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Bungaribee Industrial Estate - Huntingwood

Salinity Assessment & Management Plan

February 2009

GHD GEOTECHNICS

INFRASTRUCTURE | MINING & INDUSTRY | DEFENCE | PROPERTY & BUILDINGS | ENVIRONMENT

19 February 2009

Goodman International Pty Ltd
Level 10, 60 Castlereagh Street
SYDNEY NSW 2000

Our ref: 21/17871//AZ054.doc

Attn: Brendon Quinn

Dear Brendon

Bungaribee Industrial Estate - Huntingwood
Salinity Assessment & Management Plan

This report presents the results of a salinity investigation conducted by GHD Geotechnics at the site of the proposed Bungaribee Industrial Estate, Huntingwood West. This investigation was undertaken in conjunction with our geotechnical investigation for the proposed industrial estate development located in Huntingwood West. The geotechnical investigation results are reported under separate cover (ref AZ035).

The findings of the salinity investigation reveal the following salinity associated constraints:

- Concentrations of salt within the soil profile, particularly in areas of waterlogging/drying in the lower landscape and at inferred permeability contrasts in the upper landscape.
- Dispersive and reactive clay soils.
- An inferred saline groundwater table in the bedrock.

In view of the above constraints, salinity management measures have been prepared for the site in order to reduce salinity impacts on the proposed development, and to reduce any adverse impacts of the proposed development on the identified salinity processes.

Groundwater monitoring recommendations for management of salinity risk during and after construction are also included.

Yours faithfully
GHD Geotechnics

Reviewed by

Bob Batchelder
Principal Geotechnical Engineer

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Document History

Revision No.	Revision Date	Description
Rev 0	17/12/08	Draft
Rev 1	19/02/09	Issued

Issued by: ....

Date: ....

Contents

1. Introduction

1.1 General

This report presents the results of a salinity investigation undertaken by GHD Geotechnics (GHD) for the proposed Bungaribee Industrial Estate (BIE) development at Huntingwood. The proposed development comprises two developmental stages, Stage 1 (South) and Stage 2 (North), as shown on Figure 1. This work was undertaken in conjunction with a geotechnical investigation for the subject site, which was reported under separate cover (ref:AZ035).

We understand that the proposed BIE development will comprise:

- Cut/fill for the building platforms. Cut to fill earthworks are expected to comprise up to 9 metres of cut and up to 8 metres of fill in Stage 1, and up to 3 metres of cut and up to 3 metres of fill in Stage 2.
- Formation of cut batter and fill embankment slopes.
- Pavements for internal roadways, car parks and vehicular traffic.
- New road intersections at the great Western Highway and Brabham Drive.

The purpose of the salinity investigation was to assess the presence of salinity processes on site, and to provide salinity management recommendations as appropriate, in order to address any impacts of salinity on the proposed development and any adverse impacts of the proposed development on salinity.

The salinity investigation was conducted in accordance with our proposal submitted to Goodman on 4 August 2008 (reference AY783). In particular, the investigation and assessment have been prepared in accordance with applicable salinity guidelines, including the *Western Sydney Salinity Code of Practice* (2003) and *Site Investigations for Urban Salinity* (2002).

1.2 Limitations

This report has been prepared for the use of Goodman International Ltd in relation to the proposed development of the Bungaribee Industrial Estate, Huntingwood, and takes account of concept design information provided to us. Changes to project scope may require review and revision of the recommendations provided herein.

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

2. Site Setting

2.1 Description

The BIE site is located in Huntingwood, between the Great Western Highway to the north and the M4 Freeway to the south. It comprises 56 ha of land known as the Huntingwood West – Bungaribee Industrial Estate. The site can be sub-divided into two areas: Stage 1 (Southern Site and Estate Rd) and Stage 2 (Northern Site), as on Figure 1.

The site falls gently to moderately from east to west, towards a nearly ‘flat’ floodplain area adjacent to Eastern Creek, which flows to the north. Some of this flatter floodplain area, below the ‘break of slope’, comprises a minor portion of the site. The highest ground is located in the south-eastern corner of the site.

Topographically, the site comprises a gently undulating ‘upland’ region for the most part, with a narrow region along the western boundary, which is relatively flat where it joins the ‘floodplain’ of Eastern Creek.

There are a number of ‘overland flow’ drainage gullies draining to the west. There is also a drainage gully flowing from near the south-east corner of the site to the north-west then north, into the (waterlogged) north-east area of the site, which contains a number of marsh areas. We understand that a stormwater culvert from Brabham Drive also drains into this gully.

The western (approximately) half of the site is covered by grasses with occasional trees (previously cultivated farm land). Grasses with areas of sparse to moderate trees cover the eastern part of the site, with a number of reed-covered marsh areas in the north-east.

2.2 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 2).

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 western area, nominally from the ‘break of slope’ westwards towards Eastern Creek. Quaternary alluvium typically comprises fine-grained sand, silt and clay.

2.3 Soil Landscapes

Reference to the 1:100,000 scale Soil Landscape Series Sheet for Penrith (sheet 9030) reproduced in part on Figure 3, shows that the site lies within the Blacktown residual soil landscape with South Creek fluvial soil landscape lying to the west of the site, around Eastern Creek.

The Blacktown Unit is described as a ‘Residual Landscape’ with gentle undulating rises on Wianamatta Group bedrock, slopes generally <5% and broad round hill crests. 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 known salinity and dispersive soil hazard, particularly in lower slopes and streamlines where soils have the potential to become waterlogged.

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 soils and dispersive/erodible soils. This unit generally has a low capability for urban development due to flood hazard/erosion, varying alluvial soils and salinity.

We note that while the geological mapping, as discussed above, shows the alluvium to underlie the western edge of the site, the soil landscape mapping shows it to lie slightly further west. While the mapping, at 1:100,000 scale, is ‘coarse’, the topography typically will reflect the differing subsurface conditions, with alluvium (South Creek landscape) anticipated below the ‘break of slope’.

2.4 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 to high salinity potential, with higher salinity potential on the upper slope drainage courses but only ‘moderate’ salinity potential near Eastern Creek where this is adjacent to the site boundary. This is unusual, as normally the higher salinity potential is associated with the lower landscape, although elevated salinity can occur in any part of the Blacktown Landscape where waterlogging and evaporation result in the concentration of salts.

3. Investigation Procedure

The salinity investigation undertaken comprised:

- A site salinity walkover, with associated shallow soil and surface water/well sampling and testing for pH and electrical conductivity (EC).
- Salinity (pH and EC) testing conducted within our laboratory on soil samples recovered from the geotechnical investigation holes.

3.1 Site Walkover

The site walkover was conducted on 15 November 2008 by a Principal Engineer from this office, and comprised:

- A walkover of the site, including the creek areas in the central and western parts of the site, in order to identify and record:
  - Saline soil landscapes, terrain type, saline indicator vegetation, saline scalds, salt deposits, vegetation dieback.
  - Dispersive erosion, seepage discharge areas.
- Sampling of surface waters and soils for field and laboratory testing in order to assist with characterisation of the salinity aspects of the site. This sampling also included recording the depth to groundwater and obtaining a water sample from the well installed in BH06, in the highest (south-east) area of the site.
- Photographs to record salinity observations. A selection of these is provided in Appendix A.

The positions of surface soil/water samples, and of site photographs taken during the site walkover, were recorded using autonomous GPS, which is generally accurate to within about 10m of the grid position.

The positions of the observation and sampling points are shown on Figure 1.

3.2 Geotechnical Investigation Data

3.2.1 Lower Landscape

This section refers to the floodplain area, below the break of slope, where, in summary, the subsurface conditions comprised:

- Alluvium comprising mainly firm to stiff clays, clayey sands and gravels extending to depths ranging from some 1.0-2.5 m below the existing ground surface, and generally overlying residual soils.
- Residual clay soils and some clayey sands were encountered at most test locations, extending to bedrock (where encountered) at depths ranging from about 2.0-4.0 m below the existing ground surface.
- The bedrock generally comprised grey and brown, extremely to highly weathered, very low strength sandstone (inferred Minchinbury Sandstone).

3.2.2 Slopes and Upper Landscape

This refers to the majority of the site area, above the break of slope, where in summary, the subsurface conditions comprised:

- Some areas of minor fill/clay alluvium, generally less than 1m in thickness, and colluvium of up to 1.5m below the existing ground surface in places.
- Residual clay soils encountered at all investigation locations, and extending to depths of backhoe refusal and auger v-bit refusal at about 1.0-5.0 m below the existing ground surface.
- Bedrock generally comprised shale and siltstone with minor sandstone and was encountered at depths ranging from about 2m – 5m below existing site levels.
- Laboratory testing on a selection of the recovered soils samples indicated that the alluvial clays were slightly to highly dispersive and the residual soils were non–dispersive to moderately dispersive.
- In the 'floodplain' region, seepage/groundwater was recorded at depths ranging from about 2.0-4.0 m. The deeper records were obtained in standpipe piezometers where the water level may have still been rising on completion of the investigations.

Following review of the geotechnical investigation logs, a suite of soil samples were scheduled for salinity-associated laboratory testing.

The testing programme for both the site walkover and geotechnical investigation samples is described below.

3.3 Field and Laboratory Testing

The following field and laboratory tests were conducted on the soil and water samples recovered:

<u>Site Walkover</u>

- 8 soil samples were mixed at 5:1 ratio of distilled water:soil by volume, and then tested for pH and Electrical Conductivity (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.
- 2 surface water samples were collected from standing water in excavated/dispersive erosion holes and 1 well water sample was obtained from BH06. These were tested for pH and conductivity (ECw).

<u>Geotechnical Investigation</u>

- Soil samples collected from selected geotechnical test pits and boreholes were also tested for EC and pH, as described above, and for sulphates and chlorides.

The results of the field and laboratory testing for pH and EC, together with salinity classification data are summarised in Tables 1 to 5. The results of testing for sulphates and chlorides will be reported in the final report.

4. Salinity Investigation Results

4.1 Walkover Observations

For visual record of the site walkover, reference should be made to selected photographs contained in Appendix A. Our site observations are provided below:

- Saline indicator plants, including Swamp Sheoak (Casuarina Glauca) and Couch grass, were observed within the lower landscape and near Eastern Creek. Moreover, waterlogging and saline tolerant paper bark trees were observed across most of the upper landscape. Reed overgrown swamps were also observed in the north-east, waterlogged upper landscape zone. Refer to photographs Pano 1 – Pano 2 and P1 – P5.
- Saline scalding was observed in the lower landscape of the site, on an abandoned track leading to a former trotting track. Refer to photograph P2.
- Dead trees, possibly resulting from saline die-back, were observed in the lower south-west and in the waterlogged north-east of the site. Refer to Pano 1 and P3.
- The potentially dispersive nature of the site soils was evident from an observed sink hole in the north-eastern area of the site. Refer to P4.
- Groundwater was recorded at 3.2m depth (approx. RL53.5m) in BH06, approximately 0.6m above the bedrock top. Examination of the core photos for this borehole reveals two iron-stained joints, which may indicate the source of the seepage into this borehole. The rise in the groundwater level since the geotechnical investigations completed a month previous is inferred to be due, at least partially, to significant rainfall, which occurred shortly before the salinity walkover. This rainfall will also have temporarily suppressed surface soil/water salinity at the site, as recorded at the time of the walkover.

4.1.1 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 x 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.

Salinity and pH Readings – Site Walkover 13/11/08 **TABLE 1**

Test Hole	Sample Depth (m)	Soil Description	Soil pH	Conductivity EC (dS/m)	Texture Factor F	Equivalent Conductivity ECe (dS/m)
SS1	0–0.05	Lt Brown CLAY/SILT (topsoil)	6.61	0.025	9	0.2
SS2	0.05-0.1	Red Brown CLAY	5.34	1.542	8	12.3
SS3	0.05-0.1	Red Brown CLAY	5.52	0.062	8	0.5
SS4	0.1-0.15	Red Brown CLAY	7.07	0.102	8	0.8
SS5	0.05-0.1	Brown CLAY	4.88	1.404	8	11.2
SS6	0.05-0.1	Dark Brown CLAY	5.62	1.600	8	12.8
SS7	0.05-0.1	Dark Brown CLAY/SILT	5.87	0.048	9	0.4
SS8	0.05-0.1	Orange Brown CLAY	5.80	0.561	8	4.5
SS9	0.05-0.1	Lt Brown CLAY	5.64	0.024	8	0.2

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

Very saline surface soil conditions were recorded in the lower landscape (SS5), the waterlogged area in the north-east of the site (SS6) and also in a bare (saline scald?) upper landscape area near a stand of paperbark trees and couch grass in the higher south-east area of the site (SS2). The other samples recorded non-saline (<2dS/m) to moderately saline.

It must be noted that the salinity walkover was conducted after recent heavy rainfall. Accordingly, much of the near – surface salinity will have been 'flushed' away or will have seeped lower into the soil profile, resulting in apparently 'less saline' conditions than is expected if the sampling had been conducted after a significant period of drier weather.

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

Salinity and pH Readings – Geotechnical Investigation **TABLE 3**

Test Hole	Sample	Soil Description	Soil pH	Conductivity EC (dS/m)	Texture Factor F	Equivalent Conductivity ECe (dS/m)
TP37	2.4-2.6	Grey brown sandy CLAY	6.7	0.250	8.5	2.1
BH02	0.5-0.95	Grey mottled red CLAY	5.3	0.169	8	1.4
BH02	1.5-1.95	Grey mottled red CLAY	5.2	0.840	8	6.7
BH02	5.3-5.4	Grey brown EW SHALE	7.3	1.184	10	11.8
BH06	0.5-0.95	Grey brown CLAY	5.6	0.757	8	6.1
BH06	4.0-4.1	Grey brown EW SHALE	6.3	0.795	10	8.0
BH07	0.5-0.95	Brown CLAY	7.1	0.120	8	1.0
BH07	1.5-1.95	Grey brown CLAY	7.2	0.819	8	6.6
BH07	3.0-3.45	Grey brown CLAY	7.3	0.572	8	4.6
BH07	4.0-4.15	Grey brown CLAY	7.5	0.974	8	7.8
BH07	4.2-4.3	Brown MW SANDSTONE	7.3	1.107	11	12.2
BH09	0.5-0.95	Orange brown CLAY	5.1	0.533	8	4.3
BH09	1.5-1.95	Grey brown sandy CLAY	6.0	0.793	8.5	6.7
BH09	3.0-3.45	Grey brown sandy CLAY	6.3	0.940	8.5	8.0
BH09	4.0-4.4	Grey brown EW SHALE	6.6	1.021	10	10.2
BH09	4.5-4.6	Grey brown HW SHALE	6.6	1.366	10	13.7

The following comments are made on the results shown in Table 3 above:

- Apart from the near surface sampling in BH02 and BH07, moderate to very saline soil conditions were encountered in all of the boreholes. Slightly saline conditions were recorded in the near surface sampling in BH02 and BH07 .
- The recorded salinity concentration typically increased with depth, and was particularly evident at the interface of the regolith with the bedrock (inferred due to seepage at this permeability contrast).
- After periods of extended rainfall, deeper (saline) seepage is considered to move laterally at permeability contrasts (such as sandstone layers) and to 'emerge' beneath the soil cover on the slope (saline seep). In particular, reference to the sandstone bed at 6.0-7.0 m depth in BH06 and the recording of very saline soil conditions in surface soil sample 'SS2' at similar elevation to this bed, but downslope of BH06, is consistent with this consideration.

4.1.2 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 5.

Salinity and pH Readings – Water Samples **TABLE 4**

Sample	Depth (m)	Location	pH	Conductivity ECw (dS/m)	Factor	TDS (ppm)
SW1	Surface	Pond in Upper Landscape	6.68	0.427	640	273
SW2	Surface	Water in Sinkhole NE Part Site	6.82	0.553	640	354
BH06	Well	South East – Upper Landscape	7.49	1.458	640	933

The Australian Water Resources Council (AWRC 1976) has defined classes for salinity of water as shown in Table 5 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

Based on the above results, the surface water samples collected recorded 'fresh' water quality. However, the groundwater sample collected from BH06, in the highest part of the site, recorded marginally saline water.

4.1.3 Chloride and Sulphate Concentrations

The results of laboratory testing for chloride and sulphate concentrations in selected 'higher' EC soil and water samples are summarised in Table 6 following:

Chloride & Sulphate Concentrations – Soil & Water Samples **TABLE 6**

Sample No.	Depth (m)	Sample Type (Units)	Chloride	Sulphate
SW3	Surface	Water (mg/L)	320	120
SS2	0 – 0.05	Soil (mg/kg)	190	33
SS5	0 – 0.05	Soil (mg/kg)	2450	57
SS6	0 – 0.05	Soil (mg/kg)	56	17
BH2	5.3 - 5.4	Soil (mg/kg)	960	110
BH6	0.5 – 0.95	Soil (mg/kg)	1850	560

Sample No.	Depth (m)	Sample Type (Units)	Chloride	Sulphate
BH6	4.0 – 4.1	Soil (mg/kg)	1100	64
BH7	1.5 – 1.95	Soil (mg/kg)	1980	200
BH9	1.5 – 1.95	Soil (mg/kg)	2100	170
BH9	4.5 – 4.6	Soil (mg/kg)	1950	230

Test Certificates for the above analyses are provided in Appendix B.

5. Discussion

5.1 General

Dispersive and saline soil processes on the site have been inferred from the site walkover observations, surface water and shallow soil sampling/testing, and water testing from piezometers.

5.2 Dispersive Soils

The presence of dispersive soils is inherent in the site geology, was visually identified on site, and has subsequently been confirmed by laboratory testing, as reported in the geotechnical report.

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. Generally, 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 sulphate resistant cement for buried concrete and masonry, due to increased sulphate concentrations.

5.3 Salinity

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

- A saline groundwater table.
- Concentrated salinity in/near the drainage lines, but according to the DIPNR (large scale, 1:100,000) salinity mapping, lessened to some degree in the vicinity of Eastern Creek. This is consistent with the presence of a higher permeability bedrock (sandstone) in this area allowing some flushing of the collected salts. However, very saline soil conditions were still recorded in surface soil sample SS5, collected in this lower landscape area during the salinity walkover.
- Saline seepage zones in the upper landscape at inferred permeability contrasts, such as sandstone beds/layers within the shale/siltstone bedrock. The seepage zones are inferred

to be active during/after significant rainfall. Such permeability contrasts appear to have resulted in at least one occurrence of 'very high' salinity recorded on a surface soil sample (SS2) during the site walkover, and could also explain the prevalence of paperbark trees across the upper landscape (due waterlogging/seepage zones occurring where such contrasts contact the regolith (soil profile).

- Salinity concentrations, where classified as 'non-saline', can still contain salt concentration up to 2 dS/m (1200 ppm) at the trigger threshold level for the salinity category. It must be noted that the Dryland Salinity categories were developed for agricultural purposes, and rather than referring to the absence/near absence of salts, this category refers to the level of salinity which affects crops. Localised 'high saline' concentrations can still form in such soils if the development causes areas of poor drainage/waterlogging, where water carrying dissolved salt evaporates, leaving the salt concentrate behind. Thus the whole site, being in a saline soil area, requires salinity management considerations – predominantly with respect to drainage.
- The salinity appears associated, principally, with inferred saline groundwater, and with flushing of the salt through saline seeps at permeability contrasts, as discussed above. While normally this groundwater occurs deep (typically>4m) within the bedrock in the upper landscape, this site appears particularly susceptible to receiving recharge water from higher up the slope (off-site to the east) which migrates through the sandstone beds. These saline seeps may also occur during wet periods at levels above the groundwater table due to permeability contrasts within the horizontally layered bedrock, and also at the interface of the soil profile (regolith) with the bedrock.
- The groundwater 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 in alluvium 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 at the base of the topsoil horizon during rainfall periods. Water would also seep down to the bedrock through the regolith, leaching salts downwards.
- Areas of recharge to the groundwater are expected on the higher landscape. Discharge areas typically comprise the lower landscape regolith (alluvium) around creek lines (such as inferred from the seepage recorded in TP405), and any saline seeps at permeability contrasts, such as described above.
- Salinity is also associated with the atmospheric salt load, estimated at some 15kg/ha per year for Huntingwood. Some of this salinity is removed by surface runoff, but part of the salt load migrates down towards the groundwater table, or to saline seepage through the 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 these 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 waterlogging 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 waterlogging/evaporation uphill of the compacted area, unless subsurface drainage is installed to allow this water to 'flow through'. Moreover, adequate fall should 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 waterlogging 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.

5.3.1 Chlorides and Sulphates

The chloride and sulphate concentrations recorded on selected soil and water samples indicated non-aggressive exposure classifications in accordance with Tables 6.1 and 6.2 in AS2159:1995 (Piling Design and Installation) for buried steel and concrete.

It must be noted that in areas on the subject site where a shallow saline groundwater (<2m depth) exists and/or where seepage and waterlogging can occur, salts may concentrate to very high levels in zones of wetting and drying. Such high concentrations of salinity can result in localised adverse exposure classifications for such zones e.g., 'severe' rating for exposure as per AS2159:1995. It is thus necessary to control the site drainage in accordance with the procedures outlined above, in order to avoid as far as possible the formation of waterlogged areas on the site.

Importantly, moderately to severe exposure classification conditions are suggested in AS3600 for buried steel and concrete on sites located in moderate to high dryland salinity risk areas, such as the subject site.

6. Salinity Management

The proposed development earthworks, although following good salinity design strategy by adopting predominantly a filled platform construction in the lower/more saline affected landscape, will also need to account for saline seepage at permeability contrasts within the bedrock in both the upper and lower landscapes.

Areas that will be covered by buildings/warehouse construction, will reduce concentration of salts near surface from evaporation, but will require effective perimeter stormwater and subsurface drainage in order to reduce potential saline seepage into the fill.

6.1 Objectives

The objectives of salinity management at the site are:

- 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 objectives identified above.

Typically, management measures need to address:

- Earthworks to limit cuts down into the saline water table and to provide filling rather than cuts in lower landscape areas. At this site provision will be needed to route potential saline seepage from the east, past/through the development, to approved discharge e.g., Eastern Creek.
- Drainage to reduce recharge to the groundwater table, avoid waterlogging and to intercept seepage.
- Use of saline resistant building materials.
- Adoption of saline resistant building techniques.
- Reduce erosion of dispersive soils.
- The use of capillary-evaporation break/filter layers 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 management/landscaping.
- Special requirements as identified e.g., treatment around creeks and in waterlogged areas.
- Appropriate design of services, including the potential for water leaks.

6.2 Management Measures

Salinity response measures recommended for this site include:

- 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). In addition, provision for mid-slope drainage at permeability contrast (sandstone bed) outcrops in cuts may be required to limit ongoing erosion issues, if significant seepages occur.

- 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 ‘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, and utilising potable water for mortar and concrete mixing. In particular, the use of masonry and concrete products with at least ‘moderate’ resistance (AS2159) to chloride and sulphate is recommended.
- Collect all roof and stormwater runoff, in order to reduce groundwater recharge that may affect off-site areas, which are located lower on the slope.
- Ensure all water carrying pipes/channels are well constructed and maintained in order to minimise any leakage of water.
- Provide good drainage to road subgrades and use durable (generally igneous) roadbase for pavement construction.
- Avoid construction or landscaping that bypasses the damp course, such as rendering or landscaping mulch/soil in contact with walls and rising above the level of the damp course.
- Provide adequate ventilation beneath any suspended sub-floor areas.
- Maintain areas of established native vegetation where possible.
- Minimise irrigation requirements by use of appropriate watering systems, mulching and by planting native vegetation where possible/practical.
- The use of mulch in lower lying areas adjacent to creek lines/drainage courses in order to provide an evaporation break.
- Maintain topsoil cover on exposed batters, in order to minimise the potential for dispersive erosion.

6.3 Monitoring

Monitoring of the groundwater level and quality would be advantageous in assessing and refining the salinity impacts/management measures. 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 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.

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

A geotechnical engineer experienced in salinity management should assess the monitoring results.

References

1. Soil Conservation Service of NSW, Soil Landscape Series Sheet 9030, Penrith.
2. Geological Survey of NSW, Department of Minerals and Energy, Geological Series Sheet 9030, Penrith, Edition 1, 1991.
3. Department of Infrastructure, Planning and Natural Resources, Salinity Potential in Western Sydney 2002, (March, 2003).
4. Standards Australia, Australian Standard: Piling – Design and installation, AS 2159 – 1995.
5. Department of Land & Water Conservation, Site Investigations for Urban Salinity, (2002).
6. Department of Land & Water Conservation, Building in a Saline Environment, (2002).
7. Western Sydney Regional Organisation of Councils, Western Sydney Salinity Code of Practice (March 2002, Amended January 2004).
8. Department of Land & Water Conservation, Dryland Salinity, (Scott Taylor 1996).
9. Standards Australia, Australian Standard: Concrete Structures, AS 3600 – 2001.

Standard Sheets

General Notes

Laboratory Testing

GENERAL NOTES

GHD GEOTECHNICS
Specialist Services in Geotechnical Engineering, Geology, Field/Laboratory Testing and Hydrogeology
www.ghd.com.au/ghdgeotechnics

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.

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.

Reports are the subject of copyright and shall not be reproduced either totally or in part without the express permission of GHD.

Ref: DS5.5.1 Issue 1.5 Date: 04/06/2008

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.

GHD

Figures

LEGEND

BH01	BOREHOLE	GEOTECHNICAL INVESTIGATION
TP10	TEST PIT	
SS1	SURFACE SOIL SAMPLE	SALINITY INVESTIGATION
SW1	SURFACE WATER SAMPLE	
P1	PHOTO AND DIRECTION	
PANO 1	PANORAMA AND DIRECTION	
	SITE BOUNDARY	
	PROPOSED FIXED ROAD NETWORK	

0 50 100 150m
SCALE 1:5000 AT ORIGINAL SIZE

NOTE: CONTOUR INTERVAL 0.25m

REFERENCE: BASE SURVEY PROVIDED BY GOODMAN PROPERTY SERVICE PTY LTD

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GHD GEOTECHNICS

Goodman International Ltd
Bungaribee Industrial Estate - Huntingwood
Geotechnical Investigation
Test Location Plan

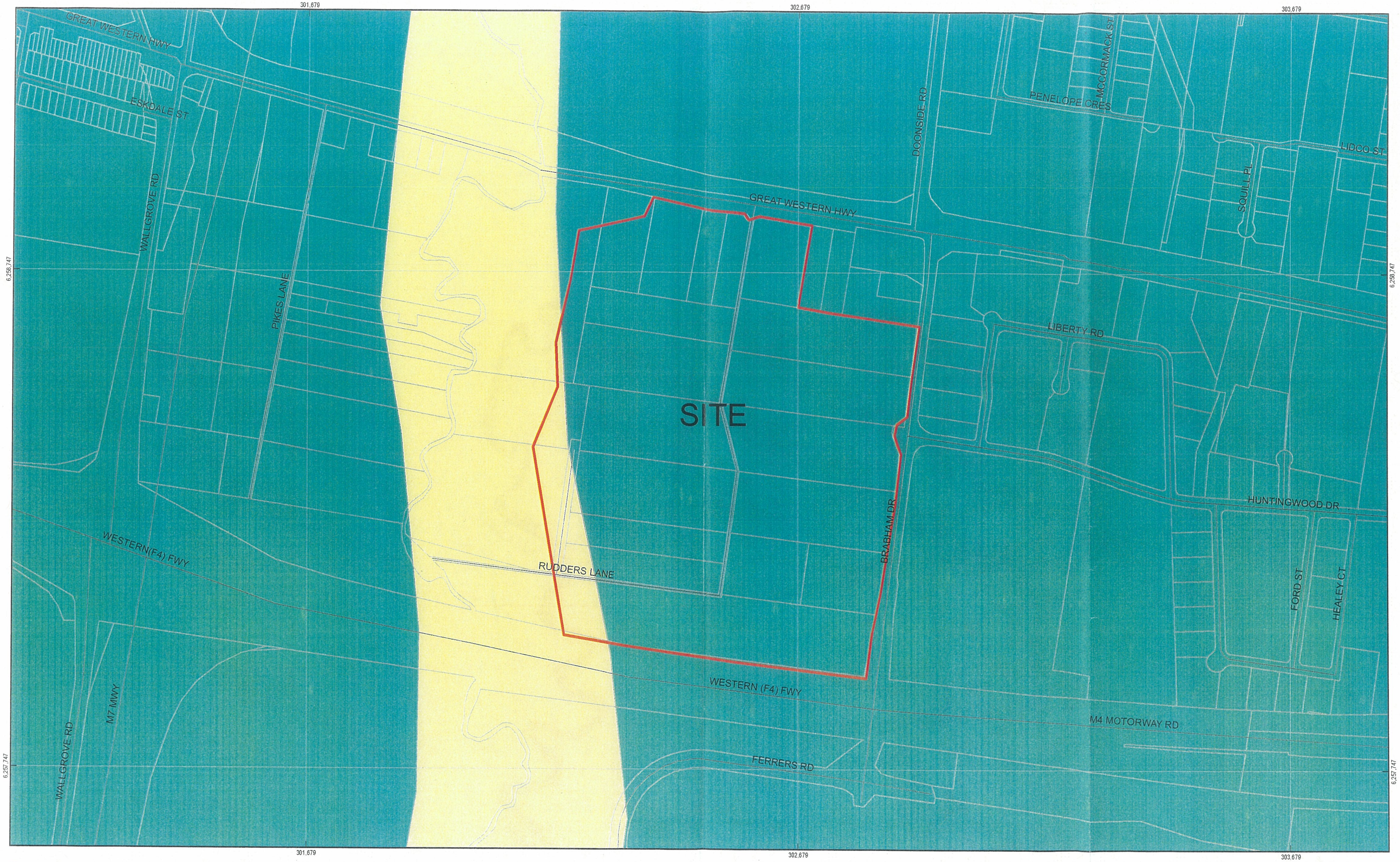
scale | 1:5000 for A3 date | December 2008

job no. | 21-17871-01
rev no. | A

Figure 1

57-63 Herbert St Artarmon NSW 2064 Australia, Locked Bag 2727 St Leonards NSW 1590 T 61 2 9462 4700 F 61 2 9462 4710 E atnmail@ghd.com.au W www.ghd.com.au/ghdgeotechnics

Plot Date: 20 February, 2009 - 12:37 PM Cad File No: 21-17871-FIG-001.dwg



1:7,000 (at A3)

0 75 150 300 Metres

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

N

LEGEND

Site Location

Bringelly Shale

Quaternary Alluvium

Locality Map

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Goodman International Ltd
Bungarribee Industrial Estate - Huntingwood
Salinity Investigation

Job Number	21-17871-01
Revision	A
Date	December 2008

Geology Map

Figure 2

G:\21\17871\CADD\GIS\MapDocuments\21-17871-FIG002.mxd

57-63 Herbert Street Artarmon NSW 2064 T 61 2 9462 4700 F 61 2 9462 4710 E artmail@ghd.com.au W www.ghd.com.au

Data Sources: NSW Department of Primary Industries Penrith Geology Map Sheet 9030 1:100,000 series, NSW Department of Lands DCDB 2008. Created by: rcjohnson

1:7,000 (at A3)

0 75 150 300 Metres

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

N

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Site Boundary

Soil Landscape

Blacktown Unit

South Creek Unit

Locality Map

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Bungarribee Industrial Estate - Huntingwood
Salinity Investigation

Job Number	21-17871-01
Revision	A
Date	December 2008

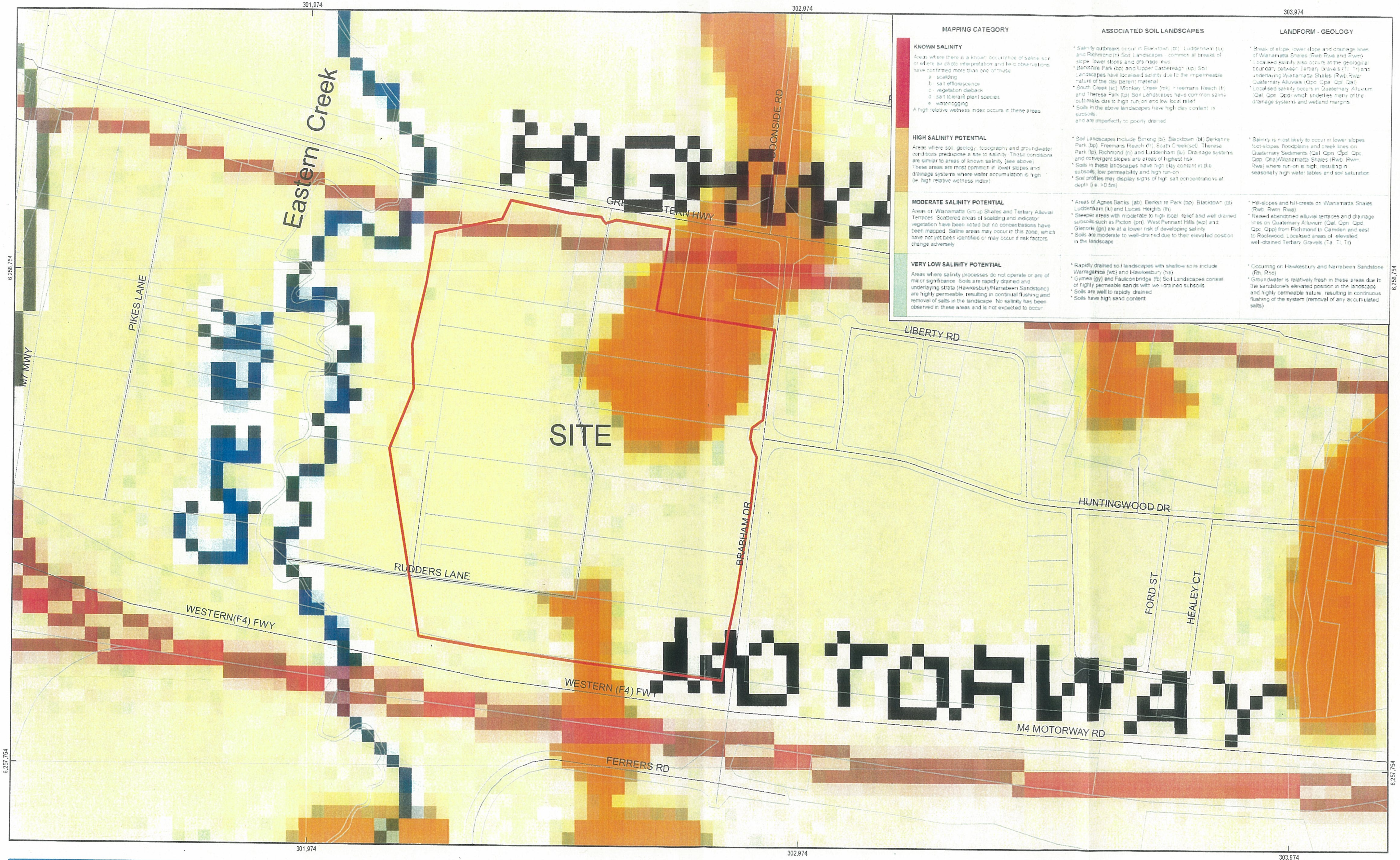
Soil Landscape Map

Figure 3

G:\21\17871\CADD\GIS\MapDocuments\21-17871-FIG003.mxd

57-63 Herbert Street Artarmon NSW 2064 T 61 2 9462 4700 F 61 2 9462 4710 E artmail@ghd.com.au W www.ghd.com.au

Data Sources: NSW Department of Environment and Climate Change, Penrith 9030 1: 100 000 Soil Landscapes 1990, NSW Department of Lands DCDB 2008 Created by: rcjohnson



MAPPING CATEGORY	ASSOCIATED SOIL LANDSCAPES	LANDFORM - GEOLOGY
KNOWN SALINITY Areas where there is a known occurrence of saline soil or where air photo interpretation and field observations have confirmed more than one of these a - scalding b - salt efflorescence c - vegetation dieback d - salt tolerant plant species e - waterlogging A high relative wetness index occurs in these areas	* Salinity outbreaks occur in Blacktown (bt), Luddenham (lu) and Richmond (ri) Soil Landscapes - common at breaks of slope, lower slopes and drainage lines * Berkshire Park (bp) and Upper Castlereagh (up) Soil Landscapes have localised salinity due to the impermeable nature of the clay parent material * South Creek (sc), Monkey Creek (mk), Freemans Reach (fr) and Theresa Park (tp) Soil Landscapes have common saline outbreaks due to high run-on and low local relief * Soils in the above landscapes have high clay content in subsoils. and are imperfectly to poorly drained	* Break of slope, lower slope and drainage lines of Wianamatta Shales (Rwb Rwa and Rwm) * Localised salinity also occurs at the geological boundary between Tertiary Gravels (Tl, Tr) and underlaying Wianamatta Shales (Rwb,Rwa) Quaternary Alluvials (Qpc, Cpa, Qpl, Qal) * Localised salinity occurs in Quaternary Alluvium (Qal, Qpn, Qpd) which underlies many of the drainage systems and wetland margins
HIGH SALINITY POTENTIAL Areas where soil, geology, topography and groundwater conditions predispose a site to salinity. These conditions are similar to areas of known salinity (see above). These areas are most common in lower slopes and drainage systems where water accumulation is high (ie. high relative wetness index)	* Soil Landscapes include Birrong (bi), Blacktown (bt) Berkshire Park (bp), Freemans Reach (fr), South Creek(sc0, Theresa Park (tp), Richmond (ri) and Luddenham (lu). Drainage systems and convergent slopes are areas of highest risk * Soils in these landscapes have high clay content in the subsoils, low permeability and high run-on * Soil profiles may display signs of high salt concentrations at depth (i.e. >0.5m)	* Salinity is most likely to occur in lower slopes foot-slopes, floodplains and creek lines on Quaternary Sediments (Qal, Qpn, Qpd, Qpc, Qpp, Qha)Wianamatta Shales (Rwb, Rwm, Rwa) where run-on is high, resulting in seasonally high water tables and soil saturation
MODERATE SALINITY POTENTIAL Areas on Wianamatta Group Shales and Tertiary Alluvial Terraces. Scattered areas of scalding and indicator vegetation have been noted but no concentrations have been mapped. Saline areas may occur in this zone, which have not yet been identified or may occur if risk factors change adversely	* Areas of Agnes Banks (ab), Berkshire Park (bp), Blacktown (bt) Luddenham (lu) and Lucas Heights (lh) * Steeper areas with moderate to high local relief and well drained subsoils such as Picton (pn), West Pennant Hills (wp) and Glenorie (gn) are at a lower risk of developing salinity * Soils are moderate to well-drained due to their elevated position in the landscape	* Hill-slopes and hill-crests on Wianamatta Shales (Rwb, Rwm, Rwa) * Raised abandoned alluvial terraces and drainage lines on Quaternary Alluvium (Qal, Qpn, Qpd, Qpc, Qpp) from Richmond to Camden and east to Rookwood. Localised areas of elevated well-drained Tertiary Gravels (Ta, Tl, Tr)
VERY LOW SALINITY POTENTIAL Areas where salinity processes do not operate or are of minor significance. Soils are rapidly drained and underlaying strata (Hawkesbury/Narrabeen Sandstone) are highly permeable, resulting in continual flushing and removal of salts in the landscape. No salinity has been observed in these areas and is not expected to occur	* Rapidly drained soil landscapes with shallow soils include Warragamba (wb) and Hawkesbury (ha) * Gymea (gy) and Faulconbridge (fb) Soil Landscapes consist of highly permeable sands with well-drained subsoils * Soils are well to rapidly drained * Soils have high sand content	* Occurring on Hawkesbury and Narrabeen Sandstone (Rh, Rno) * Groundwater is relatively fresh in these areas due to the sandstone's elevated position in the landscape and highly permeable nature, resulting in continuous flushing of the system (removal of any accumulated salts)

1:7,000 (at A3)

0 75 150 300 Metres

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

N

LEGEND
Site Location
Roads
Land Parcels

Locality Map

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Goodman Property Services Pty Ltd
Huntingwood West - Bungarribee Industrial Estate
Salinity Investigation

Job Number	21-17871-01
Revision	A
Date	December 2008

Salinity Potential

Figure 4

G:\21\17871\CADD\GIS\MapDocuments\21-17871-FIG004.mxd

57-63 Herbert Street Artarmon NSW 2064 T 61 2 9462 4700 F 61 2 9462 4710 E artmail@ghd.com.au W www.ghd.com.au

Data Sources: NSW Department of Environment and Climate Change Salinity Potential 2002 NSW Department of Lands DCDB 2008 Created by: rcjohnson

Appendix A

Site Walkover Photographs

Panoramas	Pano 1 – Pano 3
Photographs	P1- P5

Pano 1 View West from the SE Corner of the site. Gum trees, Paperbark and grasses

Pano 2 View West in a lower 'gully' on the South-West of the site. Casuarina Glauca on LHS and along Eastern Creek in the background (saline indicator species). Dead trees (saline die-back?).

Pano 3 View north along drainage depression leading to the North East of the site. Reeds (salt tolerant) in pond in centre of photo, and paperbarks (waterlogging/salt tolerant) around, but no Casuarina Glauca or Juncus Acutus (typical saline indicator species).

P 1 Higher landscape.'Perched' water in an excavation adjacent to a stand of gum and paperbark trees. Couch grass. Dispersive erosion

P 2 Lower landscape. Track to old trotting course. Bare (saline scald?) zone. Couch (saline indicator species). Soil sample SS5 (Very Saline).

P 3 Mix of gum trees and paperbark in drainage depression (waterlogging zone). Drainage is impeded by the road embankment to the north (in background). SS6 (Very Saline). Dead tree in background is possibly saline die-back.

P 4 Edge of Swamp, NE Section of the Site. Couch, Reeds. No Standing Water. SS7 (Non-Saline)

P 5 Sink Hole Near Swamp. Dispersive Soil Indicator. Couch grass. SW2 (Non-Saline)

Appendix B

Laboratory Test Certificates

WT1413A	SW3
WT1413	SS2, SS5 & SS6
WT1412	BH2, BH6, BH7 & BH9

WATERTEST

Office:
PO BOX 591
SEVEN HILLS NSW 2147

Laboratory:
1/4 ABBOTT ROAD
SEVEN HILLS NSW 2147
Telephone: (02) 9838 8294
Fax: (02) 9838 8919
A.C.N. 098 982 140
A.B.N. 76 098 982 140
NATA No: 1884

ANALYTICAL REPORT for:

GHD GEOTECHNICS PTY LTD

LOCKED BAG 2727
ST LEONARDS NSW 1590

ATTN: DAVID BROOKE

JOB NO: WT1413A

CLIENT ORDER: 2117871

DATE RECEIVED: 16/12/08

DATE COMPLETED: 22/12/08

TYPE OF SAMPLES: WATER

NO OF SAMPLES: 1

NATA — This document is issued in accordance with NATA's accreditation requirements. Accredited for compliance with ISO/IEC 17025

....
Issued on 14/01/09
Sue Wyman
(Laboratory Supervisor)

WATERTEST

ANALYTICAL REPORT

JOB NO: WT1413A
CLIENT ORDER: 2117871

DATE OF COLLECTION SAMPLES		SW3	SW3 DUP
Sulphate	mg/L	120	
Chloride	mg/L	320	310

LABORATORY DUPLICATE REPORT

JOB NO: WT1413A
CLIENT ORDER: 2117871

Sample Number	Analyte	Units	MDL	Sample Result	Duplicate Result	%RPD
SW3	Chloride	mg/L	1	320	310	3

Acceptance criteria:

RPD <50% for low level (<10xMDL)
RPD <20% for medium level (10-50xMDL)
RPD <10% for high level (>50xMDL)
No limit applies at <2xMDL

MDL = Method Detection Limit

All results are within the acceptance criteria

ANALYTICAL REPORT

JOB NO: WT1413A
CLIENT ORDER: 2117871

METHODS OF PREPARATION AND ANALYSIS

The tests contained in this report have been carried out on the samples as received by the laboratory, in accordance with APHA Standard Methods of Water and Wastewater 21st Edition, or other approved methods listed below:

4110B	Sulphate
4500D	Chloride

A preliminary report was faxed on 13/01/09

WATERTEST

Office:
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Laboratory:
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Fax: (02) 9838 8919
A.C.N. 098 982 140
A.B.N. 76 098 982 140
NATA No: 1884

ANALYTICAL REPORT for:

GHD GEOTECHNICS PTY LTD

LOCKED BAG 2727
ST LEONARDS NSW 1590

ATTN: DAVID BROOKE

JOB NO:	WT1413
CLIENT ORDER:	2117871
DATE RECEIVED:	16/12/08
DATE COMPLETED:	22/12/08
TYPE OF SAMPLES:	SOIL
NO OF SAMPLES:	3

NATA
This document is issued in accordance with NATA's accreditation requirements
Accredited for compliance with ISO/IEC 17025

....
Issued on 14/01/09
Sue Wyman
(Laboratory Supervisor)

WATERTEST

ANALYTICAL REPORT

JOB NO: WT1413
CLIENT ORDER: 2117871

	SAMPLES	SO4 mg/kg	Cl mg/kg
1	SS2	33	190
2	SS5	57	2450
3	SS6	17	56
MDL		5	5
Method Code		8.29	8.16
Preparation		P3	P3

ANALYTICAL REPORT

JOB NO: WT1413
CLIENT ORDER: 2117871

METHODS OF PREPARATION AND ANALYSIS

The tests contained in this report have been carried out on the samples as received by the laboratory.

P3 Sample dried, jaw crushed and sieved at 1.0mm

8.29 Sulphate Ion Content - BS 1377 Part 3 (1990)
Determined by APHA 20th Ed 4110B
8.16 Chloride in Soil - Based on RTA T1010
Determined by APHA 20th Ed 4110B

A preliminary report was faxed on 13/01/09

WATERTEST

Office:
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Laboratory:
1/4 ABBOTT ROAD
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Telephone: (02) 9838 8294
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A.C.N. 098 982 140
A.B.N. 76 098 982 140
NATA No: 1884

ANALYTICAL REPORT for:

GHD GEOTECHNICS PTY LTD

LOCKED BAG 2727
ST LEONARDS NSW 1590

ATTN: DAVID BROOKE

JOB NO:	WT1412
CLIENT ORDER:	2117871
DATE RECEIVED:	16/12/08
DATE COMPLETED:	22/12/08
TYPE OF SAMPLES:	SOIL
NO OF SAMPLES:	6

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....
Issued on 14/01/09
Sue Wyman
(Laboratory Supervisor)

WATERTEST

ANALYTICAL REPORT

JOB NO: WT1412
CLIENT ORDER: 2117871

	SAMPLES	SO4 mg/kg	Cl mg/kg
1	BH2 5.3-5.4m	110	960
2	BH6 0.5-0.95m	560	1850
3	BH6 4.0-4.1m	64	1100
4	BH7 1.5-1.95m	200	1980
5	BH9 1.5-1.95m	170	2100
6	BH9 4.5-4.6m	230	1950

	SO4	Cl
MDL	5	5
Method Code	8.29	8.16A
Preparation	P3	P3

WATERTEST

ANALYTICAL REPORT

JOB NO: WT1412
CLIENT ORDER: 2117871

METHODS OF PREPARATION AND ANALYSIS

The tests contained in this report have been carried out on the samples as received by the laboratory.

P3	Sample dried, jaw crushed and sieved at 1.0mm
8.29	Sulphate Ion Content - BS 1377 Part 3 (1990) Determined by APHA 20th Ed 4110B
8.16A	Chloride in Soil - Based on RTA T1010

A preliminary report was faxed on 13/01/09

GHD Pty Ltd **ABN 39 008 488 373**

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Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	ARBatchelder	Tony Colenbrander		Tony Colenbrander		
1	ARBatchelder	Tony Colenbrander		Tony Colenbrander	A Colenbrander	24/2/09