# Archbold Road, Eastern Creek: Groundwater and Salinity Assessment for Proposed Quarry Rehabilitation Project and Developable Land

Light Horse Business Centre

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*Light Horse Business Centre (LHBC) proposes redevelopment of land at Eastern Creek. The proposed development comprises bulk earthworks and facility construction for the use of the site as a materials processing centre (MPC), waste transfer station (WTS) and non-putrescible class 2 inert and solid waste landfill within the existing quarry void.*

*The facility is proposed for resource recovery accepting solid, inert building and demolition wastes. Liquid wastes, medical wastes, toxic and hazardous wastes will not be received at the facility. Green wastes, excluding putrescible material containing foodstuffs will be received and handled at the facility. Wastes will be treated by sorting, crushing and screening in order to recover resources for recycling. Recycled materials may be blended to form saleable products which will be stored on the site until sold. Un-recoverable materials, estimated at 20% of the volume received, will be transferred to the landfill area for disposal.*

*The land when fully operational will include a recycled materials sales facility, an inwards weighbridge, outwards weighbridge, wheel washing station, administration office, employee facilities, workshop, bunded above ground fuel storage, hard stand processing and stockpile areas, paved sales areas, parking areas, roadways, lighting, drainage, leachate wells, water treatment and storage facilities, radio controlled water spray system, security fencing and gates.*

*The proposal also incorporates the preparation of the remainder of the site for future industrial use by using the quarry overburden to grade the site to a 5% fall.*

*Site Setting*

*Current landuse comprises a deep hard-rock quarry, an area used for spoil storage/disposal in the form of large heaps of spoil (virgin excavated natural material or VENM), and an area of cleared pasture. The main surface water feature in the area is Ropes Creek, located approximately 400 metres west of the site boundary. A gully (minor tributary of Ropes Creek) runs east to west across the cleared farmland that forms the southern part of the site. Excess water pumped from the quarry has been discharged to this gully for around 40 years, and this will probably have changed the character of the gully considerably.*

*The site is underlain by strata of the Wianamatta Group, generally comprising claystone, siltstone and minor sandstone. The strata of the Wianamatta Shale group have limited potential to transmit groundwater flow, with the majority of flow occurring via fractures and bedding planes. The formation generally forms a layered aquifer system, with discrete aquifers occurring within horizontal fracture zones. The groundwater pressure surface generally follows topography. Groundwater levels in the area of the site are probably around 50mAHD. Quality of deep groundwater is generally poor, with high salinity levels. Groundwater usage in the area is very limited.*

*A weathered profile comprising mottled clays generally overlies the shale, and a perched shallow groundwater system can occur within this stratum.*

*The Minchinbury Diatreme comprising volcanic breccia occurs beneath the site and is exploited by the Hanson quarry. This would originally have formed a large, fractured rock mass within the Bringelly Shale but has largely been removed by quarrying.*

*Pumping from the quarry has resulted in substantial depressurisation of the local groundwater systems, with levels around 100m below the estimated natural groundwater level. Estimated inflow rates are around 125 kL/day or less, indicating low permeability of the surrounding strata.*

*Salinity is known to occur in shallow soils and groundwater seepages in Western Sydney. Published information shows the site to be classified as moderate salinity potential. Previous site investigation showed no evidence of serious salinity impacts, and concluded that soils on site are moderately saline, but that with appropriate site drainage, redevelopment would probably improve the salinity situation. No evidence of serious salinity impacts was observed during detailed site inspection. Shallow groundwater becomes saline close to the assumed discharge zones, suggesting discharge of saline groundwater from the intermediate and deep shale aquifers.*

Assessment of Potential Impacts – Quarry Rehabilitation

*Groundwater inflow to the quarry is very low, with the estimate of 125 kL/day likely to include rainfall runoff and recirculation. Pumping from the quarry over many years has resulting in substantial depressurisation of the surrounding groundwater systems. The extent of drawdown is expected to be localised in the shallow groundwater system, and most extensive in the deep aquifers. If pumping ceases, groundwater levels will rebound, eventually returning to close to natural levels of around 50mAHD or greater over a timescale of tens of years or more.*

*The quarry represents a very low risk site for rehabilitation in terms of potential environmental impacts, because of the low permeability of the strata; the strong inward hydraulic gradient; and the low groundwater inflow rate. It is therefore considered highly suited to rehabilitation by controlled filling, providing that appropriate management and control measures are implemented, including collection and pumping of groundwater seepage and rainfall infiltration. Provision of a low permeability barrier or landfill liner is not considered necessary.*

Assessment of Potential Impacts – Developable Land

*Existing salinity impacts are limited to waterlogging (due to leakage from dams or poor existing drainage) and increased groundwater salinity close to natural drainage lines, probably reflecting discharge of deep groundwater from the Bringelly Shale.*

*The proposed development of an industrial/business park on the site will involve construction of roads, buildings, parking/storage areas, stormwater drainage and landscaping. Existing VENM spoil heaps will be removed, and minor recontouring of natural ground levels undertaken, but this is expected be minor. The only substantial area of existing native vegetation on the site will be retained as a conservation feature. The effects of development are likely to be reduced rainfall recharge and improved drainage, reducing shallow groundwater levels and incidence of waterlogging. Potential for the proposed development and landuse to cause or exacerbate salinity impacts is very limited.*

*The proposed development does not pose an unacceptable risk to groundwater quality.*

Recommendations – Quarry Rehabilitation

*Provision of a low permeability barrier across the base or sides of the quarry is not considered necessary. A water interception and collection system is required, to allow control of water accumulation within the quarry during filling. This should comprise either a permanent basal drainage blanket with sumps and risers, or a series of drainage systems constructed progressively during filling. Surface runoff should be collected.*

*Water levels in the base of the quarry should be maintained as required operationally, either a few metres below the fill surface, or at a lower level to provide buffering storage. Pumped water is expected to be suitable for on-site reuse, but treatment is likely to be required prior to discharge to surface waters.*

*Control of water levels within the quarry will allow management of groundwater levels in the quarry and surrounding strata, if required. The nature of the fill to be used for rehabilitation will be carefully controlled. No further mitigation measures are considered necessary to protect groundwater.*

*Some additional investigation groundwater conditions is required to determine baseline conditions, and ongoing monitoring will be required during rehabilitation. Drilling of at least 3 multi-level piezometers is recommended around the quarry, followed by monitoring of these and pumped volumes. Numerical modelling of the local groundwater system and repressurisation is also recommended, to allow prediction of final groundwater levels and flow regime.*

Recommendations - Developable Land

*Standard construction materials should be suitable in most parts of the site, although there is some risk that excavation and construction close to drainage lines may encounter saline groundwater. Further investigation of salinity conditions should be carried out as part of the geotechnical investigations for construction of hardstandings, buildings, roadways and the drainage system, particularly for high risk areas.*

*In general, development should be planned in accordance with published guidance (Nicholson, 2003), including the following:*

- *avoid/minimise exposure of saline subsoils, minimise cut and fill;*
- *retain vegetation and avoid disturbance in riparian zones and poorly drained areas;*
- *retain and establish vegetation is areas subject to erosion and disturbance;*
- *consider salt-resistant construction materials in areas of shallow saline water tables;*
- *monitor perched water tables.*

*Landscaped areas should be planned with salt-tolerant vegetation, and irrigation should be minimal.*

*Detailed mitigation and monitoring requirements should be covered in a Salinity Management Plan for the site, to be submitted to Council for approval as part of the detailed design process (i.e. after the DA has been granted). This will include a monitoring program to be implemented prior to* *development, continuing until a reasonable period after development, and including water level and salinity monitoring of shallow groundwater.*

# 1. Introduction

Light Horse Business Centre (LHBC) proposes redevelopment of land at Eastern Creek. Current landuse comprises a deep hard-rock quarry, an area used for spoil storage/disposal in the form of large heaps of virgin excavated natural material (VENM), and an area of cleared pasture.

The proposed development comprises bulk earthworks and facility construction for the use of the site as a materials processing centre (MPC), waste transfer station (WTS) and non-putrescible class 2 inert and solid waste landfill within the existing quarry void.

The facility is proposed for resource recovery accepting solid, inert building and demolition wastes. Liquid wastes, medical wastes, toxic and hazardous wastes will not be received at the facility. Green wastes, excluding putrescible material containing foodstuffs will be received and handled at the facility. Wastes will be treated by sorting, crushing and screening in order to recover resources for recycling. Recycled materials may be blended to form saleable products which will be stored on the site until sold. Un-recoverable materials, estimated at 20% of the volume received, will be transferred to the landfill area for disposal.

The land when fully operational will include a recycled materials sales facility, an inwards weighbridge, outwards weighbridge, wheel washing station, administration office, employee facilities, workshop, bunded above ground fuel storage, hard stand processing and stockpile areas, paved sales areas, parking areas, roadways, lighting, drainage, leachate wells, water treatment and storage facilities, radio controlled water spray system, security fencing and gates.

The proposal also incorporates the preparation of the remainder of the site for future industrial use by using the quarry overburden to grade the site to a 5% fall.

. An area of remnant Cumberland Plain woodland in the north-west corner of the site will be retained.

Ian Grey Groundwater Consulting Pty Ltd (IGGC) has been engaged to provide an assessment of the potential impacts from both aspects of the development relating to groundwater and salinity, including suitability of the site and mitigation measures required.

This report presents the results of this assessment, and is written to accompany the development application.

# 2. Scope of Work

The scope of work covered in this report is based on IGGC's proposal of 23rd November 2005 (LT_046), and is summarised below.

*Inception, Data Review and Identification of Outline Requirements*: collection and review of available data, including: previous reports; published geology, salinity and topographic maps; search results from DNR bore database; proposed development infrastructure; pumpage data from existing quarry operator etc.

*Liaison with Regulatory Bodies*: meeting/discussion with key staff from the EPA Waste Section to determine broad requirements for investigation, construction and operation of a solid waste landfill in the quarry. Telephone discussions with DNR groundwater staff to determine requirements and restrictions that may apply.

*Site Inspection*: detailed site inspection of the developable land and the quarry site, including visual assessment of geological and salinity features, measurement of water levels in available monitoring bores and measurement of electrical conductivity in monitoring bores and creeks. Sampling of the quarry pond and limited laboratory analysis (major ions, nutrients).

*Assessment of Geological and Groundwater Conditions*: detailed description and assessment of the geological and groundwater conditions beneath the site will be provided, including likely effects on groundwater due to long-term pumping from the quarry, and expected changes once pumping ceases (groundwater rebound).

*Assessment of Viability and Potential Impacts – Quarry*: detailed assessment of the viability of rehabilitation of the quarry by controlled filling, and potential impacts on groundwater that could arise, including the following:

- implications of cessation of quarry pumping, including requirements for groundwater interception, implications for rehabilitation design/operation, expected groundwater volume/water quality and disposal requirements;
- suitability of the site for rehabilitation by controlled filling, and assessment of potential impacts;
- assessment of outline design requirements for lining and water management, including:
    - need for a low permeability liner;
    - suitable liner materials and construction methods (if required);
    - basal water collection system requirements and concept design;
    - drawings showing the conceptual liner and water management system design;

    - brief literature search of liner construction/operation in similar steep-sided quarries (if required).

- requirements for further investigation and assessment for detailed design.

*Assessment of Potential Impacts – Developable Land*: detailed assessment of the potential impacts associated with groundwater and salinity that could result from development of the land for industrial use, including the following:

- assessment of potential salinity-associated constraints on development and mitigation requirements, in accordance with the Western Sydney Salinity Code of Practice, and based on published salinity maps, existing site data, and information gathered during the site inspection. It will include the following:

    - identification of existing salinity impacts;

    - identification of potential salinity impacts due to land-use changes associated with development;

    - salinity implications of groundwater level changes associated with cessation of quarry pumping;

    - potential constraints on development and likely mitigation requirements;

    - requirements for detailed investigation, monitoring and assessment;

- assessment of potential impacts on groundwater resources and associated receptors arising from the proposed development, and identification of mitigation requirements.

*Reporting*: provision of a detailed draft report for review, containing full details of the above assessments and suitable for submission in support of the DA. Comments will be incorporated prior to the final report being issued.

This report does not address detailed design, geotechnical issues, contamination or surface water drainage.

# 3. Background and Site Setting

## 3.1 Proposed Development

The proposed development is in two parts, and a brief description is provided below.

Developable Land: the site areas excluding the quarry and immediate surrounds will undergo bulk earthworks for future industrial use. Development will include removal of the VENM spoil heaps, recontouring as required, and construction of site roads, parking areas, etc. Development will include a stormwater drainage system to manage runoff from hardstanding, roof and landscaped areas, including appropriate retention and pollution control structures, and discharging to the local surface water system (and eventually to Ropes Creek). The area of remnant Cumberland Forest in the north-western corner of the site will be retained as a conservation feature.

Quarry: excavation from the quarry will largely cease, and filling will take place to allow rehabilitation of the quarry area, and to allow subsequent redevelopment. Fill will comprise soil-type material placed and compacted. Some minor excavation will continue during rehabilitation, including progressive excavation of haul roads etc., to assist with the rehabilitation process.

## 3.2 Site Features and Topography

The site can be divided into three main areas: the existing quarry; the spoil heap area to the west and north-west; and the cleared farmland to the south-west. The main features are summarised as follows:

Quarry: the quarry is a deep excavation with a maximum vertical depth of around 180 metres, and plan dimensions of around 600m (east-west) by 400m (north-south). The quarry sides are stepped, comprising steep slopes (70 to 80º) 10 to 15m high separated by flat benches around 7m wide (J&K, 2004). The upper part of the quarry is excavated through shale and sandstone, and has variable but generally lower-angled slopes (30º to sub-vertical). The base of the quarry is fairly flat, and drains to a sump from which groundwater ingress and rainwater run-off is pumped. The quarry is operated by Hanson (formerly Pioneer) and extraction continues to date.

VENM spoil heap area: the area to the west and north-west of the quarry has been used for storage/disposal of quarry overburden and spoil (VENM), and contains large, fairly flat-topped spoil heaps up to 30m high with side slope angles typically around 45º. The spoil heaps occupy the majority of this area of the site, although the northern area (up to 250m from the northern boundary) and a narrow strip along the western boundary appear relatively undisturbed.

Cleared Pasture: the area to the south-west of the quarry comprises undulating cleared pasture, generally sloping to the south and west at around 5º. A minor drainage line runs through the southern part of this area and joins Ropes Creek west of the site. Vegetation comprises grasses, with a few trees in the south-eastern part of the area.

The triangular area west of Archbold Road comprises a generally flat and low-lying area of cleared pasture, with few trees.

Site features are shown on *Figure 3.1.*

## 3.3 Surface Water Features

The main surface water feature in the area is Ropes Creek, located approximately 400 metres west of the site boundary. A gully (minor tributary of Ropes Creek) runs east to west across the cleared farmland that forms the southern part of the site. Excess water pumped from the quarry has been discharged to this gully for around 40 years, and this will probably have changed the character of the gully considerably. The gully is presently in a fairly degraded condition, with erosion features evident along the banks. Two or more other minor drainage lines cross the cleared land west of Archibald Road (both within and outside of the proposed development site). These would originally have had some expression on the site but are assumed to have been obscured by spoil heaps.

A dam is present in the north-western corner of the site, and would be retained as a conservation feature. A small dam is also present on the minor drainage line crossing the triangular area west of Archbold Road.

A number of minor seepages or wet areas were evident during the site inspection. Those in the cleared farmland west of the Hanson processing area are likely to reflect seepage from nearby dams. The wet areas between the spoil heaps and Archbold Road are likely to be due to obstruction of runoff drainage lines by spoil heaps, site roads and Archbold Road. They may be exacerbated by seepage of accumulated infiltration within the spoil heaps.

The majority of the surface drainage from the site is to Ropes Creek either via tributaries or directly via overland flow. A small area of the site immediately east of the quarry drains to Angus Creek, a tributary of Eastern Creek. Runoff and groundwater seepage from the quarry sub-catchment drains to the basal quarry pond, from where it is pumped to an intermediate pond, and from there to surface dams for re-use on site or for discharge to the tributary of Ropes Creek.

A review of historical aerial photography taken in 1947 prior to site development (CH2M Hill, 2004) indicates two drainage lines, one running east to west across the southern part of the site (existing) and a smaller one running south-east to north-west across the northern part of the site. The latter drainage line has been completely disrupted by placement of spoil, but is still present to the west of the site boundary and Archibald Road.

Discharge of pumped water from the quarry to the southern gully was taking place during the field inspection, and field water quality measurements showed water quality similar to that measured in the quarry pond, with highly alkaline (pH 9.85) and fresh to brackish

(EC 1,241 µS/cm) conditions. Discharge of pumped water over many years is likely to have altered the nature of the gully substantially, both in terms of the flow regime and water quality.

Water quality measurements for the dam located in the north-western corner of the site were also taken, and this showed fresh water (EC 345µS/cm) with very high pH of slightly over 10. Such highly alkaline water is likely to have been in intimate contact with igneous geological material for some time, and this is assumed to reflect seepage of water from the spoil heaps. Removal of the spoil heaps may result in a reduction in the pH of dam water in the long term.

Surface water and drainage features are shown on *Figure 3.1*.

## 3.4 Geology and Soil

Reference to the published 1:100,000 Penrith area geology map (Clarke & Jones, 1991a) indicates that the area around the site is underlain by strata of the Wianamatta Group. The upper unit is the Bringelly Shale, a formation dominated by claystone and siltstone with thin laminite horizons and minor sandstone and with a thickness of at least 100m. This is underlain by the Minchinbury Sandstone, a 3m to 6m thick quartz-lithic sandstone; followed by the Ashfield Shale which comprises sandstone-siltstone laminite and sideritic claystone.

The Wianamatta Group is underlain by the Hawkesbury Sandstone, the top of which is expected to occur at below -80mAHD in the area of the site due to the presence of a palaeochannel (Jones and Clarke, 1991b), and is therefore likely to be well below the base of the quarry.

The Minchinbury Diatreme occurs beneath the site and is exploited by the Hanson quarry. This is considered to be the remnant of an explosive volcanic vent, and forms a steep-sided or vertical inverted conical structure approximately 850m by 300m and pear-shaped in plan. The diatreme comprises volcanic breccia made up of basaltic lapilli (4 to 32mm fragments) and blocks in a fine-grained matrix of tuff and siltstone. Vertically bedded sandstone/siltstone (Bringelly Shale) has been dragged down a ring fault surrounding the diatreme (Jones and Clarke, 1991b).

The edge of the diatreme is generally within the quarry, with the upper benches excavated through weathered or unweathered shale country rock. However, the diatreme extends beyond the south-western limit of the quarry, forming a low hill in the northern part of the cleared farmland. Volcanic strata are exposed in the road cuttings in this area.

Alluvial deposits of Quaternary age occur along Ropes Creek, located to the west of the site. Minor alluvium may occur along the course of a tributary creek which crosses the southern part of the site.

Reference to the 1:100,000 scale soil landscape map of the Penrith area (Bannerman & Hazleton, 1990) indicates the following soil types:

- moderately reactive highly plastic clay soils up to 1m deep over the outcrop of the Bringelly Shale;
- moderately reactive deep layered fluvial soils around Ropes Creek;
- disturbed ground over the site of the quarry.

## 3.5 Hydrogeology

### 3.5.1 Hydrogeological Setting

The hydrogeology of the site and surrounding area is largely controlled by the geology. The strata of the Wianamatta Shale group are generally of low permeability, and have a limited potential to transmit groundwater flow. The majority of groundwater flow occurs via fractures and bedding planes, with negligible flow through the rock mass.

The formation generally forms a layered aquifer system, with discrete aquifers occurring within horizontal fracture zones and with limited inter-connection between zones. The groundwater pressure surface generally follows topography, with groundwater flowing from recharge areas on high ground to discharge areas (generally creeks, rivers and wetland areas). Groundwater levels generally reflect the level of the nearest discharge zones, and in the area of the site would be expected to be around 50mAHD. A slight downward hydraulic gradient typically exists between horizontal aquifer zones.

Prior to development of the quarry the diatreme formed a low hill, and groundwater flow would have radiated from this area towards the surrounding low ground and creeks.

Groundwater quality is generally poor, with high salinity levels from connate salts within the formation and the limited flushing due to low groundwater flow rates.

A weathered profile comprising mottled clays generally overlies the shale, and a perched shallow groundwater system can occur within this stratum.

The Minchinbury Diatreme would originally have formed a large, fractured rock mass within the Bringelly Shale. The permeability of the volcanic breccia relative to the surrounding shales and sandstone is not known, however the intrusion originally formed a low hill and the local high point, and would be expected to represent a groundwater recharge area, with groundwater flowing from high levels around the intrusion towards likely discharge areas associated with Ropes Creek to the west and Eastern Creek to the east. Groundwater quality associated with igneous bodies such as the diatreme can show highly alkaline water, and high levels of inorganic nitrogen can also be present.

Intrusion of the diatreme will have resulted in faulting and increased fracturing of the surrounding strata, and subsequent quarrying activities will have also increased local fracturing as a result of blasting and pressure relief. This is likely to have increased the permeability of the strata surrounding the quarry.

Alluvial deposits occur around Ropes Creek, and limited alluvial material may occur immediately around the tributary. Such strata are highly variable, but are likely to comprise sands, silts and clays. Groundwater is likely to be hydraulically connected to the creek. Localised recharge from creek water is likely to result in relatively fresh groundwater, although discharge of more saline groundwater from the shale can occur through the alluvial material.

A search of the DNR database provided details of 18 registered bores located within 5 km of the site. The majority of these are test/monitoring bores, although there are also two shallow irrigation wells, an aquaculture waste disposal bore and a shallow domestic bore.

Bore details are summarised in *Table 3.1*, and locations are shown on *Figure 3.2*.

Information from the DNR records confirms the hydrogeological setting, with groundwater levels typically 10 to 25 metres below surface. Water quality data are limited, but the reported salinity levels are relatively low for Bringelly Shale.

Groundwater use in the area is limited, with only three registered bores for abstraction of groundwater, all three of which are shallow and exploit perched groundwater in residual clays or minor alluvium. There is also an aquaculture waste disposal bore. All other recorded bores in the area are monitoring or test bores. This low level of groundwater exploitation reflects the generally low yields and high salinity obtained from bores drilled into the shale.

**Table 3.1 Summary Details of Registered Bores**

| Ref | Bore No | Easting (mMGA) | Northing (mMGA) | Depth (m) | Purpose | Standing Water Level (m) | Salinity (mg/L TDS) | Date Drilled | Screen (m) | Geology |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | GW101087 | 294624 | 6255732 | 90.3 | Monitoring | | | 1996 | 70.5 to 88.3 | |
| 2 | GW101083 | 294912 | 6255522 | 78 | Monitoring | | | 1996 | 58.2 to76 | |
| 3 | GW102673 | 295163 | 6255774 | 78 | Monitoring | 9.68 | 4750 | 1993 | Multiple | Siltstone/sandstone/shale |
| 4 | GW102674 | 295369 | 6255779 | 71.9 | Monitoring | | 4400 | 1993 | Multiple | Shale/siltstone/sandstone |
| 5 | GW101085 | 295857 | 6255789 | 99.3 | Monitoring/test | | | 1996 | 79.5 to 97.3 | |
| 6 | GW101082 | 296112 | 6255918 | 40.3 | Monitoring/test | 12.43 | | 1996 | 30.4 to 39.3 | |
| 7 | GW104060 | 301538 | 6255572 | 24.6 | Monitoring | | | 2001 | 8.6 to 23.6 | 5m clay over shale |
| 8 | GW104061 | 301820 | 6255566 | 24.5 | Monitoring | | | 2001 | 8.5 to 23.5 | siltstone/shale |
| 9 | GW104062 | 302387 | 6255420 | 24.4 | Monitoring | 17 | 2800 | 2001 | 5.4 to 23.4 | 4m clay over shale |
| 10 | GW104063 | 302689 | 6255343 | 27.4 | Monitoring | | | 2001 | 8.4 to 26.4 | 5m clay over shale |
| 11 | GW075076 | 294522 | 6261087 | 13.5 | Monitoring (DWR) | 7 | | 1999 | 10.5 to 13.5 | clay |
| 12 | GW075077 | 295109 | 6260936 | 12.5 | Monitoring (DWR) | 12.5 | | 1999 | 9.5 to 12.5 | 12.5m clay over shale |
| 13 | GW075078 | 295501 | 6260807 | 8 | Monitoring (DWR) | | | 1999 | 1 to 8 | 7.8m clay over shale |
| 14 | GW028415 | 297090 | 6260390 | 7.6 | Irrigation | | | 1966 | | 3m clay, 1.8m gravel over shale |
| 15 | GW028414 | 298655 | 6259660 | 6.1 | Irrigation | 3.9 | | 1966 | | clay over shale |
| 16 | GW018361 | 300615 | 6259765 | 217.9 | Aquaculture Waste Disposal | | | 1961 | OH from 12.1 | 14m clay over basalt/shale/sandstone |
| 17 | GW105479 | 296998 | 6262176 | 14 | Monitoring (mobil) | 12.9 | | 2003 | | |
| 18 | GW026226 | 300760 | 6263530 | 8.5 | Domestic | 1 | | 1966 | | 7.9m clay over shale |

Notes: MGA is Map Grid of Australia; mg/L is milligrams per litre; TDS is total dissolved solids; OH is open hole.

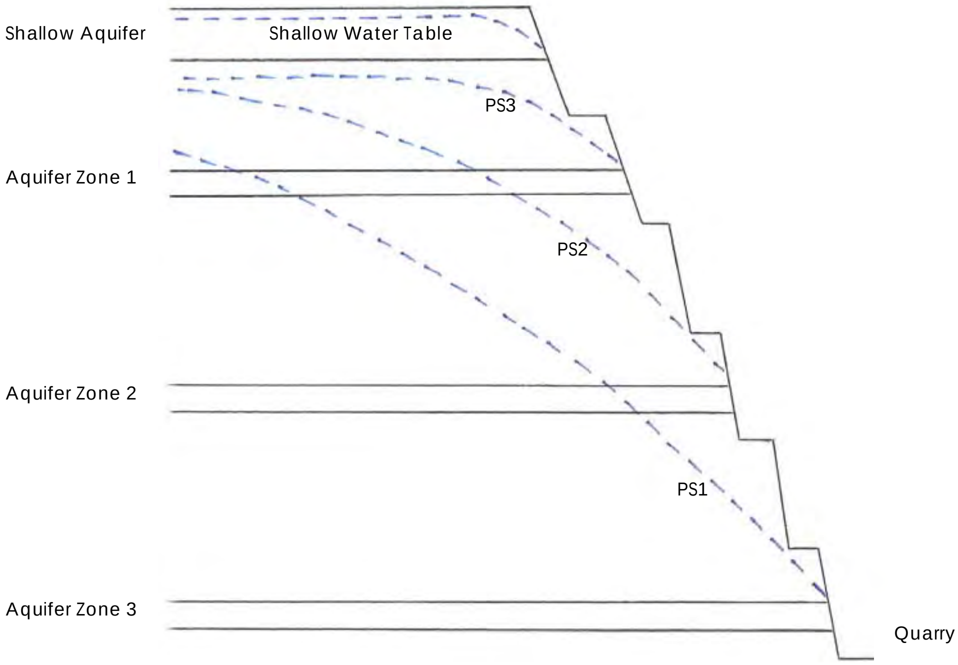
### 3.5.2 Quarry Hydrogeology

The presence of a deep quarry for over 40 years has resulted in substantial depressurisation of the local groundwater systems. The base of the quarry is presently at an elevation of around -57 mAHD, i.e. around 100m below the estimated natural groundwater level. This head difference represents a very high hydraulic gradient into the quarry from the surrounding aquifers.

Rainfall runoff from the quarry catchment and groundwater seepage from the sides and base of the quarry are currently collected in a sump at the base of the quarry and pumped to Ropes Creek. No formal measurement of pumped volumes is made by the quarry operator. Anecdotal information indicates that water is pumped from the basal pond at a rate of around 40 L/s, with pumping typically taking place for 2 hours every 2 to 3 days, with pumping occurring more frequently during wet weather and less so during dry periods. Some recirculation of pumped water probably occurs due to leakage from the intermediate and surface level pond. This suggests a typical groundwater seepage rate of around 125 kL/day, although this figure is likely to include a component of rainfall runoff. This is a very low rate of inflow for a quarry of this size and depth, and indicates that the surrounding strata are of low permeability.

The low permeability of the strata in and around the quarry mean that depressurisation is likely have resulted in a steep drawdown cone. The extent of depressurisation is likely to be fairly limited in the shallow aquifers within the soils/weathered profile and upper shale, but may extend to a kilometre or more from the quarry in the deep aquifers. The conceptual groundwater regime around the quarry is illustrated in *Figure 3.3*.

Figure 3.3: Conceptual Groundwater Regime (Simplified, not to scale)




Notes: PS is piezometric or pressure surface

Observations made by quarry staff are that seepages generally occur immediately after rain and persist for a few days to a few weeks. There are some areas of permanent seepage, although the inflow rates from these are reportedly low. In general seepage is greatest from the north-eastern quarry face, and lowest in the western area. This suggests that the permeability of the remaining igneous body is relatively low.

A site inspection was carried out on 1st December 2005 after several days of reasonable rainfall and at the end of a generally wet month. This confirmed the information provided by quarry staff, with limited seepage observed. The main seepages noted were in the north-eastern area, but even these were minor.

A samples of water from the basal quarry pond was collected and submitted for NATA-accredited laboratory analysis in a chilled esky under chain-of-custody documentation. Field parameters were also measured for a seepage from the north-eastern quarry face. Water quality results are presented in *Table 3.2*.

**Table 3.2 Water Quality Results – Quarry Pond and Seepage (mg/L unless stated)**

| Analyte | Quarry Pond | NE Seepage |
|---|---|---|
| Electrical Conductivity (µS/cm) | 1,288 | 1,973 |
| pH (pH units) | 8.6 | 9.14 |
| Total Alkalinity as $CaCO_3$ | 380 | - |
| Hydroxide Alkalinity as $CaCO_3$ | <1 | - |
| Carbonate Alkalinity as $CaCO_3$ | 46 | - |
| Bicarbonate Alkalinity as $CaCO_3$ | 333 | - |

| Analyte | Quarry Pond | NE Seepage |
|---|---|---|
| Sulphate as $SO_4$ | 129 | - |
| Chloride | 72.8 | - |
| Calcium | 2 | - |
| Magnesium | 1 | - |
| Sodium | 289 | - |
| Potassium | 2 | - |
| Fluoride | 0.4 | - |
| Ammonia as N | 0.089 | - |
| Nitrite as N | 0.12 | - |
| Nitrate as N | 7.34 | - |
| Reactive Phosphorus as P | 0.02 | - |

The relatively low salinity of the water in the quarry pond suggests that groundwater ingress is mostly comprised of local recharge from rainfall within the zone of more fractured strata immediately around the quarry, with limited input of groundwater from the wider Bringelly Shale aquifers. The laboratory analysis shows unusual chemistry, with very high alkalinity and high sodium, but low levels of calcium. This indicates a sodium bicarbonate water type, atypical for groundwater from most strata. The sample also shows the presence of inorganic nitrogen as nitrate (with minor nitrite and ammonia). Prior to discharge into the quarry, groundwater in the surrounding strata may be under reducing conditions, with the nitrogen present as ammonia, oxidising to nitrite then nitrate on exposure to air. This is supported by the presence of nitrite in the sample (nitrite is very unstable with a short half life under most aqueous conditions). It should be noted that the water sampled from the quarry pond comprises groundwater mixed with low salinity rainfall run-off. Groundwater is likely to be even more alkaline, with higher nitrogen levels and higher salinity.

Regular monitoring of discharge water is undertaken by Hanson, but testing is limited to suspended solids and pH. pH of discharge water is generally around 8.5.

## 3.6 Salinity

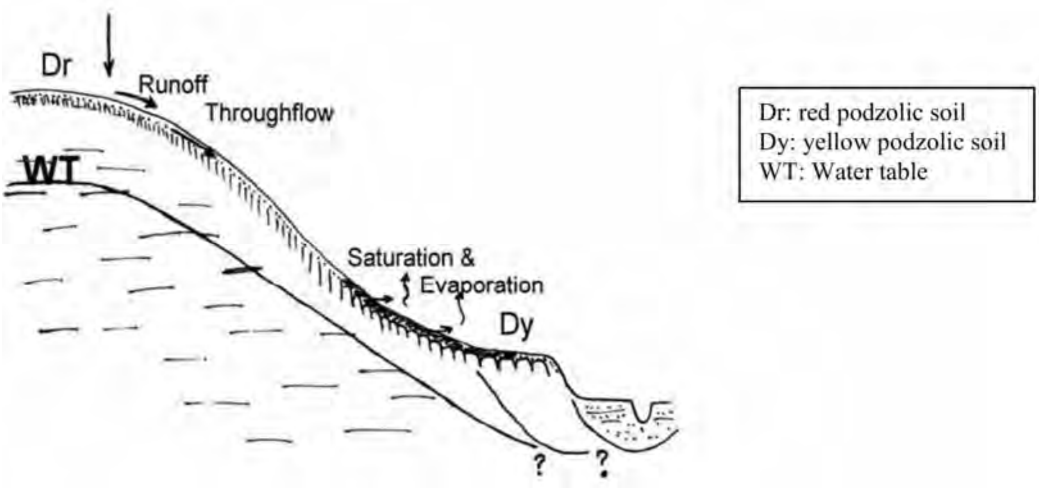
### 3.6.1 Background

Salinity is known to occur in shallow soils and groundwater seepages in Western Sydney, generally associated with the Wianamatta Group shales. Salinity impacts include damage to buildings or roads, vegetation dieback, erosion and waterlogging, and can be exacerbated by development or changes in surface, drainage and vegetation conditions if these are not planned on the basis of site conditions.

Reference to the published map of salinity potential in Western Sydney (DIPNR, 2003) indicates that the majority of the site is classified as moderate salinity potential, with areas of high potential shown along Ropes Creek, the tributary running through the southern part of the site, and possibly the north-west corner of the site close to the junction of Archibald Road and the M4 motorway.  An area of known salinity is shown as occurring where the M4 motorway crosses Ropes Creek.

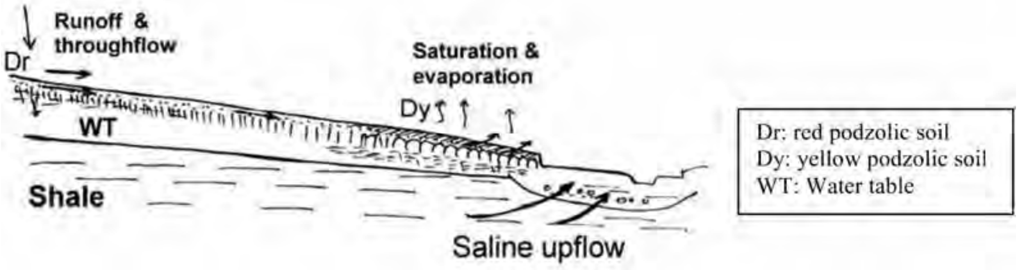
Soil landscapes in Western Sydney commonly comprise poorly drained duplex soils, with a relatively permeable loamy topsoil over a low permeability clay subsoil, and this situation is likely to prevail across most of the site.  Soil water moves more easily through the loamy topsoil (often flowing across the underlying clay), and salt can accumulate in the subsoil.  Surface expression of salinity occurs where soil water accumulates and seeps to the surface, and evaporation concentrates the salts; typically on lower slopes or flats (Nicholson, 2003).  This situation is shown in *Figure 3.4*.

Figure 3.4: Salinity Associated with Shale Soil Landscape (Mitchell, 2000)




Salinity can also arise in areas of saline groundwater discharge from deeper aquifers. Groundwater in the Bringelly shale is typically brackish to saline, and this water discharges naturally along creeks and gullies.  Salinity expressions occur in discharge zones and when groundwater is sufficiently shallow for capillary action to bring water and salt to the surface.  These effects are exacerbated should groundwater levels rise due to increased recharge accompanying vegetation removal and landuse changes etc.  This situation is shown in *Figure 3.5*.

Figure 3.5: Salinity Associated with Deep Groundwater Discharge (Mitchell, 2000)




### 3.6.2 Site Conditions

Previous investigation has been undertaken into salinity on the site (PSM, 2005).  This included review of published information, site inspection, drilling of boreholes (9 in total, 7 on the current site), soil sampling, piezometer installation (4 in total, 3 on the current site) and groundwater levels measurement.

No evidence of serious salinity impacts was reported. Results of soil testing from the bores showed the following:

- sulphate levels were all well below those considered potentially aggressive to concrete piles;
- chloride levels were all below those considered potentially aggressive to steel piles;
- soil electrical conductivity (EC) levels generally indicated non-saline topsoil, moderately saline residual soils, and very saline shale bedrock.

The report concluded that soils on site are moderately saline, but that with appropriate site drainage, redevelopment would probably improve the salinity situation.

Salinity investigation of neighbouring land to the east has also been undertaken (SMEC, 2002). This also identified moderately saline soils accompanied by elevated electrical conductivity in surface water features. The need for appropriate salinity management procedures was identified, and the potential for an improved salinity situation with appropriate management was again identified.

A detailed site inspection was carried out on 1st December 2005, including: a walkover survey of the site; identification of surface water features, waterlogged areas and existing bores; and measurement of groundwater levels and electrical conductivity of groundwater and surface water where possible. Seven existing shallow piezometers were located: three from the previous salinity investigation (PSM, 2005, prefix BH); and four from an earlier investigation into potential contamination (ADI, 1995, prefix MW). Locations of these piezometers are shown on *Figure 3.1*, and details are provided in *Table 3.3*.

**Table 3.3 Summary of Shallow Piezometers**

| Piezometer | Depth (mbgl) | Water Level (mbgl) | Water Level (mAHD – approx) | EC (µS/cm) | pH |
|---|---|---|---|---|---|
| BH3 | 3.5 | Dry | - | - | - |
| BH4 | 5 | 2.5 | 51.7 (estimated) | 30,410 | 6.73 |
| BH8 | 4.3 | Dry | - | - | - |
| MW2 | 8 | 3.7 | 51.4 | 18,830 | 6.76 |
| MW3 | 8 | 3.2 | 63.2 | 1,400 | 7.14 |
| MW4 | 8 | 2.1 | 68.8 | 937 | 7.1 |
| MW5 | 8 | 4.7 | 66.9 | 1,384 | 6.92 |

Reasonably wet conditions preceded the site inspection, making identification of salinity features slightly more difficult.

No evidence of serious salinity impacts was observed: there were no indications of salt scalds, salt crystals, vegetation dieback or other salinity effects. Several areas of waterlogging were observed as discussed in *Section 3.3*: however these appear to be associated primarily with leakage from dams or poor surface water drainage. Placement of spoil heaps will have increased infiltration of rainfall, and both the presence of spoil heaps and construction of site roads have impeded surface water drainage, and these factors have exacerbated waterlogging on the north-western area of the site.

Water level and salinity data from the shallow piezometers indicates groundwater flow in the shallow formations following the topography, with recharge occurring on the higher ground and discharge likely to be taking place along the gullies. The high groundwater level in MW4 is anomalous, and is likely to reflect leakage from the nearby dam for quarry discharge water. Salinity of the shallow groundwater is low on the higher ground and mid slopes, but groundwater becomes saline close to the assumed discharge zones. This suggests that discharge of saline groundwater from the intermediate and deep Bringelly Shale aquifers is occurring in these areas, as the increase appears to be too great to be explained by evaporative concentration alone.

The investigation carried out to date is considered sufficient to provide an understanding of salinity processes on the site and to allow assessment of potential impacts associated with development. The number of bores and samples is considered to meet the guidelines for such investigations (DLWC, 2002). No additional investigation is recommended at this stage.

# 4. Assessment of Potential Impacts – Quarry Rehabilitation

## 4.1 Groundwater Inflow

Groundwater inflow to the quarry has been estimated at around 125 kL/day based on anecdotal information on pumping provided by Hanson staff. This figure is likely to include a substantial component of rainfall runoff and some recirculation, and thus probably overestimates the rate of groundwater inflow. This very low rate of inflow means that there are unlikely to be any major operational difficulties with groundwater management. In addition, the rate of groundwater inflow will decrease over time should water levels within the quarry be allowed to rise.

Groundwater seepage (together with rainfall runoff and infiltration) will be collected and pumped from the quarry during filling. This water is expected to show chemistry broadly similar to that from the existing quarry pond, with high pH and elevated nitrogen levels (both natural). This water may require treatment prior to discharge to the local surface water system (if required).

## 4.2 Predicted Groundwater Level Behaviour and Implications

Groundwater levels in the aquifer systems surrounding the quarry have been subject to substantial depressurisation as a result of groundwater pumping during the 40+ years of quarrying. This has resulted in groundwater heads around 100m below natural levels immediately around the quarry, and the quarry forms the centre of a cone of depression or drawdown. The lateral extent of this drawdown cone is not known. The low transmissivity of the surrounding strata suggests a steep cone that is unlikely to extend beyond one kilometre or so from the quarry rim. The extent of drawdown is expected to be localised in the shallow groundwater system, and most extensive in the deep aquifers.

If pumping from the quarry were to cease, groundwater levels would rebound, eventually returning to close to natural levels of around 50mAHD or greater. The timescale for complete recovery of groundwater levels would depend on a number of factors, including rainfall recharge, the characteristics of the local aquifers (permeability and storage coefficient) and the size of the drawdown cone. Insufficient information is available for accurate estimates to be made of this timescale, but it would be expected to be in the order of tens of years or greater.

Repressurisation is expected to bring a return to groundwater conditions similar to those that would have occurred naturally prior to quarry and dewatering. The potential for long-term adverse impacts is therefore limited, particularly as the effects of dewatering on the shallow aquifers are expected to be localised.

Notwithstanding this, understanding of detailed local groundwater conditions is limited at present, and further studies will be required to confirm these and to ensure that repressurisation will not result in groundwater levels above or close to proposed surface levels on the development site, and in the local area. The exact final groundwater conditions are not known at this time as they will depend on the detailed hydrogeological conditions around the quarry, including permeability and rainfall recharge. These will be slightly different to the conditions prevailing prior to quarrying because of increased fracturing of surrounding strata, the presence of a mass of fill material within the quarry, and the changed land use and surface conditions.

Operation of a controlled rehabilitation program in the quarry will necessitate pumping of collected groundwater inflow and rainfall runoff/infiltration. This will allow control of the repressurisation process, and can be used to prevent any adverse impacts in the unlikely event that this is necessary.

## 4.3 Suitability for Rehabilitation by Controlled Filling

The quarry represents a very low risk site for rehabilitation in terms of potential groundwater and related impacts, because of the following factors:

- the strong inward hydraulic gradient under existing condition remove the possibility of migration of contaminated groundwater away from the quarry during the operational phase, and during the initial post-closure period;
- the low permeability of the surrounding strata, poor natural groundwater quality and low level of groundwater use in the area greatly limit the potential for impacts on groundwater should an outward hydraulic gradient develop in the future;
- the low groundwater inflow rate means that groundwater inflow will not present operational difficulties with water management;
- the nature of the quarry will necessitate active management of stormwater, with collected water pumped to discharge points via settlement ponds etc.;

The quarry is therefore considered highly suited to rehabilitation by controlled filling, providing that appropriate management and control measures are implemented.

## 4.4 Outline Design Requirements

The quarry site is in a very safe hydrogeological setting for rehabilitation from both an operational viewpoint and in terms of potential groundwater impacts. The following outlines recommended design requirements for the site.

### 4.4.1 Requirement for of a Low Permeability Barrier

Provision of a low permeability barrier or landfill liner is not considered necessary across the base or up the sides of the quarry for the following reasons:

- The low risk hydrogeological setting afforded by the low permeability of the surrounding strata, the poor natural water quality and low level of groundwater use in the area, and the strong inward hydraulic gradient;
- The very low rate of groundwater inflow; and,
- The low-risk nature of the proposed fill material, i.e. engineered fill rather than waste.

Provision of a barrier system in the quarry would offer no management or environmental benefits, other than a reduction in the already low rate of groundwater inflow.

### 4.4.2 Management Requirements for Collected Water

Groundwater and rainfall runoff are currently pumped from the quarry to allow extraction of rock. Groundwater will continue to seep into the quarry during rehabilitation via fractures in the base and sidewalls of the quarry. Rainwater will also collect in the base of the quarry via infiltration through the placed fill and runoff from the quarry sides.

In a landfill site, water seeping through the waste and collecting in the base of the site is referred to as leachate. This water undergoes chemical changes within the waste mass, both by leaching chemicals from the waste and through chemical and biological processes occurring during decomposition of the degradable content. In this case, the fill material will comprise controlled soil-type material, and the potential for leaching and chemical changes will be limited. The term “collected water” will therefore be used instead of leachate.

Provision of an interception and collection system is required to allow control of water accumulation within the quarry during filling, both for operational reasons (to prevent water levels rising too close to the surface of placed fill) and to allow control of the repressurisation process that will take place in the surrounding groundwater system. There are two broad options for design of the collection system:

- a permanent basal drainage system, comprising a basal drainage blanket with a herringbone arrangement of slotted pipes (alternatively a herringbone arrangement of slotted pipes surrounding by rubble drains may be acceptable), a main basal sump fed by the piped drains, and a riser to allow pumping of collected water. The riser should ideally comprise an inclined solid pipe running up the side of the quarry and fixed to the sidewalls to prevent damage or dislocation due to settlement of fill. However a vertical riser progressively constructed through the fill would be acceptable if preferred. A secondary sump and riser is recommended to allow contingency water management in the event of failure of the primary system; or,

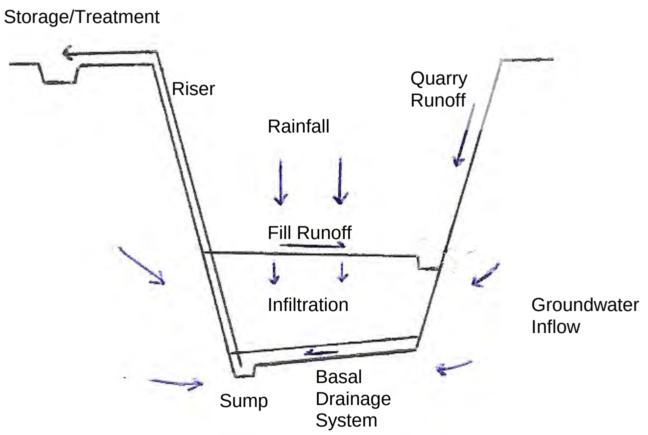
- progressive construction of drainage systems at various levels during rehabilitation, to allow control of collected water levels during each phase of filling. The first drainage layer and sump would therefore be constructed on the quarry base, and filling would proceed with the sump raised progressively until the final height of the first filling phase was reached. The fill surface would then be laid to fall to a new sump and compacted, and a new drainage layer placed (with piped rains as needed and overlain by geotextile). Filling would then proceed again.

The former allows full control of water level within the quarry at all times, although it does rely on efficiency of drains, sumps and risers being maintained throughout and after filling, with a final burial depth of around 180m. The latter approach avoids this problem, although care would be needed with water management during construction of each new drainage system to ensure that sufficient collection and pumping capacity is available at all times.

In addition, the fill surface should be laid and compacted at a suitable gradient, and surface runoff directed to a collection dam where possible. Run-off from haul roads and stockpiling/processing areas should also be collected.

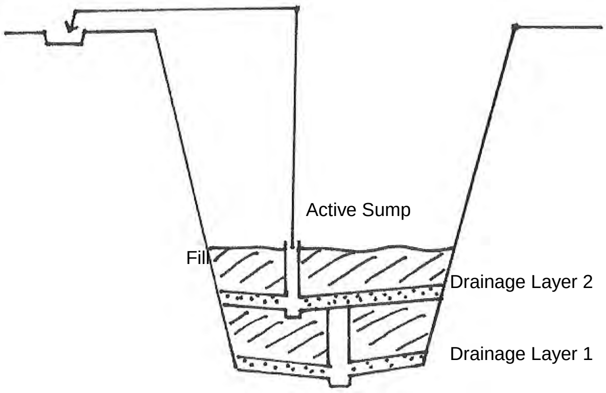
The main features and conceptual design of the water collection system are shown in *Figure 4.1*.

Figure 4.1: Water Collection System – Conceptual Design

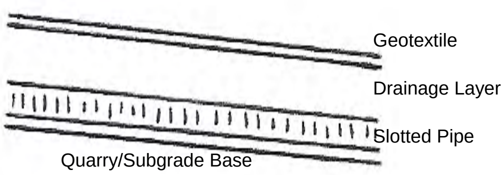



Conceptual Permanent Drainage System and Inflows

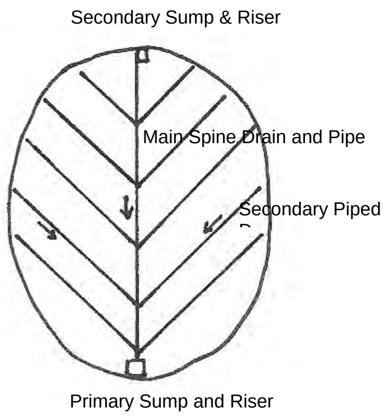
Figure 4.1: Water Collection System – Conceptual Design (continued)




Conceptual Progressive Drainage Systems




Drainage Layer (Section)




Drainage Layer (Plan)

All pipes and risers should have appropriate crush and shear resistance, and should be designed to allow cleaning for maintenance and in the event of blockage.

Water levels in the base of the quarry should be maintained as required operationally. Maintenance of very low water levels is <u>not</u> recommended, as this would result in maximum groundwater inflow. Water levels should be maintained a few metres below the lowest point on the fill surface at any time, or at a lower level if buffering storage within the fill mass is required for runoff generated during storm events.

Water level control to meet groundwater management requirements may also be needed, depending on the results of further studies and monitoring.

Collected water should be pumped to holding ponds for testing and treatment (if required), prior to reuse on site for dust suppression etc., or discharge to the stormwater system. Irrigation over the fill mass to promote evaporation could also be considered if volumetric reduction is required. Based on the available data, collected water is expected to be suitable for on-site reuse, but treatment is likely to be required to reduce nutrient levels prior to discharge to the local surface water system.

## 4.5 Mitigation Measures and Requirements for Further Investigation

Assessment of the existing quarry excavation and surrounding groundwater regime indicates that the site is well-suited to rehabilitation of the quarry by controlled filling, with a low risk to the environment and no difficult management issues identified. However, the local groundwater regime is not understood in detail, and there is some uncertainty relating to rebound of groundwater levels on cessation or reduction of pumping.

Control of water levels within the quarry will allow management of groundwater levels in the quarry and surrounding strata, if required. The nature of the fill to be used for rehabilitation will be carefully controlled. No further mitigation measures are considered necessary to protect groundwater.

Investigation of groundwater conditions in the surrounding strata is required to determine baseline conditions, and ongoing monitoring will be required during rehabilitation. Drilling of at least 3 multi-level piezometers is recommended around the quarry, followed by permeability testing, water quality testing and water level monitoring. The deepest monitoring zones should be close to the level of the existing quarry base. Water level monitoring should be undertaken using pressure transducers and dataloggers to allow transient groundwater level responses to pumping and rainfall recharge to be determined. Requirements for ongoing monitoring should be determined based on the results on investigation. At this stage regular monitoring is likely to be limited to water level monitoring.

Numerical modelling of the local groundwater system and repressurisation due to cessation or reduction in groundwater pumping is recommended. The key outcomes of this work will be final predicted groundwater levels and flow regime, and the timescale for water level recovery. This information is required for planning of final ground levels and ongoing requirements for groundwater management and monitoring.

Finally, monitoring of volumes pumped from the quarry by Hanson during the final stages of quarrying should be implemented by installation of a flow meter on the discharge pipe to the surface ponds or equivalent monitoring. This will provide more accurate information on pumped volumes.  Further monitoring of pumped and/or seepage water quality is also recommended to provide more information on the likely chemistry of collected water and any treatment requirements.

# 5. Assessment of Potential Impacts – Developable Land

Published guidance on management of salinity in Western Sydney for redevelopment sites (Nicholson, 2003) provides planning and investigation requirements for large redevelopment/rezoning applications.

Firstly, the salinity potential of the site locality (the site and surrounding area) should be identified. In this case, because an area of high salinity risk is present close by, there is a high salinity potential for the locality. Based on the scale of the proposed development and the salinity potential of the locality, the guidance then requires salinity management responses along the following lines:

- Identify and review existing reports;
- Understand salinity process on the site and determine requirements for site specific investigation;
- Consider salinity management options and requirements;
- Develop site-specific Salinity Management Plan;
- Address salinity management requirements in Precinct Plan, Master Plan or Development Control Plan for the site.

The first three of these requirements should be addressed at this stage, with the last two addressed during the detailed design process once the DA has been granted. The first two items have been addressed in *Section 3.6*.

## 5.1 Existing Salinity Impacts

Review of published information and previous reports together with inspection of the site indicate that existing salinity impacts are limited. There are no visible indication of salt scalds, vegetation dieback or other indicators of serious salinity effects. Existing salinity impacts are limited to the following:

- Waterlogging mostly due to leakage from dams or poor existing drainage;
- Increased salinity close to natural drainage lines, probably reflecting discharge of deep groundwater from the Bringelly Shale.

A more detailed description of existing impacts is provided in *Section 3.6.*

## 5.2 Salinity Implications and Potential Impacts – Proposed Landuse

The proposed development on the site will involve construction of roads, buildings, parking/storage areas and landscaping. Existing spoil heaps will be removed by reprocessing. Some recontouring of natural ground levels is likely to be undertaken, but this is expected be minor. The only substantial area of existing native vegetation on the site will be retained as a conservation feature.

The proposed development involves construction of large areas of hard surfaces, and provision of a formal stormwater drainage system for the site. Vegetation removal will be limited to pasture and minor scrub. The effects of this are likely to be as follows:

- reduced rainfall recharge, and therefore reductions in both shallow groundwater levels and incidence of surface waterlogging;
- improved drainage due to removal of spoil heaps and provision of a formal drainage system will reduce or remove existing incidence of waterlogging.

Potential for the proposed development and landuse to cause or exacerbate salinity impacts is therefore very limited. Moderately to highly saline soils may be present on the site, particularly close to drainage lines, and excavation of these could release additional salt into the environment. Construction in areas of high water tables and elevated salinity (i.e. close to drainage lines) could result in salinity damage to roads or buildings, although the potential for such impacts is limited.

## 5.3 Salinity Implications of Deep Groundwater Level Changes

Repressurisation of the deep shale aquifer has the potential to cause salinity impacts if final pressures are close to ground surface, as this would increase discharge of deep, saline groundwater, and could also bring salts stored in shallow soils to the surface. Some increase in the incidence of surface waterlogging could also occur. However, salinity effects are largely associated with the shallow, perched aquifer in the soils and residual clay. This water table is unlikely to have been substantially affected by depressurisation, and the potential for increased impacts is limited unless the rebound groundwater pressures are higher than those that existed prior to quarrying.

Depressurisation may have reduced the flux of saline water discharging to drainage lines from the deeper shale aquifers, and repressurisation would cause this flux to return to levels similar to those occurring naturally. Given the low permeability of the shale aquifers and the shallow soils this increase is likely to be minor.

## 5.4 Potential Groundwater Impacts

Redevelopment and landuse changes can potentially impact on groundwater quality or on the availability of groundwater resources. The former generally occurs due to intentional or accidental discharge of polluting substances to soils or groundwater, as a result of poorly designed drainage systems, leaking underground storage tanks, discharges from septic tanks, inadequate pollution prevention measures around fuel storage areas etc. Impacts on groundwater resource availability can occur if landuse changes result in a substantial reduction in rainfall recharge to productive aquifers.

The site setting is one of low sensitivity with respect to potential groundwater impacts. The underlying Bringelly Shale has a low resource potential, with water bores generally having low yields of high salinity groundwater. Groundwater usage in the area of the site is very low. The low permeability of the shale and the overlying residual clays greatly limits the potential for near-surface pollution to reach groundwater.

The proposed development does not include any activities that pose a particular risk to groundwater quality. The development will be sewered, and stormwater drainage will be directed to the local surface water system. The development therefore does not pose an unacceptable risk to groundwater quality, subject to standard pollution prevention measures for fuel storage etc.

Development may result in a small reduction in groundwater recharge, but this will not affect the resource value of the local groundwater systems, and has benefits in terms of salinity.

## 5.5 Potential Constraints on Development and Mitigation Requirements

The site is in a low risk area with respect to potential groundwater impacts, and there are no constraints on development or mitigation requirements other than standard pollution prevention measures.

The risk associated with salinity is also low, and development is expected to reduce existing salinity impacts as a result of reduced recharge and improved drainage.

There is some risk of salinity damage to buildings, roads or infrastructure associated with development. Results from previous investigation (PSM, 2005) show sulphate and chloride levels in all soil samples below those considered potentially aggressive to foundations, indicating that standard construction materials should be suitable in most parts of the site. However, there is some risk that excavation and construction close to drainage lines or in low-lying areas may encounter saline groundwater at shallow depth. The presence of building foundations or roadways in contact with or in the capillary zone of a saline water table can result in salinity damage to susceptible materials.

Inflow rates to excavations are expected to be low, and are not likely to cause problems during excavation and construction.

In general, development should be planned in accordance with salinity guidance (Nicholson, 2003). The main aspects relevant to the site are as follows:

- avoid/minimise exposure of saline subsoils, minimise cut and fill;
- retain vegetation and avoid disturbance in riparian zones and poorly drained areas;
- retain and establish vegetation is areas subject to erosion and disturbance;
- consider salt-resistant construction materials in areas of shallow saline water tables;
- monitor perched water tables.

Landscaped areas should be planned with salt-tolerant vegetation, and any irrigation should be minimal and based on requirements of vegetation.

Detailed mitigation and monitoring requirements should be covered in a Salinity Management Plan for the site, to be submitted to Council for approval.

Discussions with Hanson regarding long-term plans for the dams within the processing area south of the quarry should be held, as leakage from these appears to be causing waterlogging of the nearby developable land.

## 5.6 Requirements for Further Investigation

Further investigation of salinity conditions should be carried out as part of the geotechnical investigations for construction of hardstandings, buildings, roadways and the drainage system.

High risk salinity areas close to drainage lines should be identified, and geotechnical investigation of these areas should include measurement of soil salinity and shallow groundwater levels.

A monitoring program should be implemented prior to development, continuing until a reasonable period after development. This should include water level and salinity monitoring of shallow groundwater, and requirements should be detailed in the Salinity Management Plan for the site.

The Precinct Plan for the development area requires submission of a Salinity Management Plan (SMP) with any development application: however it is proposed that the SMP be prepared as part of the detailed design process once the DA has been granted, and submitted for Council approval. The requirement for an SMP can be conditioned in the DA. Existing information is sufficient to demonstrate that salinity risks do not pose an obstacle to the proposed development, and the proposed approach allows the SMP to be developed based on the detailed design of the site drainage system and other features.

# 6. Conclusions

LHBC proposes redevelopment of land at Eastern Creek. Current landuse comprises a deep hard-rock quarry, an area used for spoil storage/disposal in the form of large VENM spoil heaps, and an area of cleared pasture.

The proposed development comprises bulk earthworks and facility construction for the use of the site as a materials processing centre (MPC), waste transfer station (WTS) and non-putrescible class 2 inert and solid waste landfill within the existing quarry void.

The facility is proposed for resource recovery accepting solid, inert building and demolition wastes. Liquid wastes, medical wastes, toxic and hazardous wastes will not be received at the facility. Green wastes, excluding putrescible material containing foodstuffs will be received and handled at the facility. Wastes will be treated by sorting, crushing and screening in order to recover resources for recycling. Recycled materials may be blended to form saleable products which will be stored on the site until sold. Un-recoverable materials, estimated at 20% of the volume received, will be transferred to the landfill area for disposal.

The land when fully operational will include a recycled materials sales facility, an inwards weighbridge, outwards weighbridge, wheel washing station, administration office, employee facilities, workshop, bunded above ground fuel storage, hard stand processing and stockpile areas, paved sales areas, parking areas, roadways, lighting, drainage, leachate wells, water treatment and storage facilities, radio controlled water spray system, security fencing and gates.

The proposal also incorporates the preparation of the remainder of the site for future industrial use by using the quarry overburden to grade the site to a 5% fall.

An area of remnant Cumberland forest in the north-west corner of the site will be retained.

*Site Features and Topography*

The site can be divided into three main areas:

Quarry: a deep excavation with steep, stepped sides, approximately 180m deep and plan dimensions of around 600m by 400m;

VENM spoil heap area: the area west and north-west of the quarry contains large, fairly flat-topped spoil heaps up to 30m high; and, Cleared Pasture: the area to the south-west of the quarry and west of Archbold Road comprises undulating cleared pasture with a minor drainage line running through the southern part.

The main surface water feature in the area is Ropes Creek, located approximately 400 metres west of the site boundary. A gully (minor tributary of Ropes Creek) runs east to west across the cleared farmland that forms the southern part of the site. Excess water pumped from the quarry has been discharged to this gully for around 40 years, and this will probably have changed the character of the gully considerably.

*Geology and Soil*

The site is underlain by strata of the Wianamatta Group, generally comprising claystone, siltstone and minor sandstone.

The Minchinbury Diatreme occurs beneath the site and is exploited by the Hanson quarry. This is a steep-sided conical structure approximately 850m by 300m, comprising volcanic breccia. The diatreme extends beyond the south-western limit of the quarry.

Alluvial deposits of Quaternary age occur along Ropes Creek, and minor alluvium may occur along drainage lines.

*Hydrogeology*

The strata of the Wianamatta Shale group have limited potential to transmit groundwater flow, with the majority of flow occurring via fractures and bedding planes. The formation generally forms a layered aquifer system, with discrete aquifers occurring within horizontal fracture zones. The groundwater pressure surface generally follows topography. Groundwater levels in the area of the site are probably around 50mAHD. Groundwater quality is generally poor, with high salinity levels. Groundwater usage in the area is very limited.

A weathered profile comprising mottled clays generally overlies the shale, and a perched shallow groundwater system can occur within this stratum.

The Minchinbury Diatreme would originally have formed a large, fractured rock mass within the Bringelly Shale. Groundwater quality associated with such igneous bodies can show highly alkaline water and high levels of inorganic nitrogen.

Intrusion and quarrying of the diatreme will have increased fracturing of the surrounding strata, increasing the permeability. Pumping from the quarry has resulted in substantial depressurisation of the local groundwater systems, with levels around 100m below the estimated natural groundwater level. Estimated inflow rates are around 125 kL/day or less, indicating low permeability of the surrounding strata. Limited water quality data suggests relatively low salinity but high pH and presence of inorganic nitrogen, typical for groundwater associated with an igneous body mixed with rainfall runoff.

*Salinity*

Salinity is known to occur in shallow soils and groundwater seepages in Western Sydney, with impacts including damage to buildings or roads, vegetation dieback, erosion and waterlogging. Published information shows the site to be classified as moderate salinity potential, with high potential in the area.

Previous site investigation showed no evidence of serious salinity impacts, and soil testing did not indicate conditions aggressive to foundations. The report concluded that soils on site are moderately saline, but that with appropriate site drainage, redevelopment would probably improve the salinity situation. No evidence of serious salinity impacts was observed during detailed site inspection. Several areas of waterlogging were observed, however these appear to be associated primarily with leakage from dams or poor surface water drainage due to spoil heaps and site roads.

Groundwater flow in the shallow formations follows the topography, with recharge occurring on the higher ground and discharge likely to be taking place along the gullies. Salinity of the shallow groundwater is low on the higher ground and mid slopes, but groundwater becomes saline close to the assumed discharge zones, suggesting discharge of saline groundwater from the intermediate and deep shale aquifers.

*Assessment of Potential Impacts – Quarry Rehabilitation*

Groundwater inflow to the quarry is very low, with the estimate of 125 kL/day likely to include rainfall runoff and recirculation. Groundwater seepage and rainfall infiltration will be collected and pumped from the quarry during filling: this water is expected to be highly alkaline with elevated nitrogen levels (both natural), and treatment may be required.

Pumping from the quarry has resulting in substantial depressurisation of the surrounding groundwater systems, with the quarry forming the centre of a drawdown cone. The extent of drawdown is expected to be localised in the shallow groundwater system, and most extensive in the deep aquifers. If pumping ceases, groundwater levels will rebound, eventually returning to close to natural levels of around 50mAHD or greater over a timescale of tens of years or more. The exact final groundwater conditions and time scale for repressurisation are not known at this time as they will depend on the detailed hydrogeological conditions around the quarry. Pumping from the quarry during rehabilitation can be used to control this process, if necessary.

The quarry represents a very low risk site for rehabilitation in terms of potential environmental impacts, because of the low permeability of the strata; the strong inward hydraulic gradient; and the low groundwater inflow rate.

It is therefore considered highly suited to rehabilitation by controlled filling, providing that appropriate management and control measures are implemented. Provision of a low permeability barrier or landfill liner is not considered necessary and would offer no environmental or management benefits because of the above factors, and because of the nature of the proposed fill material.

*Assessment of Potential Impacts – Developable Land*

Existing salinity impacts are limited to waterlogging (due to leakage from dams or poor existing drainage) and increased groundwater salinity close to natural drainage lines, probably reflecting discharge of deep groundwater from the Bringelly Shale.

The proposed development of an industrial/business park on the site will involve construction of roads, buildings, parking/storage areas, stormwater drainage and landscaping. Existing spoil heaps will be removed, and minor recontouring of natural ground levels undertaken, but this is expected be minor. The only substantial area of existing native vegetation on the site will be retained as a conservation feature. The effects of this are likely to be reduced rainfall recharge and improved drainage, reducing shallow groundwater levels and incidence of waterlogging.

Potential for the proposed development and landuse to cause or exacerbate salinity impacts is very limited. Excavation of saline soils could release additional salt into the environment, and construction in areas of high water tables and salinity could result in salinity damage to roads or buildings.

The site setting is one of low sensitivity with respect to potential groundwater impacts, and the proposed development does not include any activities that pose a particular risk to groundwater quality. The development therefore does not pose an unacceptable risk to groundwater quality. Development may result in a small reduction in groundwater recharge, but this will not affect the resource value of the local groundwater systems, and has benefits in terms of salinity.

# 7. Recommendations

*General*

Assessment of the existing quarry excavation and surrounding groundwater regime indicates that the site is well-suited to rehabilitation of the quarry by controlled filling, with a low risk to the environment and no difficult management issues identified. However, the local groundwater regime is not understood in detail, and there is some uncertainty relating to rebound of groundwater levels on cessation or reduction of pumping.

Investigation of groundwater conditions in the surrounding strata is required to determine baseline conditions, and ongoing monitoring will be required during rehabilitation. Drilling of at least 3 multi-level piezometers is recommended around the quarry, followed by permeability testing, sampling and water level monitoring.

Numerical modelling of the local groundwater system and repressurisation due to cessation or reduction in groundwater pumping is also recommended, to allow prediction of final groundwater levels and flow regime, and the timescale for water level recovery. This information is required for planning of final ground levels and ongoing requirements for groundwater management and monitoring.

Monitoring of volumes pumped from the quarry during the final stages of quarrying should be carried out to provide more accurate information. Further monitoring of pumped/ seepage water quality is also recommended to provide more information on the likely chemistry of collected water and any treatment requirements.

*Quarry Rehabilitation*

Provision of a low permeability barrier across the base or sides of the quarry is not considered necessary. A water interception and collection system is required to allow control of water accumulation within the quarry during filling. This should comprise either of the following: a permanent system comprising a basal drainage blanket with a herringbone arrangement of slotted pipes (or similar) with a main basal sump and riser (ideally an inclined riser fixed to the sides of the quarry), and a secondary sump and riser; or a series of drainage systems constructed progressively during filling at various levels through the fill profile (with only the upper drainage system in use at any time)

Fill should be laid at a suitable gradient, and surface runoff collected.

Water levels in the base of the quarry should be maintained as required operationally, either a few metres below the fill surface, or at a lower level to provide buffering storage. Water level control to meet groundwater management requirements may also be needed. Pumped water is expected to be suitable for on-site reuse, but treatment is likely to be required prior to discharge to surface waters.

Control of water levels within the quarry will allow management of groundwater levels in the quarry and surrounding strata, if required. The nature of the fill to be used for rehabilitation will be carefully controlled. No further mitigation measures are considered necessary to protect groundwater.

*Developable Land*

Results from previous investigation (PSM, 2005) show sulphate and chloride levels in all soil samples below those considered potentially aggressive to foundations, indicating that standard construction materials should be suitable in most parts of the site. However, there is some risk that excavation and construction close to drainage lines or in low-lying areas may encounter saline groundwater. The presence of building foundations or roadways in contact with or in the capillary zone of a saline water table can result in salinity damage to susceptible materials. Further investigation of salinity conditions should be carried out as part of the geotechnical investigations for construction of hardstandings, buildings, roadways and the drainage system, particularly for high risk areas close to drainage lines.

In general, development should be planned in accordance with published guidance (Nicholson, 2003), including the following:

- avoid/minimise exposure of saline subsoils, minimise cut and fill;
- retain vegetation and avoid disturbance in riparian zones and poorly drained areas;
- retain and establish vegetation is areas subject to erosion and disturbance;

- consider salt-resistant construction materials in areas of shallow saline water tables;
- monitor perched water tables.

Landscaped areas should be planned with salt-tolerant vegetation, and any irrigation should be minimal and based on requirements of vegetation.

Detailed mitigation and monitoring requirements should be covered in a Salinity Management Plan for the site, to be submitted to Council for approval as part of the detailed design process (i.e. after the DA has been granted).

A monitoring program should be implemented prior to development, continuing until a reasonable period after development. This should include water level and salinity monitoring of shallow groundwater, and requirements should be detailed in the Salinity Management Plan for the site.

# 8. References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# Figures

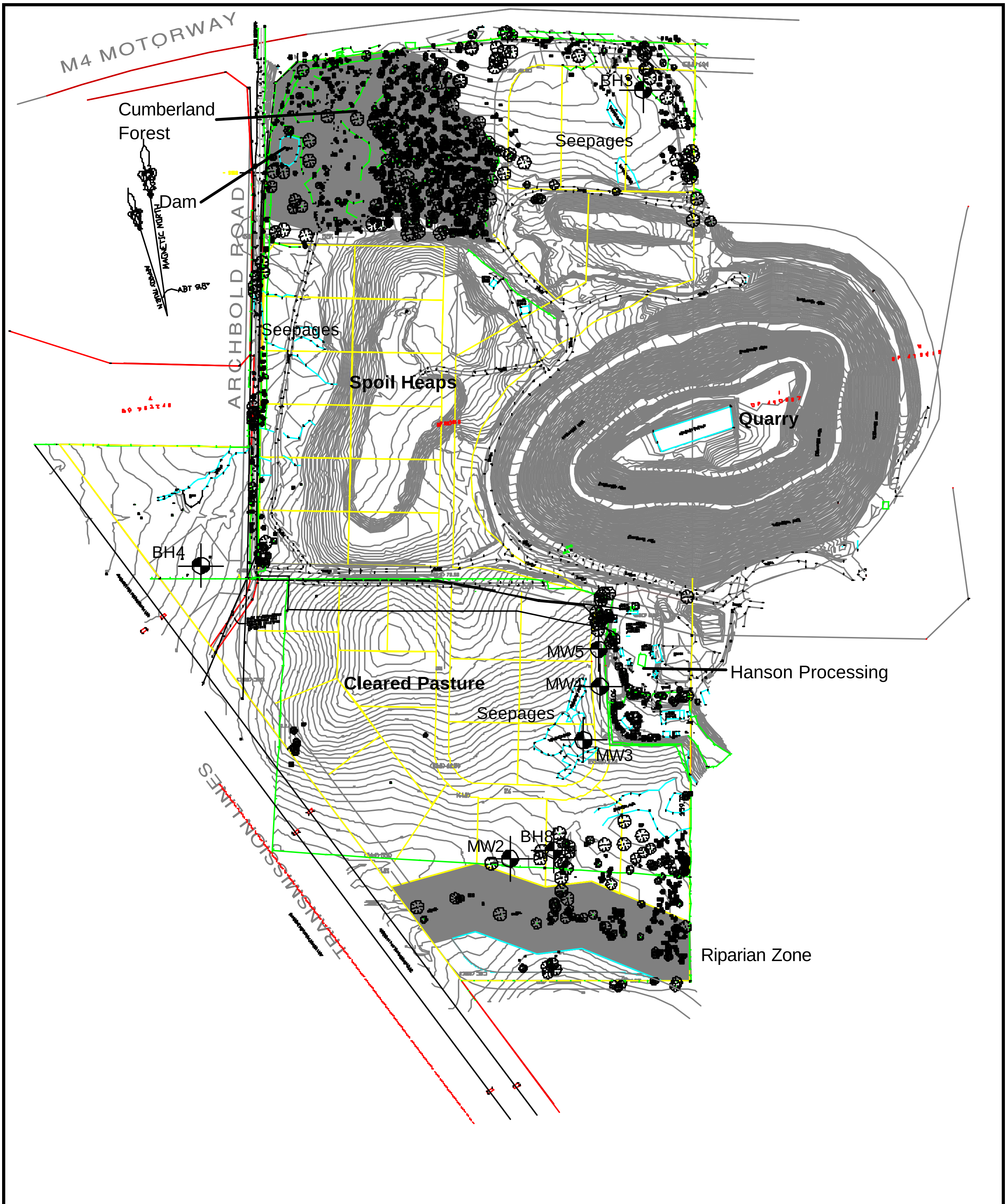


**FIGURE 3.1: Site Features**

Project: Groundwater and Salinity Assessment
Location: Archibold Road, Eastern Creek
Client: Light Horse Business Centre Pty Ltd
Project No: BJ07

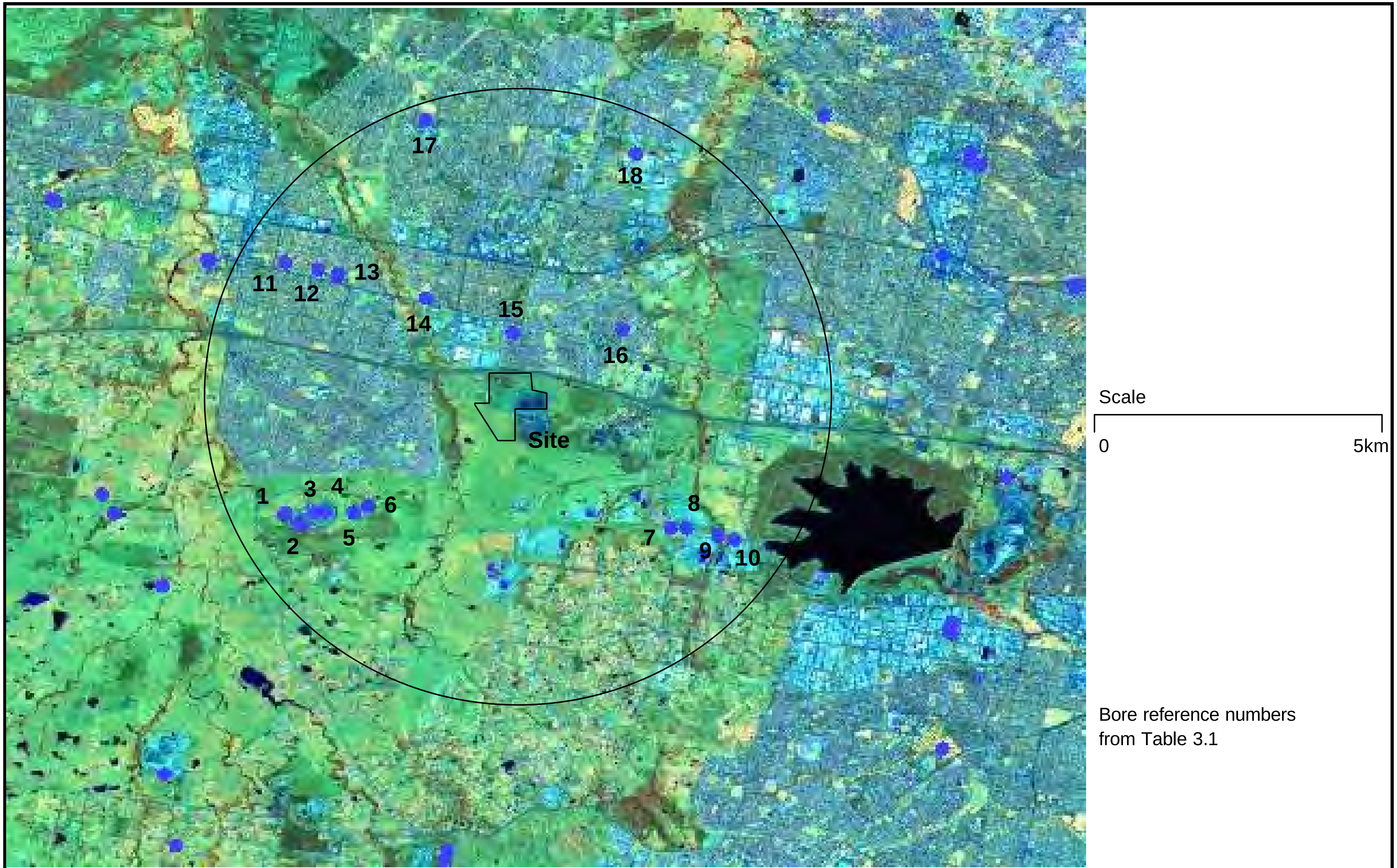


**FIGURE 3.2: Locations of Registered Bores**

Project: Groundwater and Salinity Assessment
Location: Archibold Road, Eastern Creek
Client: Light Horse Business Centre Pty Ltd
Project No: BJ07