

Leachate Collection System

Concept Design

for ThaQuarry Pty Ltd

August 2008

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FINAL REPORT

ThaQuarry Pty Ltd

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August 2008

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**Environmental Resources Management
Australia**
Building C, 33 Saunders Street
Pyrmont, NSW 2009
Telephone +61 2 8584 8888
Facsimile +61 2 8584 8800
www.erm.com

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1.1***INTRODUCTION***

ThaQuarry Pty Ltd and ACN 114 843 453 Pty Ltd seek project approval for the construction and operation of a resource recovery facility (including a materials processing centre (MPC) and waste transfer station (WTS), and a General solid waste landfill at Eastern Creek, in Sydney's west, New South Wales (NSW). Project approval is sought under Part 3A of the *Environmental Planning and Assessment Act, 1979*. The application process is to be managed on behalf of both parties by ThaQuarry Pty Ltd under the project name Light Horse Business Centre.

Environmental Resources Management Pty Ltd (ERM) was commissioned by the proponent to prepare conceptual designs for leachate collection and review approaches to landfill waste disposal at the proposed Light Horse Business Centre. This study forms part of the Environmental Assessment for the proposed landfill.

The predominant feature at the proposed Project site is a breccia quarry known as the Pioneer Quarry, where extractive operations started in the 1950s. The quarry has now reached the end of its economic life and all quarrying activities at the site ceased in September 2006 though the quarry void remains. The proposed landfill facility will be located in the quarry void. Key features of the proposed landfill are summarised in *Table 1.1*.

Table 1.1 *Key Landfill Features*

Item	Description
Waste Input	Non-putrescible class 2 inert and solid waste originating from construction and demolition (inert building and demolition wastes) and commercial and industrial waste streams, contaminated soils and asbestos waste. Waste input will exclude foodstuffs, liquid wastes, medical wastes, toxic and hazardous wastes.
Fill rate	Estimated 0.4 to 1 million tonnes per annum (mtpa), with an average fill rate of 0.7 mtpa.
Neighbours	M4 Motorway and low density residential and industrial areas of Minchinbury to the north and bounded on other sides by open grazing land, with the Hanson Asphalt Batching Plant and Hanson yard along part of its eastern boundary.

Item	Description
Nearest Surface Water Features	Ropes Creek approximately 500m west of the site boundary and a tributary of this creek running east-west across undeveloped grazing land that forms the southern part of the site.
Surrounding topography	Gently undulating to flat
Geometry of void	Open cut elliptical void approximately 430 metres (m) x 700m and up to 150m in depth. Surface area is around 265,000 m ² at ground surface and 12,000 m ² at the base.
Walls of void	Benches of approximately 7 to 8m in width descend down the sides of the void. The upper part of the quarry is excavated through unconsolidated sediments including clays and weathered shales and therefore has lower angled slopes. A spiral access road around 20m in width around the edge of the void descends to the quarry base.
Base of void	A rectangular level area (-57m above Australian Height Datum (AHD) ^(a)). A raised area (approximately 8m higher ^(b)) is present to the east of the rectangular base. The base is fairly flat and drains to a sump from which groundwater ingress and run off is currently pumped.

Notes:

- (a) ERM (2008a) Light Horse Business Centre, Eastern Creek, NSW, Australia: Groundwater Assessment
- (b) From plan of existing void

1.2

OBJECTIVES

The objectives of this study are to:

- provide an opinion on whether a liner would be needed for the landfill;
- develop and provide detail on options for collecting leachate at the proposed landfill;
- recommend a preferred option for leachate collection, taking account of site geology, hydrogeology, water chemistry, calculated water balance and client specifications;
- recommend leachate collection system components that aim to preserve structural integrity and longevity of the piping and drainage materials in the landfill; and
- recommend measures to maintain and minimise the potential for failure of the leachate drainage system.

1.3

GEOLOGY AND HYDROGEOLOGY

A full review of the geology and hydrogeology of the site is set out in Volume 2 of the EAR *Appendix B: Groundwater Assessment*, prepared by Environmental Resources Management (ERM), July 2008. The key features that relate to the collection of leachate are:

- the surficial geology comprises clay and weathered shales to depths approximating 32 m bgl. Some fill material was identified in wells located on bunded areas to depths approximating 6 m. Intact shales predominate below the weathered shales down to depths approximating 146 m bgl. A survey of the pit wall suggests some geological changes and fracturing along the eastern and southern walls of the pit. The Hawkesbury Sandstone is likely to be located approximately 20 m below the base of the quarry;
- there is an intermittent shallow perched groundwater system located around the quarry within the fill, clay and weathered shale. Permeabilities of these deposits range from 1.46E^{-3} m/day to 0.25 m/day. Based on the very isolated seepage observed from the clay and weathered shales exposed on the pit walls, this system is not in significant hydraulic contact with the quarry. This suggests that, provided leachate levels within the pit are kept below the base of the shallow aquifer system, leachate migration into this system is unlikely to occur. The water quality of this aquifer is considered to be poor and of limited human and environmental value; and
- there is a deeper regional groundwater system located within the shale deposits. The permeability of this shale has been calculated to be very low (1.75E^{-6} m/day to 8.7E^{-6} m/day). These permeabilities are below specified criteria for clay liners. The elevation of this water table is likely to be in excess of 24 m AHD, which approximates 82 m above the pit base. This indicates a strong inward hydraulic gradient and suggests that the bulk formation hydraulic properties (including fracturing) of the surrounding geology are low. Given the low permeabilities of the geology surrounding the pit there is unlikely to be significant hydraulic contact between the quarry pit and the underlying Hawkesbury Sandstone. These factors negate the need for the landfill to be lined. Overall, seepage from regional groundwater system into the quarry pit was estimated to approximate 2 m³/day. The water quality of this aquifer is considered to be poor and of limited human and environmental value.

It is anticipated that the ‘best case’ infilling rate of the landfill will approximate 400,000 tonnes/year (estimated to be 235,000 m³/year), however under ‘worst case’ conditions the infilling rate is likely to approximate 1,000,000 tonnes/year (estimated to be 588,000 m³/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 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 (refer to *Annex B Leachate Modelling spreadsheet*).

The spreadsheet based model was developed 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 2 m³/day;
- a surface area of the landfill base of 12,000 m² and a maximum surface area of 265,000 m²;
- 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 is also designed to incorporate the infilling procedure outlined above.

Details of the proposed infilling procedure are presented in the *Figure 3.5* of the main report and are detailed by ERM (2008a).

The key 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 1.2 below summarises the conservatively estimated volumes of surface water and leachate generated within the landfill. Based on this leachate generated is anticipated to range between 45 and 872 m³/day, with an average of 241 m³/day;*
- *in order to maintain groundwater elevations at acceptable levels within the landfill pumping rates from the landfill will be required to range between 250 m³/day and 500 m³/day;*
- *providing that pumping rates do not fall below 241 m³/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 90 m³/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 1.2* represent the results for a ‘best case’ landfill filling rate. These results were found not to change significantly under worst case conditions.

Table 1.2 Surface water and Leachate Generation Estimates (Spreadsheet Water Balance Model)

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

1. Values are based on monthly rainfall data.

1.5

WATER CHEMISTRY OF LEACHATE

Table 1.3 presents the anticipated contaminant concentrations present within leachate discharged from the landfill. Further detail on the rationale behind the values listed are provided in ERM (2008a), but a summarised as follows:

- the landfill is likely to accept solid and inert wastes. The NSW EPA (1999) Guidelines for the Classification of Liquid and Non-liquid Waste provide threshold concentrations for leachate from solid waste material. The threshold concentrations for key solid waste contaminants are presented in *Table 1.3* and are considered to represent the upper limits of contamination expected to leach from the landfill waste;
- the likely leachate concentrations presented in *Table 1.3* have been obtained from a similar solid waste landfill located at Alexandria, NSW;
- the leachate concentrations are compared against Sydney Water trade waste criteria as this is the proposed primary means of discharging leachate water from the site;
- based on the information presented in *Table 1.3* expected contaminants requiring treatment will include:
 - ammonia, barium, petroleum hydrocarbons and polycyclic aromatic hydrocarbons, which are considered likely to be present within likely leachate concentrations; and
 - BTEX, chlorinated phenols, chloroform, cyanide, fluoride, metals and phenols, which are considered unlikely to be present at the concentrations identified in *Table 1.3* but which should be included in initial monitoring and treated if identified in excess of the trade waste criteria; and
- All infrastructure developed to house and transport leachate (i.e. the leachate collection system) will need to be constructed of materials to withstand the chemicals present within the leachate. Therefore the data presented within *Table 1.3* will form the base chemistry data for selecting suitable infrastructure materials when detailed design is undertaken following development application approval.

Table 1.3 Potential Contaminant Concentrations within Seepage Water

Contaminant	Solid Waste	Likely Leachate Concentration	Trade waste Discharge Criteria
	Leachable Concentration		
	TCLP2 (mg/L)	mg/L	mg/L
Aluminium	Nc	0.04	100
Ammonia as N	Nc	229	100
Arsenic	5	0.008	1
Barium	Nc	2.4	2
Benzene	0.5	0.002	0.1
Benzo(a)pyrene	0.04	nc	nc

Contaminant	Solid Waste	Likely Leachate Concentration	Trade waste Discharge Criteria
	Leachable Concentration		
	TCLP2 (mg/L)	mg/L	mg/L
Beryllium	1	nc	nc
Bicarbonate	Nc	2500	nc
Calcium	Nc	139	nc
Cadmium	1	0.0001	1
Carbon tetrachloride	0.5	nc	nc
Carbonate	nc	nc	nc
Chloride	nc	1860	nc
Chlorobenzene	100	nc	nc
Chloroform	6	nc	0.1
Chromium (total)	nc	0.023	3
Chromium (VI)	5	nd	3
Cobalt	nc	0.008	5
Copper	nc	0.002	5
m-Cresol	200	nc	nc
o-Cresol	200	nc	nc
p-Cresol	200	nc	nc
Cresol (total)	200	nc	nc
Cyanide (amenable)	3.5	nc	1
Cyanide (total)	16	nc	nc
2,4-D	10	nc	nc
1,2-Dichlorobenzene	4.3	nc	nc
1,4-Dichlorobenzene	7.5	nc	nc
1,2-Dichloroethane	0.5	nc	nc
1,1-Dichloroethylene	0.7	nc	nc
Dichloromethane	8.6	nc	nc
2,4-Dinitrotoluene	0.13	nc	nc
Electrical Conductivity ($\mu\text{S}/\text{cm}$)	nc	8573	nc
Ethylbenzene	30	nd	1
Fluoride	150	0.8	20
Iron	nc	12.5	50
Lead	5	0.002	2
Manganese	nc	0.211	10
Magnesium	nc	97	nc
Mercury	0.2	nd	0.03
Methyl ethyl ketone	200	nc	nc
Molybdenum	5	nc	100
Naphthalene	nc	13.4	nc
Nickel	2	nc	3
Nitrite	nc	0.032	nc
Nitrate	nc	0.027	nc
Nitrobenzene	2	nc	
C6-C9 petroleum hydrocarbons	nc	0.05	nc

Contaminant	Solid Waste	Likely Leachate Concentration	Trade waste Discharge Criteria
	Leachable Concentration		
	TCLP2 (mg/L)	mg/L	mg/L
C10-C36 petroleum hydrocarbons	nc	15.11	10 ^b
pH	nc	6.6 - 7.49	7 - 10
Phenol (nonnchalogenated)	14.4	0.233	10
Potassium	nc	230	nc
Polychlorinated biphenyls	nc	nc	nc
Polycyclic aromatic hydrocarbons(total)	nc	13.4	5
Scheduled chemicals	nc	nc	nc
Selenium	1	nc	5
Silver	5	nc	5
Sodium	nc	1490	nc
Styrene (vinyl benzene)	3	nc	nc
Sulphate	nc	1	2000
1,1,1,2 – Tetrachloroethane	10	nc	nc
1,1,2,2nc Tetrachloroethane	1.3	nc	nc
Tetrachloroethylene	0.7	nc	0.3
Toluene	14.4	nd	1
Total Dissolved Solids	nc	4520	10000
1,1,1-Trichloroethane	30	nc	nc
1,1,2-Trichloroethane	1.2	nc	nc
Trichloroethylene	0.5	nc	0.1
2,4,5-Trichlorophenol	400	nc	0.05 ^a
2,4,6 Trichrolophenol	2	nc	0.05 ^a
Vinyl chloride	0.2	nc	nc
Xylenes (total)	50	nd	2
Zinc	nc	0.191	5

Notes

- nc = no criteria.
- nd = non-detect.
- leachate concentration exceeds trade waste critieria.
- ^a 0.05 is trade waste criteria for total chlorinated phenolics.
- ^b 10 is the trade waste criteria for total petroleum hydrocarbons (C6 to C36).
- The likely leachate concentrations are based on leachate sampling analysis completed at Alexandria Solid Waste Landfill by Ian Grey Consulting Ltd. Sampling was completed on 8 occasions at quarterly intervals between 23/01/06 and 17/10/2007.
- Solid Waste TCLP data is from the Department of Environment & Conservation NSW (1999) Environmental Guidelines: Assessment, Classification & Management of Liquid and Non-liquid Wastes EPA, Table A4.
- The trade waste criteria are the acceptance standards listed on the sydney water website.

1.6

TREATMENT PROCESS

An overview of the entire treatment process is presented in *Figure 7*. This figure summarises the data flow volumes anticipated and potential treatment required before disposal to trade waste.

Additional information presented within this figure is summarised as follows:

- the preliminary treatment system has been designed to process 500m³/day. This is sufficient to process the proposed discharge rates from the landfill leachate collection system; and
- surface storage capacity of leachate will be available prior to treatment (1,100 m³) and post treatment (1,100 m³). The prior treatment storage will be used to house run-off from green waste areas, which subsequently be either irrigated back onto the green waste or transferred at a maximum anticipated rate of 10 m³/day to the treatment system. The post treatment storage facility will be used to house treated water that will be disposed of via other methods, which are yet to be confirmed. This process will serve to reduce overall discharge to trade waste.

2.1***INTRODUCTION***

The leachate containment system and potential need for a landfill liner varies as a function of the depth and the soil/rock strata encountered at the base of the landfill facility and within the surrounding side slopes. The conceptual design for the leachate containment system takes account of the requirement set out in NSW EPA (1996) *Environmental Guidelines: Solid Waste Landfills* and the infilling procedure and leachate generation rates as discussed in *Section 1.4*.

2.2***NEED FOR LINER*****2.2.1*****Lower Part of Void (32m to Nominally 150m bgs (Base of Void))***

The lowest-most stratum, located below 32 bgs is the Bringelly Shale ⁽¹⁾. This is reported to have a hydraulic conductivity of 8.7×10^{-6} m/day ⁽²⁾ (or 1×10^{-10} m/sec), thus functioning as a relatively impermeable barrier between the waste and the surrounding environment. For comparison, it is noted that the hydraulic conductivity of this material is less than that of a standard compacted landfill soil liner layer (1×10^{-9} m/sec ⁽³⁾) and comparable with a bentonite mat/geosynthetic clay liner (GCL) (1×10^{-6} to 1×10^{-13} m/sec ⁽⁴⁾). It is conservatively estimated that approximately 2 m³/day of leachate would flow through this stratum from the landfill if water elevations rose above the regional groundwater system, which is estimated to be > 24 m AHD. This would only occur post landfilling and after pumping has ceased. This volume of discharge will occur with the presence or absence of a clay liner. Therefore it is not anticipated that a liner will improve the leachate containment and as such it is not recommended to line this area of the landfill.

2.2.2***Mid Part of Void (18 to 32m bgs)***

Above the Bringelly Shale, in the side slopes of the quarry void is weathered shale and clay strata, approximately 14m in thickness.

(1) ERM (2008a)

(2) ERM (2008a), hydraulic conductivity for borehole BH04. Conservatively, assume higher end of range (1.75×10^{-6} to 8.7×10^{-6} m/day).

(3) NSW, EPA (1996) Environmental Guidelines: Solid Waste Landfills. Characteristics of a suitable recompacted clay or modified soil liner of at least 90cm thick.

(4) US EPA (2001) Geosynthetic Clay Liners Used in Municipal Solid Waste Landfills

This layer is reported to have a hydraulic conductivity of 0.25 m/day⁽⁵⁾ (2.9×10^{-6} m/sec) and a perched groundwater table throughout nearly the entire depth. The presence of the perched water table will provide an inward gradient of groundwater from this layer into the landfill and thus will reduce or eliminate the potential for off-site migration of leachate from waste disposed at or above this stratum. It is also noted that the aquifer system in this lithology is intermittent and is not considered to be in significant hydraulic contact with the landfill.

After landfill closure and the cessation of dewatering, there is potential for leachate elevations to slowly increase within the landfill and rise above the elevations within the surrounding groundwater system. This could result in discharge of leachate to the perched aquifer system. This will increase the potential for adverse environmental impacts from water discharging from this aquifer to the surrounding environment, which suggests that the landfill may require lining at shallow depths. However, given the low human and environmental value of this aquifer system, this should only be considered as a contingency measure subject to further investigation to characterise and mitigate leachate generation after landfill closure and the cessation of dewatering. There is likely to be in excess of 40 years available to gather data and complete these investigations before land filling reaches the levels where lining may be required.

2.2.3 *Upper Part of Void (0 to 18m bgs)*

The uppermost layer of the quarry void side slopes is similar to the mid part of the void (see *Section 2.2.2*) in some areas, however in other areas is comprised of sandy gravel fill soil up to approximately 18m in depth and of an unknown (most likely higher) hydraulic conductivity. The areas of fill are presumed to be soil that was excavated from the quarry plan area at the outset of quarry development and it is unlikely to have been compacted when placed. This area of the side slopes will require further management prior to establishment of the landfill. The options recommended for this area are:

- excavation and removal of the fill soil for use as a final cover/capping soil over the proposed landfill area;
- excavation, and replacement of the fill soil using compaction to construct this as a soil liner layer; or
- re-compaction of the soil as necessary for structural integrity and installation of a geomembrane liner over the slope surface extending from the crest of the quarry to below the interface with the underlying weathered shale/clay strata.

(5) ERM (2008a), hydraulic conductivity for boreholes BH05, BH08, BH09. Conservatively, assume higher end of range (1.7×10^{-3} to 0.25 m/day).

The leachate level within the waste mass of the landfill should be maintained below both the fill soil (if it is retained) and the base of the weathered shale/clay strata. The installation of wells at selected times during the active life of the landfill and/or after completion of waste placement will allow for monitoring of the leachate level. As a contingency measure, in the event that leachate levels rise higher than anticipated or desired, these monitoring wells can be constructed to also serve to extract leachate directly from the waste mass.

2.3

CONCLUSION AND RECOMMENDATIONS

Additional leachate containment using a landfill liner is not recommended for the landfill, provided that the top 18m of fill soil material is removed and/or otherwise proactively managed by compaction as a liner or installation of an HDPE geomembrane to adequately contain leachate. In line with NSW (1996) guidance, a further hydrogeological investigation of the landfill will be required at detailed design stage. After land-filling and the cessation of leachate dewatering there is potential for the leachate water elevations to rise above the regional water table and recharge the shallow perched aquifer system. Further investigation of the potential for this to occur and options to mitigate this potential impact should be completed during the initial phases of infilling.

The low hydraulic conductivity of the Bringelly Shale surrounding the proposed landfill facility results in minimal exfiltration of leachate (estimated to approximate 2 m³/day) from the landfill even under the worst-case scenario that the waste mass is saturated. Additional containment is therefore not recommended for this area (32m bgs and below). However, a leachate collection and removal system should be installed across the landfill base and operated to minimize the leachate head within the landfill, by actively removing leachate as it is delivered into it.

The leachate collection system may be required to operate at a minimal rate post landfill closure (approx. 1 L/s), however, an assessment of the leachate volumes generated and the potential for the regional aquifer system to absorb the leachate produced post closure will confirm if this is necessary.

The leachate level within the waste mass should be monitored by wells installed to depth. As a mitigation measure, in the event that the saturation zone rises within 3m of the interface between the Bringelly Shale and the overlying weathered shale/clay strata, leachate will be extracted from wells installed directly within the waste. The discharge from these wells should be treated as necessary.

The upper 18m of fill soil requires further management. The three options for this layer are removing the fill for capping of the landfill, compaction of the fill to form this into a soil liner layer or installation of a geomembrane liner over this side slope area.

3.1***DESIGN PARAMETERS***

The leachate collection system is designed to handle the estimated maximum of 500 m³ of leachate required to be discharged per day. This allows for the ‘best case’ and ‘worst case’ infilling scenarios as previously discussed. The rate of infilling does not effect the design with regard to the physical properties of the materials to be used. The key challenges in designing the system are:

- the depth of the void. This gives a large leachate head and poses challenges associated with handling leachate collection equipment;
- the geometry of the void. The conical-shaped benched void poses issues with locating the leachate riser and requires benches to be engineered; and
- operating below groundwater level. This requires particular attention to be paid to ensuring the surrounding strata are relatively impermeable and/or an inward hydraulic gradient is maintained.

The following sections describe the key components of the leachate collection system with options as appropriate. These options and descriptions take account of the site geology, hydrogeology, water chemistry, calculated water balance, client specifications, the need for materials to have longevity within the landfill and the need for contingency measures should key parts of the leachate collection system fail, as required under the NSW EPA (1996) guidelines.

3.2***BASAL DRAINAGE SYSTEM***

The collection system across the landfill base is to be comprised of several components for efficient collection and removal of leachate, as described below.

3.2.1***Drainage Layer***

Options considered for the drainage layer include geosynthetic and granular materials.

Given the depth of the waste (up to 150m) and the resulting vertical pressures (approximately 1,500kPa), it is unlikely that geosynthetic materials will remain functionally intact and therefore these materials are not a practical alternative. By default, granular materials are to be employed in the basal drainage system.

A minimum 500mm thick, high-permeability granular blanket will be placed across the entire landfill base area (See *Figure 3* in *Annex A*). It is anticipated that this granular material will be comprised of predominantly rock (gravel/cobbles) of greater than 25mm diameter.

In line with NSW EPA (1996), the drainage material should exhibit a coefficient of permeability $K > 1 \times 10^{-3} \text{ ms}^{-1}$ and the gravel should be rounded, smooth surfaced and non-reactive in mildly acidic conditions. The material should be relatively uniform in grain size and free of carbonates that could form encrustations around collector pipes.

The longitudinal gradient on the landfill base will be a minimum of 1%, to ensure good drainage towards the sump. The existing quarry floor already has sufficient fall. Trenches should also fall inwardly toward the main drain pipe. The hydraulic conductivity of the granular material will be sufficient to transport leachate to the sump within a limited period of time (less than 1 day) from its appearance in the collection system.

The leachate collection drainage layer needs to have sufficient thickness to manage the maximum hydraulic head between the piping network (refer Section 3.2.3 below) without pressurizing the drainage layer; and to increase the “life expectancy” of the system from clogging. The maximum hydraulic head within the system is determined based on the horizontal permeability of the leachate collection layer granular material and the pipe spacing. The advantage to minimizing the hydraulic head (both maximum and average) within the drainage layer material across the base is to reduce the potential of leachate exfiltration from the landfill and maximize the “life expectancy” of the system from clogging.

Investigation of existing operating/closed landfills indicates that the resistance of a leachate collection layer to clogging is, given a constant concentration of leachate (a conservative assumption), a function of:

- the horizontal permeability of the layer (higher permeability material is less likely to clog);
- the hydraulic head within the layer; and
- the thickness of the layer (greater drainage layer thicknesses have a longer “life expectancy”)

In concept, the make-up of the leachate collection drainage layer is a relatively uniform gradation stone (for example, a nominally 50mm “single-size”). Such a stone will allow for high horizontal permeability and thus high velocities to the piping network; thus reducing retention time within the system and discouraging the development of biofilm and reducing the potential for biological clogging.

3.2.2

Geotextile

There are applications that suggest either inclusion or exclusion of a geotextile is acceptable dependent upon the nature of the waste and leachate, and proper design of the granular drainage layer/selection of the geotextile.

In general, leachate with higher chemical oxygen demand (COD), calcium and/or suspended solids are more susceptible to clogging of the collection system. Given any waste and leachate composition, the granular drainage layer material should be relatively uniform in size (single-sized) to maximize the horizontal permeability. Such a layer is not typically an appropriate filter for waste; therefore consideration should be given to inclusion of an additional layer of graded granular material and/or select waste material; as well as potential use of a geotextile. In general, geotextiles with larger openings are more resistant to clogging. Also, if a geotextile is employed, it should be placed as distant as practically possible from the piping network within the leachate drainage layer material to minimize the potential of clogging the entire drainage system.

The final decision of use of a granular material only or the addition of a geotextile should be made by the engineer responsible for the Preliminary Design/Detailed Design in consideration of the overall landfill and leachate collection system design.

3.2.3

Collection Pipes

To further assure the transport time and for redundancy, a network of collection pipes in a chevron/herringbone pattern (See *Figure 1* in Annex A) will be installed, with 150mm diameter laterals spaced nominally 25m on-centre, and a central 300 mm diameter header pipe. These requirements are within the guideline diameters and spacing set out within *Benchmark Technique 1* of NSW EPA (1996).

Pipes could be of polyethylene, concrete or steel. Steel and concrete pipes would need epoxy coating to ensure longevity in the landfill, which would be costly. Polyethylene offers the most suitable material to provide maximum chemical resistance to leachate constituents. The polyethylene pipes would be embedded into trenches beneath the blanket gravel drainage layer, to maintain structural integrity.

The pipe size and spacing as shown are based on extensive previous landfill design experience and only intended as an indication of the Concept Design; with the actual size,

spacing and configuration/orientation relative to the landfill base (within trenches are placed on the landfill base) to be determined at later project design stages (Preliminary Design and/or Detailed Design) based on detailed analyses. It is further noted that these factors (pipe size, spacing and configuration/orientation) are dependent upon a number of considerations, including:

- the average vertical permeability of the overlying waste mass;
- the anticipated leachate generation rate;
- the landfill base gradient;
- the horizontal permeability of the leachate collection layer granular material;
- the targeted average hydraulic head on the landfill base;
- the thickness of the leachate collection layer granular material;
- the pipe flow capacity; the vertical loading on the pipe;
- the trench size/shape; and
- the pipe spacing and the degree of redundancy desired.

As an example, assuming that the overlying waste has an average vertical permeability of 2×10^{-6} m/s (a maximum leachate flow of 2,000 m³/day over the 12,000 m² basal area), then 150mm diameter (high density polyethylene [HDPE] pipes on a 25m spacing would be expected to be sufficient to maintain the maximum and average hydraulic head on the landfill base at in the order of approximately 13mm and 10mm, respectively; employing a very coarse, (nominally 50mm) "single-sized" granular material. This is a very low and acceptable level by the state-of-the practice in landfill engineering. It should also be noted be noted that the pipes would not flow full.

The level/degree of redundancy has not been fully considered in development of the above conceptual assessment; but as an example, the estimated flow could be managed by not only the pipe but also through only the gravel within an appropriately dimensioned trench (less than 350mm x 350mm).

3.2.4 *Sump and Risers*

A sump will be located at the lowest elevation of the base, serving to collect the leachate in preparation for removal.

The sump will contain two (2) risers and a housing for leachate extraction pumps at the western end of the landfill (See *Figures 1* and *2* in *Annex A*). The leachate extraction pumps are sized with a capacity of nominally 500 m³/day. A single pump will operate in one riser under normal conditions, while the second pump will serve as standby, for use if unusually high flow rates are reported (eg under high rainfall events) into the leachate collection system.

3.3 RISER

3.3.1 Options

There are several options for the configuration of the leachate removal system riser pipes. These options are illustrated in *Figure 4* in *Annex A*, and described as follows:

- **Option 1:** A vertical riser projecting through the landfill, constructed of concrete pipe sections installed incrementally as the waste level rises; and
- **Option 2:** A riser encased in concrete installed on and within the near surface layers of the slope; and
- **Option 3:** An inclined drilled-shaft.

The advantages and limitations of each are set out in *Table 3.1*.

Table 3.1 Advantages and Disadvantages of Riser options

Option	Advantages	Disadvantages
Option 1: Vertical Riser	<ul style="list-style-type: none"> • Cost effective • Ease of Installation (in segments as waste level rises) • Potentially can serve as leachate collection column (if walls are perforated and surrounded by granular materials) 	<ul style="list-style-type: none"> • Subject to down-drag as surrounding waste settles • Requires special manufacture (wall thickness large to resist compressive forces) • Subject to damage/misalignment (from being struck by vehicles and/or waste placement activities) • Difficult to operate (power supply and discharge line routed across waste surface requiring frequent relocation) • Concrete requires protective coating (interior and exterior)
Option 2: Riser installed on or in sideslope	<ul style="list-style-type: none"> • Not subject to down-drag forces • Can be constructed from within the existing quarry void • Not subject to damage/misalignment during waste placement operations 	<ul style="list-style-type: none"> • Need to structurally supported against side of quarry at full length of riser • More effort to install when compared with Option 1

	<ul style="list-style-type: none"> • Ease of operation (all operations performed from surrounding ground surface rather than waste mass) • Pipe forming conduit may not require protective coating inside or out, with the exception of the portion within the sump pipe (encased in concrete) • Possible to construct and operate in segments (without disruption of waste placement operations) • though possible to construct and operate in segments - say, below haul road/above haul road
Option 3: Inclined drilled shaft	<ul style="list-style-type: none"> • Not subject to down-drag forces • Ease of operation (constructed and operated from surrounding ground surface external to landfill) • Conduit does not require protective coating, with the exception of the portion within the sump • Not subject to damage/misalignment during waste placement operation • Most difficult to install (compared with options 1 and 2) • Least cost effective • Complete installation required prior to waste placement

In each option, the riser pipe is nominally 1.2m in diameter to allow easy access of the pump and, as a contingency, the equipment necessary in the event that cleaning or other maintenance of the leachate collection system is necessary.

The sections of concrete riser in Option 1 will require special manufacture, specifically with walls as much as an estimated nominal 600 mm thick to withstand the pressures resulting from settlement of the surrounding waste mass and down drag of the concrete riser.

Option 2 is recommended because of the possibility to construct and operate in segments without disruption of waste placement operations. Option two also allows for anchoring the risers to the quarry walls, thus minimising down-drag impacts. The pipe would need to be of sufficient design strength to ensure crushing would not occur.

Option 1 is rejected mainly because of the high down-drag of the surrounding waste settling. Option 3 is rejected because of the high costs and the difficulties to install.

3.3.2

Technical specifications of option 2

The riser pipe in *Option 2* consists of an appropriately designed and engineered reinforced concrete pipe, partly embedded in the batter walls of the quarry (see figure 4).

This option allows for construction in stages, without disruption of waste placement operations. The leachate riser will be installed in stages anchored to the quarry wall with an initial rise of approximately 15-20 metres from the quarry floor. Further staged installation will occur as the waste level increased in the void.

A brief overview of the leachate riser construction in stages following the filling process is described below and presented schematically in Figure 2. The “initial stage” and the “following stages” are then continued until the quarry is filled.

Initial stage (see Figure 8)

- a drainage layer is constructed in order to direct leachate towards a leachate sump to the east of the quarry. That leachate collection system will be built progressively across the base of the quarry as the waste is disposed to minimise clean stormwater ingress in the collection system;
- the leachate well is placed within the leachate collection sump and will be used to pump leachate to a treatment facility at ground level;
- filling will occur starting on the eastern side of the quarry (where the sump is located) and progressively move towards the western side of the quarry;
- a bund will be placed to separate the initial fill area and the upper areas of the quarry floor; and
- runoff from the upper batters, haul road and that to the east of the bund will be captured in a suitably lined clean water pond and either pumped to tanks or be used directly in dust suppression at the base of the quarry.

Following stage (see figure 8)

- once filling on the eastern end has attained a suitable height (around 10 meters) and the area of the upper fill will be suitable for traffic access, and the haul road will be realigned for access directly to this area;
- when filling reaches the eastern end of the quarry, and before any more sections of the haul road are removed, the leachate well will be extended through the disused haul road to a level higher than the current filling level (i.e. an additional 15 to 20 meters);

- the riser is to be appropriately constructed and engineered such that any void behind the pipe and the wall is filled with appropriate filling material and/or structural support;
- a leachate trench is located directly downslope of the active filling area to collect run off from the active filling area ; and
- the construction of the risers can happen from inside the quarry void, and the pumping operation will be performed from ground level. Where the pipe is embedded in the haul road, this will limit the potential for crushing of the pipe. The outside segments of the pipes are designed and engineered in a way leaving no chance for crushing. The leachate pumps will be able to be extracted on a appropriately engineered rail system for maintenance or replacement.

3.4

MAINTAINING THE LEACHATE CONTAINMENT AND COLLECTION SYSTEM

The leachate collection system should be routinely monitored, inspected and flushed as may be necessary, employing proven methods. Monitoring of the system can be accomplished by measuring and logging the volume of leachate extracted as a function of time.

A reduction in the flow rate during the operational life of the landfill is typically an indication that the system is under the influence of clogging mechanisms. Inspection is accomplished through closed-circuit television (CCTV), and may not be necessary if the system is closely monitored and maintained. Maintenance of the system is practically limited to backflushing of the pipes and the perforations, and is typically accomplished through the application of high-pressure water jetting, with access provided through the removal (riser pipe) system.

The required frequency of system maintenance is dependent upon a number of factors, both general and specific details, including:

- the nature of waste disposed of in the landfill;
- the “strength” and infiltration flow rate of the leachate vertically into the collection layer;
- implementation of leachate recirculation practices;
- the thickness of the granular collection layer material;
- the configuration (size, spacing, use of trenches, etc.) of the pipe network within the collection layer;

- the size of the particles composing the collection layer material; and the size and number of perforations in the collection pipe.

Development of biological clogging material typically begins with the formation of a soft biofilm which is relatively easily removed by flushing. With time, the biofilm ultimately results in the formation of a more solid material which is considerably more difficult or practically impossible to remove.

In general, the maintenance frequency should be sufficient to remove the biofilm and minimize, to the extent practically possible, the formation of the more solid, encrusted material. Industry practice suggests that this will likely be less frequent at the outset of landfilling operations, and more frequent with increasing biological activity within the waste mass.

3.5

SURFACE WATER MANAGEMENT

Surface water management is a critical component to successful operation as well as the overall environmental protection of the landfill. The nature of the landfill, being a former quarry entirely below ground, results in the site being subject to incident rainfall without the potential for gravity diversion. Surface water modelling has determined that surface-water within the quarry catchment has the potential of generating from as much as 1,638 m³/day of leachate (ERM, 2008a). Therefore segregation of clean surface water runoff from capped areas and areas not yet having received waste, from leachate is critical.

Conceptually, there are several practical means by which segregation of surface water runoff and leachate could be accomplished (See *Figures 5 and 6 in Annex A*), used both alone or in combination:

- **Option 1:** Use of In Pit (Haul) Roads. The existing in pit roads around the perimeter of the quarry void will continue to be used for access of waste delivery vehicles to the active waste placement area. These roads could be modified to include surface water management features (channels or similar) to intercept water. In addition, vertical sumps containing pumps could be included within the design to remove surface water as this is collected. Although it is not anticipated that such a system would be effective in segregating all surface water runoff, it is expected that significant volumes could be captured and removed.
- **Option 2:** Alternatively or in addition to the options above, large volumes of surface water runoff from clean areas within the landfill facility could be captured and routed to temporary holding facilities located on the surface of previously placed waste, but away from the currently active waste placement areas (see *Figure 6 in Annex A*).

This method will be integral to and coordinated with the overall sequence of waste placement (see *Section 3.5* below).

Surface water management for the landfill area is discussed further in the Storm (2008) report, which forms *Annex B* of the ERM (2008b) Environmental Assessment Report for the Project. Storm (2008) recommends Option 2 in conjunction with a modified version of Option 1, where the haul roads are used in the drainage, but sumps and pumps are not included.

3.6

FILLING PLAN

Waste placement will initially proceed across the base of the landfill and progress upward with the waste deposited in horizontal layers commonly referred to as "lifts" (See *Figure 6* in *Annex A*). The landfill base area will be sub-divided into smaller areas for efficient operation and to allow for the segregation of surface water from waste and leachate. In the operation of a given lift, the landfill base can be considered to be sub-divided into two general areas. Waste placement activities will be confined to one area (the active emplacement area) and surface water from this area will be collected through the leachate system. Segregated surface water from the capped area will be collected in a temporary surface water pond, from where it can be drawn down for reuse for dust suppression or ultimately transported by tanker to the surrounding ground surface.

When a lift is completed on one side of the base area, the temporary surface water pond will be relocated to the upper-most surface of the waste, and waste placement activities continued on the opposite side.

The leachate treatment system exists of two stages being a sequence batch reactor (or sequential batch reactor) followed by a WaterFresh treatment.

4.1***SEQUENCE BATCH REACTOR***

Sequencing batch reactors (SBR) or sequential batch reactors are industrial processing tanks for the treatment of waste water. SBR reactors treat waste water such as sewage or output from anaerobic digesters or mechanical biological treatment facilities in batches. Oxygen is bubbled through the waste water to reduce biochemical oxygen demand and chemical oxygen demand to make suitable for discharge into sewers or for use on land.

The installation of the SBR consists of a tank with raw wastewater coming in at one end and treated water flowing out the other. The raw waste water is distributed over the whole area of the tank. This helps to mix the incoming influent and the returned activated sludge thus beginning the digestion process.

There are four stages to treatment: fill, aeration, settling and decanting. The aeration stage involves adding air to the mixed solids and liquid either by the use of fixed or floating mechanical pumps or by blowing it into finely perforated membranes fixed to the floor of the tank. During this period the inlet valve to the tank is open and a returned activated sludge pump takes mixed liquid and solids (mixed liquor) from the outlet end of the tank to the inlet. This "seeds" the incoming sewage with live bacteria. The aeration process encourages the production of nitrogen compounds as the bacteria increase their number, a process known as nitrification. During the settling stage the sludge formed by the bacteria is allowed to settle to the bottom of the tank. The aerobic bacteria continue to multiply until the dissolve oxygen is all but used up. Decanting is the process of discharging the treated effluent above the level of the settled sludge.

The sequence batch reactor at the site is expected to be used as a primary treatment system which will comply with Sydney Water requirements for discharge to sewer. Tanks to be placed at the site will likely be 110,000 L tanks with decanting capacity of approximately 80,000 L. The approximate treatment period will vary between 7 to 9 hours depending on weather (colder weather will require longer treatment times).

Whilst this system treats ammonia to negligible levels effluent after the SBR stage is not able to be used in dust suppression due to other contaminants (and bacteria) being present.

The second stage will consist of the WaterFresh treatment to eliminate all the bacteria, reduce the solids and provide adequate dust suppression water able to be discharged to stormwater or sprayed.

WaterFresh is an Australian water treatment technology company that has developed a modular and innovative method to treat effluent into potable or A + reuse water within one hour. It provides a wide range of solutions to treating all grades of water using its High Velocity Sonic Disintegrator (HVSD) technology.

Waterfresh Plants utilise a single stage mechanical process to effectively provide total pathogen destruction and hence complete disinfection (a 99.999% reduction of known pathogens in raw sewage). At the moment one Waterfresh system is able to treat up to 200,000 – 240,000 Litres per day.

It is expected that the treated effluent from the SBR be run through a series of sand and multimedia filters and then into the Waterfresh system. The water may then be stored in tanks or a treated effluent dam (depending on quantity) for reuse around the site.

Essentially, the SBR will remove ammonia from the waste water, the filter will remove the suspended solids and the Waterfresh system will kill pathogen and provide complete disinfection. We are presently in the process of getting the system approved for our Alexandria Landfill operations. The water treatment systems are expected to be placed on the southern side of the quarry, next to the eastern (hanson berms).

5.1**PRIMARY DISPOSAL OPTION**

The primary disposal option for the treated leachate water is as trade waste. Industrial customers need to meet the conditions of Sydney Waters Trade Waste Management Plan. The relevant trade waste discharge criteria are presented in *Table 1.3* of this report.

A trade waste consent agreement will be sought for the disposal of leachate to Sydney's sewer system. Each industrial customer that discharges trade wastewater to the sewer system needs to negotiate a trade waste consent agreement with Sydney Water. Under a consent agreement, the customer is responsible for managing the wastewater.

The location of the most appropriate connection to Sydney's sewer system needs to be investigated through application to Sydney Water.

5.2**SECONDARY DISPOSAL OPTIONS**

There are several secondary disposal options that are being considered to reduce disposal volumes of leachate to trade waste. These options include:

1. Rejection into the landfill;
2. Irrigation of the active landfill (over the face of the tipping area); and
3. Treatment (beneficial use) and disposal over land (landscaping f.ex.)

The first two options will be investigated and instituted where possible once sufficient depth of waste is achieved to allow for leachate storage in the waste mass itself. The beneficial on-site reuse of the treated leachate will be investigated upon collection of monitoring data to assess leachate water quality.

6.1

PREFERRED OPTIONS FOR LEACHATE COLLECTION & CONTINGENCY MEASURES

A variety of options for different components of the leachate collection system have been set out and reviewed in this report. The preferred options selected are based on site geology, hydrogeology, water chemistry, water balance and client specifications. In summary, the preferred options for leachate collection are:

- a granular basal layer;
- basal collection pipes embedded in trenches leading to a sump at the base of the landfill;
- leachate collection pipes made from polyethylene;
- a sump located at the western end of the landfill;
- two leachate risers located to the western end of the landfill;
- leachate risers installed on/in side slope by sculpting / excavating or directional drilling; and
- management of surface water runoff into the pit by using drainage infrastructure along in pit haul roads and a temporary holding facility on the waste surface.

The details of the preferred system, taking account of the need to maintain the longevity of piping and drainage material within the landfill, are set out in *Table 6.1*.

Table 6.1 Details of Preferred System for Leachate Collection

Item	Description
Liner	Based on available information on geology and aquifer characteristics, a landfill liner is not considered necessary. Attention should be paid to the uppermost 0 to 18m of soil fill, which may require removal, re-compaction or placement of a geomembrane liner extending from the crest of the quarry to the interface between the fill and the underlying weathered clay/shale.
Basal drainage layer	Minimum 500mm thick high-permeability granular drainage blanket (anticipated to be 25 to 100mm in size) placed across the entire base of the landfill.

Item	Description
Gradient of base	Minimum of 1%, sloped towards the sump
Collection pipes (basal layer)	Network of polyethylene collection pipes in chevron/herringbone pattern of 100mm diameter laterals spaced nominally 15m on centre, central 300mm diameter header. All to be embedded in trenches beneath the granular blanket.
Sump	Located at the western end of the landfill (See <i>Figure 1</i> in Annex A).
Riser	Two risers located within the sump. Riser pipe nominally 1.2m in diameter to allow easy access to pump. Riser to be installed on/in the side slope by sculpting and/or excavating into benches or directional drilling.
Leachate extraction pumps	Sized nominally with a 500m ³ /day capacity. This takes account of the fact that not all water within the landfill void will reach the sump (some will be diverted by the surface water management system) and the fact that when there are high rainfall events, the waste within the landfill will act as a buffer, delaying the arrival of leachate at a sump over a longer period. One service pump and one standby for use in case of breakdown of the first and if there is an unusually high flow rate of leachate during high rainfall events.
Surface water management	Modification of haul roads to include surface water management features (eg channels or similar). Capture of large volumes of surface water in temporary holding facilities on surface of previously placed waste, but away from active waste placement areas. Further details provided in Storm (2008).

6.1.1

Contingency Measures for Preferred Option

The principal areas where the leachate collection system has the potential to fail are:

- clogging of the drainage and pipe network and
- pump failure.

Clogging can be prevented by good system design. Use of a suitable, open rock drainage material to prevent clogging (as above), ensuring gradients at the base are at least 1% and providing a means of flushing the system will help to prevent this.

As a further contingency, the technology exists to flush leachate collection pipe networks from the ground surface using water jets controlled by robotic systems.

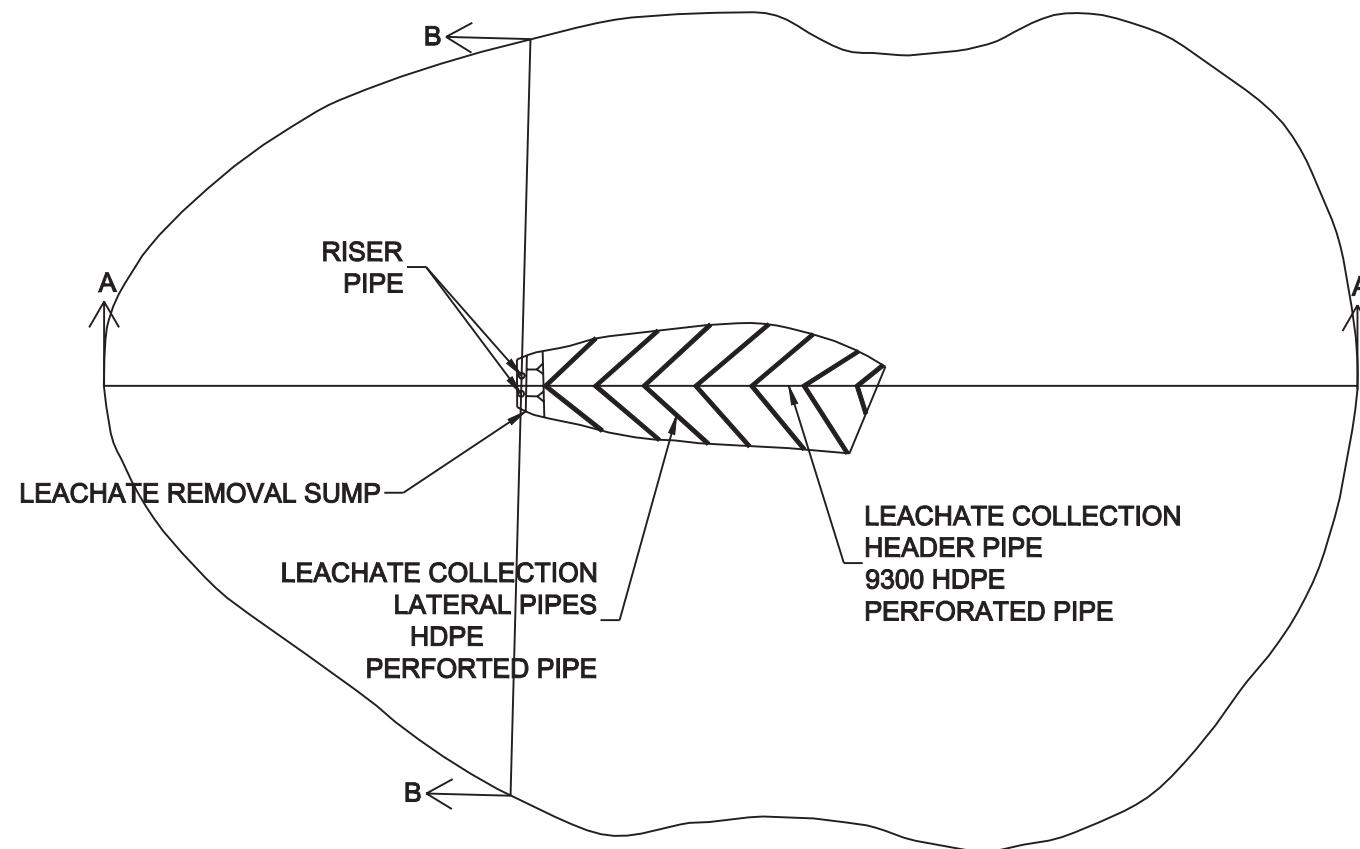
There will be one service and one standby pump and two risers to ensure that there is always a means of removing a failed pump.

REFERENCES

- DECC (1999) **Environmental Guidelines: Assessment, Classification & Management of Liquid & Non-liquid Wastes** Department of Environment and Conservation (NSW), Sydney.
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- ERM (2008b) **Light Horse Business Centre Environmental Assessment** Prepared for ThaQuarry Pty Ltd, January 2008.
- NSW DECC (2007) **Draft Environmental Guidelines: Landfilling**, Department of Environment and Climate Change, August 2007.
- NSW EPA (1996) **Environmental Guidelines: Solid Waste Landfills** Environmental Protection Authority, Chatswood.
- Storm (2008) **Site Surface Water Management Plan** Prepared for ERM, January 2008.
- US EPA (2001) **Geosynthetic Clay Liners Used in Municipal Solid Waste Landfills** United States Environmental Protection Agency, US.

Annex A

Figures

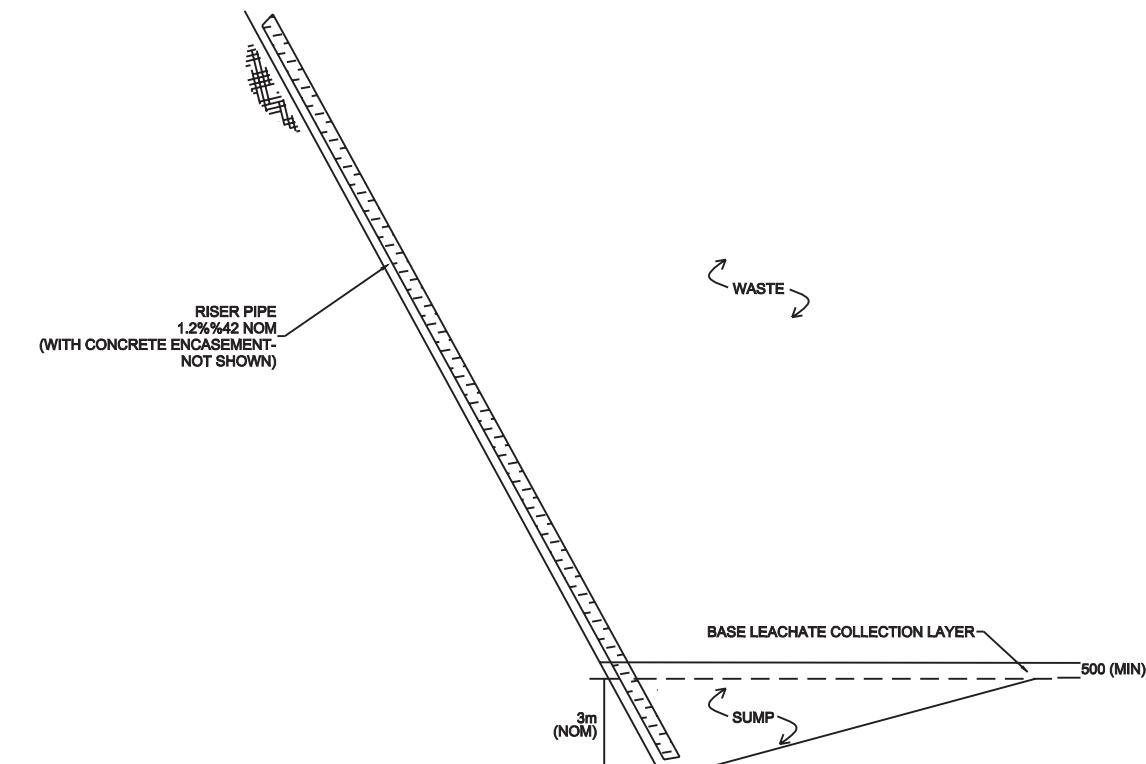


PLAN VIEW OF LANDFILL AND
BASE LEACHATE COLLECTION SYSTEM
N.T.S

Figure 1
Leachate Collection System

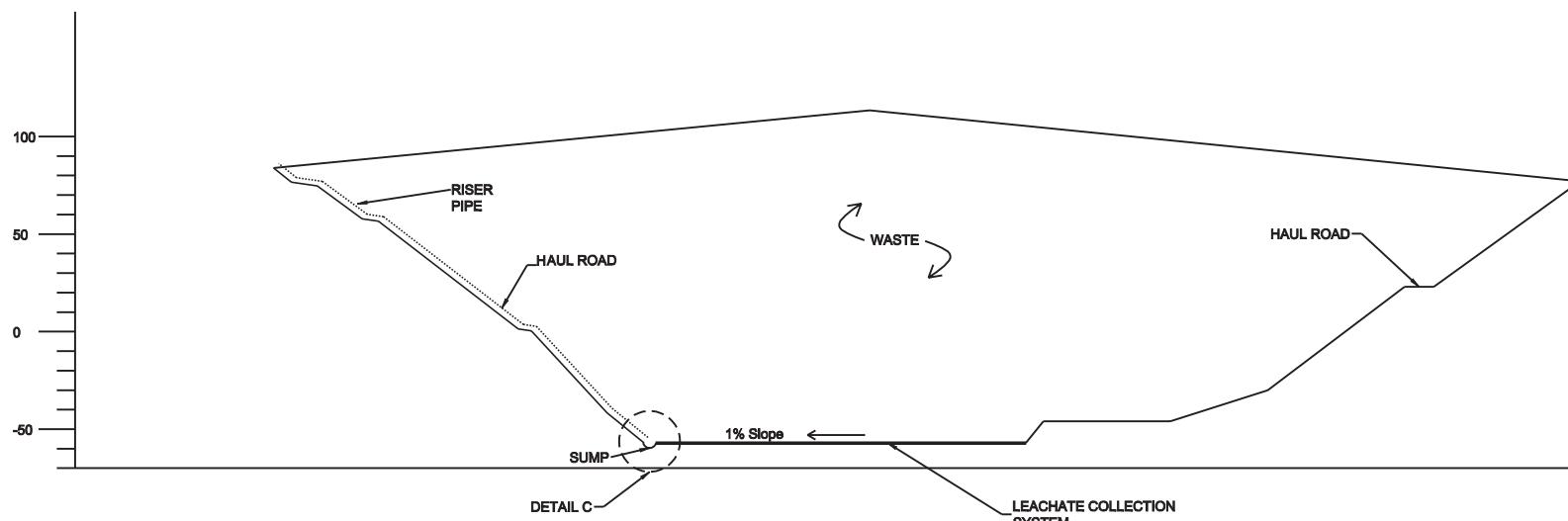
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Project:	Lighthorse Business Centre EA	
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Date:	08/04/2008	Reviewed by: -
Drawn by:	ML	
Source:	-	
Scale:	Not to Scale	

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NOTES:
1. SUMP FILLED WITH SAME STONE AS BASE LEACHATE COLLECTION LAYER
2. RISER PIPE PERFORATED WITHIN SUMP

DETAIL C LEACHATE COLLECTION/ REMOVAL SUMP (N.T.S)



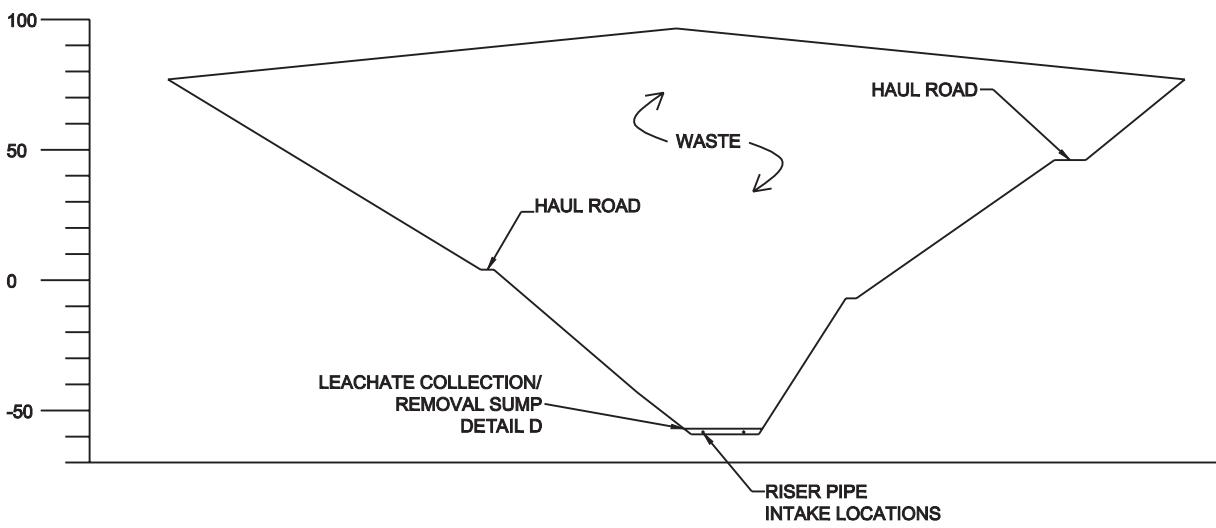
NOTES:
1. ONLY BENCHES WITH HAUL ROADS ARE SHOWN

CROSS SECTION A-A
LANDFILL BASE LEACHATE COLLECTION LAYER

Figure 2
Leachate Collection System
Cross Section A-A

Client:	ThaQuarry Pty Ltd
Project:	Lighthorse Business Centre EA
Drawing No:	0071234s_L_04
Date:	08/04/2008
Drawn by:	ML
Source:	-
Scale:	Not to Scale

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CROSS SECTION B-B
LANDFILL BASE LEACHATE COLLECTION LAYER

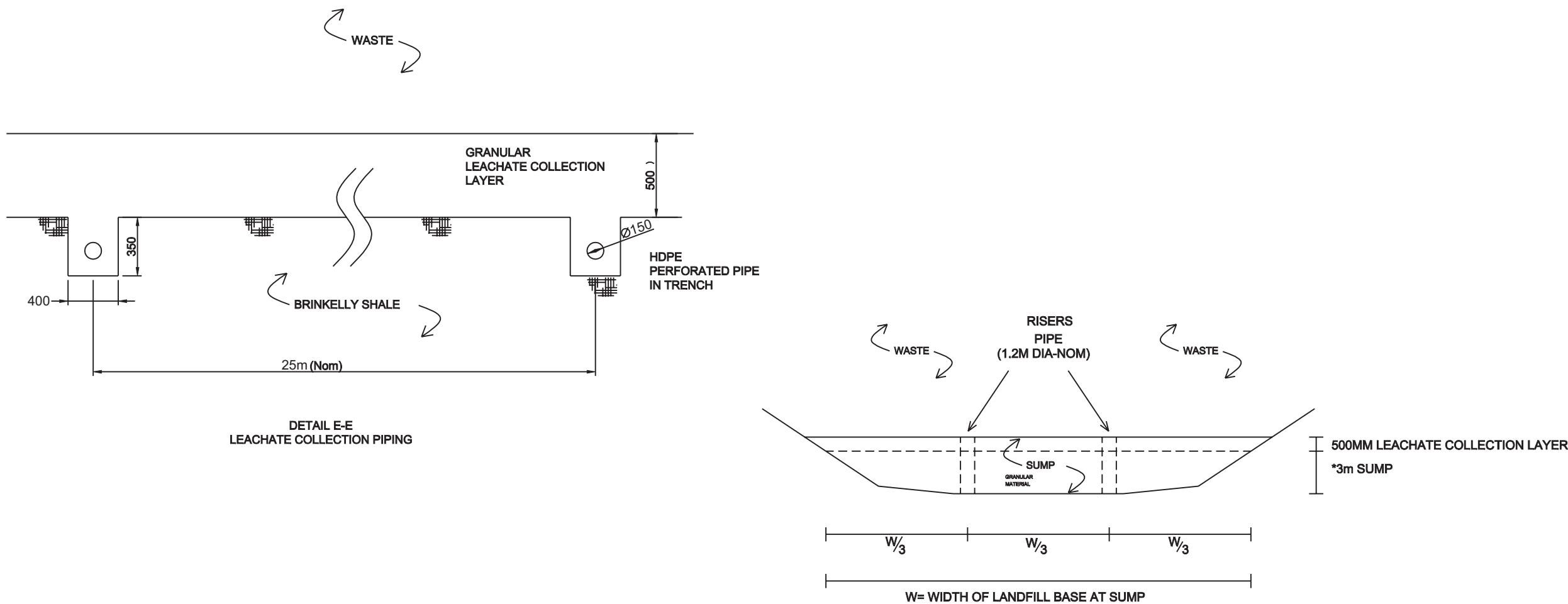


Figure 3
Leachate Collection System
Cross Section B-B

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Project: Lighthorse Business Centre EA
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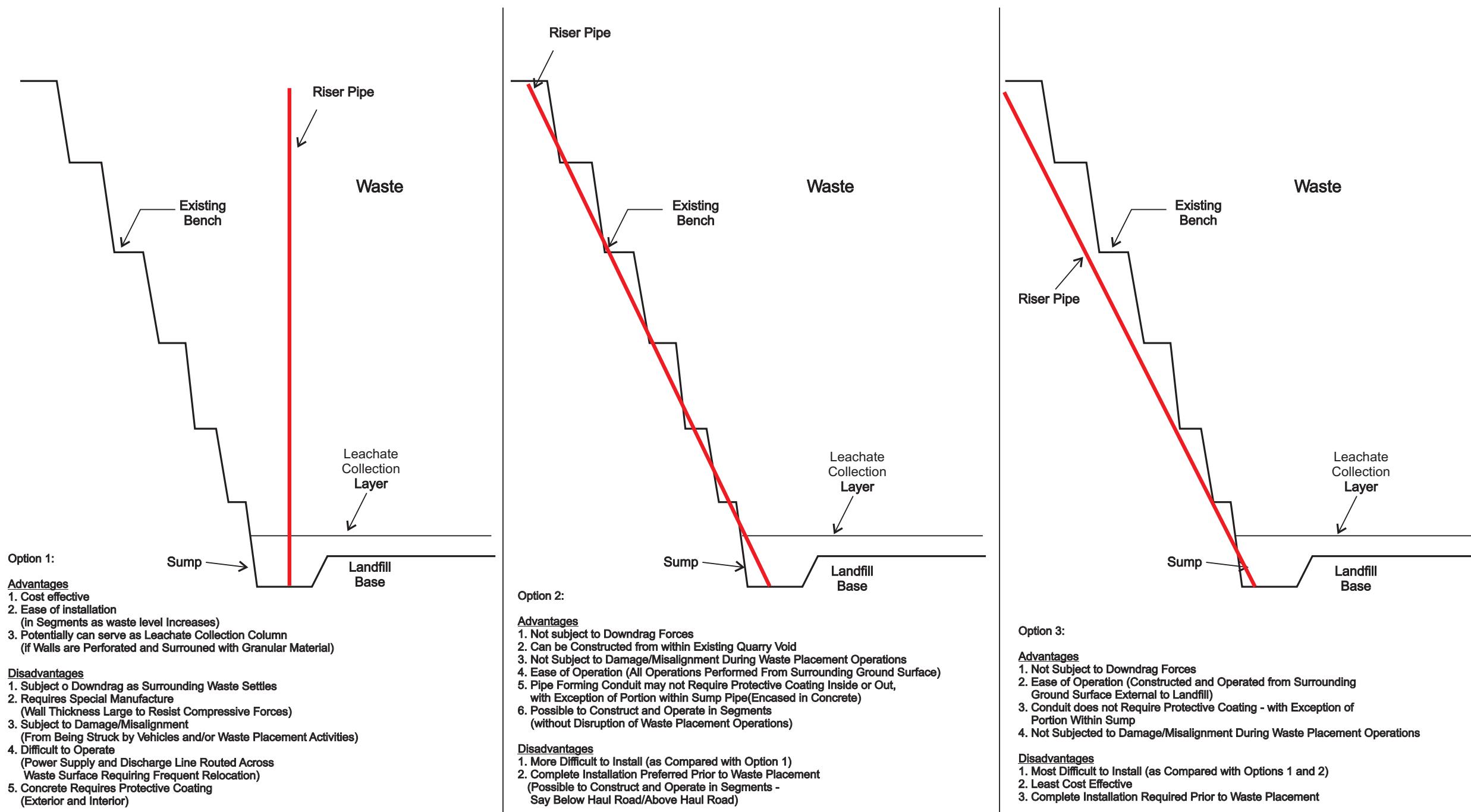
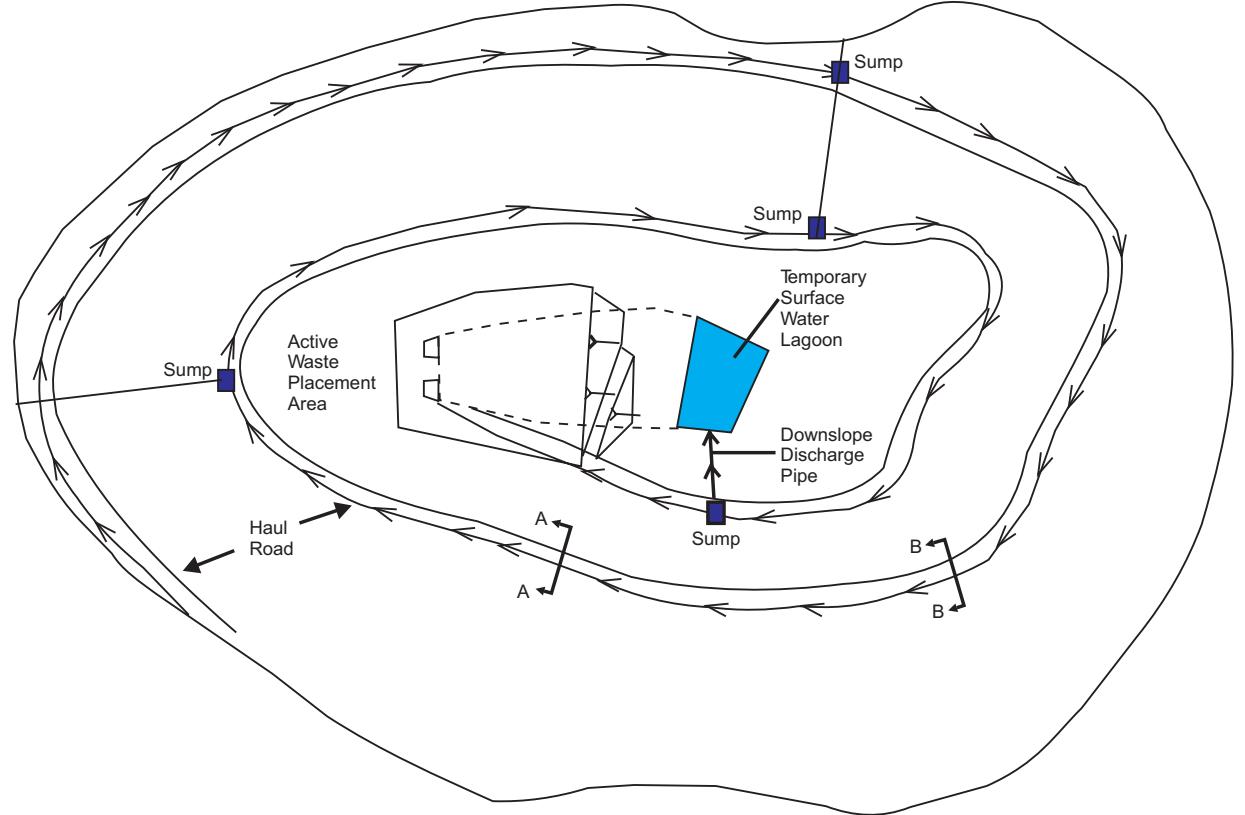


Figure 4
Options for Leachate Riser

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Project:	Lighthorse Business Centre EA
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Date:	08/04/2008
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Reviewed by:	-
Source:	-
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Surface Water Management Concept Design Sketch

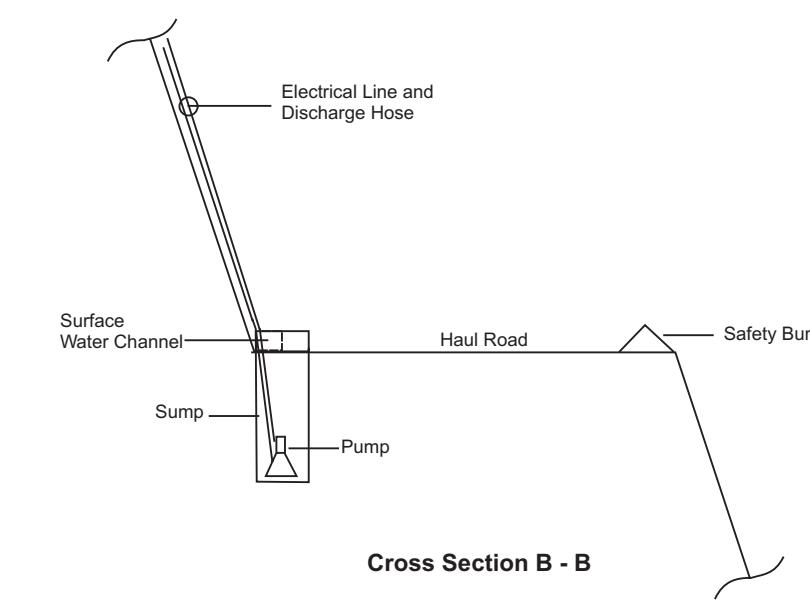
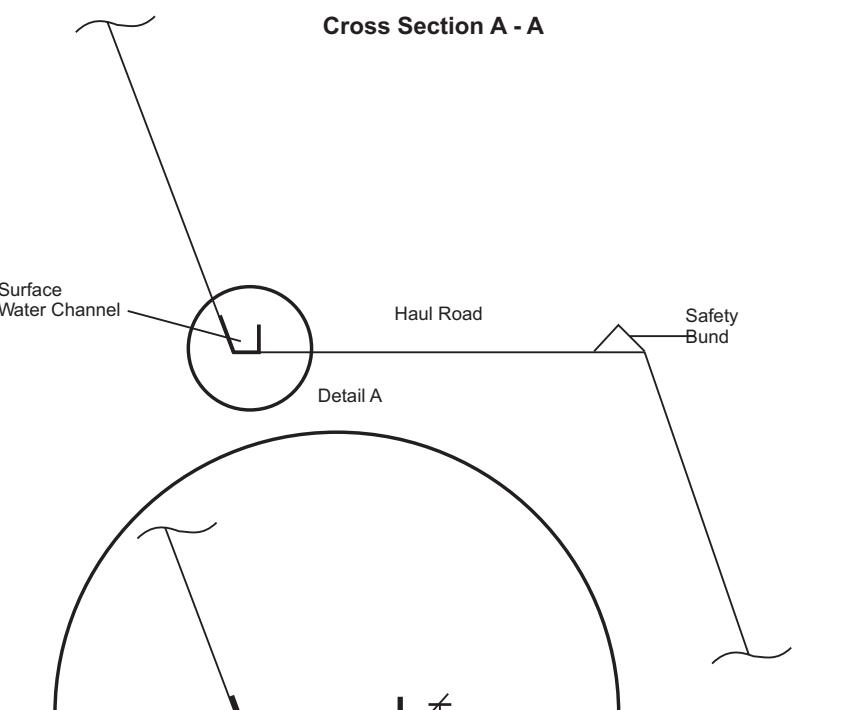
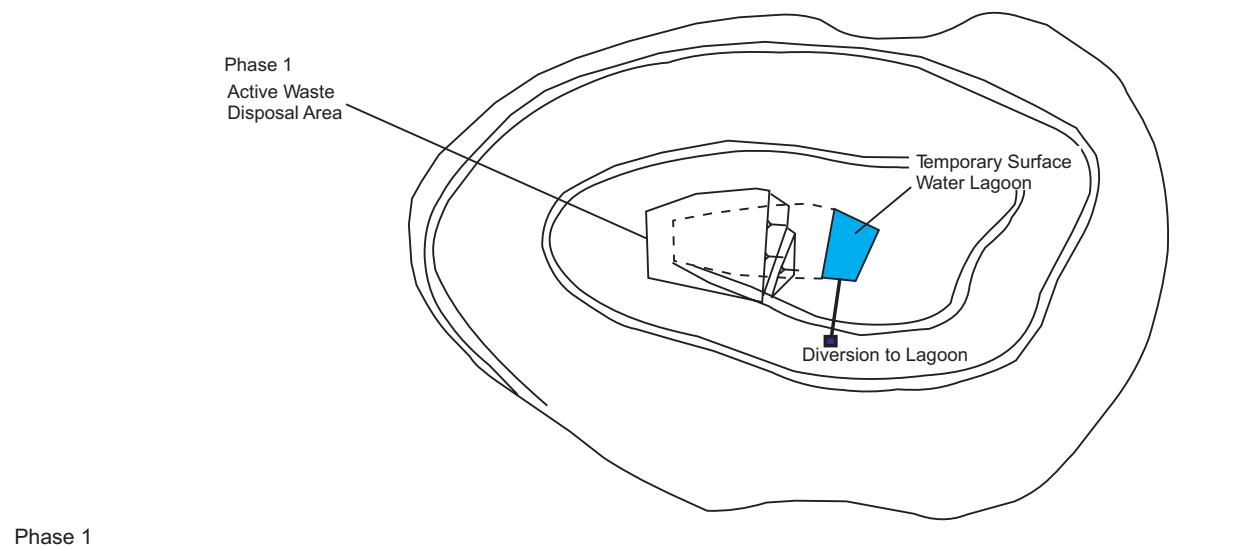


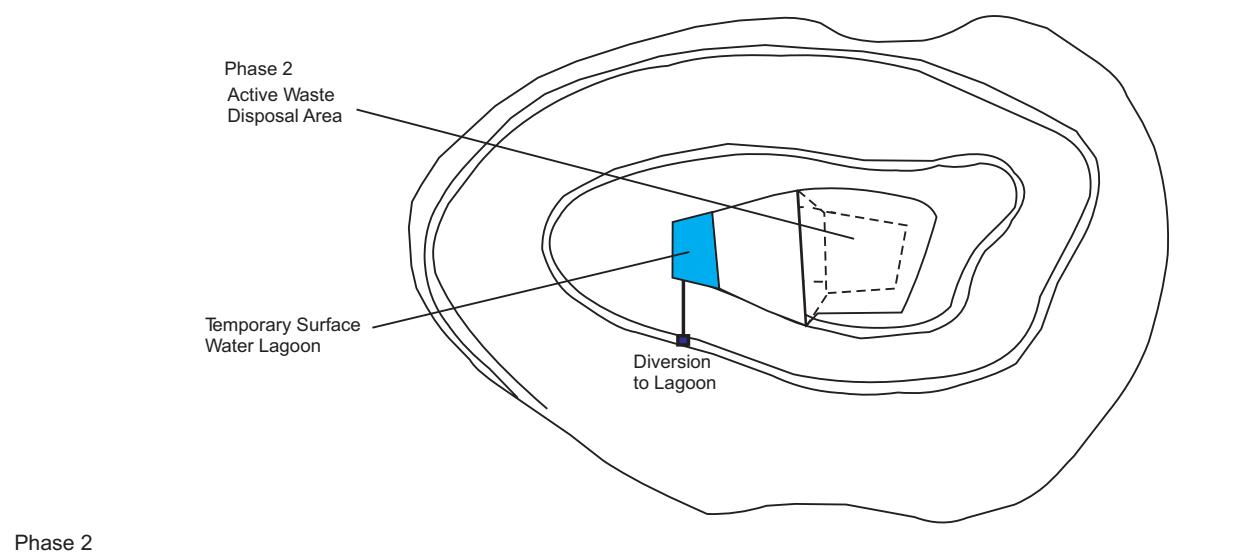
Figure 5
Surface Water Management Concept Design

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Project:	Lighthorse Business Centre EA	
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Scale:	Not to Scale	

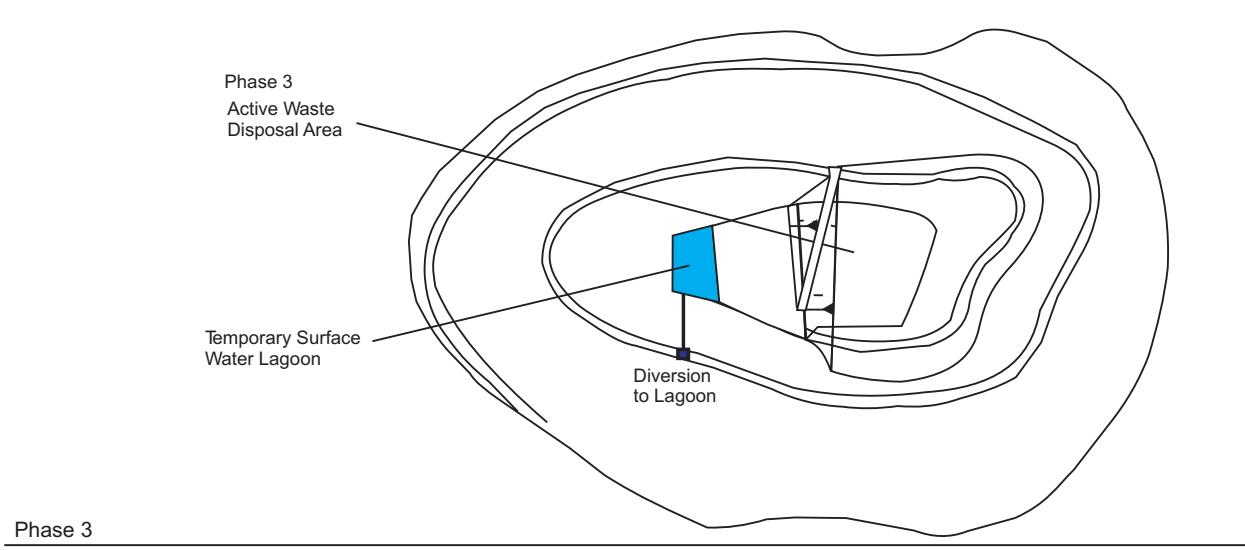
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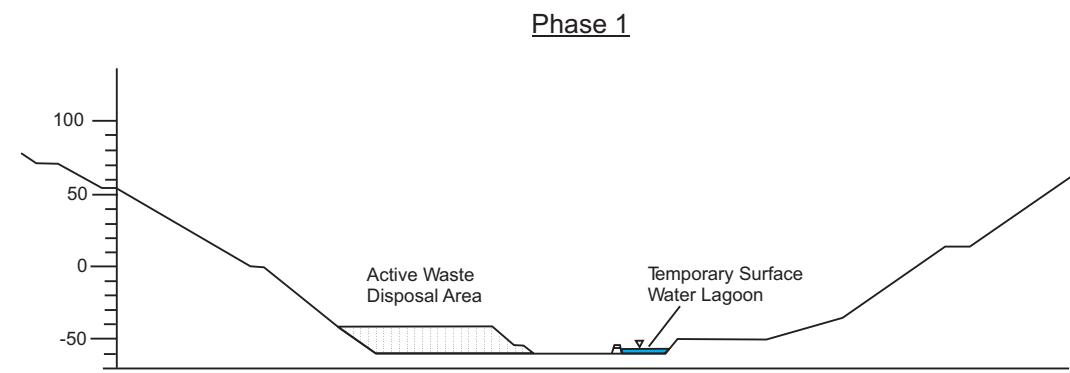
Phase 1



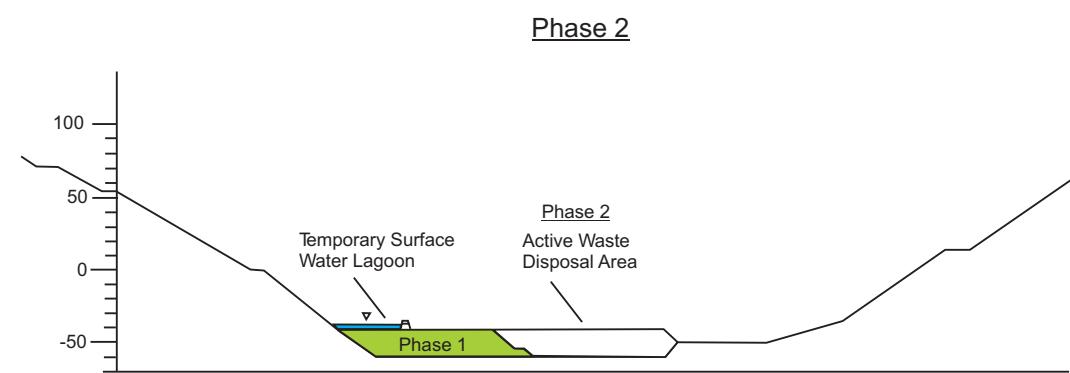
Phase 2



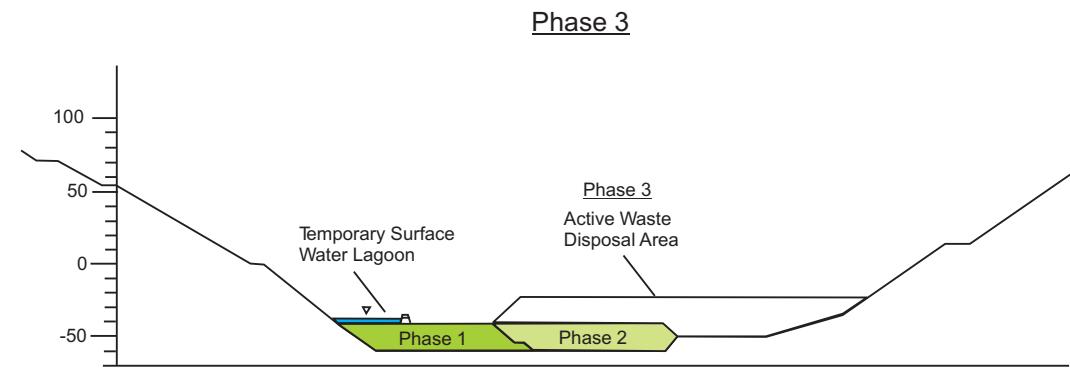
Phase 3



Phase 1



Phase 2



Phase 3

Figure 6
Indicative Plan and Section for Landfill Phasing Showing Temporary Surface Water Lagoon

Client:	ThaQuarry Pty Ltd	
Project:	Lighthorse Business Centre EA	
Drawing No:	0071234s_L_08	Drawing size: A3
Date:	08/04/2008	Reviewed by: -
Drawn by:	ML	-
Source:	-	
Scale:	Not to Scale	

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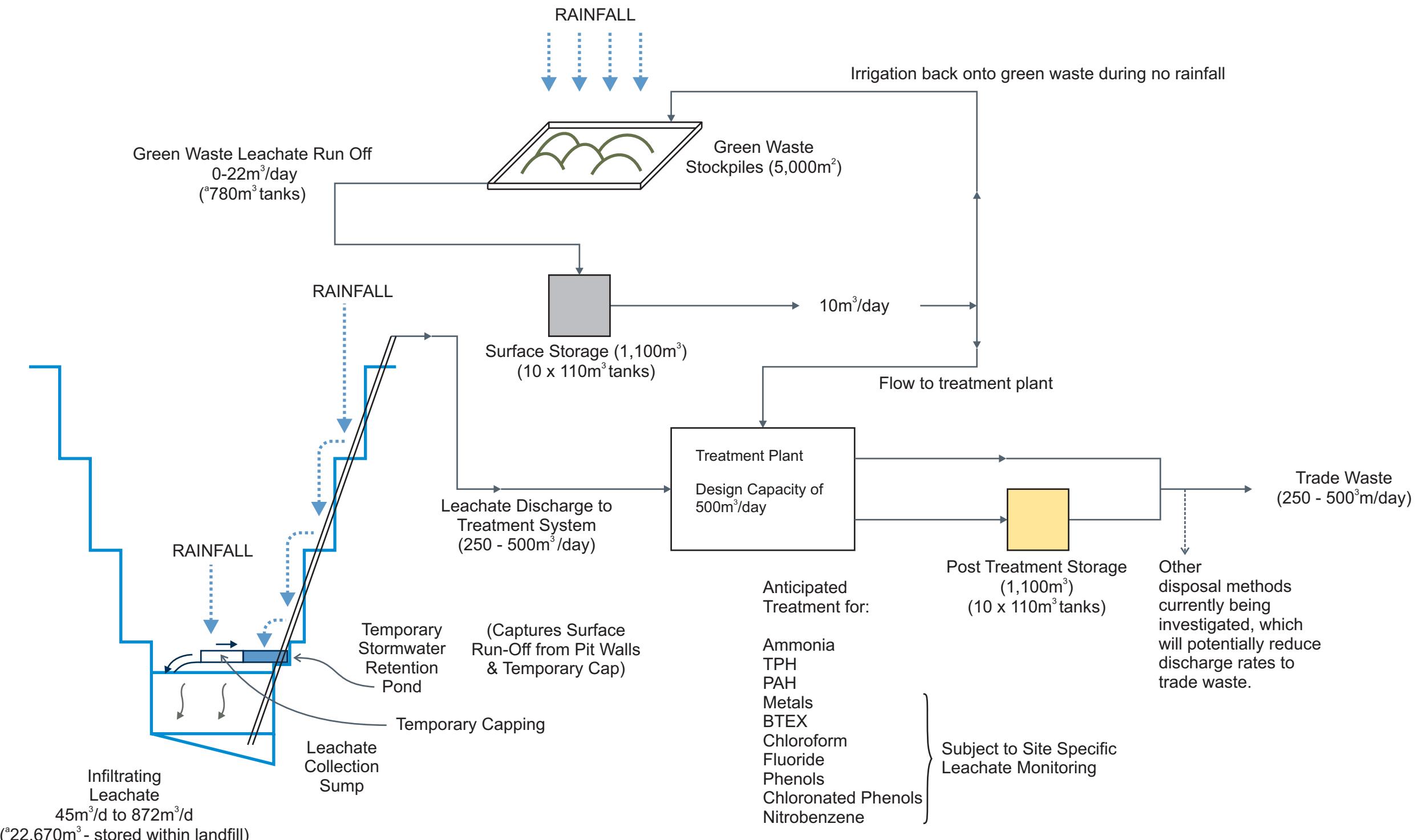


Figure 7
Leachate Processing & Management Diagram

Client: ThaQuarry Pty. Ltd.
Project: Light Horse Business Centre
Drawing No: 0071234s_L_01
Date: 31/07/2008 Drawing size: A3
Drawn by: ML Reviewed by: -
Source: -
Scale: Not to Scale

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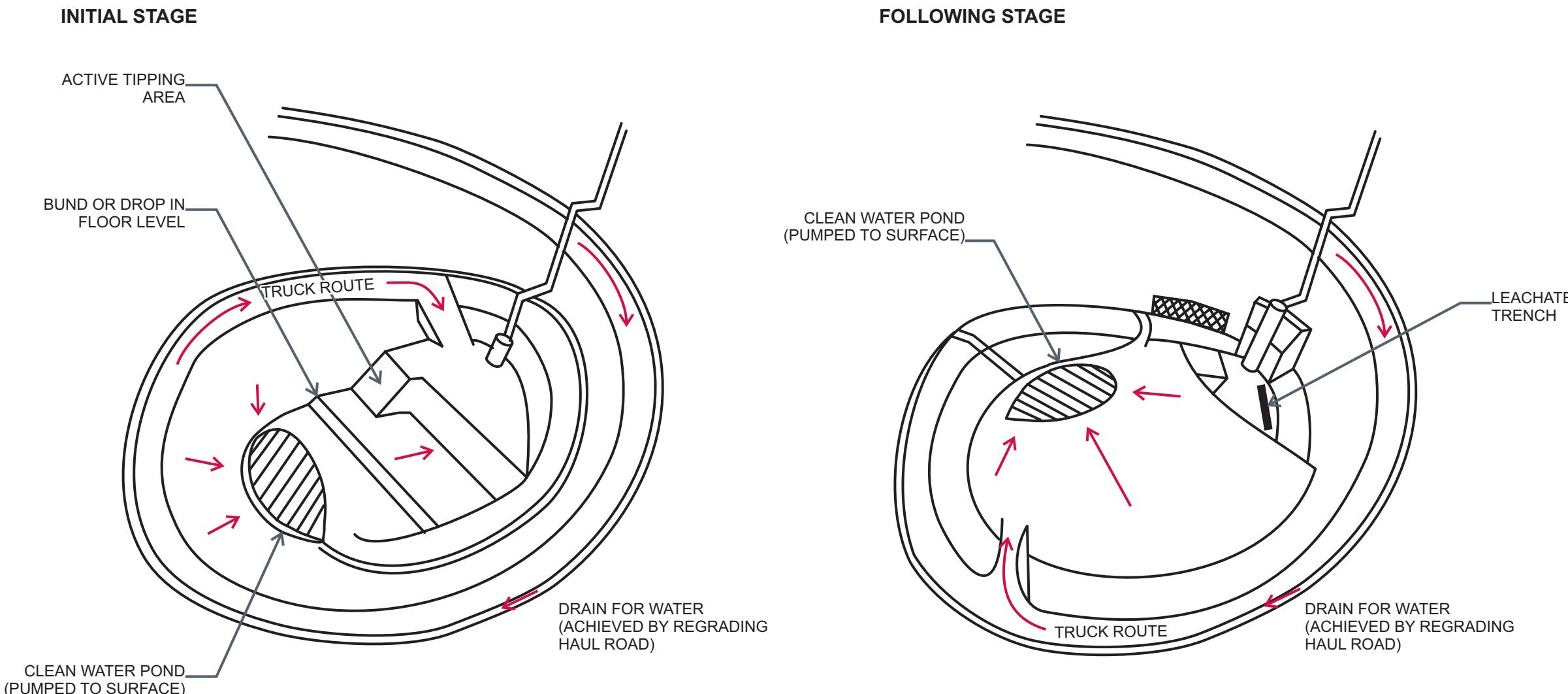


Figure 8
Leachate Well Built in Stages

Client:	ThaQuarry Pty Ltd	
Project:	Lighthorse Business Centre EA	
Drawing No:	0071234s_L_02	Drawing size: A3
Date:	08/04/2008	Reviewed by: -
Drawn by:	ML	
Source:	-	
Scale:	Not to Scale	

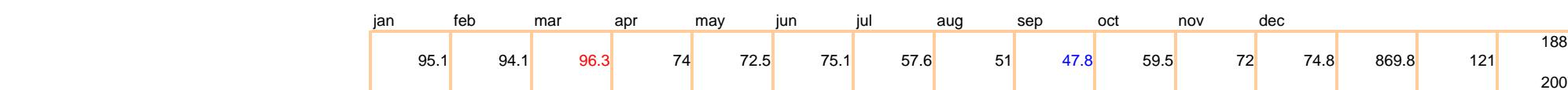
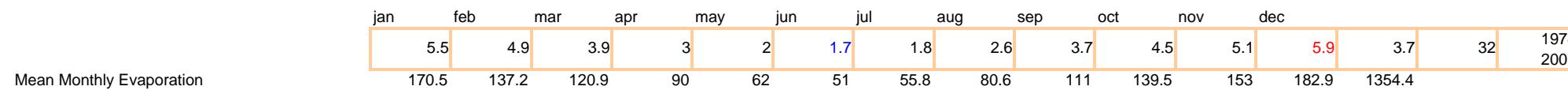
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Annex B

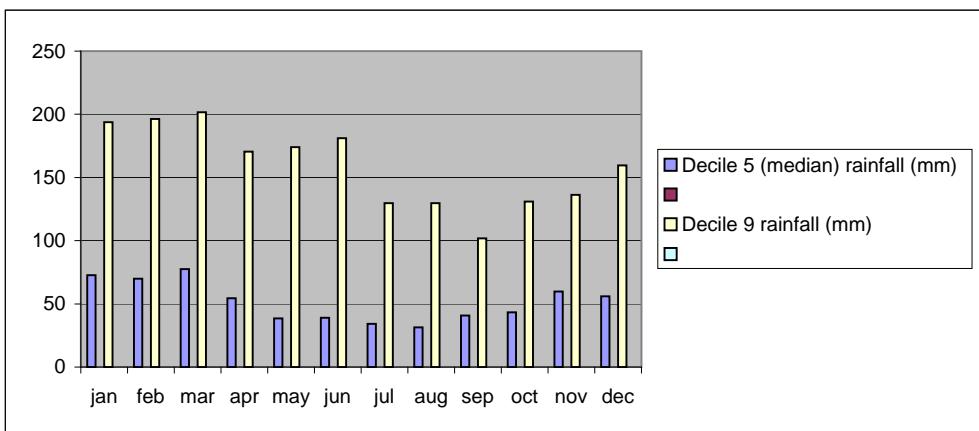
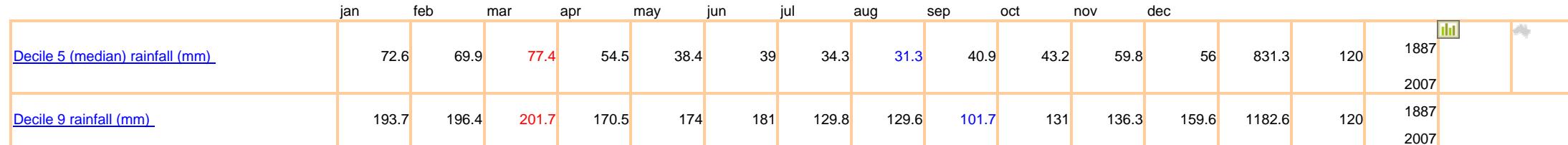
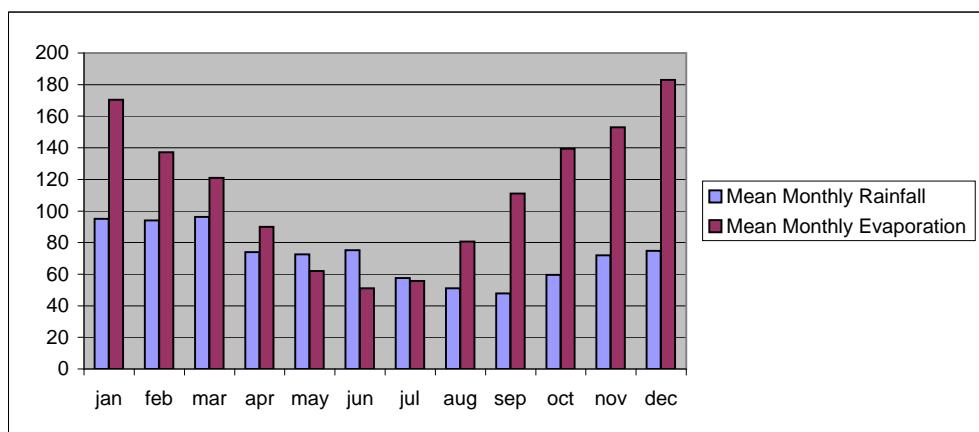
Leachate Model

Site information

Site name: PROSPECT RESERVOIR
Site number: 067019
Latitude: 33.82 °S **Longitude:** 150.91 °E
Elevation: 61 m
Commenced: 1887 **Status:** Open
Latest available data: 16 Jul 2008



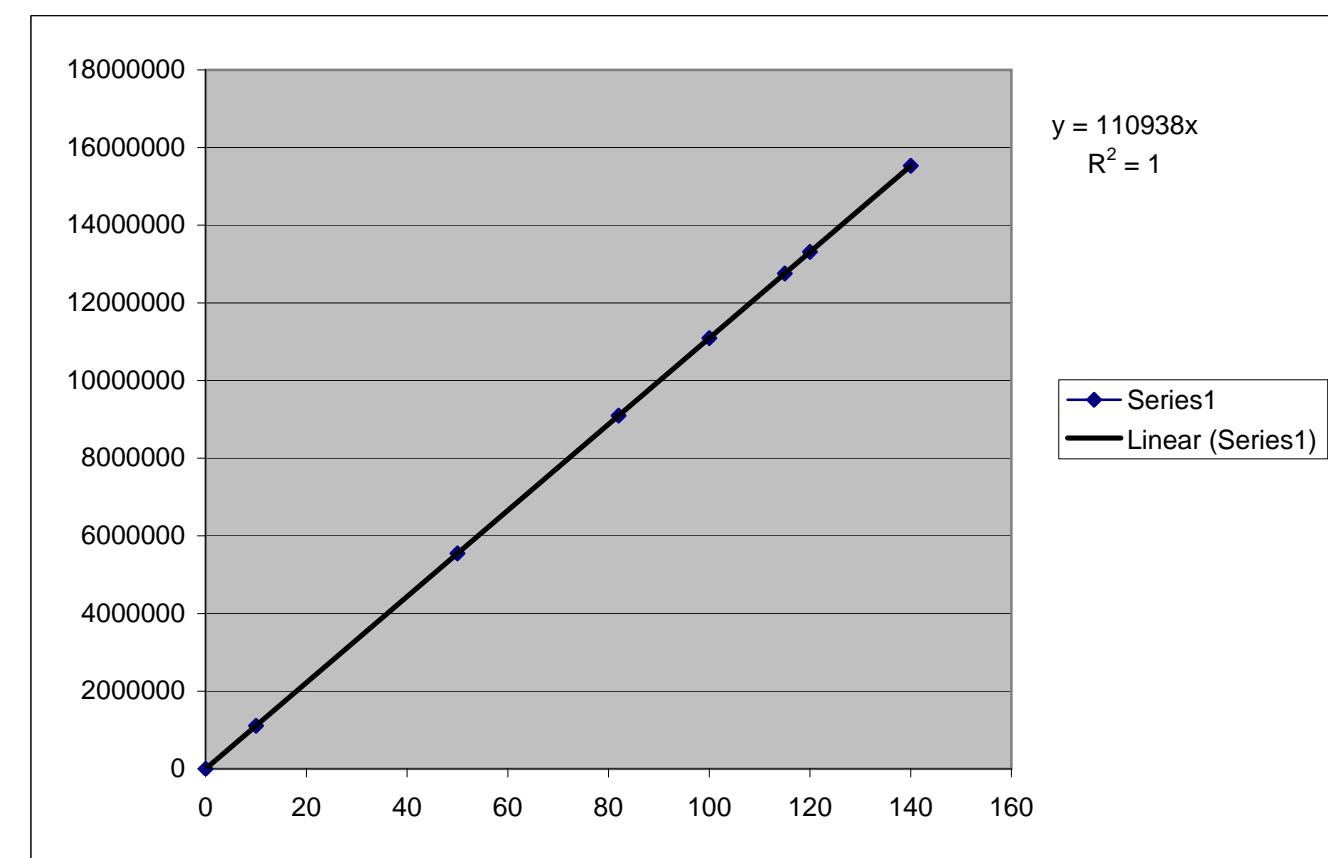
	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
Mean Monthly Rainfall	95.1	94.1	96.3	74	72.5	75.1	57.6	51	47.8	59.5	72	74.8
Mean Monthly Evaporation	170.5	137.2	120.9	90	62	51	55.8	80.6	111	139.5	153	182.9



Radius	Area	Calculated area (m ²)
62	12000	12077.848
290	265000	264242.2

Slope (Z) 1.628571 dimensionless

depth (m)	radius (m)	diameter (m)	volume (m ³)	Area (m ²)
140	290	580	15531283.04	264242.2
120	257.4286	514.8571429	13312528.32	208218.67
115	249.2857	498.5714286	12757839.64	195254.46
100	224.8571	449.7142857	11093773.6	158861.83
82	195.5429	391.0857143	9096894.352	120140.68
50	143.4286	286.8571429	5546886.8	64636.455
10	78.28571	156.5714286	1109377.36	19256.228
0	62	124	0	12077.848



Pumping rate (m ³ /day)	Leachate Level 10th Percentile Monthly Rainfall (m above base of Landfill)	Lower Variance (mm)	Leachate Level Average Monthly Rainfall (m above base of landfill)	Higher Variance (mm)	Leachate Level 90th Percentile Monthly Rainfall (m above base of landfill)
150	0	40.9	40.9	74	114.9
250	0	5.27	5.27	25.15	30.42
350	0	0.59	0.59	4.87	5.46
500	0	0.1	0.1	2.9	3

