

Additional Sediment and Erosion Control Measures
Prevention of sediment generation is the most effective method of stormwater quality control, and provision of erosion and sediment control measures across the catchment area is therefore a critical aspect of stormwater management. Control measures include silt fences, vegetation of inactive areas and maintenance of appropriate surface gradients.

6. Surface Water, Groundwater & Leachate Monitoring Programme

The planning condition for the surface water, groundwater and leachate monitoring programme states:

The surface water, groundwater, and leachate monitoring programme must:

- be generally consistent with the guidance in Benchmark Techniques 4, 5, 6, 7 and 8 of Appendix A of the EPA *Environmental Guidelines for Solid Waste Landfills* (1996, or the relevant sections of the latest version of the guideline); and
- include:
    - baseline data;
    - details of the proposed monitoring network; and
    - the parameters for testing and respective trigger levels for action under the surface water, groundwater and leachate response plan (see below).

The following subsections of the report seek to address the above planning condition.

6.1 Monitoring Plan - General

Monitoring would be implemented to assist in verification of the current water management plan and future water balance calculations, including the following:

- Leachate volume pumped from the sump and discharged to sewer (monthly);
- Leachate quality discharged to sewer (every 22 days);
- Volume of groundwater and clean operational water pumped out from within the pit (monthly);
- Leachate levels within the main sump (daily);
- Groundwater levels in the piezometers surrounding the quarry (quarterly);
- Groundwater quality from piezometers (quarterly);
- Stormwater quality for reuse on site (4 rain events per annum).

The monitoring programme frequency is summarised in Table 10.

Table 10: Proposed Water Management Monitoring Programme

Monitoring Type	Frequency
Leachate volume pumped from sump/discharged to sewer	Monthly
Leachate quality monitoring	Every 22 days according to Sydney Water requirements
Leachate level in sump	Daily, reported on a quarterly basis
Clean operational water within the pit/ discharged volume	Monthly
Groundwater boreholes level	Quarterly
Stormwater quality (run-off and groundwater) reused on site	Four rain events per annum
Groundwater quality	Quarterly
Surface water quality (Ropes Creek)	Quarterly

6.2 Groundwater Monitoring Programme

Benchmark Techniques No. 4 and 5 (BT4, BT5) outline the requirements for a groundwater monitoring network and monitoring programme. The groundwater monitoring programme should effectively monitor and report groundwater character, and ensure early detection and reporting of possible pollution of groundwater.

A comprehensive hydrological investigation of the site and the surrounding groundwater regime has been conducted and is presented in Appendix D. DP has also noted the findings of the peer review of the IGGC hydrogeological reports by Dr Boyd Dent of Red Earth Geosciences (Red Earth Geosciences, 2009; 2010).

Quarterly monitoring will utilise the existing monitoring well network comprising nested piezometers presented on Figure 5.2 of the IGGC report (Appendix D). A suitably qualified environmental consultant must complete all groundwater monitoring and reporting.

Groundwater levels will be recorded in the piezometers surrounding the quarry using an electronic dip meter or whistle. The groundwater monitoring consultant should give consideration to the piezometer depths and analytes (e.g. oxygen sensitive analaytes) when selecting the groundwater sampling method. The sampling method should be consistent for successive monitoring events to maximise data comparability.

A set of groundwater environmental indicator parameters for groundwater quality are presented in Table 11. It is noted that the actual parameters required under the routine monitoring programme will be stipulated on the Environment Protection Licence and may vary slightly from the table below. The parameters in the table below are extracted from BT5 (EPA, 1996).

Table 11: Indicator Parameters

Chemical Determinand	Analytical Detection Limit (µg/L)
Electrical Conductivity	1 mS/m
Ph	0.1 pH unit
Redox Potential	1 Eh
Temperature	0.1
Adsorbable organic halides (AOX)	10
Alkalinity	1000
Ammonia	50
Calcium	5000
Chloride	5000
Fluoride	500
Iron	500
Manganese	50
Magnesium	5000
Nitrate	100
Total phenolics	50
Potassium	5000
Sodium	5000
Sulphate	5000
Total organic carbon (TOC)	50

Quarterly groundwater sampling must include adequate field and laboratory quality control samples including duplicates, trip spikes, trip blanks and equipment rinsate samples.

6.2.1 Establishing Baseline Data

Establishment of baseline groundwater quality and baseline concentration ranges prior to the commencement of landfilling activities at the site is required.

Two groundwater sampling events were completed at the site by ERM. The initial sampling event was completed between 7 and 9 November 2007 and 22 and 23 November 2007. The second sampling event was completed between 20 February and 30 March 2008.

It is considered that the initial rounds of groundwater monitoring will also be suitable for inclusion into a baseline dataset. The determination of what data is suitable to retain in the baseline dataset should be made by the monitoring consultant (hydrogeologist). It is anticipated that at least data from the initial two quarterly monitoring events would be suitable to use in the baseline dataset.

The monitoring consultant will need to tabulate the previous ERM data in addition to subsequent data deemed suitable for inclusion in the baseline dataset. It would be prudent to collect as much quarterly monitoring data prior to commencement of landfilling activities as practicable to establish a robust baseline dataset that includes seasonal variability.

6.2.2 Reporting of Groundwater Monitoring

Groundwater data will be summarised, graphed and interpreted to determine trends, assess impacts against the baseline water quality at the site, and evaluate any exceedances of relevant published guideline values (e.g. ANZECC (2000)).

Trigger levels for action should be based on the variance from baseline range concentrations (yet to be established) with respect to naturally occurring groundwater constituents. Trigger values for anthropogenic contaminants (e.g. AOX or total phenolics) should be based on detection of the contaminants in groundwater above the analytical detection limit, as this may indicate that leachate is impacting the groundwater. Further comparison of detected concentrations against relevant published guideline values (e.g. ANZECC (2000)) should be undertaken in order to evaluate the overall risk posed by naturally occurring and anthropogenic contaminants in the groundwater.

In the event of the monitoring consultant (hydrogeologist) detects a possible failure of the leachate containment system, a groundwater assessment programme should be established to determine the extent of that failure. This would form part of a groundwater action plan or water contamination remediation plan as required under Benchmark technique No 9 (BT9). The formulation of the action plan will depend on the nature and extent of the groundwater contamination. Further information on a groundwater response plan is presented in Section 7.2 of this SWLMP report.

6.3 Surface Water Monitoring Programme

The surface water monitoring programme must be able to demonstrate that surface water is not polluted by the landfill. Surveyed monitoring points will be established at the entry and discharge points of the OSD basins. The locations will be monitored a minimum of four times per year during a rain event.

If the surface water monitoring programme detects water pollution, the occupier should follow the procedures outlined in the Water Contamination Remediation Plan to investigate surface water pollution.

Stormwater from the clean area of Sector A and the clean area of Sector B discharges via GPT1 and GPT2 to the OSD basins via swales.

The quality of the water released (if any) should be in accordance with the site Environment Protection Licence. Typically, the licence will only permit discharge once the water in storage has been tested to ensure it complies with specified water quality standards for discharge. The water quality criteria in Table 12 are suggested based on the requirements of the draft OEH site licence and on ANZECC (2000) criteria.

Table 12: Proposed Stormwater Quality Criteria for Discharge

Analyte	Unit	Proposed Criterion
Ammonia	mg/L	0.9[1]
pH	pH Units	6.5 to 8.5[2]
Dissolved Oxygen	% Saturation	80-110%[2]
Oil & Grease	mg/L	10[3]
Suspended Solids	mg/L	50[3]
Total Organic Carbon	mg/L	10[3]
Lead	mg/L	0.0034[1]
Phenol	mg/L	0.32[1]
Total Nitrogen	µg/L	350[4]
Total Phosphorous	µg/L	25[4]

Notes: 1: ANZECC (2000) Default Trigger Values, Toxicants
2: ANZECC (2000) Criteria for Environmental Stressors
3: Typical DEC discharge water quality criteria applied for industrial and/or landfill sites in Sydney
4: Blacktown City Council Water Quality and Quantity Monitoring Programme 2008 – 2012

The OSD basins, swales and GPTs will be inspected daily as part of the daily Site Environmental Inspection to be undertaken by the site Operational Manager. Sediment ponds must be maintained in a manner that ensures these retain an appropriate freeboard to minimise the potential for any turbid discharge. The health of the wetland plants must be maintained to ensure water quality control. Depth indicators will be installed and maintained within the OSD basins, that indicate the required freeboard to be maintained. If daily inspections reveal the build up of sediment, or that the health of the wetlands is failing, immediate maintenance will be undertaken. Otherwise, maintenance on the OSD basins will occur every three months.

All results of maintenance and monitoring will be available for inspection on site by the OEH, and will be reported in the annual report to the OEH in accordance with the Environment Protection Licence

6.4 Leachate Monitoring Programme

The leachate monitoring programme will involve three components:

- Monitoring of the leachate level in the primary (basal) sump;
- Monitoring of the leachate level in successive sumps;
- Monitoring leachate quality prior to discharge to sewer; and

- Monitoring leachate generation volumes to calibrate the leachate water balance.

Leachate level monitoring in the basal sump and the active successive sump will be done on a daily basis. Level monitoring will be used to evaluate the connectivity of leachate accumulation at the base of the landfill relative to perched leachate that accumulates in the active successive sump. It will also be used to monitor the proposed storage of leachate in the landfill (i.e. recovery of the leachate head to 70 – 80m above the quarry base.

Leachate disposal for the treated leachate is as trade waste. Industrial customers need to meet the conditions of Sydney Waters trade waste criteria. Monitoring of leachate water quality for discharge to sewer will be done in accordance with the requirements of the Trade Waste Agreement with Sydney Water.

Monitoring of pumped leachate volumes will be done using flow meters. The monitoring data will be used to further refine the water balance based on actual generation rates.

7. Surface Water, Groundwater & Leachate Response Plan

The planning condition for the surface water, groundwater and leachate response plans states:

The surface water, groundwater and leachate response plan must:

- include a protocol for the investigation, notification and mitigation of any exceedances of the respective trigger levels; and
- describe the array of measures that could be implemented to respond to any surface or groundwater contamination that may be caused by the development.

The following subsections of the report seeks to address the above planning condition.

7.1 Surface Water Response Plan

In the event of any identified contamination the following steps will be taken:

- The water will be re-sampled and retested as soon as possible;
- If the indication of contamination persists, the flow will be contained, i.e. the discharge point will be closed;
- OEH will be notified;
- A Water Remediation Plan, suited to the particular circumstances, will be put into place, to the satisfaction of Council and the OEH.

7.2 Groundwater / Leachate Response Plan

The primary objective of groundwater contaminated remedial plan is to ensure that the escape of leachate does not continue to contaminate groundwater quality following its detection. In order to achieve this objective, an individual plan relating to groundwater and surface water will need to be prepared upon detection of any anomalies in the groundwater quality.

As discussed in the groundwater and surface water management and controls that in the event of any identified contamination in groundwater the following steps will be taken. Initially the OEH will be informed within 24 hours of the exceedance and within 14 days in writing and steps will be taken to re-sample from the locations which showed the exceedance of the established environmental trigger levels.

Re-sampling results will determine if an adverse trend is developing, or whether the initial exceedances were isolated incidents or spurious readings. Once a trend has been established which indicates deteriorating groundwater quality then a suitable groundwater remediation action plan will be developed and notification of environmental harm made to the OEH.

Detailed plans cannot be provided until the nature of the problem has been identified. Proposals for voluntary groundwater remediation (i.e. the groundwater remediation action plan) will be forwarded to the OEH for agreement.

Results of the monitoring programme, details of any required action plans and implementation of the remediation programme and its results will be provided in the annual report as specified in the site license.

8. Conclusions on Soil, Water & Leachate Management Plan

This report describes the proposed soil, water and leachate management practices for the recycling premises and the landfill premises at the LHBC site. These are based on a variety of reports prepared by others. It includes stormwater management for the proposed separation of the site into clean operational (draining to the stormwater system or used in dust suppression) and leachate areas (draining to a leachate re-injection trench).

The estimated average leachate generation rate can be expected to vary between 45m^3/day and a maximum of 872m^3/day (ERM, 2008). However due to the storage capacity provided by the waste mass and the separation of the site areas for collection of clean water within the pit for the purposes of landfill mitigation measures e.g. dust suppression, the total leachate generation is expected to be at most 500m^3 per day. The proposed site leachate management and disposal system is considered adequate to deal with these volumes, and includes excess capacity and buffering storage to deal with higher short-term flows during wet weather periods.

Filling Plan

The current filling plan involves tipping in the active area of the landfilling premises. Filling and capping of filled areas is being carried out progressively. Filling at the Site is estimated to take over 20 years, based on proposed waste input rates. A new filling plan will be produced at least six months before filling is due to be completed.

Groundwater Monitoring Network

The proposed groundwater monitoring network is based on the hydrogeological conditions of the site. The proposed monitoring network is considered to be adequate to enable satisfactory monitoring of groundwater conditions and to determine the effects of the landfill site on the surrounding groundwater systems.

Hydraulic Containment and Potential for Leachate Migration

Operation at the site is proposed to be on the basis of hydraulic containment, whereby leachate is maintained at a level below that in the surrounding groundwater systems, in order to maintain an inward hydraulic gradient. The system will be based on the concept design proposed by Earth2Water comprising compartmentalised waste cells and partial landfill lining (i.e. a basal, followed by two intermediate liners with no side wall liner).

DP understands from Alexandria Landfill Pty Ltd that the OEH has suggested that leachate may be stored in the landfill provided leachate elevations are maintained below the base of the regional groundwater levels (to maintain an inward head gradient). Based on the regional groundwater elevations observed at the site, this would suggest a potential leachate elevation approximating to a level 70 – 80m above the pit base, which in turn suggests that there is potential from time to time to operate at pumping rates well below 500m^3.

However, average pumping rates above 250m^3/day are likely to be required to conservatively ensure an adequate inward hydraulic gradient towards the landfill. The proposed leachate treatment system, being able to treat double that amount, should be adequate to deal with this daily treatment and pumping average. Additional sequencing batch reactors (SBR) could be used to supplement the system based on the actual volumes of leachate generated if required.

Review of Data

The data gathered from the monitoring programme associated with implementation of this report should be reviewed on a regular basis. Changes to the overall system including monitoring requirements / frequency would be recommended based on the data reviews.

9. References

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Red Earth Geosciences, 2009. Draft Review of Hydrogeological Investigations and Considerations for Development of a Disused Quarry at Eastern Creek, NSW.

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Storm Consulting 2008. Site Surface Water Management Plan.

10. Limitation of this Report

Douglas Partners (DP) has prepared this report for this project at Light Horse Business Centre off Old Wallgrove Road, Eastern Creek, in accordance with DP's proposal SYD090902 dated 5 October 2009 and acceptance received from Christopher Biggs dated 14 October 2009. The work was carried out under DP Conditions of Engagement. This report is provided for the exclusive use of the Alexandria Landfill Pty Ltd for the specific project and purpose as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

Whilst DP has prepared this report, completing a detailed technical review of reports prepared by others was not part of DP's scope of work, and in this regard, DP is not formally endorsing the calculations, designs or recommendations provided by others (e.g. ERM, IGGC, Martens and Storm Consulting) summarised herein unless expressly stated.

This report must be read in conjunction with all of the attached notes and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion stated in this report.

This report, or sections from this report, should not be used as part of a specification for a project, without review and agreement by DP. This is because this report has been written as advice and opinion rather than instructions for construction.

Douglas Partners Pty Ltd

About this Report

Douglas Partners

Introduction

These notes have been provided to amplify DP's report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

DP's reports are based on information gained from limited subsurface excavations and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

Copyright

This report is the property of Douglas Partners Pty Ltd. The report may only be used for the purpose for which it was commissioned and in accordance with the Conditions of Engagement for the commission supplied at the time of proposal. Unauthorised use of this report in any form whatsoever is prohibited.

Borehole and Test Pit Logs

The borehole and test pit logs presented in this report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable or possible to justify on economic grounds. In any case the boreholes and test pits represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

Groundwater

Where groundwater levels are measured in boreholes there are several potential problems, namely:

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole is left open;
- A localised, perched water table may lead to an erroneous indication of the true water table;
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical and environmental aspects, and recommendations or suggestions for design and construction. However, DP cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

If these occur, DP will be pleased to assist with investigations or advice to resolve the matter.

About this Report

Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

Information for Contractual Purposes

Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.