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Marsden Park Developments Pty Ltd

Preliminary Report for Marsden Park Industrial Precinct

Salinity Assessment

July 2009

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1. Executive Summary

1.1 Introduction

GHD Pty Ltd (GHD) Geotechnics has undertaken a Planning Level Salinity Assessment of some 570ha of land off Richmond Road, Marsden Park, NSW. This work was conducted concurrently with a preliminary contamination assessment (Phase1/Phase2) carried out by GHD's Contaminated Lands Group (CLG). The site assessed comprises the Marsden Park Industrial Precinct (MPIP), as shown on Figure 1, which is part of the North West Growth Centre.

The site currently includes both industrial and rural/residential development, and is earmarked for re-zoning and re-development as industrial/employment land, with likely small areas of public open space and residential development.

Preliminary salinity advice was prepared, based on a desktop study and site observations conducted by GHD Geotechnics in August 2008. Based on this preliminary study, salinity sampling recommendations were provided into a Sampling Analysis and Quality Plan (SAQP) being prepared by GHD's CLG, for intrusive (Phase 2) contamination investigations (reported under separate cover).

The preliminary salinity assessment identified a number of salinity zones within the site - dependent on topography, geology, soil landscape and previous land use. Data from the SAQP was utilised to augment/confirm these salinity zones.

Objectives

The objectives of the preliminary salinity assessment were to:

- Determine whether saline processes were evident within the Site.
- Provide a description of the impact of saline processes on the proposed development.
- Provide a description of the impact of the proposed development on saline processes.
- Describe the constraints and salinity management requirements pertinent to the proposed development.

Scope of Works

The scope of investigation work completed by GHD included the following:

- A desktop study.
- A site walkover and surface soil/water sampling program.
- Input into the SAQP for salinity assessment purposes.
- Salinity testing of intrusive investigation soil and groundwater samples.
- Preparation of a preliminary (planning level) salinity report.

Summary of Investigation Results

The findings of the planning level salinity assessment indicate that, while there is evidence of salinity, there do not appear to be any major underlying salinity issues that would prevent development of the site. The following generalised salinity associated characteristics were identified:

- The presence of dispersive and reactive clay soils within the regolith (soil cover to bedrock) across the site.
- A saline groundwater table, which is expected to be shallow in the lower lying parts of the site.
- Concentrations of salt present within the soil profile, particularly in areas of water-logging and drying.
- Saline scalds and saline seepage was observed, particularly in the lower landscape.
- Salinity indicator vegetation was observed, mainly in the lower landscape.
- Die-back of gum trees was noted, possibly influenced by salinity.

These characteristics, and the associated salinity constraints within different salinity domains are discussed within this report.

Supplementary salinity investigations and monitoring are recommended in order to reduce salinity impacts on the proposed development. In particular, this refers to the disused quarry area.

2. Introduction

2.1 General

This report presents the results of a planning level salinity report undertaken by GHD Geotechnics, in order to provide a preliminary level salinity assessment for potential rezoning and development of the site known as Marsden Park Industrial Precinct (MPIP), as shown on Figure 1. This assessment was undertaken, in accordance with the principles listed in the DLWC guidance document (2002) *Site Investigations for Urban Development*, and in conjunction with our preliminary geotechnical assessment for the site, which is reported under separate cover (AZ159, May 2009).

The MPIP is part of the North West Growth Centre and is earmarked for re-zoning and re-development. This report will assist in the facilitation of the planning stage of this development.

The salinity assessment was undertaken in accordance with our proposal of 9 July 2008, which also included contamination and geotechnical planning level assessments (reported under separate cover).

The purpose of the salinity assessment was to assess whether saline processes were evident within the Site, to provide a description of the impact of any such salinity characteristics and to describe the constraints and salinity management requirements pertinent to the proposed development.

2.2 Scope of Work

The scope of the salinity assessment included:

- A desktop study of published information on topographical, geological and soil landscape information pertinent to the site.
- Site walkover observations, surface soil and water sampling, and field testing conducted by a Principal Geotechnical Engineer, in order to provide ground truthing.
- Input into the Sampling Analysis and Quality Plan (SAQP) for salinity selection and assessment of samples obtained in the Phase 2 intrusive contamination investigations.
- The preparation of a preliminary (planning level) salinity report.

2.3 Limitations

This report has been prepared for the use of Marsden Park Developments Pty Ltd (MPD) in relation to the rezoning investigations and proposed development for the site, and comprises appraisal/comments for planning purposes only.

This report should be read in conjunction with the attached General Notes.

3. Desk Study Review

3.1 Reference Documentation

The following published documentation was referenced in the desk study:

- DIPNR Map of Salinity Potential for Western Sydney 2002.
- Geological Series Sheet 9030 for Penrith (1:100,00 scale)
- Soil Landscape Series Sheet 9030 for Penrith (1:100,000 scale)
- Topographic Map for Riverstone 9030-I-S (1:25,000 scale).
- Aerial photographs covering the site.

3.2 Site Setting

The site, as shown on Figure 1, is located off Richmond Road, Marsden Park, NSW, approximately 500m north west of the M7 Westlink freeway.

Land in close proximity to Bells Creek, which runs along the eastern boundary of the site, is understood to be subject to flooding

3.3 Topography

Contours as shown on Figure 1 illustrate the site topography. Apart from the south-east section of the site (east of Bells Creek), the main site area slopes gently to the west and east from a central ridge running SE-NW. The highest point on the site lies near the central southern boundary at about RL 60m AHD. In the east, along Bells Creek the elevation ranges from about RL25-30m AHD and in the west, from about RL 35-40m AHD. The far south-east portion of the proposed development, east of Bells Creek, straddles a north-south trending ridge, with steeper slopes present on the east side of this ridge (circa 1V:5H to 1V:10H).

Drainage courses/tributaries form minor valleys that drain to Bells Creek in the east and to South Creek in the west.

The topography around the existing waste facility in the central north-west of the site has been altered by quarrying and stockpiling operations, as indicated by the concentration of 40-50m AHD contours in this area (refer Figure 1).

3.4 Soil Landscapes

The soils landscapes, as shown on Figure 2, include Berkshire Park (fluvial) Landscape comprising a significant portion of the western site area. However, reference to the Geological mapping (Figure 3) shows this area to comprise Bringelly Shale (residual) strata. Limited field observations and sampling indicates this area is underlain by residual soil (consistent with the geological mapping), with localised (fluvial) deposits present only in the vicinity of creeks and drainage lines.

Also as shown on Figure 2, most of the site is shown situated on the Blacktown Unit landscape with a zone of South Creek (fluvial) landscape running north-south in the vicinity of Bells Creek.

The Blacktown soil landscape is described as a 'Residual Landscape' with gentle undulating rises on Wianamatta Group (shale) bedrock. The soils typically comprise hard setting, mottled texture contrast soils, including shallow (<1.5m) red and brown podsols on the crests, grading to deeper (>2m) yellow podsols on the lower slopes and near drainage lines. This landscape is associated with dryland salinity, low to very low permeability soils, which are moderately to highly reactive and dispersive. Waterlogging and known salinity hazard is common in streamlines. This unit typically has a high capability for urban development, when conducted with appropriate salinity and geotechnical design measures.

The South Creek soil landscape is described as a 'Fluvial Landscape' comprising floodplains, valley flats and drainage depressions on the Cumberland Plain. It is typically flat with incised channels and predominantly cleared. The soils are often deep, consisting of alluvium over residual clays/bedrock. This landscape is also associated with known salinity hazard, flood hazard, localised moderately reactive and dispersive/erodable soils. This unit typically has a low capability for urban development due to flood hazard/erosion, varying alluvial soils and salinity.

The Berkshire Park soil landscape is described as a 'Fluvial Landscape' comprising gently undulating rises of Tertiary alluvium terraces of the Hawkesbury/Nepean river system. The soils typically comprise 'heavy' clays and clayey sands with silcrete (cemented) cobbles and boulders. This unit, which apart from a small segment in the north-west corner of the site is expected to lie outside of the proposed development, appears to have significant capability for urban development when conducted with appropriate salinity and geotechnical design measures, and subject to floodplain considerations. Stated limitations are very high wind erosion potential, gully, sheet and rill erosion on dissected areas, waterlogging and impermeable soils.

3.5 Geology

Reference to the 1:100,000 scale Geological Series Sheet for Penrith (sheet 9030) indicates that most of the site is underlain by Bringelly Shale of the Wianamatta Group (refer to Figure 3).

Bringelly Shale, which was formed as an alluvial and estuarine coastal plain (saline) deposit, generally forms the slopes and upper landscape within the site, and comprises essentially shale, carbonaceous claystone, claystone, laminite, fine to medium grained quartz-lithic sandstone, with rare coal and tuff. Claystone and siltstone are normally dominant. The Bringelly Shale contains swelling clay minerals that can result in ready disintegration of the rock fabric on immersion in fresh water (apart from the Minchinbury Sandstone basal unit) and is generally less durable on exposure than the underlying Ashfield Shale (also Wianamatta Group).

Quaternary alluvium is shown to underlie the area in the vicinity of Bells Creek, and is inferred in the vicinity of the tributary creeks/drainage lines, though not shown at the 1:100,000 scale mapping. Quaternary Alluvium typically comprises fine grained sand, silt and clay. The nature of the alluvium is variable and depends on the lithology of the source material and characteristics of the depositional stream flow. It is often poorly drained and subject to flooding.

St Marys Formation Tertiary alluvium (Ts) is shown over the ridge previously described as trending in a north-south direction across the far south-east portion of the site (east of Bells Creek). The Ts is present as a remnant alluvial terrace, with a moderate to steep slope down towards lower ground in the east. This strata, which typically comprises clay and sands deposited in the Tertiary Period (older than the Quaternary deposits), can be ferruginously cemented.

Londonderry Clay Tertiary alluvium (Tl), which comprises clay with minor sand and ferruginous cementation, shown to underlie a small zone on the north-west corner of the site.

Volcanic Breccia Daitreme (Jv) underlies an area that has been intruded by volcanic activity to form the large volcanic breccia diatreme shown in the central west of the site (refer Figure 3). This intrusion has been quarried in order to provide gravel.

Diatremes are generally considered to be the result of a volcanic eruption. Their composition can be highly variable, with the rapid expulsion of volcanic material and host rock, and collapse of surrounding material forming breccia (variously a mixture of pyroclastics, ash, shale and sandstone). Diatremes may present adverse conditions for excavation and for founding strata.

Igneous (basaltic or doleritic) dykes and joint swarms may also exist in the surrounding region, due to the past volcanic activity. Dykes are linear, sub-vertical volcanic intrusions of variable width (general in the range of 0.3 to 3 m, though can be wider). At the surface, dykes in the Sydney Region are generally weathered back to clay (and may not be noted when encountered in residual clays of the Bringelly Shale due to similar surface weathering). As such, undetected dykes may be present in this region. Joint swarms are closely spaced sub-vertical joint sets, which occur as a result of tectonic stresses/movements, and may be more prevalent in areas of volcanic activity. The presence of dykes and joint swarms could to lead to concentration of seepage (drainage issues) and to difficult excavation/founding conditions.

Saline groundwater is typically expected within the Bringelly Shale and Quaternary Alluvium, with joints and more permeable horizons within the bedrock expected to be the main avenues for groundwater migration.

3.6 Salinity Potential

The site is shown on the Salinity Potential Map for Western Sydney (DIPNR 2002), reproduced in part on Figure 4, to lie within an area of moderate salinity potential, with high salinity potential in the vicinity of the creek and drainage lines.

Areas of moderate salinity potential generally consist of areas susceptible to saline affectation if disturbed, particularly if saline groundwater/seepage is intercepted and/or if areas of water-logging can occur. These areas are generally higher in the landscape where the geology pre-disposes a site salinity potential.

High saline risk zones occur generally lower in the landscape, or at permeability contrasts, where saline groundwater may come within close proximity to the ground surface or where seepage causes waterlogged conditions, thereby concentrating salts. Typically scattered saline indicator vegetation occurs in these areas.

Dispersive erosion is often a feature of the soils in such dryland salinity areas.

Areas with moderate salinity potential, if managed inappropriately can lead to worsening salinity conditions creating high salinity potential and salinity outbreaks, and to increased off-site discharge of saline water. Such areas are also often prone to dispersive soil erosion.

3.7 Groundwater

Perched (saline) groundwater may be present within any localised (shallow) filled areas and generally within the soils in the lower landscape.

Saline groundwater is also expected to be present at relatively shallow depth in the lower landscape, hosted by fracturing/jointing within the Wianamatta Shales. This groundwater is likely to have some connectivity within Quaternary Alluvium (if present).

The 1:2 000 000 Department of Water Resources Groundwater in NSW, Assessment of Pollution Risk map indicates that the groundwater salinity is >14 000mg/l and therefore unsuitable for stock use. This map also indicates that the site is likely to be underlain by shales and that the potential for groundwater movement is likely to be low.

3.8 Aerial Photograph Interpretation

Aerial photo sets taken in the period 1947 to 2005 were viewed through a stereoscope and the following observations were made;

- The major change to the Site area has been the formation of the quarry/landfill area (GD5) and associated filling to the south-west (GD5a) of the quarry area. Both the quarry area and the fill area to the south-west (SWF) are shown approximately on Figure 1.
- The vegetation has changed from grasses with sparse tree coverage to essentially cleared and grassed land, with some localised areas of denser tree cover, and with the ongoing earthworks within the quarry site.
- The SWF appears to have covered the north-east branch of a tributary watercourse that drained to the south-west. Changes to the natural drainage within this area are likely to have lead to water-logging of the site soils. As far as we are aware the SWF has not been placed as a controlled (engineered) fill.

4. Investigation Procedure

4.1 Site Walkovers

Site walkovers were conducted on 8 August 2008 and 15 December 2008 by a Principal engineer from this office, who also conducted the site geotechnical observations and associated surface soil and water sampling.

Locations of photographic observations and sampling points were recorded using a hand held autonomous GPS unit, which is generally accurate to within about 10m of the grid position.

The locations of the referenced observations are shown on Figure 5 'Salinity Domains'

Selected photographs are presented in Appendix A.

4.2 Salinity Laboratory Testing

A number of samples collected during the SAQP were tested for salinity assessment purposes as follows:

- 89 soil samples were tested for pH and EC. The recorded EC was 'factored' in accordance with Taylor (1996) for soil type/texture, in order to calculate an 'equivalent conductivity' (ECe) for salinity classification purposes.
- 8 surface water samples were also tested for pH and conductivity (ECw).

The results of the field and laboratory testing for pH and EC, together with salinity classification data are summarised in Tables 1 to 6.

5. Salinity Investigation Results

5.1 Walkover Observations

The salinity observations made on the walkovers are presented below:

- Marginally saline to brackish surface waters and non-saline soils (likely flushed by recent rainfall) were recorded in/near the head of a lower landscape valley and in the upper landscape east of the quarry. Water flowing at the time was inferred due to the quarry operations. Refer to test results for soil samples SS1/SS2, water samples SW1-SW3 and to photographs P1/P2.
- Saline scalding together with saline indicator species Juncas Acutus and Couch, salt deposits and dispersive erosion were observed in the lower landscape (valley) downslope of the 'nightsoil/fill' area (refer Figure 1). The stream water recorded in this location was saline (refer sample SW4) and the soil adjacent to the stream was highly saline (refer SS3). Refer to photographs P3/P4.
- Dead trees, possibly resulting from saline die-back, were observed near the overburden stockpiles north-west of the quarry. Refer to photograph P5.
- Waterlogged conditions with saline indicator species Juncus Acutus, Couch and Casuarina Glauca were observed in a lower landscape valley west of Richmond Road (refer photographs P6-P8). Water sample SW5, taken from a pond around a pipe culvert inlet beneath Richmond Road near this location, recorded marginally saline conditions.
- Saline indicator species including Casuarina Glauca and Couch were also recorded east of Richmond Road at the Townson Road bridge crossing of Bells Creek (refer to photograph P9). Non-saline soil conditions were recorded on the creek bank (refer soil sample SS4) and marginally saline conditions within the creek flow (refer water sample SW6).
- Observations in the area near Eastern Creek, to the south-east of the site, recorded saline indicator species Casuarina Glauca (refer photographs P10/P11).
- Marginally saline water conditions were recorded in Eastern Creek (which was swollen from recent rainfall), and in a tributary stream flowing into Eastern Creek (refer SW7/SW8). Non-saline soil conditions were recorded on the banks (refer samples SS5/SS6). Saline indicator species Casuarina Glauca and Couch were observed. Refer to photographs P12/P13.
- Recent rainfall appears to have temporarily suppressed salinity within the surface soil/water at the site.

5.1.1 Salinity and pH Readings - Soil

The pH and conductivity (EC) readings recorded on shallow soil samples during the site walkover are presented in Table 1 below, together with equivalent electrical conductivity (EC_e), as calculated by the relationship $EC \times F = EC_e$ for the particular soil condition (Taylor, Dryland Salinity, DLWC 1996), where 'F' is a texture multiplication factor dependent on the soil type. The coloured results relate to the salinity classifications provided in Table 2.

Soil Salinity (EC) and pH Readings – Site Walkover **TABLE 1**

Sample No.	Sample Depth (m)	Soil Description	Soil pH	Conductivity EC (dS/m)	Texture Factor F	Equivalent Conductivity ECe (dS/m)
SS1	0–0.05	Black Sandy Clay	7.3	0.13	8.5	1.1
SS2	0.05-0.1	Grey brown Sandy Clay	9.1	0.12	8.5	1.0
SS3	0.05-0.1	Brown Clay	7.1	6.84	8	54.7
SS4	0.1-0.15	Brown clayey sandy Gravel	7.1	0.18	9.5	1.7
SS5	0.05-0.1	Brown Sandy Clay	7.6	0.16	8.5	1.4
SS6	0.05-0.1	Brown Clay	6.9	0.09	8	0.7

Soil samples SS1 and SS2 in the above results were obtained from upper landscape locations. The other surface soil samples were taken from lower landscape locations, near water courses. The results show that after the recent heavy rainfall all but surface soil sample SS3 recorded a non-saline result. SS3, which recorded highly saline conditions was located in the lower landscape beside a saline watercourse. The salinity in this soil sample appears to result from soil suction and evaporation (wicking) of the adjacent saline water (refer surface water result for SW4 in Table 4).

The salinity classes for soil (Taylor, Dryland Salinity, DLWC 1996) are as shown in Table 2 below.

Soil Salinity Classes **TABLE 2**

Class	EC_e (dS/cm)
Non-saline	<2
Slightly saline	2-4
Moderately saline	4-8
Very saline	8-16
Highly saline	>16

It must be noted that the salinity walkover was conducted after recent heavy rainfall. Accordingly, much of the near – surface salinity is inferred to have been 'flushed' away, or to have leached lower into the soil profile, resulting in less saline conditions than might otherwise have been recorded had the sampling been conducted after a significantly drier period.

The pH and conductivity (EC) readings recorded on soil and bedrock samples recovered during the contamination investigation are presented in Table 3.

Soil Salinity (EC) and pH Readings – SAQP Test Holes **TABLE 3**

Test Hole	Sample Depth (m)	Soil Description	Soil pH	Conductivity EC (dS/m)	Texture Factor F	Equivalent Conductivity ECe (dS/m)
HA3	0-0.1	Brown Silty Sand (topsoil)	6.8	0.120	9	0.96
HA3	0.3	Brown, Sand + Gravel (fill)	7.7	0.280	10	2.80
HA5	0-0.1	Brown silty Sand (topsoil)	6	0.130	9	1.17
HA5	0.3	Yellow Sandy Clay (fill)	6.5	0.160	9	1.44
HA9	0-0.1	Gy Brn silty Sand (topsoil)	5.7	0.180	9	1.62
HA9	0.3	Or/brown Shale (fill)	6.1	0.440	10	4.40
HA13	0-0.1	Grey Silt (hillwash)	6.9	0.170	9	1.36
HA13	0.3	Grey Silt (hillwash)	5.5	0.250	9	2.25
HA14	0-0.1	Brown Silt & Clay (topsoil)	7.1	0.053	9	0.42
HA14	0.3	Brown/Grey Sandy Clay (fill)	8	0.190	9	1.71
HA15	0-0.1	Brown Sandy Clay (fill)	6.3	0.069	9	0.62
HA15	0.5	Red/brown Sandy Clay (fill)	5.1	0.240	9	2.16
HA16	0-0.1	Brown Sandy Clay (fill)	5.8	0.061	9	0.49
HA16	0.5	Or/grey Sandy Clay	4.9	0.490	9	4.41
TP1	0.2-0.4	Brown/grey Clay	6	0.190	8	1.52
TP1	0.5-0.6	Grey/red Clay	4.7	1.000	8	8.00
TP1	0.9-1	Or/brown Clay and Silt	4.9	0.330	8.5	2.81
TP5	0.3	Dark brown Clay	8.5	0.425	8	3.40
TP5	1.5	Dark brown Clay	8.1	0.962	8	7.70
TP5	2.1	Brown and red Clay	4.6	1.052	8	8.42
TP6	0-0.2	Yellow/brown Sandy Clay	4.1	0.250	8.5	3.53
TP6	0.9	Yellow/brown Clay	4.3	0.310	8	7.70
TP7	0.1	Brown Clay with silt (topsoil)	6.0	0.218	8.5	1.85
TP7	0.5	Dark brown Clay	8.6	0.375	8	3.00
TP7	2.0	Brown Clay	5.6	0.450	8	3.60
TP8	0.1	Dark brown Clay	4.2	0.149	8	1.19
TP8	0.6	Dark brown Clay	8.5	0.756	8	6.05
TP8	1.2	Dark brown Clay some gravel	8.5	0.604	8.5	5.13
TP9	0-0.1	Brown Sandy Clay (fill)	5.7	0.150	8.5	1.28
TP9	0.4	Or/grey Gravely Clay (fill)	8.6	0.280	9	2.62
TP9	1.5	Or/grey Gravely Clay (fill)	8.8	0.900	9	8.1
TP10	0-0.1	Brown Clay with silt (topsoil)	8.5	0.756	8.5	6.43

Test Hole	Sample Depth (m)	Soil Description	Soil pH	Conductivity EC (dS/m)	Texture Factor F	Equivalent Conductivity ECe (dS/m)
TP10	0.5	Red brown grey Clay	8.5	0.604	8	4.83
TP14	0-0.1	Brown Clayey Sand (fill)	5.9	0.095	10	0.95
TP14	0.5	Gy/bn Gravely Clayey Sand	9.8	0.270	10	2.7
TP14	2.6	Brown Sandstone (fill)	9.2	0.260	10	2.6
TP19	0-0.1	Brown Clay	9.4	0.300	8	2.40
TP19	0.8	Brown Clay	5.5	0.220	8	1.76
TP19	1.0	Orange red Clay	4.9	0.380	8	3.04
TP19	1.9	Orange red Clay	4.4	0.192	8	1.54
TP21	0-0.1	Lt Brown Clayey Sand (fill)	9	0.180	10	1.80
TP21	0.6	Dark brown Sandy Clay (fill)	7.5	1.200	9	10.80
TP21	1.5	Ylw brown Sandy Clay (fill)	8.1	1.100	9	9.90
TP24	0-0.1	Brn Clayey Sand (topsoil)	5.4	0.350	10	3.5
TP24	0.4	Grey brown Sandy Clay (fill)	5	1.100	9	9.9
TP24	0.9	Grey brown Clay	7.7	1.100	8	8.80
TP29	0.1	Dark brown Clay	6.5	0.266	8	2.13
TP29	0.3	Orange/brown Sandy Clay	6.5	0.490	9	4.41
TP29	0.8	Red brown Clay	4.8	0.710	8	5.68
TP29	2.1	Light grey Clay	4.5	0.836	8	6.69
TP31	0-0.1	Brown Sandy Clay	5.8	0.040	9	0.36
TP31	0.4	Orange/brown Sandy Clay	5.9	0.060	9	0.54
TP31	0.8	Orange/grey Clay	5	0.280	8	2.24
TP35	0-0.1	Dark brown Sandy Clay (fill)	7.1	0.044	9	0.40
TP35	0.5	Orange/brown Sandy Clay	6.5	0.081	9	0.72
TP35	0.9	Light brown Clay	5.3	0.330	8	2.64
TP35	1.7	Grey red Clay	4.6	0.305	8	2.44
BH1	0.1	Brown Clay with silt (topsoil)	7.2	0.179	8.5	1.52
BH1	0.5	Lt brown Clayey Sand (Fill)	5.8	0.057	10	0.57
BH1	1.0	Red Brown XW Shale (Fill)	5.7	0.170	10	1.70
BH1	2.0	Grey brown CLAY	6	0.540	8.5	4.59
BH1	3.0	Grey brown XW Shale	7.8	0.710	9	6.39
BH1	4.0	Grey brown HW Shale	9.5	0.740	10	7.40
BH1	5.0	Grey brown HW Shale	9.9	0.780	10	7.80
BH1	6.0	Grey brown HW Shale	9.4	1.200	10	12.0

Test Hole	Sample Depth (m)	Soil Description	Soil pH	Conductivity EC (dS/m)	Texture Factor F	Equivalent Conductivity ECe (dS/m)
BH3	0.5	Orange grey Clay	5.2	0.230	8	1.84
BH3	1.0	Orange brown XW Shale	5.5	0.470	9	4.23
BH3	2.0	Orange brown HW Shale	6.2	0.380	10	3.80
BH3	3.0	Orange brown HW Shale	7.4	0.350	10	3.50
MW4	0.5	Gy brn Clay & Gravel (Fill)	5.3	0.560	9	5.04
MW4	1.0	Grey brown Clay (Fill)	4.8	0.860	8	6.88
MW4	2.0	Grey Clay	5.6	1.100	8	8.80
MW4	3.0	Grey red Clay	5	0.960	8	7.68
MW4	4.0	Grey HW Shale	6.8	0.790	10	7.90
MW4	6.0	Grey HW Shale	9.5	0.740	10	7.40
MW4	7.0	Grey HW Shale	9.1	0.575	10	5.75
MW5	0-0.1	Gy bn Sandy Silt (topsoil)	7.8	0.096	9	0.86
MW5	0.5	Brown Sandy Clay	8.3	0.120	8	0.96
MW5	1.0	Brown Sandy Clay	7.2	0.270	8	2.16
MW5	2.0	Yellow Brown Sandy Clay	9.5	0.340	10	3.40
MW5	3.0	Light brown XW Shale	9.3	0.390	10	3.90
MW5	4.0	Light brown HW Shale	9.7	0.420	10	4.20
MW5	6.0	Light brown HW Shale	9.6	0.490	10	4.90
MW5	8.0	Light brown HW Shale	9.3	0.830	10	8.3
MW5	10.0	Light brown HW Shale	9.3	0.540	10	5.4

The above limited soil profile testing results indicate that:

- With the exception of an isolated result in the fill area south-west of the landfill site, the site near surface soils (0.1 -0.3m) recorded non-saline to slightly saline conditions.
- East of the quarry area, at the head of a lower landscape zone (as shown on Figure 5), and in the fill area to the south-west of the quarry (also largely within a lower landscape zone), moderately to very saline soil conditions were recorded deeper within the soil profile.
- Moderately saline to very saline soil conditions were recorded in the deeper soil profile and bedrock in the lower landscape area on the north-east of the site, and in the shale bedrock in the upper landscape in the central south-west of the site (MW5).

5.1.2 Salinity and pH Readings - Water

The pH and conductivity (EC) readings recorded on surface water, dam water and groundwater samples obtained during the site walkover and in the geotechnical investigation are presented in Table 4 below, together with total dissolved salts (TDS) as calculated by the relationship EC x 0.64 x 1000 = TDS. The coloured results relate to the salinity classifications provided in Table 4.

Surface Water Salinity (ECw) and pH Readings – Site Walkover **TABLE 4**

Sample No.	Location	pH	Conductivity ECw (dS/m)	Factor	TDS (ppm)
SW1	Refer to Site Plan – Figure 5	7.4	0.980	640	627
SW2	Refer to Site Plan – Figure 5	7.9	1.922	640	1230
SW3	Refer to Site Plan – Figure 5	7.4	0.850	640	544
SW4	Refer to Site Plan – Figure 5	8.1	6.800	640	4352
SW5	Refer to Site Plan – Figure 5	7.1	0.805	640	515
SW6	Refer to Site Plan – Figure 5	7.3	0.793	640	508
SW7	Refer to Site Plan – Figure 5	7.3	0.804	640	515
SW8	Refer to Site Plan – Figure 5	7.7	0.871	640	557

The Australian Water Resources Council (AWRC 1976) has defined classes for salinity of water as shown in Table 4 below:

AWRC Saline Water Classes **TABLE 5**

Class	EC (dS/m)	TDS (mg/L)
Fresh	<0.80	<500
Marginal	0.80-1.60	500-1,000
Brackish	1.60-4.80	1,000-3,000
Saline	>4.80	>3,000

Apart from SW4, which was saline, the results indicated marginally saline to brackish surface water conditions.

As previously noted for the soil samples, the sampling was conducted after an extended wet period, and is considered to be representative of the suppression of saline influence by 'lighter' fresh water draining to the water courses (overlying the more saline water. In drier periods, higher saline concentrations would be expected.

Water Salinity (ECw) and pH Readings – SAQP Test Holes **TABLE 6**

Sample No.	Location	Depth (m)	pH	Conductivity ECw (dS/m)	Factor	TDS (ppm)
MW1	Refer to Site Plan – Figure 5	1.5	7.4	2.56	640	1638
MW2	Refer to Site Plan – Figure 5	1.2	7.9	2.94	640	1882
MW3	Refer to Site Plan – Figure 5	2.1	7.4	6.05	640	3872
MW4	Refer to Site Plan – Figure 5	2.1	8.1	3.11	640	1990
MW5	Refer to Site Plan – Figure 5	5.9	7.1	7.84	640	5018

MW6	Refer to Site Plan – Figure 5	6.2	7.3	6.50	640	4160
MW7	Refer to Site Plan – Figure 5	4.3	7.3	6.37	640	4077

We note that in wells MW1-MW4, located lower in the landscape where shallower depth to groundwater was recorded, the salinity was in the range brackish to saline. These shallower groundwater locations may have been diluted by fresher water from the recent rainfall. In the deeper groundwater locations, which are located higher in the landscape, the water quality was recorded as saline.

6. Salinity Processes

6.1 Western Sydney

Salinity has been recognised in Western Sydney since the early 1800's with references being made to saline groundwater and brackish creeks (Mitchell 2000).

The sources of salt in Western Sydney are from the region's geology and climate.

The main geological formations of Western Sydney are the Wianamatta Shales, which formed in coastal and marine environments with a resultant naturally high connate salt content. Given the low permeability of the bedrock and their derived residual soils, much of this salt has been retained.

An atmospheric salt load of some 10 to 20 kilograms per year per hectare is estimated within rainfall for this region (Mitchell 2000). Much of this salt is flushed through and transported away from the area. The remainder is added to the soil and groundwater where it accumulates.

6.1.1 Salinity Processes in Western Sydney

There are a number of processes and indicators associated with salinity in Western Sydney and these may occur on a site individually, or in combination with each other. Some of the key salinity processes are;

Localised concentration of salinity

On a number of sites in Western Sydney salinity problems have been observed that are caused by localised concentration of salts due to the relatively high evaporation rates. The problem is associated with waterlogged soil and poor drainage.

Where frequently wet/damp soil is in contact with bricks or concrete these materials act as a 'wick' to the water and salt and as the water evaporates, the salts concentrate within them. This salt can cause damage in susceptible material over relatively short periods of time.

Shale Soil Landscapes

A number of soil landscapes in Western Sydney have poorly drained duplex (texture contrast) soils. The topsoil is usually a loam and subsoil is typically clay. As water moves more easily through loams than clays, in many of these soils, shallow soil water flows laterally across the upper B-horizon. Salt therefore usually accumulates in the clayey B-Horizon section of the soil.

The surface expression of this salinity occurs in areas where the soil water accumulates and seeps to the surface and where evaporation causes the salts to concentrate. This is common on lower slopes, or on natural and constructed flats in mid-slope across much of Western Sydney.

Salinity can also cause sodic soils and is a problem in a number of the soil landscapes of Western Sydney. These soils are defined by the dominance of sodium in the exchangeable ions of the sub-soil or B Horizon. Such soils are often boggy and may be of low strength. In particular, the swelling potential of sodic soils can create shrink/swell issues for the founding of structures, and can create very low permeability, increasing run off and exacerbating dispersive erosion. Sites containing sodic soils typically require management (drainage, chemical stabilisation) in order to minimize dispersive erosion.

Groundwater Salinity

Salinity problems occur when brackish or saline groundwater rises to a level where capillary action in the soil allows the water and dissolved salts to reach the surface, where they concentrate over time. Groundwater rises are caused by increased water infiltration and may relate to above average natural rainfall, vegetation loss, irrigation, increased water use in urban areas, or construction of seepage pits or surface water bodies. When groundwater rises to a level where capillary action brings it in contact with buildings or infrastructure, or where developments intercept the groundwater, damage due to salinity can occur.

7. Salinity Domains

The site is shown on the Salinity Potential Map for Western Sydney (DIPNR 2002), reproduced in part on Figure 4, to lie within an area of moderate salinity potential, with high salinity potential in the vicinity of the creek lines.

Essentially three Salinity Domains (SD1-SD3), as shown on Figure 5, have been identified based on the investigations described herein.

Development within the site areas, from a salinity perspective, can be conducted under a Salinity Management Plan (SMP) pertinent to the salinity affects on development proposed, and also taking into account the affects of such development on the salinity characteristics present in each of the salinity domains.

The salinity domains are described below:

7.1 SD1 - Higher Landscape

SD1 is expected to have a significantly large separation between the groundwater and the ground surface (greater than say 2.5m), and thus is expected to have a corresponding lower risk of salinity issues than areas lower in the landscape.

This higher landscape domain still classifies as 'Moderate Salinity Potential' as described in the DIPNR Salinity Potential in Western Sydney Map - 2002. However, this moderate classification does not account for any localised seepage within possible permeability contrasts near surface, where localised high salinity potentially might occur. Moreover, excavations in this domain may create salinity risk conditions similar to the lower landscape, if the depth of excavation were to bring the new ground surface into within say 2.5m of the (saline) groundwater table. This risk for excavation is increased with proximity to the lower landscape salinity domain SD2.

7.2 SD2 - Lower Landscape

SD2 lies in closer proximity to the (saline) groundwater table (inferred within about 2.5m depth) and is subject to concentration of seepage waters near creek lines and in the alluvium adjacent to creek lines. The salt comes both from the underlying (saline) groundwater (whether by seepage or through capillary action - evaporation) and from within the residual/alluvial soils.

Salinity in the landscape only affects the built environment/vegetation when in close proximity to the ground surface, thus actions which promote near surface seepage, waterlogging or close proximity to the underlying groundwater table should be either avoided if possible or properly managed. The lower landscape salinity domain SD2 has a higher salinity risk (described as moderate to high in the DIPNR Salinity Potential in Western Sydney Map - 2002) than the higher landscape salinity domain SD1, due to its closer proximity to the groundwater table and to the historical concentration of salt in this lower area through drainage and seepage migration.

During our walkover, significant salt deposits were observed East of South Street (opposite Lots

40-42) in SD2, which classifies as 'Known Salinity' in this 'High Salinity Potential' area. The lower landscape salinity domain SD2, will thus require development under a more comprehensive SMP than the higher landscape salinity domain SD2. In particular, fill rather than cuts should be used in any 're-shaping' of the ground surface in this area. Cuts, where necessary, should be minimised and/or closely managed in this landscape.

7.3 SD3 - Disturbed Landscape

SD3 comprises zones covering both the higher and lower landscapes that have been significantly disturbed by quarrying, filling and changed drainage conditions. In particular, the current quarry/landfill area, which also has a different geology over part of this (quarry) area, has been subject to significant excavation and disturbance, likely encountering the (saline) groundwater table, and removing/stockpiling soils and bedrock that contain salts.

Salinity sampling and assessment of these disturbed areas, using a combination of historical and intrusive data, will be needed in order to provide a detailed SMP for development options proposed . It is currently considered 'high risk' for salinity issues that may either affect development or be affected by further development. Moreover, the affects of the quarrying and backfilling on salinity of the surrounding area will also need to be further assessed within a SMP, with the progression of development options.

8. Discussion

From a salinity perspective, urban development of this site is expected to be suitable, subject to detailed geotechnical and salinity intrusive investigations and the development of a detailed Salinity Management Plan/s (SMP) for the proposed development options.

8.1 General

Dispersive and saline soil processes on the site have been inferred from the site walkover observations, from the limited surface water and shallow soil sampling/testing and from the assessment of the SAQP sample test results.

8.1.1 Dispersive Soils

The presence of dispersive soils is inherent in the site geology, and was visually identified on site in the salinity investigation. Further testing and comments on these soils, that confirm their dispersive nature, are included in the preliminary geotechnical report, which is presented under separate cover.

The presence of saline conditions is often linked with dispersive clay, as the exchange of calcium and magnesium ions by sodium ions (from salt) in the clay creates a weak clay structure that is susceptible to deflocculation, particularly under fresh water contact/seepage conditions.

The role of the sodium ion in salinity and dispersion of the clay structure is complex and dependent on the ionic concentration of the seepage waters. Briefly, soils that have a significant saline history tend to be dispersive when subjected to leaching by seepage of water with low ionic concentration (fresh water).

We note that for dispersive erosion to occur, there must be an exit point from beneath the topsoil layer in order for the deflocculated clay particles to migrate. Thus providing a secure, vegetated topsoil layer on a low-gradient slope (circa < 1V:3H) will assist in reducing undue erosion of batters in dispersive clays.

The most commonly used chemical treatment for dispersive soils, is the exchange of sodium ions by calcium ions through the addition of calcium sulphate (gypsum) to stabilise the clay structure. In saline leaching conditions this process can be reversed over time by re-exchange with sodium ions. The use of gypsum may also entail the need for a sulphate resistant cement for buried concrete and masonry, due to increased sulphate concentrations.

8.1.2 Salinity

The conceptual site model, developed using the information presented above, is as follows:

- Concentrated salinity in/near the creek lines and also where water-logging and evaporation occur.

- Salinity concentration was greater for areas lower in the landscape, closer to the groundwater table.
- The near surface salinity will have been suppressed by recent extended rainfall (prior to the walkover survey).
- Although, the soils samples from the upper landscape largely classify as 'non-saline' under the dryland salinity categories referenced in Section 3, these soils can still contain a salt concentration up to 2 dS/m. The salinity categories were developed for agricultural purposes, not civil works. Accordingly, rather than referring to the absence or near absence of salts, the 'non-saline' category refers to the level of salinity which affects only some crops. Localised salinity concentrations can form in such 'non-saline' soils if the development causes areas of poor drainage/water-logging to occur. In such areas, water carrying dissolved salt evaporates, causing the salt to concentrate. Thus the whole site, being in a dryland salinity risk area, requires salinity management considerations – particularly with respect to drainage.
- The salinity is inferred to be associated principally with saline groundwater in the bedrock. This water table is likely to form the major salt storage in the landscape, the salt being derived from flow through the residual clays/bedrock and by atmospheric recharge. The (saline) groundwater typically emerges in the lower landscape, particularly along creek lines and concentrates salts near the ground surface where seeps occur and in areas where the groundwater rises to the surface via capillary action and evaporates.
- Within the soil horizons, 'fresh' water seepage flows would be expected to occur during rainfall periods at the base of the topsoil horizon. Water would also seep down to the bedrock through the regolith, leaching salts downwards.
- Saline seeps may occur during wet periods at levels above the groundwater table due to permeability contrasts within the horizontally layered bedrock and at the interface of the soil profile (regolith) with the bedrock.
- Areas of recharge to the groundwater are expected on the higher landscape (Upper Slopes). Discharge areas would typically comprise the alluvium around creek lines (Lower Landscape), and any saline seeps at permeability contrasts such as described above.
- Some salinity may be associated with the atmospheric salt load, estimated at some 15kg/ha per year for the Site. Some of this salinity is removed by surface runoff, but part of the salt load migrates down to the groundwater table, through the regolith/bedrock.

The development of problematic saline conditions at a site is generally dependent upon three main factors: the salinity of the soil and rock profile; the salinity of the groundwater; and the proximity of the groundwater to the surface. Arguably the most important of those three factors is the proximity of the groundwater table to the surface. This is because saline soils and groundwater can be present on a site without causing a salinity problem, if the groundwater table/flow is sufficiently depressed.

In the case of saline groundwater, difficulties occur when the groundwater table (and thus the associated salinity) is close to the surface, because it brings the saline conditions into contact with the plant life and infrastructure. If the water table is depressed (e.g. either by natural flow patterns or by drainage/vegetation) the elements that are going to be adversely affected and the saline conditions remain separated.

In the case of saline soils, if the water table is depressed then percolation of rainfall through the top layers of soils will leach the salt from these layers resulting in the saline conditions being contained at depth away from the elements that will be adversely affected. Again, difficulties occur when the groundwater table is close to the surface or where periodic water-logging and evaporation occurs and the saline conditions are brought into contact with plant life and infrastructure.

Construction (in particular cut/fill and compaction) operations have the potential to alter the existing drainage patterns and thus may cause or increase salinity and erosion problems. Low permeability zones are likely to occur beneath and within compacted fill areas, resulting in a rise in the water table and water-logging/evaporation uphill of the compacted area, unless subsurface drainage is installed to allow this water to 'flow through'. Moreover, adequate fall should also be provided on fill platforms to prevent water ponding. Cuts may expose saline groundwater seepages, particularly on the lower slopes. Such water should be collected by subsurface drains and discharged in a controlled manner.

Collection of water in such drainage systems reduces water-logging and the possible associated damage to infrastructure and plant life such as: increased salinity leading to vegetation loss; dispersive erosion; chemical attack on buried steel and concrete; and increased offsite discharge of saline water. Moreover, retaining a maximum of native vegetation/trees and/or strategic planting and careful water management practices will assist in control of rising groundwater within the site.

Comments on potential contamination issues for the Site materials are made under separate cover.

9. Salinity Management

9.1 Proposed Development

Development of the Site is expected to involve significant cut and filling to form building platforms and site access.

Detailed drainage design measures and surface profiling to manage/control stormwater runoff and seepages will be important both during and after construction, in order to reduce erosion, to prevent water-logging and to reduce associated shrink/swell movements.

Construction will need to address localised salinity and the associated reactivity of the clay. Typically, moderate exposure conditions for chloride and sulphate attack to buried steel and concrete in accordance with AS2159 (1995, Piling Code) are expected to apply to upper landscape areas, and moderate to severe exposure conditions for the lower landscape areas. The confirmation/definition of such categories for design of buried steel and concrete geochemical resistance requirements should be conducted at detailed design stage.

Early establishment of topsoil/mulch and vegetation will assist in reducing erosion, particularly on batters/sloping ground. Where deeper rooted native species of vegetation should be preferentially adopted.

Development of earthworks will need to incorporate a salinity design strategy e.g., by adopting predominantly filled platform construction in the lower/more saline affected landscape, thus increasing the separation between the built environment and the saline groundwater.

In the higher landscape, where possible, it is desirable that a reasonable separation depth should be maintained between the groundwater table and any proposed cut levels. Deeper cuts will require careful drainage management.

Where water sensitive urban design structures and wet areas are to be incorporated (e.g., within riparian zones in the lower landscape), dams should preferentially be designed as retention structures rather than permanent water storage, and bio-treatment wet areas preferably be lined in order to isolate the planted flora from the (saline) groundwater and in order to minimise any recharge to the groundwater at those locations.

9.2 Objectives

The objectives of salinity management at the site should be:

- To limit adverse impacts of the development on saline processes within the site.
- To limit adverse impacts of the saline processes within the site on the development.

The salinity features at this site require design controls to achieve the abovementioned objectives.

9.3 Generalised Management Measures

Typically, management measures will need to address:

- Earthworks plans that limit cuts to significantly above the saline water table (where possible) and that provide filling rather than cuts in lower landscape areas.
- Drainage installed in order to reduce recharge to the groundwater table, to prevent waterlogging and to intercept seepage flows.
- The use of saline resistant building materials and building techniques in accordance with the relevant Australian Codes, including but not limited to AS2159, AS2870, AS3600 and AS3700.
- Measures to reduce the propensity for erosion of dispersive soils, such as gypsum/lime stabilisation and topsoiling/grassing.
- Adoption of saline resistant building techniques, such as referenced in the DIPNR publication 'Building In a Saline Environment'.
- The use of capillary-evaporation break/filter layers in areas subject to potential water-logging, in order to reduce any saline migration towards the ground surface, to assist in maintaining any dispersed clays under the filter layer, and to promote vegetative growth.
- Water-wise management/landscaping.
- Other special requirements as identified e.g., treatment around creeks, water retention zones and in areas subject water-logging.
- Appropriate design of services, including the minimisation of the potential for water leaks.

Generalised typical salinity response measures pertinent to this site could include but not be limited to:

- The provision of subsoil drains at the base of cuts, and on the upslope side of all roadways and compacted areas. Also provide sub-soil drainage measures behind retaining walls (for the full depth of the wall).
- Provide adequate surface profile and drainage to avoid depressions or locations of run-off water accumulation/ponding.
- Use of a waterproof membrane (minimum 0.2mm thick 'high impact resistance' to AS2870) directly beneath concrete slab-on-ground with a free draining sub-slab capillary break layer (typically fine to medium grained sand) beneath the slab between any stiffening beams (in recognition of potentially reactive soil environment - see AS2870).
- Full width waterproof damp course and construction in accordance with BCA and other relevant Australian Standards.
- Durable building products in accordance with AS3700 'Masonry Structures' and AS3600. In particular, the use of exposure class bricks and non-raked joints below the damp course layer in the lower landscape, and utilising potable water for mortar and concrete mixing.

9.4 Monitoring.

Monitoring of the groundwater level and quality is required with further development in order to assess and refine the definition of salinity impacts and to produce salinity management measures for the development options. Such monitoring should ideally be undertaken during the construction period, and for a period of at least 6 months after completion of construction (subject to review of results).

Utilisation of any existing piezometers prior to construction, plus installation of piezometers in areas where they will not be destroyed by the construction will assist in recording trends in groundwater depth and quality. Such data can be used to assess whether or not any supplementary drainage measures might be required. Typically such piezometers would be primarily located in the lower landscape with a couple of piezometers located higher in the landscape for groundwater profiling purposes.

The monitoring frequency for the piezometers would typically be monthly during construction, dropping to quarterly afterwards.

The monitoring results should be assessed by a geotechnical engineer experienced in salinity management.

References

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9. Standards Australia, Australian Standard: Residential Slabs and Footings, AS 2870 - 1996.
10. Standards Australia, Australian Standard: Concrete Structures, AS 3600 – 2001.
11. Standards Australia, Australian Standard: Masonry Structures, AS 3700 - 2001.

Standard Sheets

General Notes

Laboratory Testing

GENERAL NOTES

GHD GEOTECHNICS
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The report contains the results of a geotechnical investigation conducted for a specific purpose and client. The results should not be used by other parties, or for other purposes, as they may contain neither adequate nor appropriate information. In particular, the investigation does not cover contamination issues unless specifically required to do so by the client.

TEST HOLE LOGGING

The information on the test hole logs (boreholes, test pits, exposures etc.) is based on a visual and tactile assessment, except at the discrete locations where test information is available (field and/or laboratory results). The test hole logs include both factual data and inferred information. Moreover, the location of test holes should be considered approximate, unless noted otherwise (refer report). Reference should also be made to the relevant standard sheets for the explanation of logging procedures (Soil and Rock Descriptions, Core Log Sheet Notes etc.).

GROUNDWATER

Unless otherwise indicated, the water levels presented on the test hole logs are the levels of free water or seepage in the test hole recorded at the given time of measuring. The actual groundwater level may differ from this recorded level depending on material permeabilities (i.e. depending on response time of the measuring instrument). Further, variations of this level could occur with time due to such effects as seasonal, environmental and tidal fluctuations or construction activities. Confirmation of groundwater levels, phreatic surfaces or piezometric pressures can only be made by appropriate instrumentation techniques and monitoring programmes.

INTERPRETATION OF RESULTS

The discussion or recommendations contained within this report normally are based on a site evaluation from discrete test hole data, often with only approximate locations (e.g. GPS). Generalised, idealised or inferred subsurface conditions (including any geotechnical cross-sections) have been assumed or prepared by interpolation and/or extrapolation of these data. As such these conditions are an interpretation and must be considered as a guide only.

CHANGE IN CONDITIONS

Local variations or anomalies in the generalised ground conditions do occur in the natural environment, particularly between discrete test hole locations. Additionally, certain design or construction procedures may have been assumed in assessing the soil-structure interaction behaviour of the site. Furthermore, conditions may change at the site from those encountered at the time of the geotechnical investigation through construction activities and constantly changing natural forces.

Any change in design, in construction methods, or in ground conditions as noted during construction, from those assumed or reported should be referred to this firm for appropriate assessment and comment.

GEOTECHNICAL VERIFICATION

Verification of the geotechnical assumptions and/or model is an integral part of the design process - investigation, construction verification, and performance monitoring. Variability is a feature of the natural environment and, in many instances, verification of soil or rock quality, or foundation levels, is required. There may be a requirement to extend foundation depths, to modify a foundation system and/or to conduct monitoring as a result of this natural variability. Allowance for verification by appropriate geotechnical personnel must be recognised and programmed for construction.

FOUNDATIONS

Where referred to in the report, the soil or rock quality, or the recommended depth of any foundation (piles, caissons, footings etc.) is an engineering estimate. The estimate is influenced, and perhaps limited, by the fieldwork method and testing carried out in connection with the site investigation, and other pertinent information as has been made available. The material quality and/or foundation depth remains, however, an estimate and therefore liable to variation. Foundation drawings, designs and specifications should provide for variations in the final depth, depending upon the ground conditions at each point of support, and allow for geotechnical verification.

CLIMATE CHANGE

GHD Geotechnics acknowledges the occurrence of ongoing climate change. Cognisance is given to climate change issues as may be applicable to specific geotechnical investigations and assessments.

REPRODUCTION OF REPORTS

Where it is desired to reproduce the information contained in our geotechnical report, or other technical information, for the inclusion in contract documents or engineering specification of the subject development, such reproductions must include at least all of the relevant test hole and test data, together with the appropriate Standard Description sheets and remarks made in the written report of a factual or descriptive nature.

Ref: DS5.5.1 Issue 1.6 Date: 28/07/2009

LABORATORY TESTING

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GENERAL

Samples extracted during the fieldwork stage of a site investigation may be "disturbed" or "undisturbed" (as generally indicated on the trial hole logs) depending upon the nature and purpose of the sample as well as the method of extraction, transportation, extrusion and testing. This aspect should be taken into account when assessing test results, which must of necessity reflect the effects of such disturbance.

All soil properties (as measured by laboratory testing) exhibit inherent variability and thus a certain statistical number of tests is required in order to predict an average property with any degree of confidence. The site variability of soil strata, future changes in moisture and other conditions and the discrete sampling positions must also be considered when assessing the representative nature of the laboratory programme.

Certain laboratory test results provide interpreted soil properties as derived by conventional mathematical procedures. The applicability of such properties to engineering design must be assessed with due regard to the site, sample condition, procedure and project in hand.

TESTING

Laboratory testing is normally carried out in accordance with Australian Standard AS 1289 as amended, or RTA Standards when specified. The routine Australian Standard tests are as follows:-

Moisture Content	AS1289 2.1.1	
Liquid Limit	AS1289 3.1.1)	
Plastic Limit	AS1289 3.2.1)	collectively known as Atterberg Limits
Plasticity Index	AS1289 3.3.1)	
Linear Shrinkage	AS1289 3.4.1	
Particle Density	AS1289 3.5.1	
Particle Size Distribution	AS1289 3.6.1, 3.6.2 and 3.6.3	
Emerson Class Number	AS1289 3.8.1)	
Percent Dispersion	AS1289 3.8.2)	collectively, Dispersive Classification
Pinhole Dispersion Classification	AS1289 3.8.3)	
Hole Erosion (HE)	GHD Method	
No Erosion Filter (NEF)	GHD Method	
Organic Matter	AS1289 4.1.1	
Sulphate Content	AS1289 4.2.1	
pH Value	AS1289 4.3.1	
Resistivity	AS1289 4.4.1	
Standard Compaction	AS1289 5.1.1	
Modified Compaction	AS1289 5.2.1	
Dry Density Ratio	AS1289 5.4.1	
Minimum Density	AS1289 5.5.1	
Density Index	AS1289 5.6.1	
California Bearing Ratio	AS1289 6.1.1 and 6.1.2	
Shear Box	AS1289 6.2.2	
Undrained Triaxial Shear	AS1289 6.4.1 and 6.4.2	
One Dimensional Consolidation	AS1289 6.6.1	
Permeability Testing	AS1289 6.7.1, 6.7.2 and 6.7.3	

Where tests are used which are not covered by appropriate standard procedures, details are given in the report.

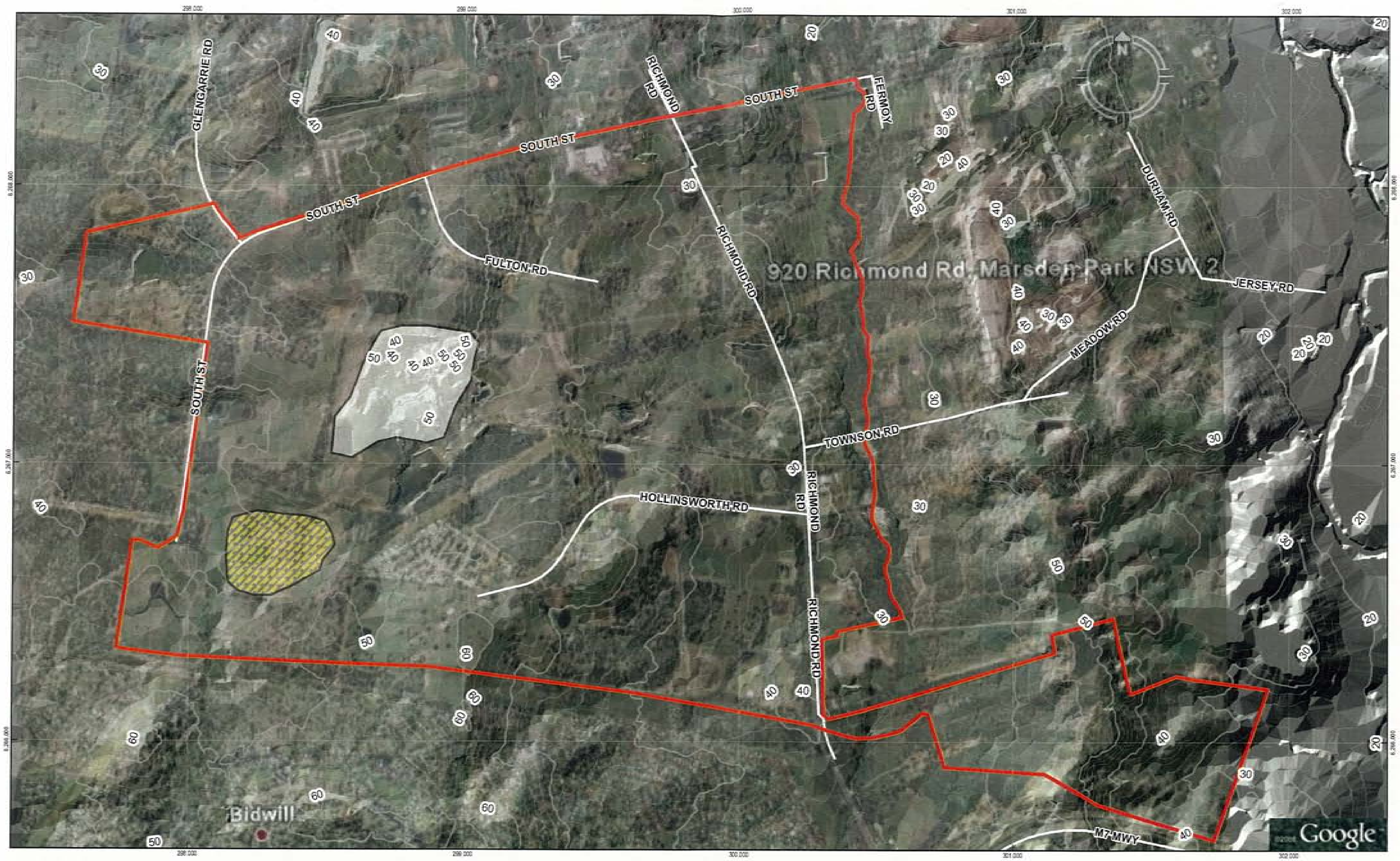
LABORATORY

Our laboratory is NATA accredited to AS ISO / IEC17025 for the listed tests.

The oedometer, triaxial and shear box equipment are fully automated for continuous operation using computer controlled data acquisition, processing and plotting systems.

Ref: DS5.5.2 Issue 1.6 Date: 04/06/2008

Figures



1:12,500 (at A3)

0 50 100 200 300 400 500

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Legend

Study Area

Fill Area (Approx)

Quarry & Landfill Area (Approx)

Contours

Major

Minor

Locality Map

SYDNEY

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Salinity Investigation

Job Number	21-17717
Revision	A
Date	12 February 2009

Site Location Plan

Figure 1

G:\21\17717\CADD\GIS\MapDocuments\21-17717-FIG001.mxd

10 Bond Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

Data Source: Google Inc. Google Earth 2008 NSW Department of Lands Cadastre, Contours 2008 Created by: pprevedoros, [illegible], RCJOHNSON

1:12,500 (at A3)

0 50 100 200 300 400 500

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Legend

- Study Area
- Cadastre
- Roads
- Soil Landscapes: bp, bt, sc

Locality Map

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Job Number	21-17717
Revision	A
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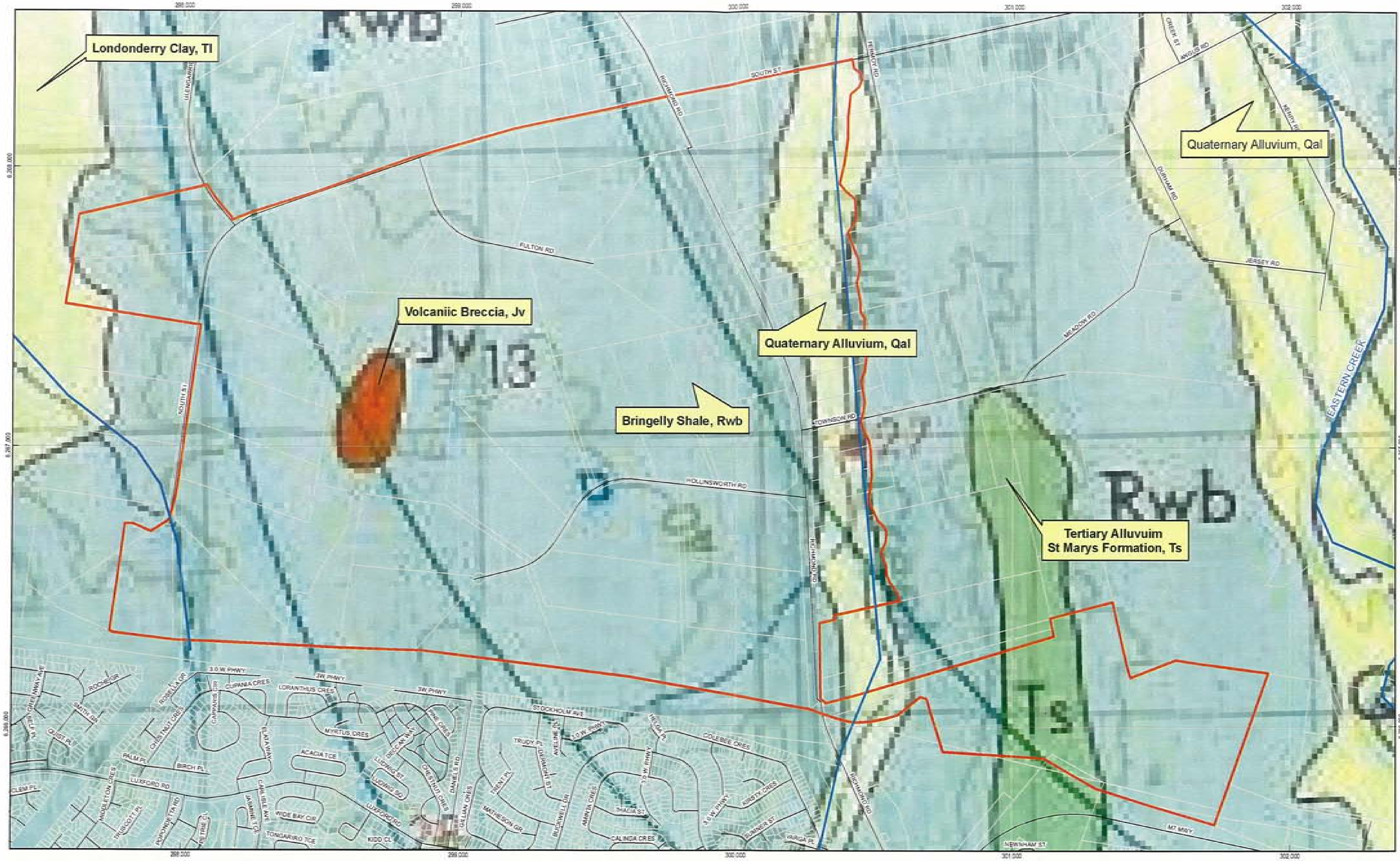
Soil Landscapes

Figure 2

G:\21\17717\CADD\GIS\MapDocuments\21-17717-FIG002.mxd

10 Bond Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

Data Source: NSW DECC Penrith 1:100K Sheet Soil Landscapes 1990 NSW Department of Lands Cadastre, Roads 2008 Created by: RCJOHNSON, gjchung



1:12,500 (at A3)

0 50 100 200 300 400 500

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Legend

- Study Area
- Cadastre
- Roads
- Watercourse

Geology: Qal, Jv, Rwb, Ts, Tl

Locality Map

SYDNEY

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AAP Corporation
Marsden Park Industrial Precinct
Salinity Investigation

Job Number	21-17717
Revision	A
Date	12 February 2009

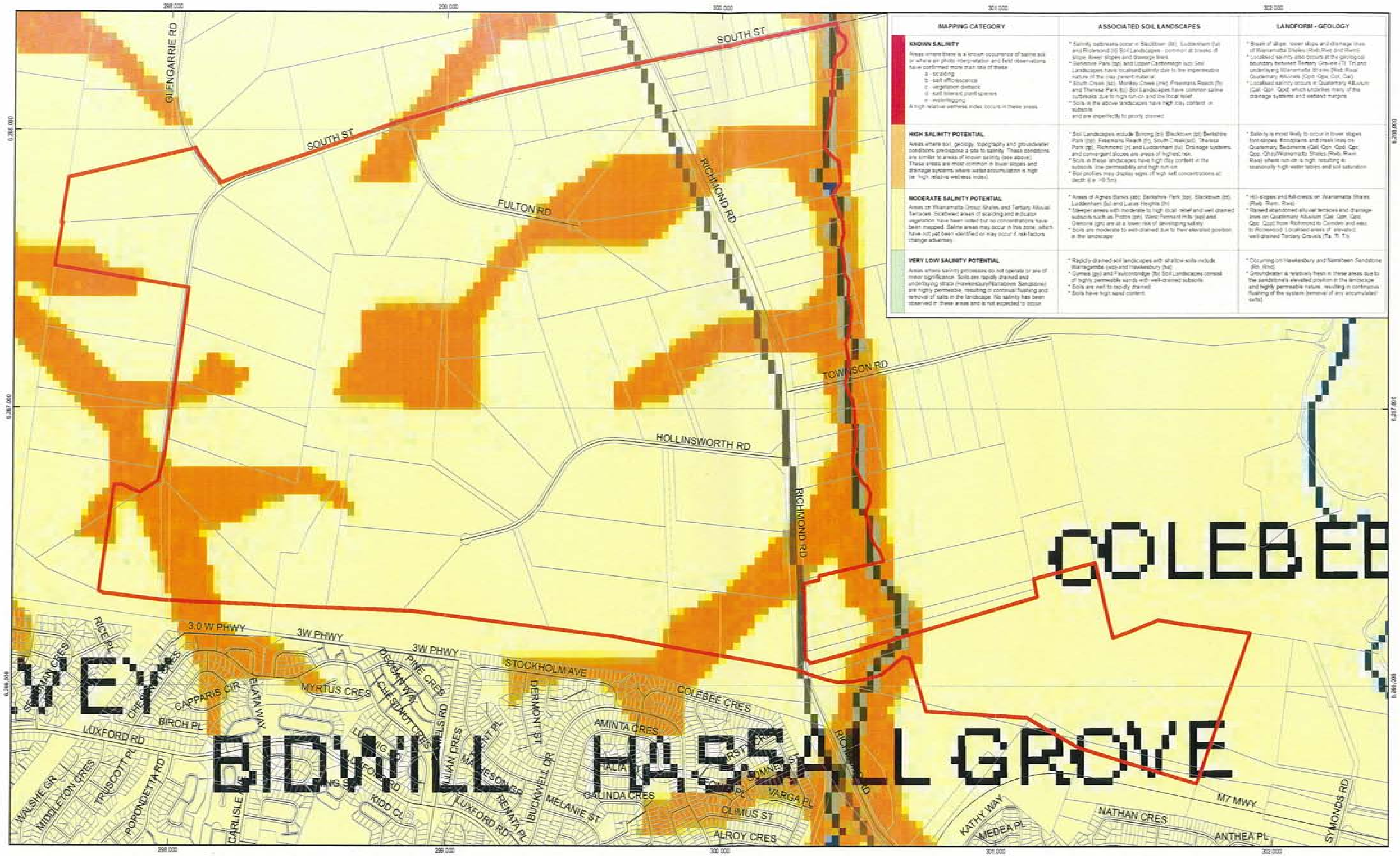
Geology

Figure 3

10 Bond Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

G:\21\17717\CADD\GIS\MapDocuments\21-17717-FIG003.mxd

Data Source: NSW Department of Lands Cadastre, Roads 2008 NSW Department of Primary Industries Sydney 100K Sheet Geology 2005 Created by: RCJOHNSON, qjchung



1:12,500 (at A3)

0 50 100 200 300 400 500

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Legend

- Study Area
- Roads
- Land Parcels

Locality Map

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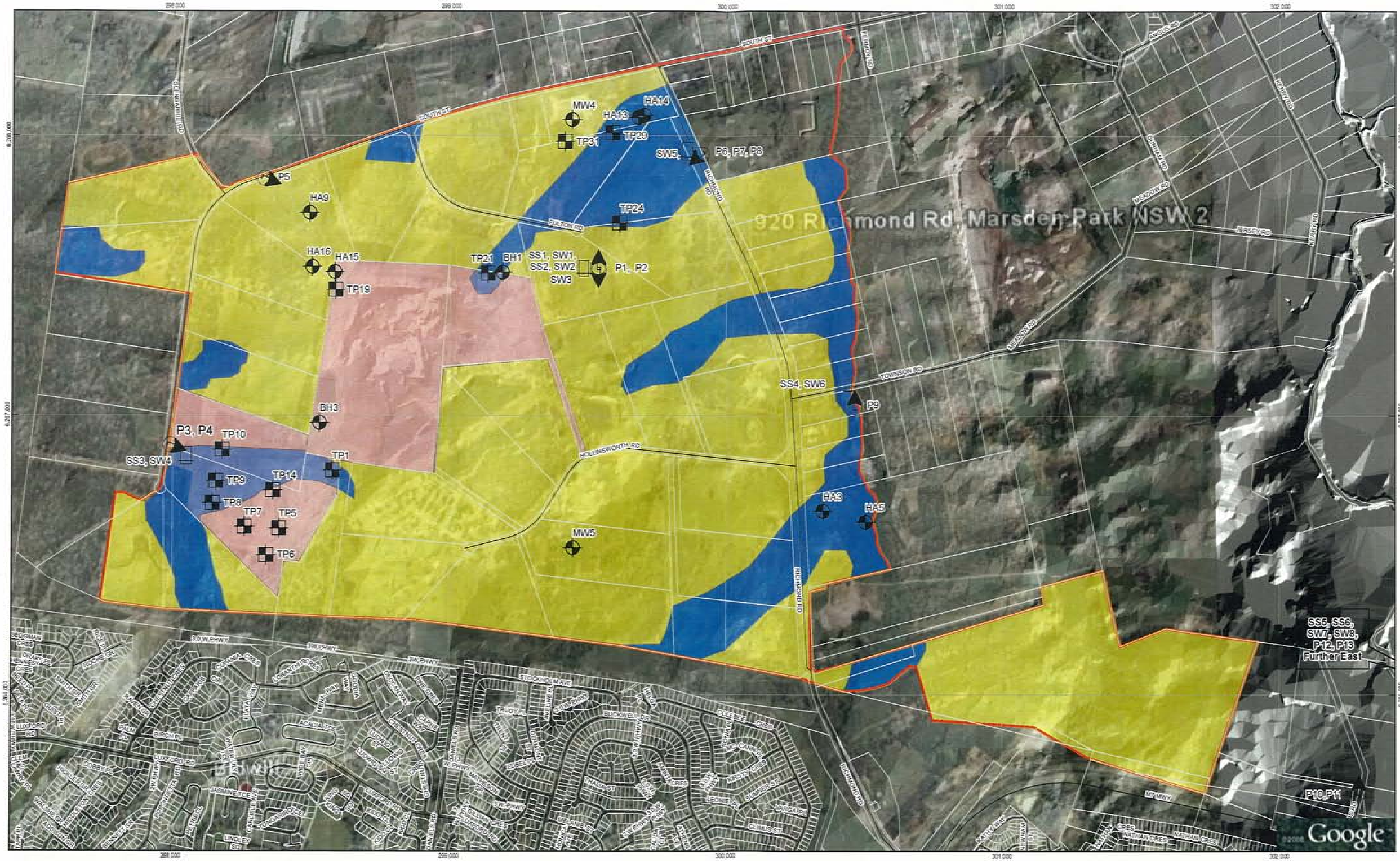
Salinity Potential

Figure 4

G:\21\17717\CADD\GIS\MapDocuments\21-17717-FIG004.mxd

10 Bond Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

Data Source: NSW DECC Salinity Potential in Western Sydney 2002 NSW Department of Lands Cadastre, Roads 2008 Created by: RCJOHNSON, cjchung



1:12,500 (at A3)

0 50 100 200 300 400 500

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Legend

- Study Area
- Cadastre
- Roads

Salinity

- Higher Landscape, Salinity Domain 1
- Lower Landscape, Salinity Domain 2
- Disturbed Landscape, Salinity Domain 3

- Test Pit
- Borehole
- Photos
- Surface Sample Location

Locality Map

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Revision	A
Date	10 February 2009

Salinity Domains

Figure 5

G:\21\17717\CADD\GIS\MapDocuments\21-17717-FIG005.mxd

10 Bond Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

Data Source: NSW Department of Lands Cadastre, Roads 2008 Google Inc. Google Earth 2008 Created by: RCJOHNSON, gjchung

Appendix A

Site Salinity Walkover Photographs

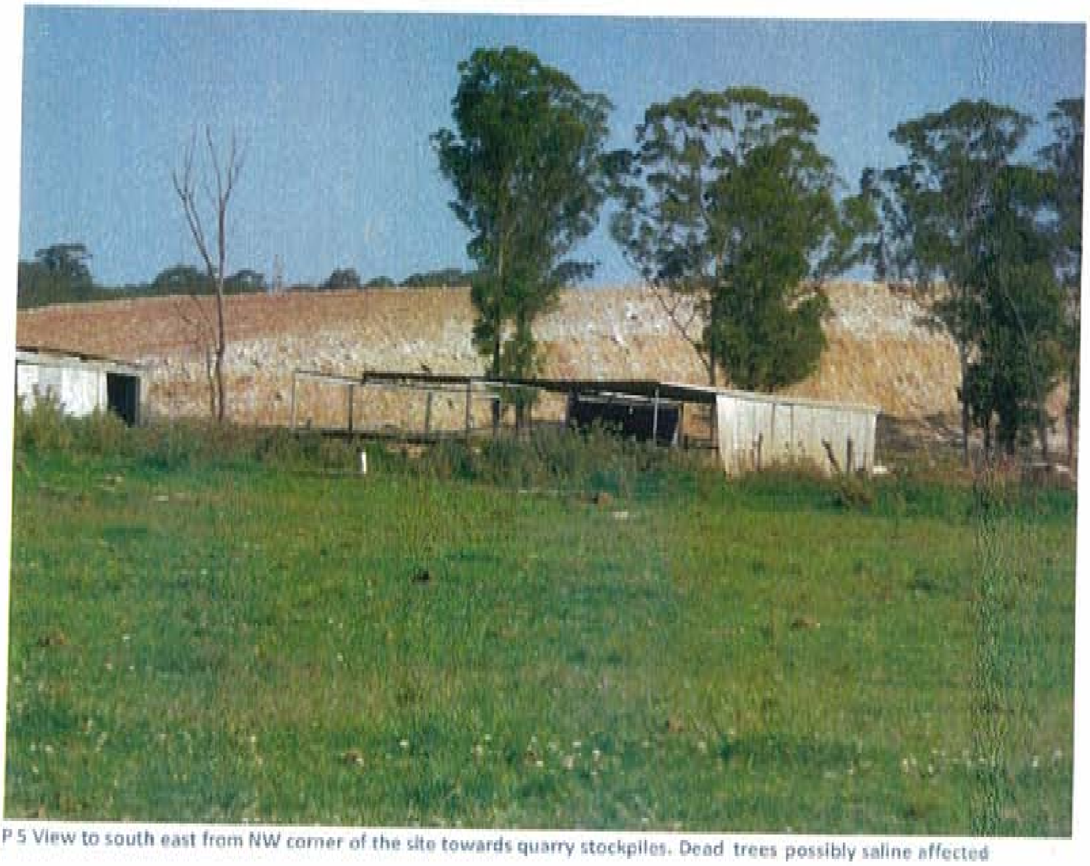
P1 – P13

P 1 Head of Lower landscape valley in Upper landscape east of Quarry. View north from access road. Overland water flow and swale appear associated with quarry operations. Couch grass saline indicator species. Soil sample SS1 water samples SW1 (foreground) and SW2 above swale in background.

P 2 Access road east of Quarry. View east. Overland flow water emerging to pond south of the quarry access road. Soil sample SS2 water sample SW3.

P 3 Lower landscape on south-west of the site, east of South Street, below night soil/fill area. Juncus Acutus, saline scalding and dispersive erosion in drain channel. Soil sample SS3. Water sample SW4

P 4 Lower landscape, saline indicator species Juncus Acutas and Couch, salt deposits. Soil sample SS3 water sample SW4



P 5 View to south east from NW corner of the site towards quarry stockpiles. Dead trees possibly saline affected

P 6 Lower landscape east of Quarry and west of Richmond Road. Waterlogged ground below dam. Saline indicator species Casuarina Glauca and Juncus Acutus. SW5 at pond above road drain culvert inlet.

P 7 Lower landscape east of Quarry. Close up on Juncus Acutus

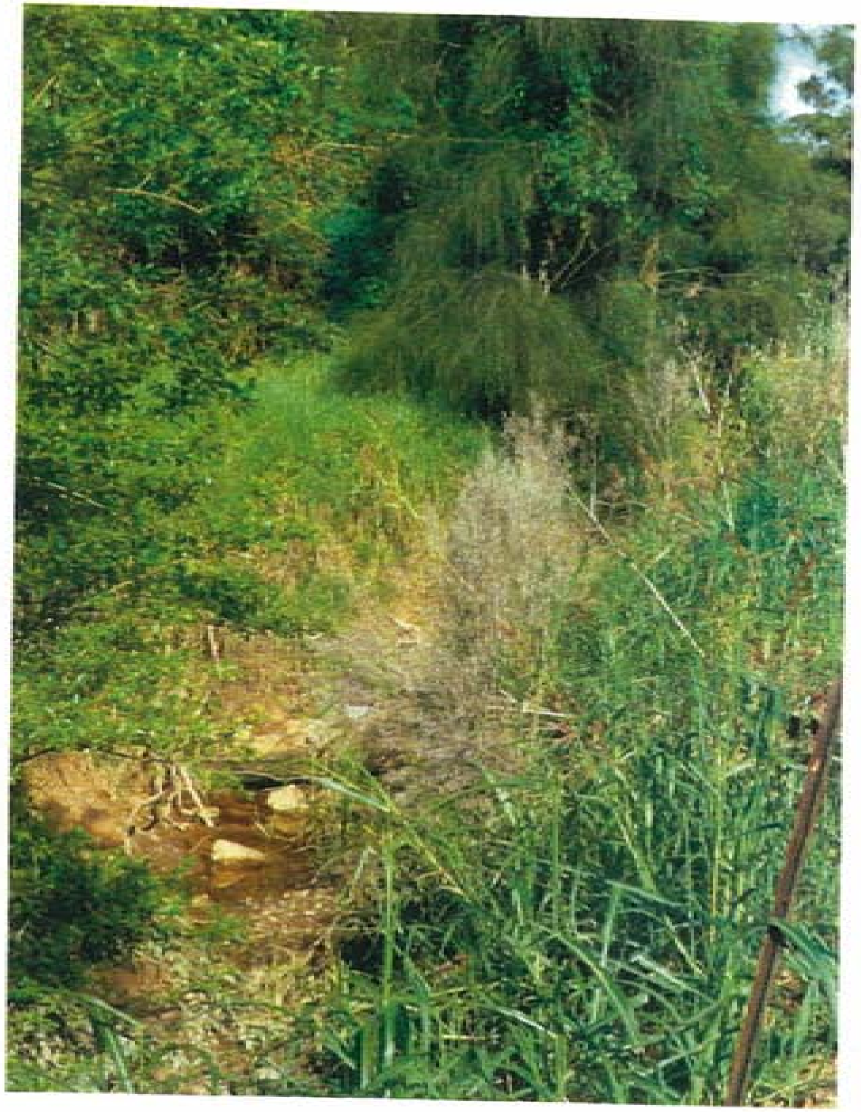
P 8 Casuarina Glauca, saline indicator vegetation. In lower landscape, mid-east of site near Richmond Road

P 9 Casuarina Glauca, saline indicator vegetation. In lower landscape, mid-east boundary of site north of Townson Road bridge over Bells Creek. Soil sample SS4. Water sample SW6

P 10 View north towards area near south eastern border of the site. Road access through construction site in background denied. Note Casuarina Glauca lining the Eastern Creek banks in the background.

P 11 Close Up of Casuarina Glauca along Eastern Creek .

P 12 Eastern Creek swollen with flow from recent rain. Casuarina Glauca and Couch saline indicator species. Soil sample SS5. Water sample SW7



P 13 Tributary stream to Eastern Creek. Casuarina Glauca and Couch saline indicator species Soil sample SS6. Water sample SW8

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Document Status

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