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Report on Salinity Assessment

Proposed Residential Subdivision
Lot 4, Raby Road
Gledswood Hills

Prepared for
Camden Council

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1. Introduction

This report presents the results of a salinity investigation undertaken as part of an overall land capability assessment for Lot 4, Raby Road, Gledswood Hills. The investigation was commissioned by TN Consulting Pty Ltd (TNC), project consultants, acting on behalf of Camden Council and was undertaken in accordance with a proposal by Douglas Partners Pty Ltd (DP) dated 11 October 2013.

The site has been identified for potential re-zoning for urban development. The primary aims of the study were to estimate the salinity of the site materials, to determine the potential for the site materials to adversely impact the development and to provide strategies for managing the salinity during development.

Details of the work undertaken and the results obtained are given in the report, together with an assessment of salinity-related constraints and a preliminary salinity management plan (SMP) for future development.

Drawings, test pit logs, laboratory test reports and a summary table of laboratory results are presented in Appendices A to D. The test pits were excavated and sampled for geotechnical, salinity and contamination testing purposes and the logs, laboratory test reports and some relevant sections of background information are included in all reports for completeness. The reader is advised to read this salinity assessment report in conjunction with all other reports forming the Land Capability Assessment.

2. Scope of Works

To fulfil the aims above, the investigation comprised:

- A review of published soils and geological information;
- A site walkover by a senior geotechnical engineer to assess possible salinity indicators in addition to features relevant to geotechnical constraints;
- A non-invasive investigation with an electromagnetic (EM) system and a Differential Global Positioning System (DGPS), followed by mapping of apparent conductivities (ground conductivities) across the whole site;
- Selection of target locations for follow-up direct investigation, based on apparent conductivities;
- Location of targets on site, using their logged DGPS co-ordinates;

- Excavation and logging of 10 test pits (Pits 1 to 10) at the target locations, with collection of regular disturbed samples to assist in strata identification and for laboratory testing of salinity and related properties;
- Correlation of laboratory salinities with apparent conductivities to establish a conversion equation and enable mapping of apparent salinities across the whole site;
- Preparation of hazard or constraint maps, indicating areas of elevated salinity, corrosivity and sodicity, which may adversely affect the development; and
- Preparation of a preliminary Salinity Management Plan, included within this report.

3. Site Description

The subdivision is proposed in an irregular area of approximately 40 ha and is identified as Lot 4, Raby Road, Gledswood Hills. The site is bounded to the north, south and east by vacant private land. The north-eastern corner is also bounded by the Macarthur Grange Country Club. The Sydney Water Supply Channel runs along the western boundary of the site. The site location is indicated in Figure 1 (below) and the site boundaries are shown on Drawings 1 to 8 in Appendix A.

The site traverses undulating terrain with an overall difference in level of about 30 m from the highest part of the site to the lowest. The highest area (RL 142.4 relative to Australian Height Datum [AHD]) is in the north-eastern corner of the site.

The site has been generally cleared of trees and is mainly grass covered. Scattered trees generally dot the site, however, a stand of trees remains at the north-western corner. Three dams are located within the site, at the northern and southern ends and 50 m south of the stand of trees (refer Drawing 1).

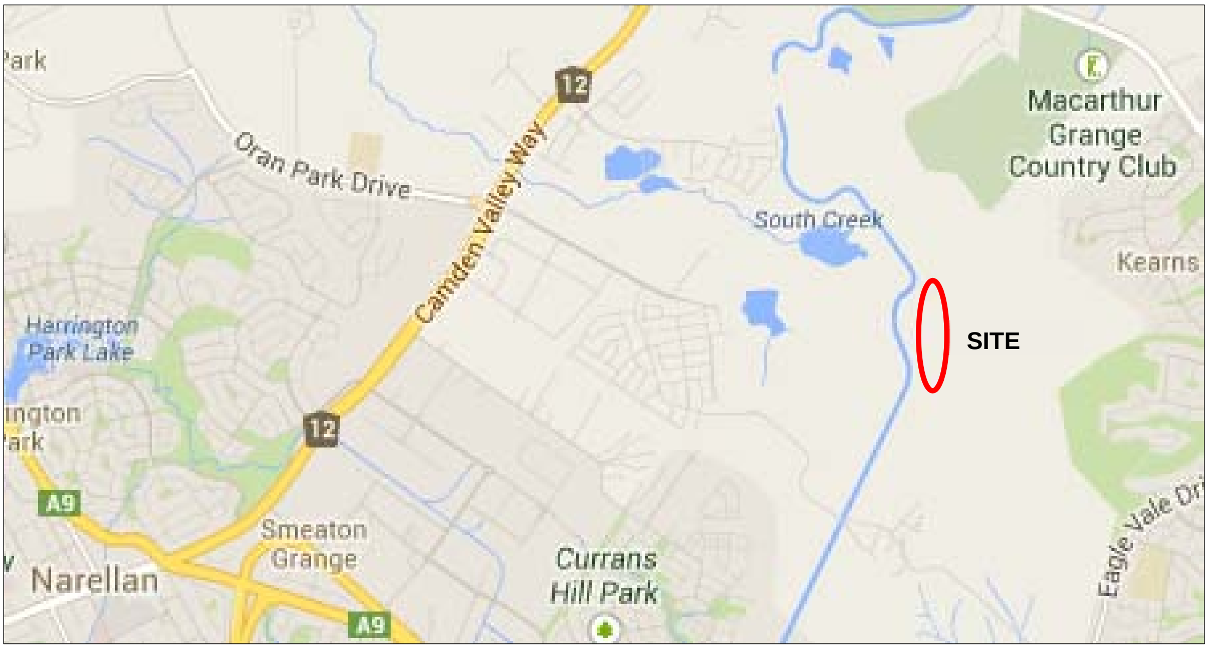


Figure 1: Site Location

4. Regional Geology and Soil Landscapes

4.1 Geology

The Wollongong – Port Hacking 1:100 000 Geological Series Sheet (Ref 1) indicates that the site is underlain by Bringelly Shale (mapping unit Rwb) of the Wianamatta Group of Triassic age. This formation typically comprises shale, carbonaceous claystone, laminite and some minor coaly bands which weather to form clays of high plasticity. The results of the investigation were consistent with the geological mapping, with siltstone and shale encountered in the pits that intersected rock.

4.2 Soil Landscapes

The Soil Landscapes of the Wollongong – Port Hacking 1:100 000 Sheet (Ref 2) indicates that the Blacktown soil landscape (soil mapping unit bt) is mapped over most of the central and western sections of the site and is characterised by topography of *"gently undulating rises on Wianamatta Group Shales, with local relief to 30 m and slopes usually less than 5%"*. This is a residual landscape which the mapping indicates comprises up to four soil horizons that range from shallow red-brown hard-setting sandy clay soils on crests and upper slopes to deep brown to yellow sand and clay soils overlying grey plastic mottled clay on mid to lower slopes. These soils are typically of low fertility, are moderately reactive and have a generally low wet-bearing strength.

An area of the Luddenham soil landscape (soil mapping unit lu) is mapped in the north-east corner of the site and southern-most extent of the site. The Luddenham soil landscape is an erosional landscape which is also developed on the Wianamatta Group rocks. It is characterised by topography of rolling to steep low hills (slope gradients of 5% to 20%; dominantly 10% to 15%) with local relief of 50 m to 80 m.

5. Hydrogeology and Salinity Potential

5.1 Hydrogeology

McNally (Ref 3) describes the general hydrogeological framework relevant to Western Sydney, including this site, where the shale terrain is known for saline groundwater (due to connate salt in shales of marine origin or to windblown sea salt) and the salt accumulates by evapo-transpiration (mostly in the B-horizon of residual soils). In areas of urban development, this can lead to damage to building foundations, lower course brickwork, road surfaces and underground services, where these impact on the saline zone or where the salts are mobilised by changing groundwater levels. Seasonal water level changes of 1 – 2 m can occur in shale aquifers due to natural causes, however urban development should attempt to maintain the natural water balance (between surface infiltration, runoff, lateral throughflow in the regolith, and evapo-transpiration) so that long term rises do not occur in the saline groundwater level.

5.2 Salinity Potential

The Department of Infrastructure, Planning and Natural Resources (DIPNR, now DNR), on their map entitled "Salinity Potential in Western Sydney 2002" (Ref 4), infers "moderate salinity potential" in the study area, which lies on the western flank of a drainage divide, draining westward towards the tributaries of South Creek. Moderate salinity potential implies that "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". These DIPNR inferences are based on soil types, surface levels and general groundwater considerations but are not in general ground-truthed, hence it is not generally known if actual soil salinities are consistent with the mapped salinity potentials.

6. Investigation Methods

6.1 Electromagnetic (EM) Profiling

EM profiling was undertaken as part of the examination of soil salinity potential, enabling rapid continuous measurement of apparent conductivity, to enable targeting of locations for soil sampling and reduce the requirements for laboratory testing of soils.

Apparent conductivity is variously referred to as ground conductivity, terrain conductivity, bulk conductivity or bulk electrical conductivity and is generally designated as σ_a or ECa. Although measurement of apparent conductivities can include contributions from a variety of sources including groundwater, conductive soil and rock minerals and metals, it has been estimated (Baden Williams in Spies and Woodgate, 2004, Ref 5) that in 75 - 90% of cases in Australia, apparent conductivity anomalies can be explained by the presence of soluble salts. Apparent conductivity can therefore be considered, in the majority of cases, a good indicator of soil salinity.

Most portable instruments measure apparent conductivity in milliSiemens per metre (mS/m) and typical measurement ranges (Table 1) have been suggested as indicative of salinity classes (Chhabra 1996, Ref 6).

Table 1: Salinity Classes in Relation to Apparent Conductivity

Class	ECa (mS/m)
Non Saline	<50
Slightly Saline	50 – 100
Moderately Saline	100 – 150
Very Saline	150 – 200
Extremely Saline	>200

The survey was undertaken using a GSSI EMP400 Profiler mounted on booms behind an all-terrain vehicle (ATV). The Profiler (pictured on the following page, on booms behind a 4WD) recorded data using the broadside, horizontal co-planar coil configuration, for a theoretical depth of investigation (response to ground conductors) of up to approximately 6 m below the coils, however this is dependent on actual soil conductivities and most of the conductivity response is expected to be in the depth range 0 – 3 m below the coils. Some depth discrimination (within the above range) is provided by concurrent measurements at three selected instrument frequencies. Prior to the investigation, the Profiler was field calibrated at 15 kHz to best approximate local conductivities and results presented herein were measured at that frequency.

A Hemisphere S320 High Precision Differential Global Positioning System (HPDGPS) was employed to record grid co-ordinates at 1 second intervals as the survey proceeded and both positional data and ECa data were acquired at 1 second intervals to the Profiler's digital data logger.

Data were obtained along approximately 19 line-km of traverse (6000 data points) on a grid of primary survey lines approximately 50 m apart), with an average data point spacing of less than 2 m. Line locations are shown on Drawing 1.

Figure 2: Profiler on booms behind a 4WD (not this project) and DGPS antenna in tray of 4WD.

6.2 Horizontal and Vertical Control

All field measurements and mapping for this project have been carried out using the Geodetic Datum of Australia 1994 (GDA94), the Map Grid of Australia 1994 (MGA94), Zone 56 and AHD. Digital mapping has been carried out in a Geographic Information System (GIS) environment using MapInfo software.

6.3 Test Pit Excavation

Subsequent to EM profiling, field work included the excavation of ten test pits (Pits 1 to 10), to depths of 2.0 m to 3.0 m using a JCB 3CX backhoe fitted with a 450 mm bucket. The pits were logged on site by a geotechnical engineer, who collected representative disturbed samples to assist in strata identification and for laboratory testing of salinity and related parameters. After carefully backfilling each test pit, the surface was reinstated to its previous level.

The test pit locations were nominated by DP on the basis of initial EM profiling analysis and were located on site by DP. The proposed locations are shown on Drawings 3 and 4 and the actual locations are shown on Drawings 5 to 8. The surface levels and co-ordinates (refer test pit logs, Appendix B) were recorded by DGPS.

All test pits were excavated in stages in order to sample soils at 0.5 m intervals to depths up to 3 m, for laboratory testing and correlation with EM profiling data.

7. Field Work Results

7.1 EM Profiling

On completion of EM profiling, navigation data were corrected for the layback of the Profiler behind the DGPS antenna and all apparent conductivity and ancillary measurements were added to the GIS database for interpolation and gridding throughout the area surveyed. Drawings 2 to 4 present the surface levels, apparent conductivities and in-phase response as colour images with continuous colour spectral scales in mAHD, mS/m and millivolts, respectively.

Areas of most interest are those at the red end of the spectrum on Drawing 3, representing the highest apparent conductivities and potentially the highest salinities. Apparent conductivities ranged from approximately 25 mS/m to 160 mS/m, potentially indicating soils in the non-saline to very saline range based on Chhabra's typical measurement ranges (refer Table 1, page 4). The value of EM profiling, with high along-line sampling density and appropriate line spacings, is the ability to identify local variations in the salinity distribution which are not visible in the broader-scale salinity potential map. Based on the mapped distribution of apparent conductivities, test pit locations were selected to enable soil sampling, primarily of the high conductivity areas but also of some low conductivity and moderate conductivity areas as controls and to populate the data set for correlation of field and laboratory results.

The in-phase measurements (Drawing 4) are generally insensitive to soil conductivity but respond to subsurface metallic conductors and were mapped to assess the degree of interference with the apparent conductivity data, resulting from the gas line underlying the area.

7.2 Test Pit Excavation

The test pit logs are included in Appendix B and should be read in conjunction with the accompanying standard notes defining classification methods and descriptive terms. The test pit locations are shown on Drawings 5 to 8.

The succession of strata is broadly summarised as follows:

TOPSOIL – silty clay topsoil to depths ranging from 0.1 – 0.3 m in all pits except Pit 3;

CLAY – silty clays and/or sandy clays to depths ranging from 1.4 m to in excess of 3.0 m in all pits, and to test pit termination (at depths of 3.0 m) in Pits 2, 4, 5, 6, 8, and 9;

BEDROCK – very low to low strength siltstone or sandstone intersected at depths ranging from 1.4 – 2.6 m in Pits 1, 3, 7 and 10, continuing to termination depths of 2.0 – 3.0 m in Pits 1 and 10. Bucket refusal was reached in Pit 10 in sandstone of medium strength.

No free groundwater was observed in the test pits for the period they were exposed. It is noted that the test pits were immediately backfilled on completion which precluded long term monitoring of groundwater levels. Groundwater levels are affected by preceding climatic conditions and soil permeability and can therefore vary with time.

8. Laboratory Test Results

Soil samples from the test pits were tested in a NATA-accredited laboratory for parameters related to salinity:

- Electrical Conductivity (EC1:5) of a 1:5 soil:water extract (all samples);
- pH (all samples);
- chloride and sulphate concentrations (selected samples);
- exchangeable sodium content, cation exchange capacity (CEC) and exchangeable sodium potential (ESP or sodicity) (selected samples); and
- Dispersion (Emerson Crumb test) (selected samples).

Detailed test report sheets are included in Appendix C and a Summary Table is presented in Appendix D.

A textural classification, by the method of the former Department of Land and Water Conservation (DLWC, Ref 7), was undertaken on each sample tested for EC1:5, to allow determination of the appropriate Textural Factor (M) for conversion of EC1:5 to soil salinity ECe (electrical conductivity of a saturated extract). These factors are included in the Summary Table, along with the soil texture groups indicated by the factors, ranging from heavy clays (M=6) to loams (M=10).

9. Salinity Assessment from Laboratory Results

The DLWC guideline for salinity investigations (Ref 7) applies the method of Richards (1954, Ref 8) and Hazelton and Murphy (1992, Ref 9) in the classification of soil salinity on the basis of ECe. The implications of the resulting salinity classes on agriculture are described in Table 2.

Table 2: Soil Salinity Classification

Class	ECe (dS/m)	Implication
Non-Saline	<2	Salinity effects mostly negligible
Slightly Saline	2 – 4	Yields of sensitive crops affected
Moderately Saline	4 – 8	Yields of many crops affected
Very Saline	8 – 16	Only tolerant crops yield satisfactorily
Highly Saline	>16	Only a few very tolerant crops yield satisfactorily

Salinity measurements on 58 samples from 10 test pit locations, many in the areas of elevated apparent conductivity determined by EM profiling, are distributed throughout the salinity classes as shown in detail in the Summary Table (Appendix D) and statistically in Table 3. A relatively even distribution of non-saline, slightly saline and moderately saline soil is inferred.

Table 3: Distribution of Individual Test Pit Sample Salinities

Class	ECe (dS/m)	% of Measurements
Non-Saline	<2	33
Slightly Saline	2 – 4	38
Moderately Saline	4 – 8	29
Very Saline	8 – 16	0
Highly Saline	>16	0

Soil sampling at 0.5 m depth intervals enabled the construction of vertical soil salinity profiles (Figure 3, following page).

These vertical profiles are generally of “normal” or “intermittent” types indicating normal water balance between infiltration and discharge (increasing salinity with depth) or some fluctuation in water levels, with residual salinity maxima in the 1 m to 2.5 m depth zone.

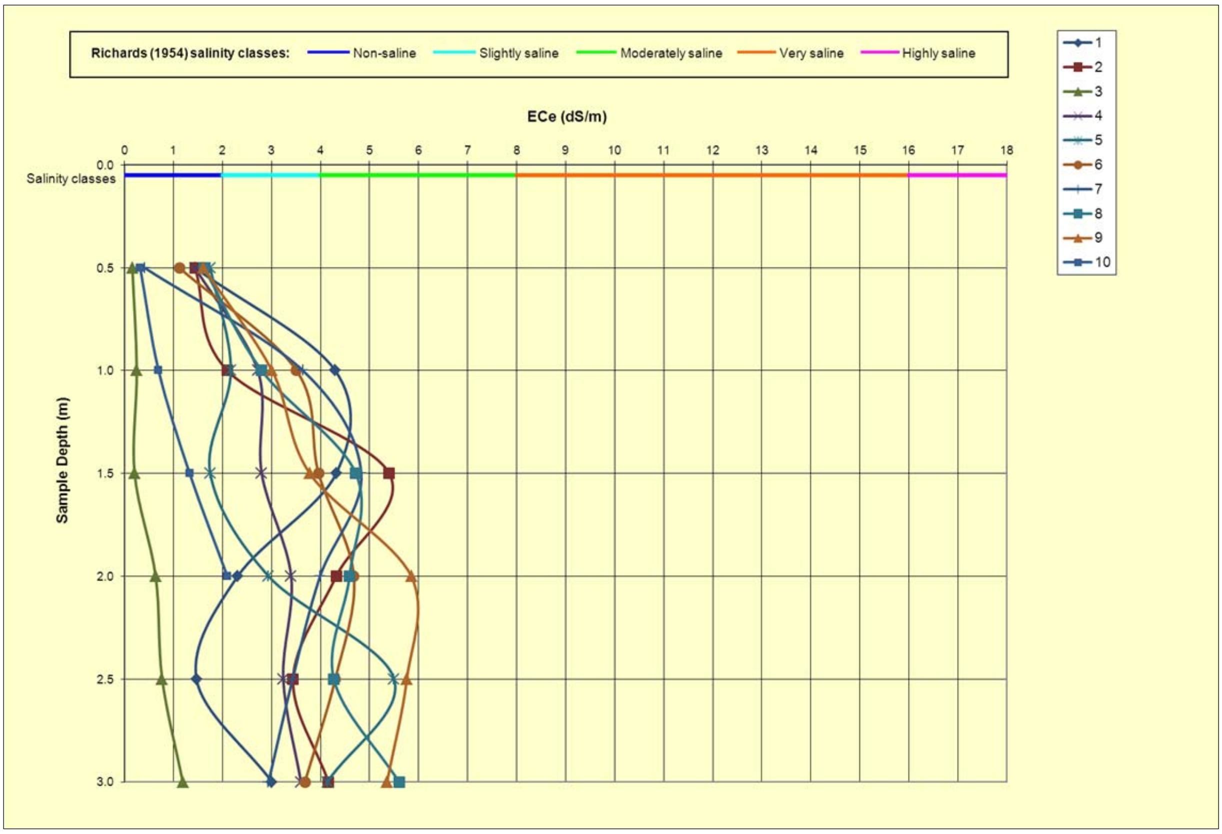


Figure 3: Vertical Soil Salinity Profiles

Individual sample salinities are subject to lateral and vertical variability of soils and finite precision in determination of the textural classes used as EC1:5 multipliers. This may lead to unrealistic salinity classifications of parts of the investigation area based on a limited number of test locations and single (e.g. maximum) salinity results in those locations, particularly if the derived ECe value lies close to a class boundary. Classification of areas based on calculated "bulk" salinities is considered more appropriate, particularly when salinities are correlated with apparent or "bulk" conductivities, measured over a volume of the subsurface below the EM profiler "footprint". Bulk salinities are not derived by physically bulking or mixing together soil samples for single laboratory measurements but are "thickness-weighted averages" calculated from individual sample salinities ECe and the vertical extents (dZ) of those salinities (taken as midway between sample depths or at the upper or lower bounds of the bulking interval), using the formula:

Bulk ECe (over depth interval Z) = $\Sigma(ECe_i * dZ_i) / Z$, where $Z = \Sigma(dZ_i)$.

This salinity assessment has been carried out prior to cut/fill design, hence analysis of salinity in specific depth zones below the present surface is not justified. Such analysis would be recommended at a later stage in the development, when a cut/fill plan is available or after bulk excavation, at which stage sampling at additional locations is also likely to be required. For the determination of salinity constraints and production of a preliminary salinity management plan at this stage of the development however, bulk salinities for the full sampled depth range (0 – 3 m) have been used. The Summary Table (Appendix D) lists all individual sample salinities and all calculated bulk salinities.

The bulk salinities at test pit locations imply that the soils are slightly saline throughout most of the site, to depths of 3 m, but are non-saline at two locations (Pit 3 and Pit 10). Lower salinities are inferred from the bulk values than from the individual sample salinities (refer Table 3, page 8), due to the combined thicknesses of intervals around slightly saline samples and the relatively low levels of moderate salinity found in the individual samples (4.1 – 5.9 dS/m of the full 4 – 8 dS/m range of the moderate class).

10. Salinity Assessment Incorporating EM Results

The DLWC salinity investigation guideline allows for a reduction in the density of test locations and the number of laboratory tests, when an EM investigation is carried out and the ECa results are correlated with the laboratory ECe results, enabling interpolation of data throughout the EM survey area at the high spatial density of that data.

To carry out the required correlations, the 2-dimensional ECa grid surface of Drawing 3 was evaluated at the exact test pit locations and the ECa values were plotted in a scattergram (Figure 4, below) against bulk ECe values. A reasonable linear trend between these parameters (correlation coefficient of 0.92) indicates that the EM system is responding to soil salinity and that the EM data obtained provides a reasonable measure of the site salinity.

The line of best fit defines the ECe/ECa trend and provides an equation by which to convert apparent conductivities ECa (in mS/m), to estimate apparent salinities ECe (in dS/m) throughout the data set.

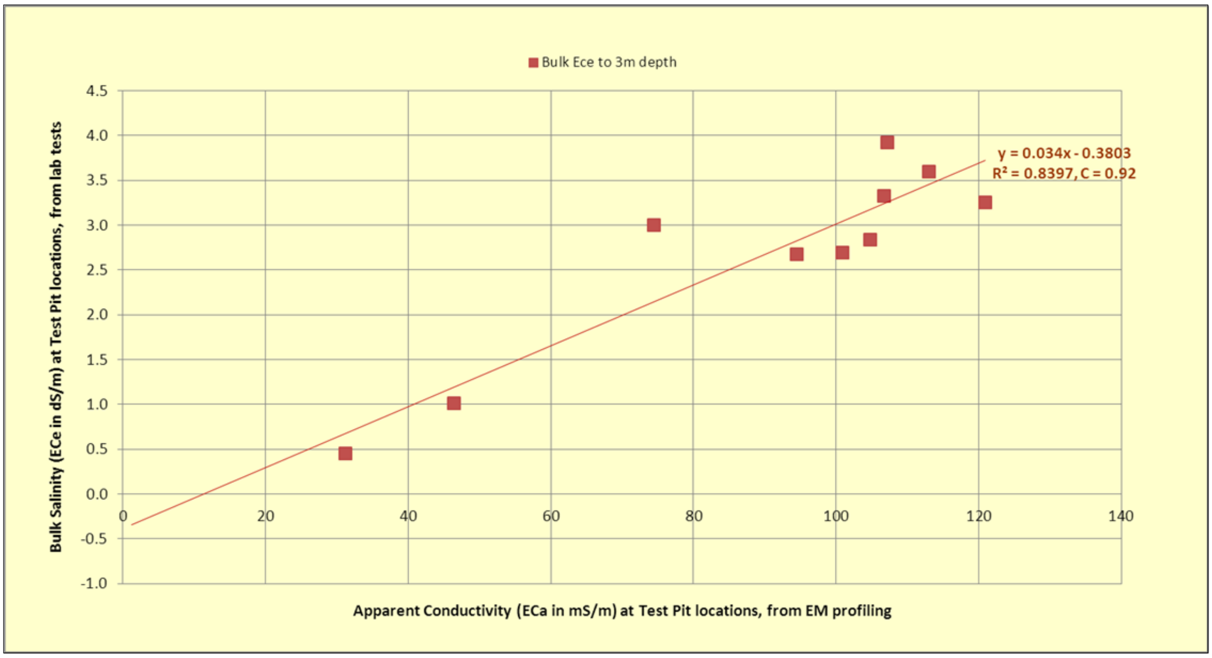


Figure 4 – Correlation of Bulk ECe and ECa data

The correlation equation (ECe = 0.034 x ECa - 0.3803) was applied to all apparent conductivity grid data for presentation as an apparent salinity image (Drawing 5) with continuous colour spectral scales in dS/m. The 2-D surface was also contoured at the 2 dS/m and 4 dS/m levels, corresponding to boundaries of the salinity classes of Richards, providing a direct subdivision of the study area into non-saline (<2 dS/m), slightly saline (2 – 4 dS/m) and moderately saline (4 – 8 dS/m) classes.

Apparent salinities shown in Drawing 5 indicate non-saline to slightly saline conditions throughout most of the investigated site area, with a minor area of moderately saline soil inferred adjacent to Pit 2 in the north-western corner of the site. No very saline or highly saline areas were inferred from the data.

11. Assessment of Soil Aggressivity to Concrete and Steel

Figure 5 presents the variations of pH with depth at the control test pits, together with the corresponding concrete and steel aggressivity ranges indicated in Australian Standard AS 2159-2009 (Piling – Design and Installation, Ref 10) for soils in Condition B (generally impermeable clay soils or all soils above groundwater). As indicated by the soil texture groups of the Summary Table (Appendix D), most samples were clay soils and no groundwater was encountered in the test pits, supporting the applicability of Soil Condition B for the aggressivity classifications.

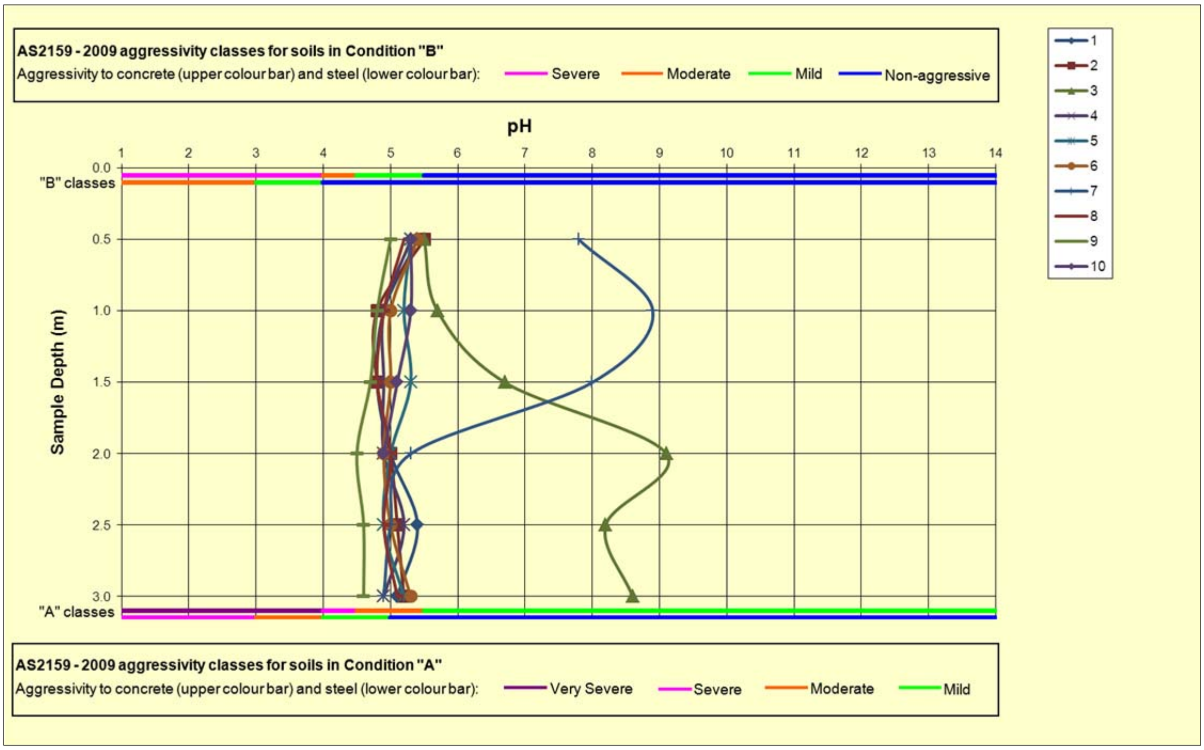


Figure 5: Vertical Soil pH Profiles

It should be noted that AS 2159-2009 was formulated to improve the longevity of deep piles where access (for inspection and remediation of salt damage) was expected to be minimal. This standard was not formulated for the protection of concrete and steel in slabs and shallow foundations or infrastructure and recommendations for concrete strength, based on AS 2159-2009 aggressivity classifications, represents a conservative approach to protection of these structures.

With the exception of Pits 3 and 7, pH values varied little with depth, indicating mild aggressivity to concrete (84% of measurements) and non-aggressivity to concrete (14% of measurements), with only one sample moderately (and only marginally) aggressive to concrete. The measured sulphate concentrations (Summary Table, Appendix D), when compared with the guidelines of AS 2159-2009, indicate that all the tested soils are non-aggressive to concrete.

The pH profiles (Figure 5, previous page) indicate that all tested soils are non-aggressive to steel. The measured chloride concentrations (Summary Table, Appendix D), when compared with the guidelines of AS 2159-2009, support the non-aggressive classification with respect to steel. However, resistivities derived from inversion of measured conductivities (EC1:5), imply mild aggressivity to steel at Pits 2 and 5 to 9, in the depth range 1 – 3 m.

12. Assessment of Soil Sodicity

The Summary Table (Appendix D) indicates that 70% of soils tested (at depths of 0.5 m) were sodic, defined (after DLWC, Ref 7) as having Exchangeable Sodium Potential between 5% and 15%. Two samples (from Pits 3 and 7) were non-sodic and one sample (from Pit 5) was highly sodic. These results indicate some potential for erodability of soils left exposed.

Dispersion potential, tested at depths of 0.5 m below ground level (bgl) by the Emerson Crumb Test (refer Summary Table, Appendix D), was determined to be Classes 5 and 6 (no dispersion).

13. Constraints to Development

13.1 Salinity Constraints

Two primary data sources were employed for assessment of soil salinity:

- ECe estimates derived from 58 laboratory tests of soil samples from 10 test pits; and
- ECa (apparent conductivity) data obtained at 6000 measurement points.

These sources of data were correlated and combined in a joint interpretation, providing a practical means of interpolating and assessing salinity in some detail throughout the whole site and defining areas where there is a risk that urban development will be affected by soil salinity, or will adversely affect the salinity of the environment.

The apparent salinity contours of Drawing 5 define the salinity constraint areas for the bulk excavation stage of this proposed development, which comprise:

- A minor area in the north-western corner of the site adjacent to Pit 2 (defined by very limited data, west of the 4 dS/m apparent salinity contour), where soils to depths of 3 m are inferred to be moderately saline; and
- A number of areas throughout the site, lying outside the closed or partially closed 2 dS/m contours (between 2 dS/m and 4 dS/m), where soils to depths of 3 m are inferred to be slightly saline.

Slightly saline conditions were found within the investigated depth zone, flagging the potential for salt-induced damage to susceptible services, slabs and shallow footings and demonstrating the need for appropriate salinity management. However, few salinity management measures are required unless soils are moderately saline or more saline, therefore the salinity-based constraints to development at this site are minimal.

As the slightly saline constraint areas are spread widely throughout the site and as the appropriate salinity management measures are not onerous, it is considered that during bulk earthworks, the soils mapped as non-saline to slightly saline (Drawing 5) should be treated as slightly saline.

13.2 Aggressivity Constraints

In the absence of cut/fill plans and without the benefit of a correlation/interpolation method equivalent to that for salinity mapping, aggressivity-related constraint maps in this report show individual locations of test pits annotated with minimum pH values (Drawing 6) and minimum resistivities (Drawing 7), the "worst case" parameters for estimation of aggressivities to concrete and steel, respectively. As indicated in Section 11 (above), soils were assessed as predominantly mildly aggressive to both concrete and steel, by the pH and resistivity criteria of AS 2159-2009, respectively.

Drawing 6 demonstrates the widespread mild aggressivity of the site soils to concrete, with moderate aggressivity indicated by a pH level at the mild/moderate class boundary value of 4.5, at one location (Pit 9 near the southern boundary).

Drawing 7 demonstrates mild aggressivity to steel over a substantial proportion of the site, with resistivities at two locations (Pits 1 and 4 in the northern quarter) only 1 – 2% above the 2000 Ohm-cm value which marks the mild aggressivity class boundary. Resistivities at two locations (Pits 3 and 10) fall clearly in the non-aggressive class.

Given these distributions and levels of the aggressivity indicators, it is considered that soils should be treated as mildly aggressive to concrete and steel throughout the site and that the site should be subject to appropriate management strategies during bulk earthworks. Concrete classifications under AS 2159-2009 allow for a 40 – 60 year lifetime, provided a minimum concrete strength of 25 MPa is applied in non-aggressive conditions, 32 MPa in mildly aggressive conditions and 40 MPa in moderately aggressive conditions. Where concrete of lower than recommended strength is employed then a shorter lifetime may be expected, however no estimates are given in the Standard of this reduced lifetime.

In areas where materials are mildly aggressive to steel, corrosion allowance should be taken into account by the designer as discussed in the Salinity Management Plan (Section 14).

13.3 Sodicity Constraints

Drawing 8 shows a widespread distribution of sodic soils, with one location (Pit 5) marginally highly sodic and one location (Pit 3) clearly non-sodic. It is considered that there is potential for sodic soils (either in-situ, transported or imported as filling) to occur at the proposed ground surface. Sodic soils have low permeability due to infilling of interstices with fine clay particles during the weathering process, restricting infiltration of surface water and potentially creating perched water tables, seepage in cut faces or ponding of water in flat open areas. In addition, sodic soils tend to erode when exposed. It is inferred that development will be constrained everywhere by sodic soils, requiring appropriate management methods to prevent the adverse effects above. As detailed in Section 14 below, management of sodic soils, following completion of bulk earthworks, is focussed on prevention of exposure.

14. Salinity Management Plan

The current salinity investigation indicates that materials within the site are in general slightly saline and are moderately saline in a limited area. Testing of other parameters associated with salinity indicates that the materials are in general mildly aggressive to concrete (by the pH criterion of AS 2159-2009) and mildly aggressive to steel (by the resistivity criterion of AS 2159-2009). In addition, shallow soils were sodic.

The following management strategies are recommended for the management of those factors with a potential to impact on the development.

A. Management should focus on capping of the upper surface of the sodic soils, both exposed by excavation and placed as filling, with a more permeable material to prevent ponding, to reduce capillary rise, to act as a drainage layer and to reduce the potential for erosion.

B. When possible, place excavated materials in fill areas with similar salinity characteristics (ie: place material onto in situ soils with a similar or higher aggressivity or salinity classification). With respect to imported fill material, testing should be undertaken prior to importation, to determine the salinity characteristics of the material, which should be non-aggressive and non-saline to slightly saline where possible but in any case not more aggressive or more saline than the material on which it is to be placed.

C. Sodic soils can also be managed by maintaining vegetation where possible and planting new salt tolerant species. The addition of organic matter, gypsum and lime can also be considered where appropriate. After gypsum addition, reduction of sodicity levels may require some time for sufficient infiltration and leaching of sodium into the subsoils, however capping of exposed sodic material should remain the primary management method. Topsoil added at the completion of bulk earthworks is, in effect, also adding organic matter which may help infiltration and leaching of sodium.

D. Avoid water collecting in low lying areas, in depressions, or behind fill. This can lead to water logging of the soils, evaporative concentration of salts, and eventual breakdown in soil structure resulting in accelerated erosion.

E. Any pavements should be designed to be well drained of surface water. There should not be excessive concentrations of runoff or ponding that would lead to waterlogging of the pavement or additional recharge to the groundwater through any more permeable zones in the underlying filling material.

F. Surface drains should generally be provided along the top of batter slopes to reduce the potential for concentrated flows of water down slopes possibly causing scour.

G. Salt tolerant grasses and trees should be considered for landscaping, to reduce soil erosion as in Strategy A above and to maintain the existing evapo-transpiration and groundwater levels. Reference should be made to an experienced landscape planner or agronomist.

The following additional strategies are recommended for completion of service installation and for house construction. These strategies should be complementary to standard good building practices recommended within the Building Code of Australia, including cover to reinforcement within concrete and correct installation of a brick damp course, so that it cannot be bridged to allow moisture to move into brick work and up the wall.

H. Where materials are classified as mildly aggressive to concrete piles (whole site - refer Section 13.2 and Drawing 6), piles should have a minimum strength of 32 MPa and a minimum cover to reinforcement of 60 mm (as per AS 2159-2009) to limit the corrosive effects of the surrounding materials (in accordance with AS 2159-2009).

I. With regard to concrete structures, for non-saline and slightly saline soils (with salinities less than 4 dS/m) (refer Section 13.1 and Drawing 5):

- o Where soils are classified as mildly aggressive to concrete (AS 3600 – A2, Ref 11) (whole site – refer Section 13.2 and Drawing 6), slabs and foundations should have a minimum strength of 25 MPa, and should be allowed to cure for a minimum of three days (as per AS 3600) to limit the corrosive effects of the surrounding soils.

J. With regard to concrete structures, for moderately saline soils with salinities of 4 – 8 dS/m (refer Section 13.1 and Drawing 5):

- o Where soils are classified as mildly aggressive to concrete (AS 3600 – A2) (whole site – refer Section 13.2 and Drawing 6), slabs and foundations should have a minimum strength of 25 MPa, a minimum cover to reinforcement of 45 mm from unprotected ground and should be allowed to cure for a minimum of three days (as per AS 3600) to limit the corrosive effects of the surrounding soils.

K. Any future installation of concrete pipes up to a maximum diameter of 750 mm, within the site, should employ fibre-reinforced cement. Alternatively, concrete pipes in these areas should be encased in outer PVC conduits or should have a minimum equivalent strength as defined in Strategies I and J above.

L. Concrete pipes with a larger diameter than 750 mm should utilise sulphate resistant cement.

M. Resistivity results indicate soils that are mildly aggressive to steel (whole site - refer Section 13.2 and Drawing 7). For these soils, the following corrosion allowances (as per AS 2159 – 2009) should be taken into account by the designer:

- o Mild: uniform corrosion allowance 0.01 – 0.02 mm/year; and

In instances where a coating is applied to the pile, if the design life of the pile is greater than the design life for the coating, consideration must be given to corrosion of the pile in accordance with the above allowance.

15. Additional Recommendations

This salinity management plan is based upon initial development concepts provided by Camden Council and revisions to these concepts should be reviewed by DP to assess the applicability of the plan to the revised concepts. Additional investigation should be undertaken when a detailed cut/fill design is available or after bulk earthworks or in development areas which are to be excavated deeper than 3 m or into rock at shallower depth (where direct sampling and testing of salinity has not been carried out). Salinity management strategies herein may need to be modified or extended following additional investigations by deep test pitting and/or drilling, sampling and laboratory testing for salinity-related properties.

16. References

1. Department of Mines 1985, Geology of Wollongong – Port Hacking 1:100 000 Geological Series Sheet No 9029 – 9129.
2. Sherwin. L., and Holmes, G. G., 1986. *Geology of Wollongong and Port Hacking 1:100 000* Sheets 9029 – 9129. New South Wales Geological Survey, Sydney.
3. McNally, G. 2005, *Investigation of Urban Salinity – Case Studies from Western Sydney, Urban Salt 2005 Conference Paper*, Parramatta.
4. Department of Infrastructure, Planning and Natural Resources, New South Wales (DIPNR) 2002, *Salinity Potential in Western Sydney*.
5. Spies, B. and Woodgate, P. 2004, Technical Report Salinity Mapping Methods in the Australian *Context*, Natural Resource Management Ministerial Council.
6. Chhabra, R. 1966, Soil Salinity and Water Quality, A. Bakema/Rotterdam/Brookfield, New York, 284 pp.
7. DNR 2002, *Site Investigations for Urban Salinity* (now managed by DPI).
8. Richards, L. A. (ed.) 1954, *Diagnosis and Improvement of Saline and Alkaline Soils* USDA Handbook No 60, Washington D.C.
9. Hazelton, P. A. and Murphy B. W. 2007, *Interpreting Soil Test Results* Department of Natural Resources.
10. Standards Australia 1995, AS 2159 – 2009 Piling Design and Installation.
11. Standards Australia 2009, AS 3600 – 2009 Concrete Structures.

17. Limitations

Douglas Partners Pty Ltd (DP) has prepared this report for this project at Lot 4, Raby Road, Gledswood Hills, in accordance with DP's proposal dated 11 October 2013. The work was carried out under DP's Conditions of Engagement. This report is provided for the exclusive use of Camden Council for this project only and for the purposes as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of DP, does so entirely at its own risk and without recourse to DP for any loss or damage. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

The results provided in the report are indicative of the sub-surface conditions on the site only at the specific sampling and/or testing locations, and then only to the depths investigated and at the time the work was carried out. Sub-surface conditions can change abruptly due to variable geological processes and also as a result of human influences. Such changes may occur after DP's field testing has been completed.

DP's advice is based upon the conditions encountered during this investigation. The accuracy of the advice provided by DP in this report may be affected by undetected variations in ground conditions across the site between and beyond the sampling and/or testing locations. The advice may also be limited by budget constraints imposed by others or by site accessibility.

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

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

The contents of this report do not constitute formal design components, such as are required by the Health and Safety Legislation and Regulations, to be included in a Safety Report specifying the hazards likely to be encountered during construction and the controls required to mitigate risk. This design process requires risk assessment to be undertaken, with such assessment being dependent upon factors relating to likelihood of occurrence and consequences of damage to property and to life. This, in turn, requires project data and analysis presently beyond the knowledge and project role respectively of DP. DP may be able, however, to assist the client in carrying out a risk assessment of potential hazards contained in the Comments section of this report, as an extension to the current scope of works, if so requested, and provided that suitable additional information is made available to DP. Any such risk assessment would, however, be necessarily restricted to the (geotechnical / environmental / groundwater) components set out in this report and to their application by the project designers to project design, construction, maintenance and demolition.

Douglas Partners Pty Ltd

Appendix A

About this Report
Drawings 1 to 8

Introduction

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

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

Copyright

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

Borehole and Test Pit Logs

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

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

Groundwater

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

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

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

Reports

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

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

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

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

About this Report

Site Anomalies

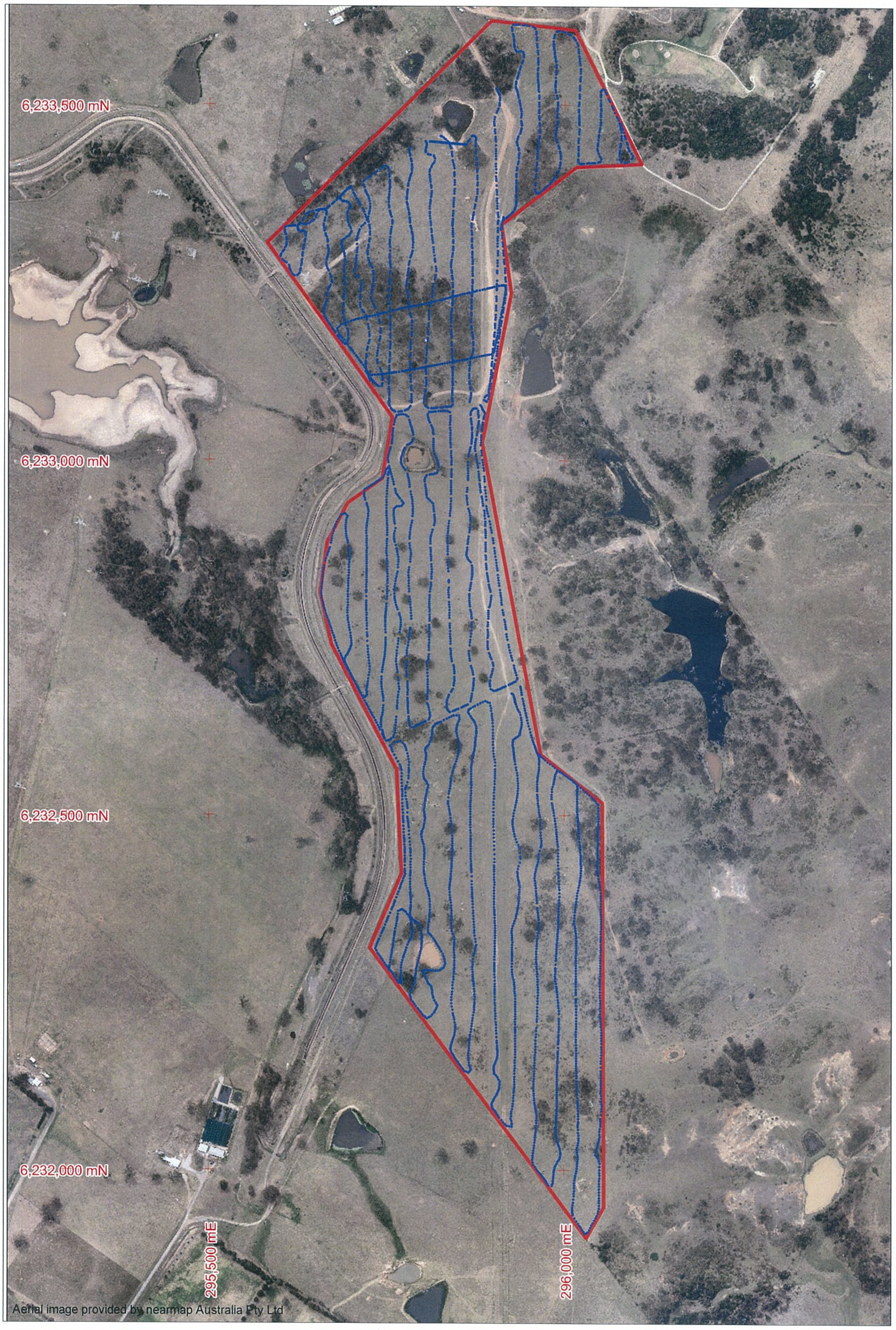
In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later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

Information for Contractual Purposes

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

Site Inspection

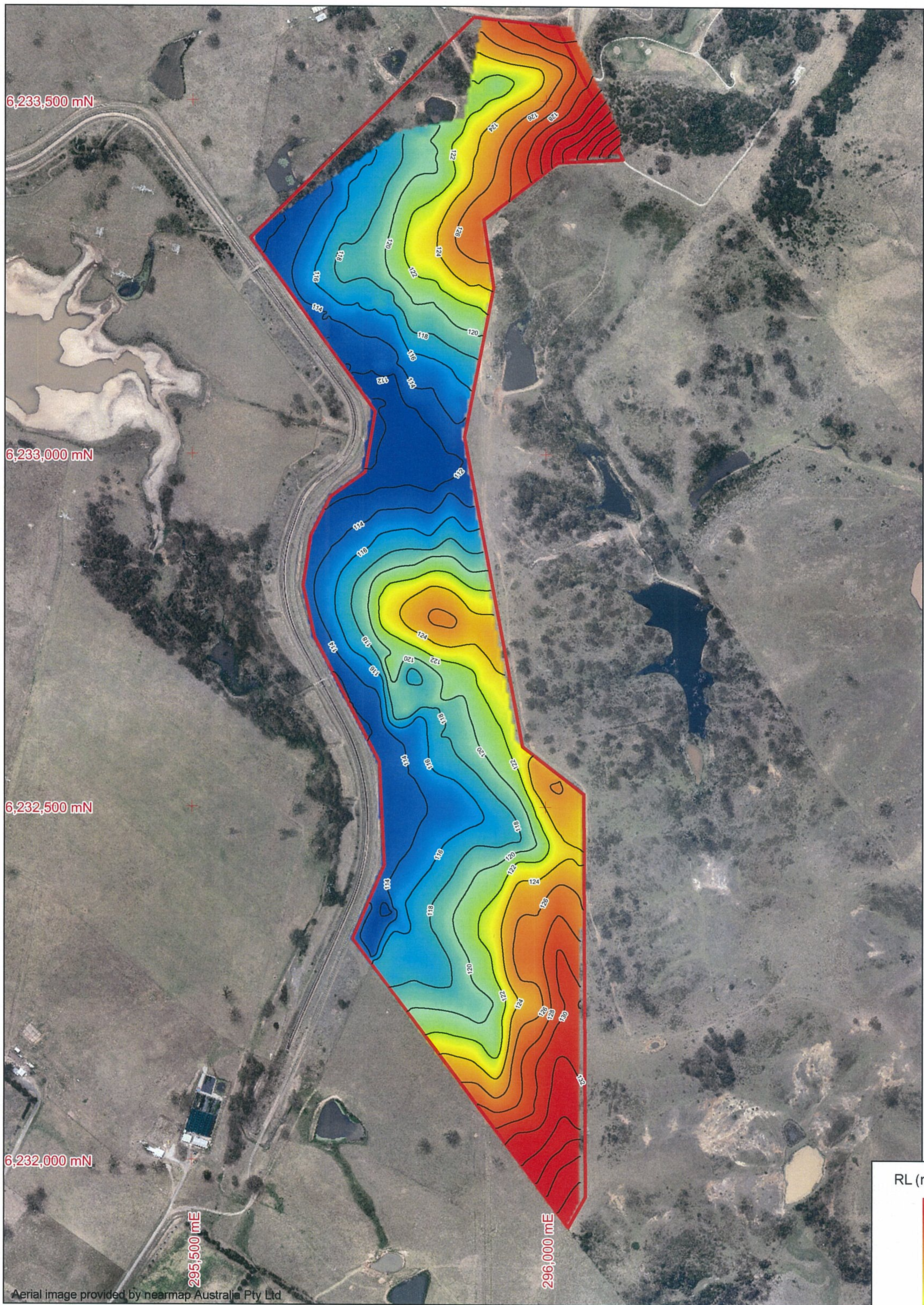
The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.



LEGEND

- Grid: GDA94 / MGA94 (Zone 56)
- Site boundary
- Data points along Electromagnetic (EM) survey lines

Douglas Partners Geotechnics / Environment / Groundwater	TITLE: **Locations of Electromagnetic Survey Lines** Salinity Assessment Proposed Residential Subdivision Lot 4, Raby Road, Gledswood Hills	MGA N	OFFICE: Macarthur DRAWN BY: JL DATE: 7.12.2013
CLIENT: Camden Council	PROJECT No: 76591.00	DRAWING No: 1	REVISION: A
			SCALE: As shown



RL (mAHD)

145
128
126
124
123
122
121
120
118
117
116
115
114
113
112
108

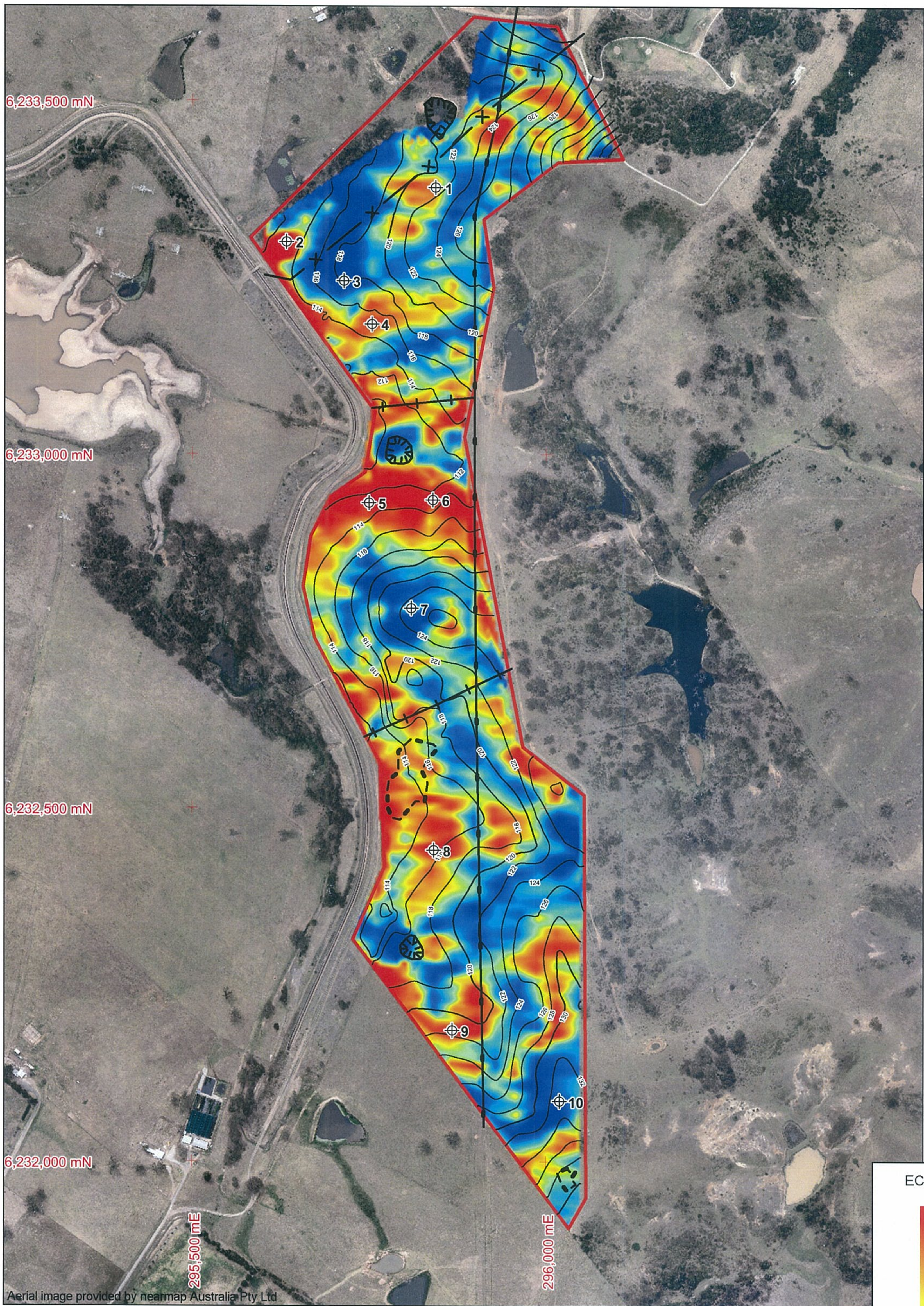
LEGEND

Grid: GDA94 / MGA94 (Zone 56)

Site boundary

Surface level contour (m AHD) estimated from DGPS data (avg std dev 0.5m)

Douglas Partners *Geotechnics / Environment / Groundwater*	TITLE: **Surface Levels** Salinity Assessment Proposed Residential Subdivision Lot 4, Raby Road, Gledswood Hills			MGA N	OFFICE: Macarthur DRAWN BY: JL DATE: 7.12.2013
CLIENT: Camden Council	PROJECT No: 76591.00	DRAWING No: 2	REVISION: A		SCALE: As shown



LEGEND

- Grid: GDA94 / MGA94 (Zone 56)
- Site boundary
- Overhead transmission line corridor
- Underground gas line corridor
- Surface level contour (mAHD)
- Area of visible metallic debris
- Fence
- Dam
- Proposed test pit

Douglas Partners
Geotechnics | Environment | Groundwater

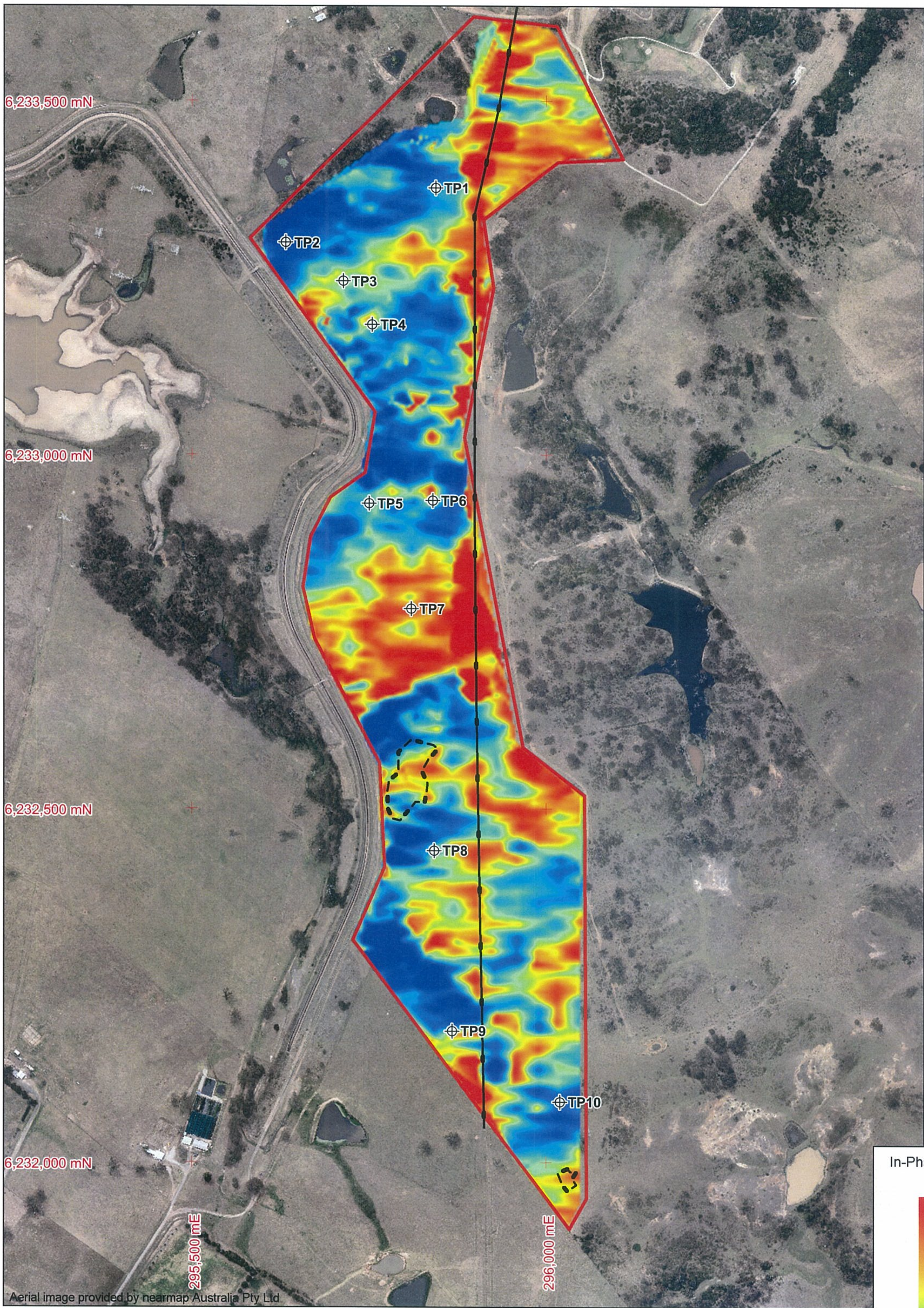
TITLE: **Apparent Conductivity measured at 15 kHz**
Salinity Assessment
Proposed Residential Subdivision
Lot 4, Raby Road, Gledswood Hills

N
MGA

OFFICE:	Macarthur
DRAWN BY:	JL
DATE:	9.01.2014
SCALE:	As shown

CLIENT: Camden Council

PROJECT No: 76591.00 | DRAWING No: 3 | REVISION: A



In-Phase Response (mV)

30,300
22,200
22,100
22,000
21,900
21,800
21,700
21,600
21,400
21,300
21,200
21,000
20,700
17,400

LEGEND

- Grid: GDA94 / MGA94 (Zone 56)
- Site boundary
- Underground gas line corridor
- Area of visible metallic debris
- Proposed test pit

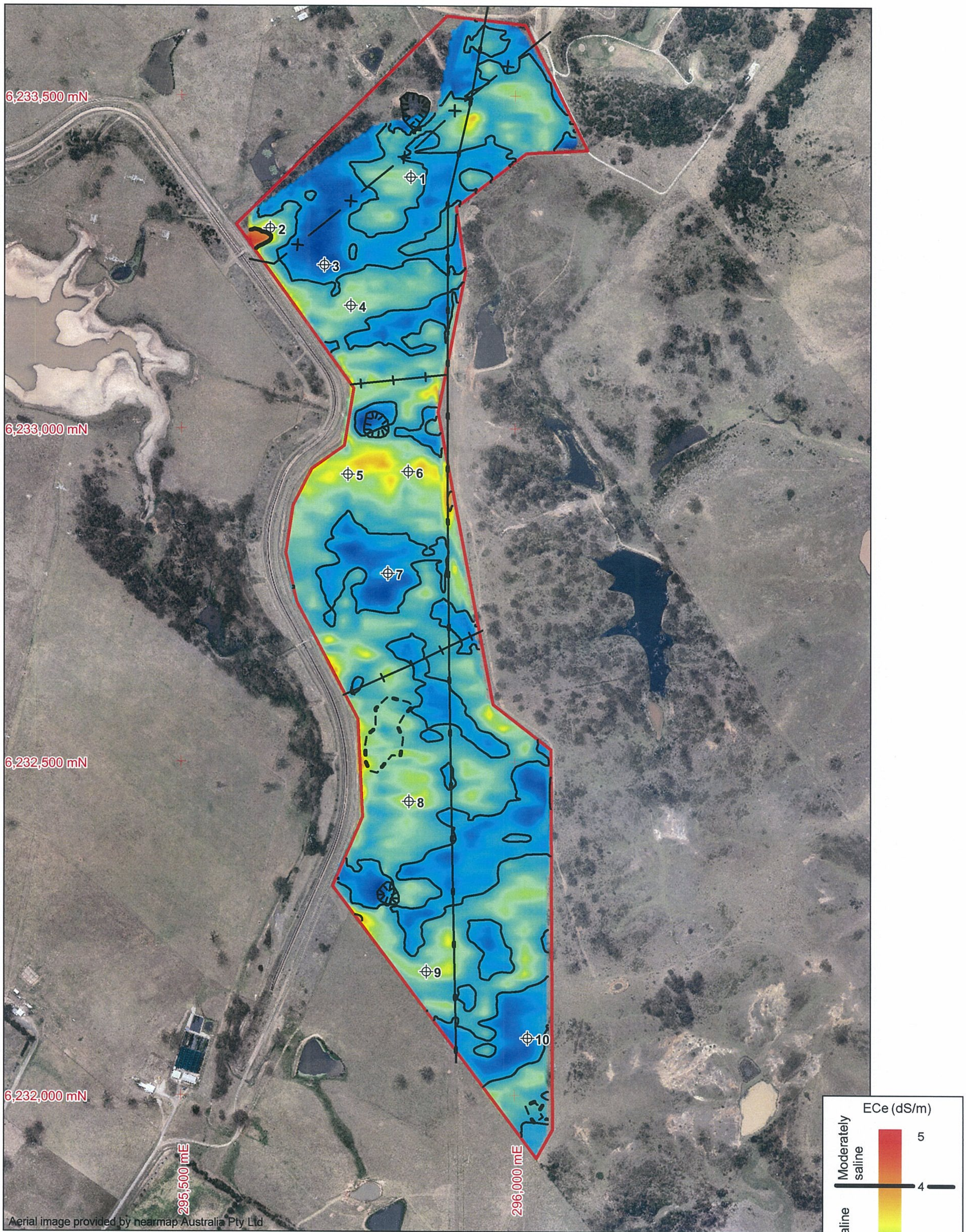
Douglas Partners
Geotechnics / Environment / Groundwater

TITLE: **In-Phase Response measured at 15 kHz**
Salinity Assessment
Proposed Residential Subdivision
Lot 4, Raby Road, Gledswood Hills

N
MGA

OFFICE: Macarthur
DRAWN BY: JL
DATE: 7.12.2013
SCALE: As shown

CLIENT: Camden Council
PROJECT No: 76591.00
DRAWING No: 4
REVISION: A

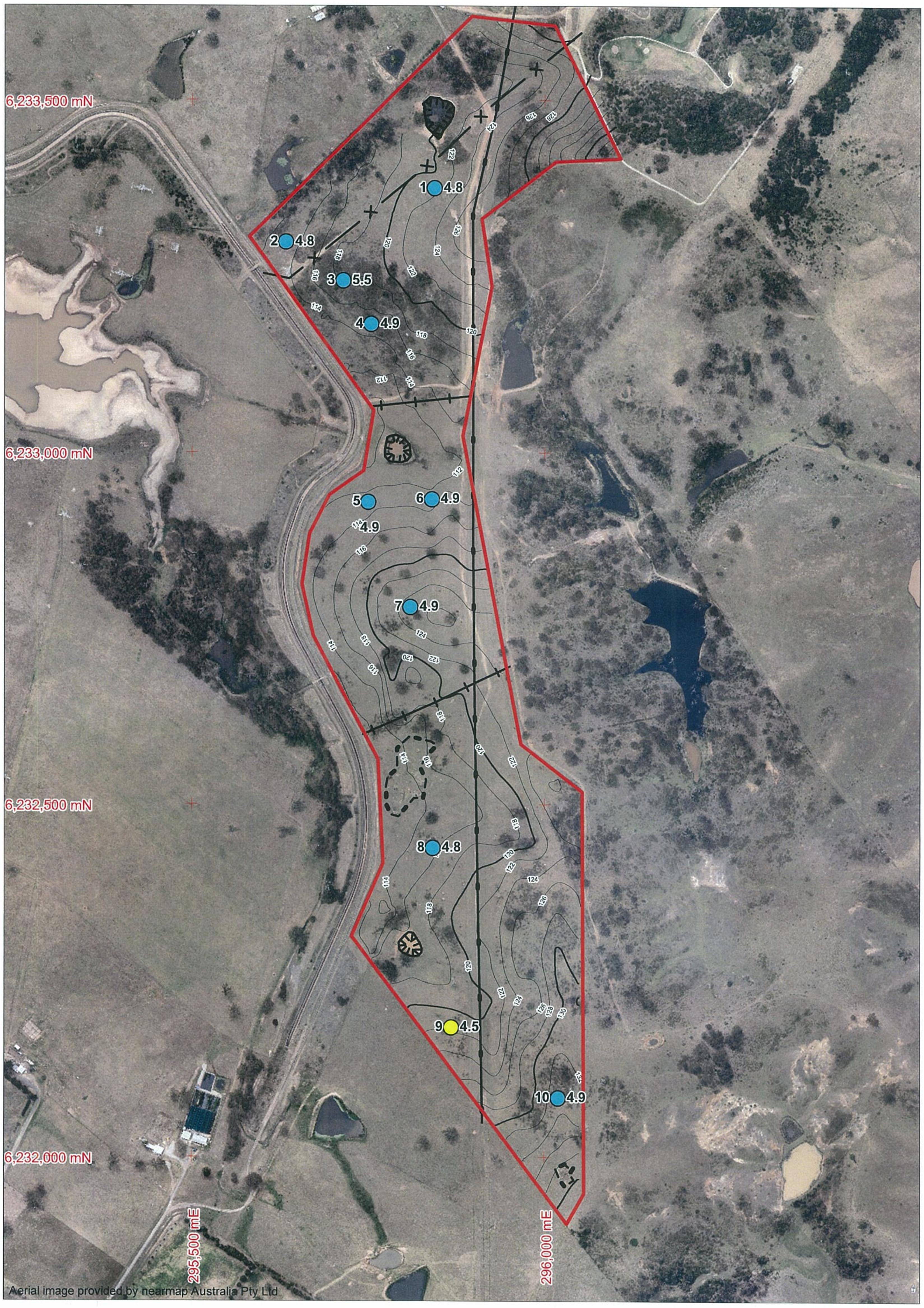


LEGEND

+	Grid: GDA94 / MGA94 (Zone 56)
Red line	Site boundary
—×—	Overhead transmission line corridor
—■—	Underground gas line corridor
Dashed outline	Area of visible metallic debris
—+—+—	Fence
Dam symbol	Dam
⌖	Test Pit sampled for salinity testing

Douglas Partners
Geotechnics | Environment | Groundwater

TITLE: **Apparent Salinity ECe from EM and Bulk ECe Data** Salinity Assessment Proposed Residential Subdivision Lot 4, Raby Road, Gledswood Hills		N MGA	OFFICE: Macarthur DRAWN BY: JL DATE: 10.01.2014
CLIENT: Camden Council	PROJECT No: 76591.00	DRAWING No: 5	REVISION: A	SCALE: As shown



LEGEND

- Grid: GDA94 / MGA94 (Zone 56)
- Site boundary
- Overhead transmission line corridor
- Underground gas line corridor
- Surface level contour (mAHD)
- Area of visible metallic debris
- Fence
- Dam
- Test pit location. Minimum pH indicates material moderately aggressive to concrete.
- Test pit location. Minimum pH indicates material mildly aggressive to concrete.

Douglas Partners
Geotechnics | Environment | Groundwater

TITLE: **Aggressivity to Concrete within Depths of 3m** Salinity Assessment Proposed Residential Subdivision Lot 4, Raby Road, Gledswood Hills		MGA N	OFFICE: Macarthur
			DRAWN BY: JL
			DATE: 10.01.2014
CLIENT: Camden Council	PROJECT No: 76591.00	DRAWING No: 6	REVISION: A
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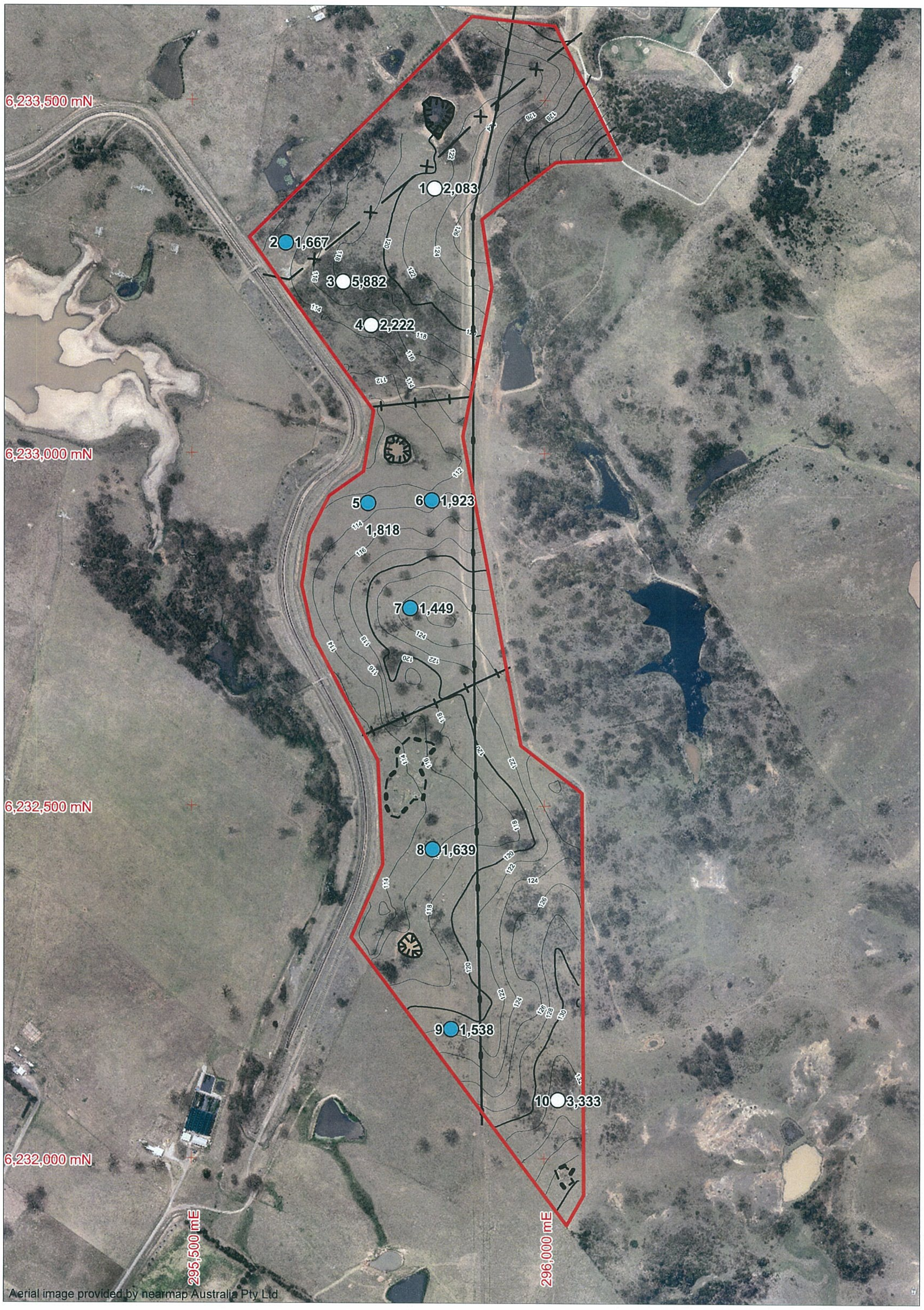


LEGEND

- Grid: GDA94 / MGA94 (Zone 56)
- Site boundary
- Overhead transmission line corridor
- Underground gas line corridor
- Surface level contour (mAHD)
- Area of visible metallic debris
- Fence
- Dam
- Test pit location. Minimum resistivity (Ohm-cm) indicates material mildly aggressive to steel.
- Test pit location. Minimum resistivity (Ohm-cm) indicates material non-aggressive to steel.

Douglas Partners
Geotechnics / Environment / Groundwater

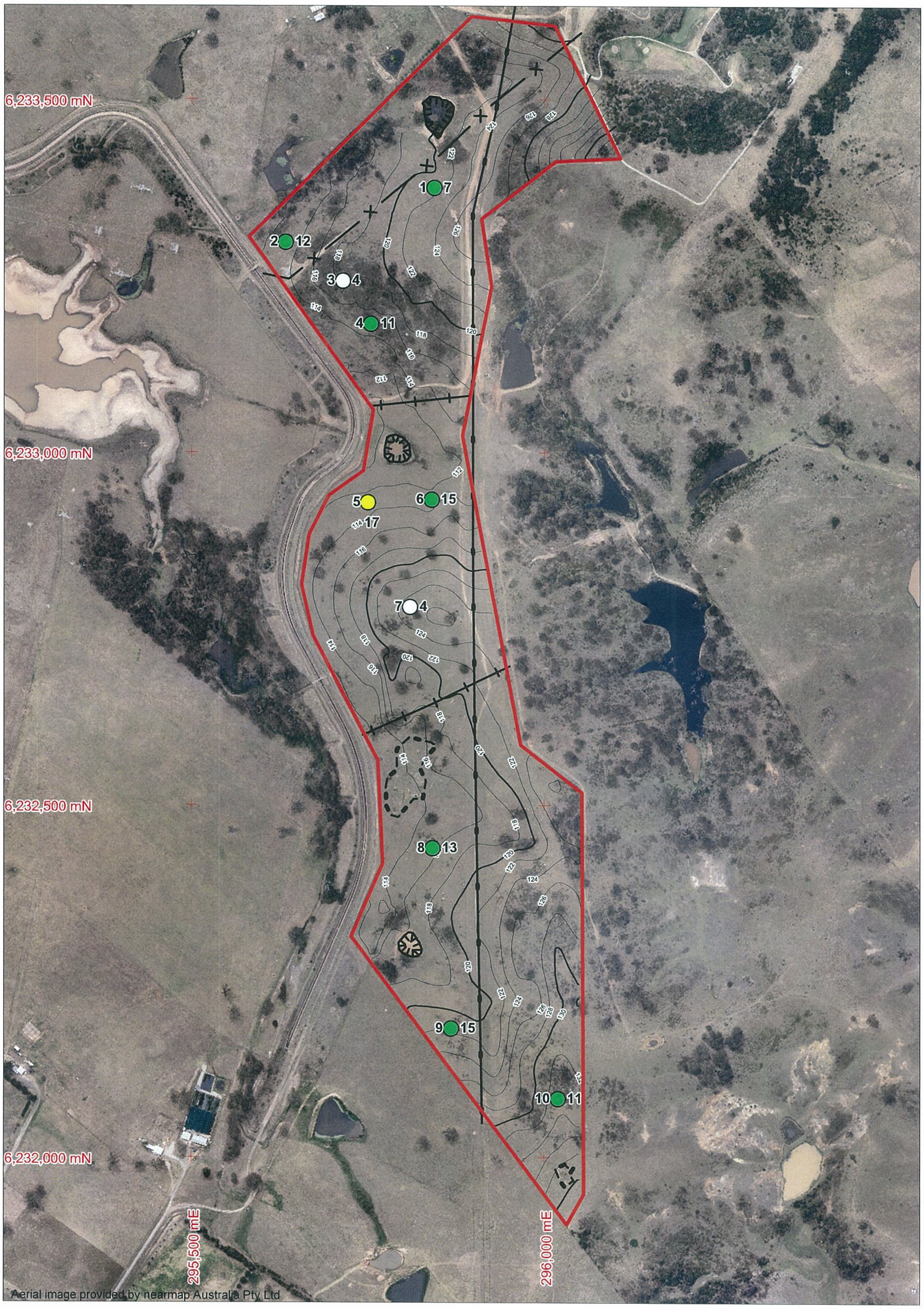
TITLE: **Aggressivity to Steel within Depths of 3m**
Salinity Assessment
Proposed Residential Subdivision
Lot 4, Raby Road, Gledswood Hills

MGA N

OFFICE:	Macarthur
DRAWN BY:	JL
DATE:	10.01.2014
SCALE:	As shown

CLIENT: Camden Council

PROJECT No: 76591.00 | DRAWING No: 7 | REVISION: A



LEGEND

- Grid: GDA94 / MGA94 (Zone 56)
- Site boundary
- Overhead transmission line corridor
- Underground gas line corridor
- Surface level contour (mAHD)
- Area of visible metallic debris
- Fence
- Dam
- Test pit location. Material at 0.5m depth is highly sodic.
- Test pit location. Material at 0.5m depth is sodic.
- Test pit location. material at 0.5m depth is non-sodic.

Douglas Partners
Geotechnics | Environment | Groundwater

TITLE: **Sodicities at Depths of 0.5m** Salinity Assessment Proposed Residential Subdivision Lot 4, Raby Road, Gledswood Hills		MGA N	OFFICE: Macarthur / DRAWN BY: JL / DATE: 10.01.2014
CLIENT: Camden Council	PROJECT No: 76591.00	DRAWING No: 8 / REVISION: A	SCALE: As shown

Appendix B

Notes – Sampling Methods
Notes – Soil Descriptions
Notes – Rock Descriptions
Test Pit Logs (Pits 1 – 10)

Sampling

Sampling is carried out during drilling or test pitting to allow engineering examination (and laboratory testing where required) of the soil or rock.

Disturbed samples taken during drilling provide information on colour, type, inclusions and, depending upon the degree of disturbance, some information on strength and structure.

Undisturbed samples are taken by pushing a thin-walled sample tube into the soil and withdrawing it to obtain a sample of the soil in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Test Pits

Test pits are usually excavated with a backhoe or an excavator, allowing close examination of the in-situ soil if it is safe to enter into the pit. The depth of excavation is limited to about 3 m for a backhoe and up to 6 m for a large excavator. A potential disadvantage of this investigation method is the larger area of disturbance to the site.

Large Diameter Augers

Boreholes can be drilled using a rotating plate or short spiral auger, generally 300 mm or larger in diameter commonly mounted on a standard piling rig. The cuttings are returned to the surface at intervals (generally not more than 0.5 m) and are disturbed but usually unchanged in moisture content. Identification of soil strata is generally much more reliable than with continuous spiral flight augers, and is usually supplemented by occasional undisturbed tube samples.

Continuous Spiral Flight Augers

The borehole is advanced using 90-115 mm diameter continuous spiral flight augers which are withdrawn at intervals to allow sampling or in-situ testing. This is a relatively economical means of drilling in clays and sands above the water table. Samples are returned to the surface, or may be collected after withdrawal of the auger flights, but they are disturbed and may be mixed with soils from the sides of the hole. Information from the drilling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively low reliability, due to the remoulding, possible mixing or softening of samples by groundwater.

Non-core Rotary Drilling

The borehole is advanced using a rotary bit, with water or drilling mud being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from the rate of penetration. Where drilling mud is used this can mask the cuttings and reliable identification is only possible from separate sampling such as SPTs.

Continuous Core Drilling

A continuous core sample can be obtained using a diamond tipped core barrel, usually with a 50 mm internal diameter. Provided full core recovery is achieved (which is not always possible in weak rocks and granular soils), this technique provides a very reliable method of investigation.

Standard Penetration Tests

Standard penetration tests (SPT) are used as a means of estimating the density or strength of soils and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289, Methods of Testing Soils for Engineering Purposes - Test 6.3.1.

The test is carried out in a borehole by driving a 50 mm diameter split sample tube under the impact of a 63 kg hammer with a free fall of 760 mm. It is normal for the tube to be driven in three successive 150 mm increments and the 'N' value is taken as the number of blows for the last 300 mm. In dense sands, very hard clays or weak rock, the full 450 mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form.

- In the case where full penetration is obtained with successive blow counts for each 150 mm of, say, 4, 6 and 7 as:

  4,6,7
  N=13

- In the case where the test is discontinued before the full penetration depth, say after 15 blows for the first 150 mm and 30 blows for the next 40 mm as:

  15, 30/40 mm

The results of the SPT tests can be related empirically to the engineering properties of the soils.

Dynamic Cone Penetrometer Tests / Perth Sand Penetrometer Tests

Dynamic penetrometer tests (DCP or PSP) are carried out by driving a steel rod into the ground using a standard weight of hammer falling a specified distance. As the rod penetrates the soil the number of blows required to penetrate each successive 150 mm depth are recorded. Normally there is a depth limitation of 1.2 m, but this may be extended in certain conditions by the use of extension rods. Two types of penetrometer are commonly used.

- Perth sand penetrometer - a 16 mm diameter flat ended rod is driven using a 9 kg hammer dropping 600 mm (AS 1289, Test 6.3.3). This test was developed for testing the density of sands and is mainly used in granular soils and filling.
- Cone penetrometer - a 16 mm diameter rod with a 20 mm diameter cone end is driven using a 9 kg hammer dropping 510 mm (AS 1289, Test 6.3.2). This test was developed initially for pavement subgrade investigations, and correlations of the test results with California Bearing Ratio have been published by various road authorities.

Description and Classification Methods

The methods of description and classification of soils and rocks used in this report are based on Australian Standard AS 1726, Geotechnical Site Investigations Code. In general, the descriptions include strength or density, colour, structure, soil or rock type and inclusions.

Soil Types

Soil types are described according to the predominant particle size, qualified by the grading of other particles present:

Type	Particle size (mm)
Boulder	>200
Cobble	63 - 200
Gravel	2.36 - 63
Sand	0.075 - 2.36
Silt	0.002 - 0.075
Clay	<0.002

The sand and gravel sizes can be further subdivided as follows:

Type	Particle size (mm)
Coarse gravel	20 - 63
Medium gravel	6 - 20
Fine gravel	2.36 - 6
Coarse sand	0.6 - 2.36
Medium sand	0.2 - 0.6
Fine sand	0.075 - 0.2

The proportions of secondary constituents of soils are described as:

Term	Proportion	Example
And	Specify	Clay (60%) and Sand (40%)
Adjective	20 - 35%	Sandy Clay
Slightly	12 - 20%	Slightly Sandy Clay
With some	5 - 12%	Clay with some sand
With a trace of	0 - 5%	Clay with a trace of sand

Definitions of grading terms used are:

- Well graded - a good representation of all particle sizes
- Poorly graded - an excess or deficiency of particular sizes within the specified range
- Uniformly graded - an excess of a particular particle size
- Gap graded - a deficiency of a particular particle size with the range

Cohesive Soils

Cohesive soils, such as clays, are classified on the basis of undrained shear strength. The strength may be measured by laboratory testing, or estimated by field tests or engineering examination. The strength terms are defined as follows:

Description	Abbreviation	Undrained shear strength (kPa)
Very soft	vs	<12
Soft	s	12 - 25
Firm	f	25 - 50
Stiff	st	50 - 100
Very stiff	vst	100 - 200
Hard	h	>200

Cohesionless Soils

Cohesionless soils, such as clean sands, are classified on the basis of relative density, generally from the results of standard penetration tests (SPT), cone penetration tests (CPT) or dynamic penetrometers (PSP). The relative density terms are given below:

Relative Density	Abbreviation	SPT N value	CPT qc value (MPa)
Very loose	vl	<4	<2
Loose	l	4 - 10	2 -5
Medium dense	md	10 - 30	5 - 15
Dense	d	30 - 50	15 - 25
Very dense	vd	>50	>25

Soil Descriptions

Soil Origin

It is often difficult to accurately determine the origin of a soil. Soils can generally be classified as:

- Residual soil - derived from in-situ weathering of the underlying rock;
- Transported soils - formed somewhere else and transported by nature to the site; or
- Filling - moved by man.

Transported soils may be further subdivided into:

- Alluvium - river deposits
- Lacustrine - lake deposits
- Aeolian - wind deposits
- Littoral - beach deposits
- Estuarine - tidal river deposits
- Talus - scree or coarse colluvium
- Slopewash or Colluvium - transported downslope by gravity assisted by water. Often includes angular rock fragments and boulders.

Rock Strength

Rock strength is defined by the Point Load Strength Index ($Is_{(50)}$) and refers to the strength of the rock substance and not the strength of the overall rock mass, which may be considerably weaker due to defects. The test procedure is described by Australian Standard 4133.4.1 - 1993. The terms used to describe rock strength are as follows:

Term	Abbreviation	Point Load Index $Is_{(50)}$ MPa	Approx Unconfined Compressive Strength MPa*
Extremely low	EL	<0.03	<0.6
Very low	VL	0.03 - 0.1	0.6 - 2
Low	L	0.1 - 0.3	2 - 6
Medium	M	0.3 - 1.0	6 - 20
High	H	1 - 3	20 - 60
Very high	VH	3 - 10	60 - 200
Extremely high	EH	>10	>200

* Assumes a ratio of 20:1 for UCS to $Is_{(50)}$

Degree of Weathering

The degree of weathering of rock is classified as follows:

Term	Abbreviation	Description
Extremely weathered	EW	Rock substance has soil properties, i.e. it can be remoulded and classified as a soil but the texture of the original rock is still evident.
Highly weathered	HW	Limonite staining or bleaching affects whole of rock substance and other signs of decomposition are evident. Porosity and strength may be altered as a result of iron leaching or deposition. Colour and strength of original fresh rock is not recognisable
Moderately weathered	MW	Staining and discolouration of rock substance has taken place
Slightly weathered	SW	Rock substance is slightly discoloured but shows little or no change of strength from fresh rock
Fresh stained	Fs	Rock substance unaffected by weathering but staining visible along defects
Fresh	Fr	No signs of decomposition or staining

Degree of Fracturing

The following classification applies to the spacing of natural fractures in diamond drill cores. It includes bedding plane partings, joints and other defects, but excludes drilling breaks.

Term	Description
Fragmented	Fragments of <20 mm
Highly Fractured	Core lengths of 20-40 mm with some fragments
Fractured	Core lengths of 40-200 mm with some shorter and longer sections
Slightly Fractured	Core lengths of 200-1000 mm with some shorter and loner sections
Unbroken	Core lengths mostly > 1000 mm

Rock Descriptions

Rock Quality Designation

The quality of the cored rock can be measured using the Rock Quality Designation (RQD) index, defined as:

$$\text{RQD \%} = \frac{\text{cumulative length of 'sound' core sections} \geq 100 \text{ mm long}}{\text{total drilled length of section being assessed}}$$

where 'sound' rock is assessed to be rock of low strength or better. The RQD applies only to natural fractures. If the core is broken by drilling or handling (i.e. drilling breaks) then the broken pieces are fitted back together and are not included in the calculation of RQD.

Stratification Spacing

For sedimentary rocks the following terms may be used to describe the spacing of bedding partings:

Term	Separation of Stratification Planes
Thinly laminated	< 6 mm
Laminated	6 mm to 20 mm
Very thinly bedded	20 mm to 60 mm
Thinly bedded	60 mm to 0.2 m
Medium bedded	0.2 m to 0.6 m
Thickly bedded	0.6 m to 2 m
Very thickly bedded	> 2 m

Symbols & Abbreviations

Douglas Partners

Introduction

These notes summarise abbreviations commonly used on borehole logs and test pit reports.

Drilling or Excavation Methods

C	Core Drilling
R	Rotary drilling
SFA	Spiral flight augers
NMLC	Diamond core - 52 mm dia
NQ	Diamond core - 47 mm dia
HQ	Diamond core - 63 mm dia
PQ	Diamond core - 81 mm dia

Water

▷	Water seep
▽	Water level

Sampling and Testing

A	Auger sample
B	Bulk sample
D	Disturbed sample
E	Environmental sample
U_{50}	Undisturbed tube sample (50mm)
W	Water sample
pp	pocket penetrometer (kPa)
PID	Photo ionisation detector
PL	Point load strength Is(50) MPa
S	Standard Penetration Test
V	Shear vane (kPa)

Description of Defects in Rock

The abbreviated descriptions of the defects should be in the following order: Depth, Type, Orientation, Coating, Shape, Roughness and Other. Drilling and handling breaks are not usually included on the logs.

Defect Type

B	Bedding plane
Cs	Clay seam
Cv	Cleavage
Cz	Crushed zone
Ds	Decomposed seam
F	Fault
J	Joint
Lam	lamination
Pt	Parting
Sz	Sheared Zone
V	Vein

Orientation

The inclination of defects is always measured from the perpendicular to the core axis.

h	horizontal
v	vertical
sh	sub-horizontal
sv	sub-vertical

Coating or Infilling Term

cln	clean
co	coating
he	healed
inf	infilled
stn	stained
ti	tight
vn	veneer

Coating Descriptor

ca	calcite
cbs	carbonaceous
cly	clay
fe	iron oxide
mn	manganese
slt	silty

Shape

cu	curved
ir	irregular
pl	planar
st	stepped
un	undulating

Roughness

po	polished
ro	rough
sl	slickensided
sm	smooth
vr	very rough

Other

fg	fragmented
bnd	band
qtz	quartz

Symbols & Abbreviations

Graphic Symbols for Soil and Rock

General

- Asphalt
- Road base
- Concrete
- Filling

Soils

- Topsoil
- Peat
- Clay
- Silty clay
- Sandy clay
- Gravelly clay
- Shaly clay
- Silt
- Clayey silt
- Sandy silt
- Sand
- Clayey sand
- Silty sand
- Gravel
- Sandy gravel
- Cobbles, boulders
- Talus

Sedimentary Rocks

- Boulder conglomerate
- Conglomerate
- Conglomeratic sandstone
- Sandstone
- Siltstone
- Laminite
- Mudstone, claystone, shale
- Coal
- Limestone

Metamorphic Rocks

- Slate, phyllite, schist
- Gneiss
- Quartzite

Igneous Rocks

- Granite
- Dolerite, basalt, andesite
- Dacite, epidote
- Tuff, breccia
- Porphyry

TEST PIT LOG

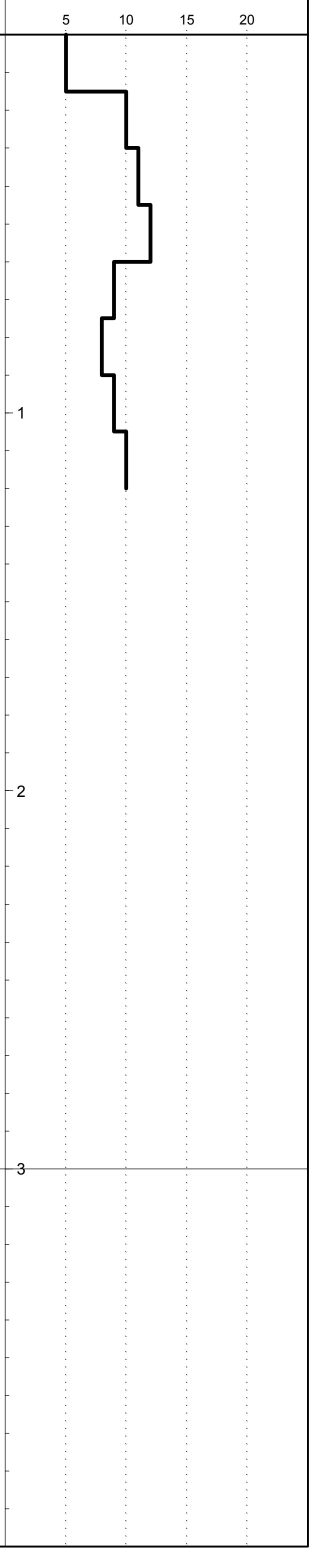
CLIENT: Camden Council
PROJECT: Proposed Residential Subdivision
LOCATION: Lot 4 Raby Road, Gledswood Hills

SURFACE LEVEL: 122.1 mAHD
EASTING: 295843
NORTHING: 6233378

PIT No: 1
PROJECT No: 76591.00
DATE: 11/12/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Sampling Type	Sampling Depth	Sample	Results & Comments	Water
122	0.0	TOPSOIL - light brown silty clay					
	0.2	SILTY CLAY - very stiff to hard, red brown silty clay, mc<pl	D	0.5			
121	1.0	SILTY CLAY - very stiff to hard, light grey mottled red brown silty clay with trace iron indurated bands, mc<pl	D	1.0			
			D	1.5			
120	2.0	SILTSTONE - very low strength, highly weathered, brown siltstone with trace clay bands	D	2.0			
			D	2.5			
119	3.0	Pit discontinued at 3.0m - limit of investigation	D	3.0			

Dynamic Penetrometer Test (blows per 150mm)



RIG: JCB 3CX backhoe - 450mm bucket
LOGGED: MV
SURVEY DATUM: MGA94 Zone 56

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

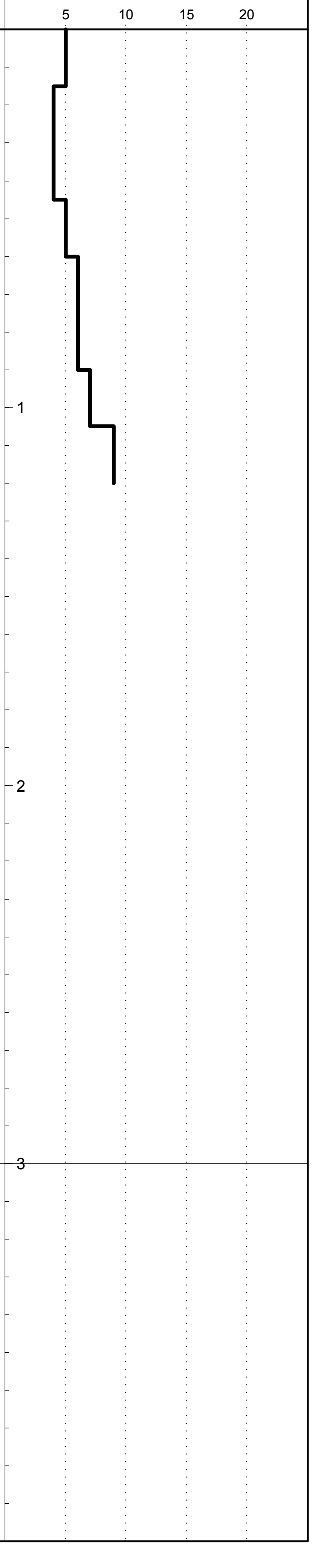
CLIENT: Camden Council
PROJECT: Proposed Residential Subdivision
LOCATION: Lot 4 Raby Road, Gledswood Hills

SURFACE LEVEL: 114.9 mAHD
EASTING: 295632
NORTHING: 6233301

PIT No: 2
PROJECT No: 76591.00
DATE: 11/12/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
		TOPSOIL - light brown silty clay with roots					
	0.2	SILTY CLAY - stiff to very stiff, red brown mottled grey silty clay,mc~pl		0.3			
			U_{50}	0.5			
			D	0.6			
			B	0.65			
114	1		D	1.0			
	1.5	SILTY CLAY - very stiff, light grey silty clay with some iron indurated bands, mc<pl	D	1.5			
113	2		D	2.0			
			D	2.5			
		- with some very low strength siltstone bands below 2.6m					
112	3 / 3.0	Pit discontinued at 3.0m - limit of investigation	D	3.0			
111							

Dynamic Penetrometer Test (blows per 150mm)



RIG: JCB 3CX backhoe - 450mm bucket
LOGGED: MV
SURVEY DATUM: MGA94 Zone 56

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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Geotechnics / Environment / Groundwater

TEST PIT LOG

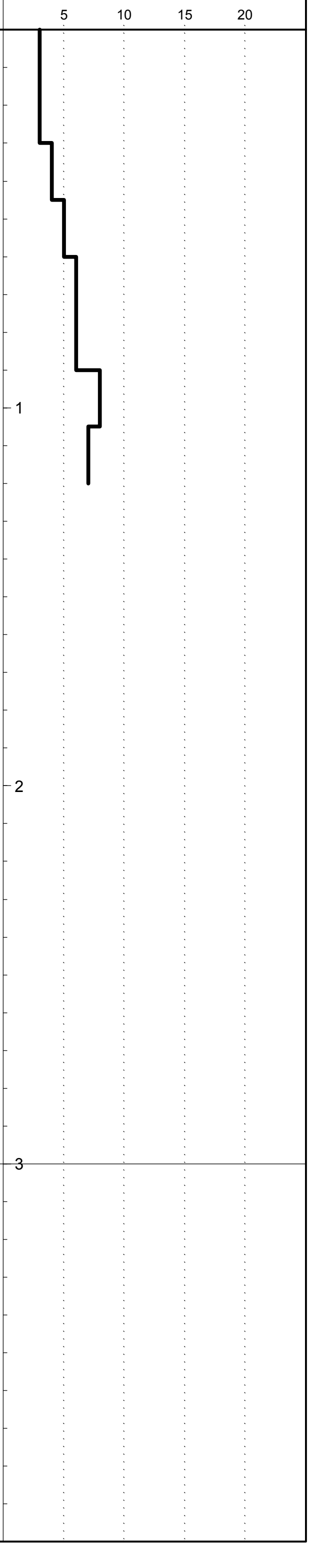
CLIENT: Camden Council
PROJECT: Proposed Residential Subdivision
LOCATION: Lot 4 Raby Road, Gledswood Hills

SURFACE LEVEL: 119.2 mAHD
EASTING: 295713
NORTHING: 6233246

PIT No: 3
PROJECT No: 76591.00
DATE: 11/12/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Sampling Type	Sampling Depth	Sample	Results & Comments	Water
119	0.0	SILTY CLAY - stiff, red brown silty clay, mc~pl	D	0.5			
	0.6	SANDY CLAY - stiff to very stiff, light brown sandy clay with some extremely low strength shale bands	D	1.0			
118			D	1.5			
117	2.0	SILTSTONE AND CLAY - very low strength, grey brown siltstone and grey clay	D	2.0			
			D	2.5			
116	3.0	Pit discontinued at 3.0m - limit of investigation	D	3.0			

Dynamic Penetrometer Test (blows per 150mm)



RIG: JCB 3CX backhoe - 450mm bucket
LOGGED: MV
SURVEY DATUM: MGA94 Zone 56

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

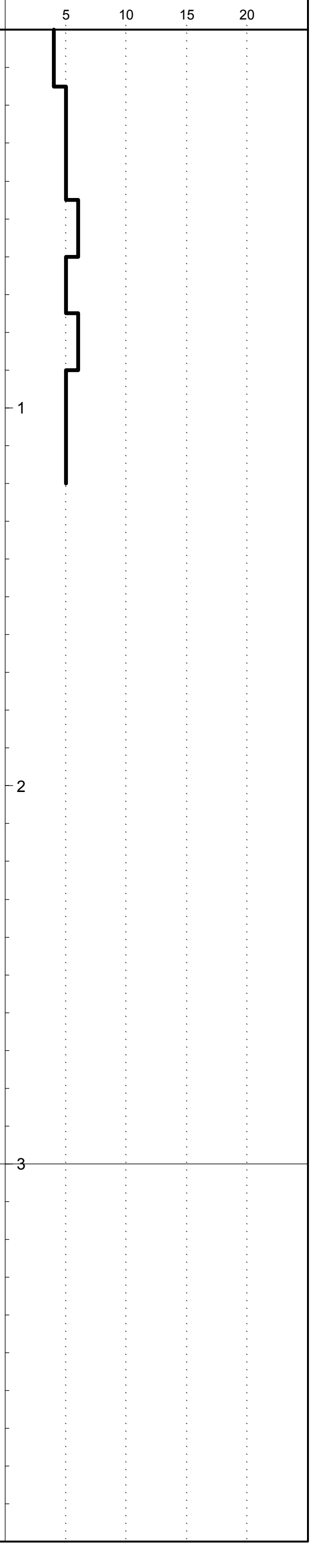
CLIENT: Camden Council
PROJECT: Proposed Residential Subdivision
LOCATION: Lot 4 Raby Road, Gledswood Hills

SURFACE LEVEL: 116.4 mAHD
EASTING: 295753
NORTHING: 6233185

PIT No: 4
PROJECT No: 76591.00
DATE: 11/12/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
		TOPSOIL - light brown silty clay						
116	0.2	SILTY CLAY - stiff to very stiff, red brown mottled grey silty clay, mc~pl		D	0.5			
	1			D	1.0			
115	1.1	SILTY CLAY - stiff to very stiff, light grey mottled red brown silty clay, mc~pl		D	1.5			
	2	- with some siltstone bands below 2.0m		D	2.0			
114				D	2.5			
	3 / 3.0	Pit discontinued at 3.0m - limit of investigation		D	3.0			
113								

Dynamic Penetrometer Test (blows per 150mm)



RIG: JCB 3CX backhoe - 450mm bucket
LOGGED: MV
SURVEY DATUM: MGA94 Zone 56

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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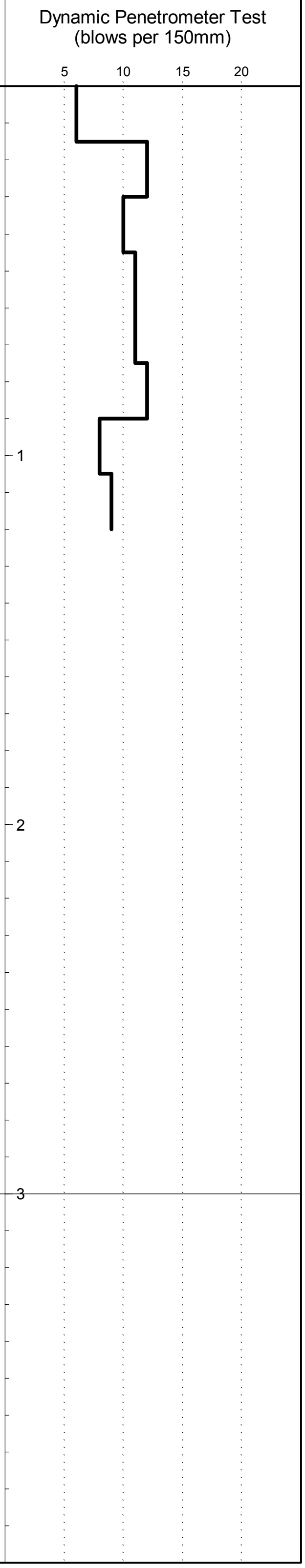
TEST PIT LOG

CLIENT: Camden Council
PROJECT: Proposed Residential Subdivision
LOCATION: Lot 4 Raby Road, Gledswood Hills

SURFACE LEVEL: 115.2 mAHD
EASTING: 295749
NORTHING: 6232932

PIT No: 5
PROJECT No: 76591.00
DATE: 11/12/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
		TOPSOIL - light brown silty clay						
115	0.1	SILTY CLAY - very stiff to hard, red brown silty clay, mc<pl		U_{50}	0.2–0.4			
				D	0.5			
114	0.6	SILTY CLAY - very stiff, light brown silty clay with some siltstone bands		D	1.0			
				B	1.0–1.1			
				D	1.5			
113				D	2.0			
				D	2.5			
	2.6	SILTY CLAY - very stiff, light grey silty clay with some extremely low strength shale bands		D	3.0			
112	3.0	Pit discontinued at 3.0m - limit of investigation						



RIG: JCB 3CX backhoe - 450mm bucket
LOGGED: MV
SURVEY DATUM: MGA94 Zone 56

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Camden Council
PROJECT: Proposed Residential Subdivision
LOCATION: Lot 4 Raby Road, Gledswood Hills

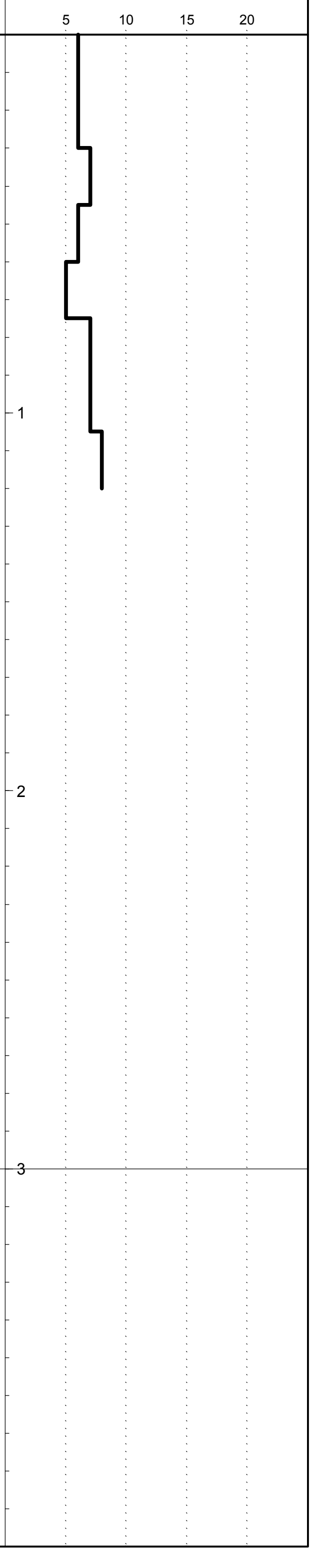
SURFACE LEVEL: 114.4 mAHD
EASTING: 295839
NORTHING: 6232936

PIT No: 6
PROJECT No: 76591.00
DATE: 11/12/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
		TOPSOIL - light brown silty clay						
	0.2	SILTY CLAY - very stiff, red brown mottled grey silty clay, mc~pl		D	0.5			
	0.6	SILTY CLAY - very stiff, light grey mottled red brown silty clay with trace iron indurated bands		D	1.0			
				D	1.5			
				D	2.0			
				D	2.5			
	3.0	Pit discontinued at 3.0m - limit of investigation		D	3.0			

RL scale: 114, 113, 112, 111. Depth scale: 1, 2, 3.

Dynamic Penetrometer Test (blows per 150mm)



RIG: JCB 3CX backhoe - 450mm bucket
LOGGED: MV
SURVEY DATUM: MGA94 Zone 56

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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Geotechnics / Environment / Groundwater

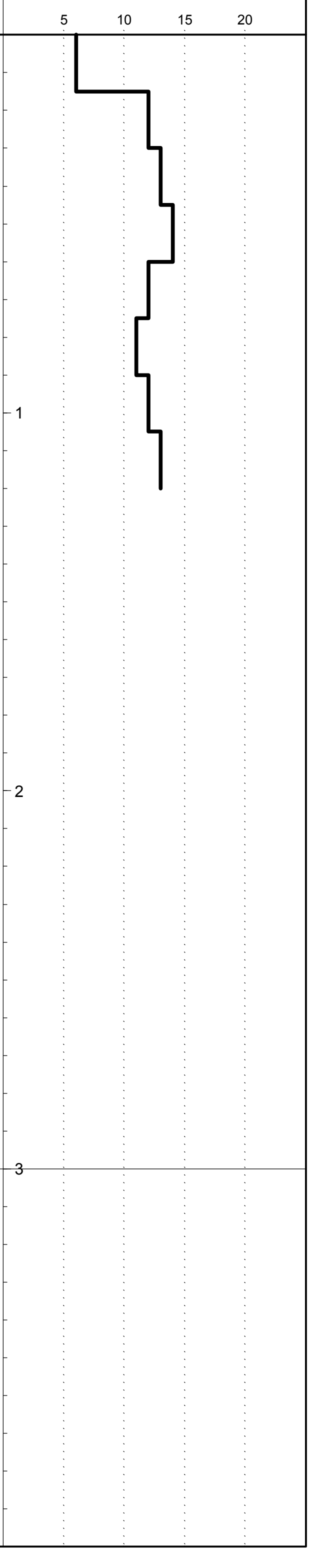
TEST PIT LOG

CLIENT: Camden Council
PROJECT: Proposed Residential Subdivision
LOCATION: Lot 4 Raby Road, Gledswood Hills

SURFACE LEVEL: 126.1 mAHD
EASTING: 295809
NORTHING: 6232783

PIT No: 7
PROJECT No: 76591.00
DATE: 11/12/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
126		TOPSOIL - light brown silty clay							
	0.3	SILTY CLAY - hard, light brown silty clay, mc<pl		D	0.5				
	0.7	SILTY CLAY - hard, light orange brown mottled grey and red brown silty clay with trace siltstone bands		D	1.0				
125	1			D	1.5				
124	2 2.0	CLAY AND SILTSTONE - very low strength, highly weathered, grey and red brown siltstone and hard clay		D	2.0				
				D	2.5				
123	3 3.0	Pit discontinued at 3.0m - limit of investigation		D	3.0				



RIG: JCB 3CX backhoe - 450mm bucket

LOGGED: MV

SURVEY DATUM: MGA94 Zone 56

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

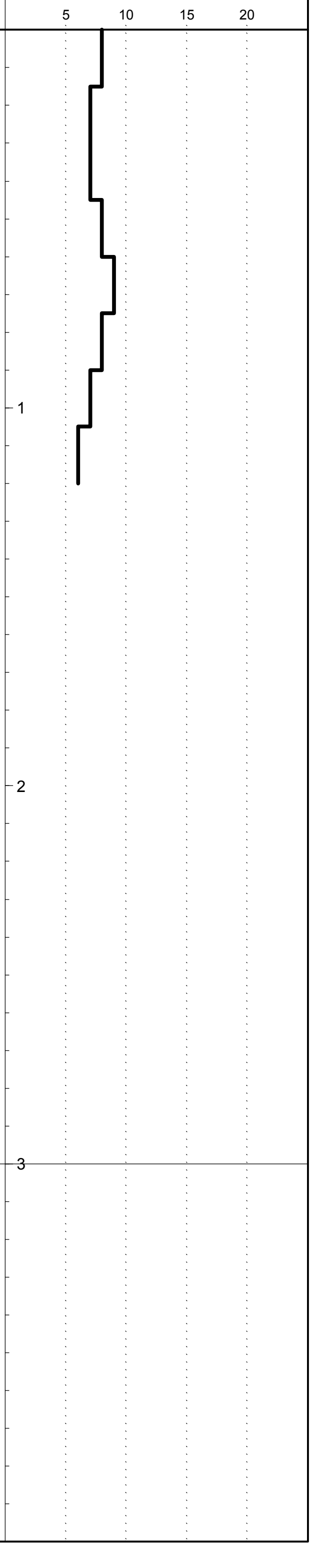
TEST PIT LOG

CLIENT: Camden Council
PROJECT: Proposed Residential Subdivision
LOCATION: Lot 4 Raby Road, Gledswood Hills

SURFACE LEVEL: 117.9 mAHD
EASTING: 295841
NORTHING: 6232441

PIT No: 8
PROJECT No: 76591.00
DATE: 11/12/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.0	TOPSOIL - brown silty clay with roots							
	0.2	SILTY CLAY - very stiff, red brown mottled grey silty clay, mc~pl		D	0.5				
117	1			D	1.0				
	1.2	SILTY CLAY - very stiff, light grey mottled red brown silty clay, mc<pl		D	1.5				
116	2	- with very low strength siltstone bands below 2.0m		D	2.0				
				D	2.5				
115	3 3.0			D	3.0				
		Pit discontinued at 3.0m - limit of investigation							
114									



RIG: JCB 3CX backhoe - 450mm bucket
LOGGED: MV
SURVEY DATUM: MGA94 Zone 56

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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Geotechnics / Environment / Groundwater

TEST PIT LOG

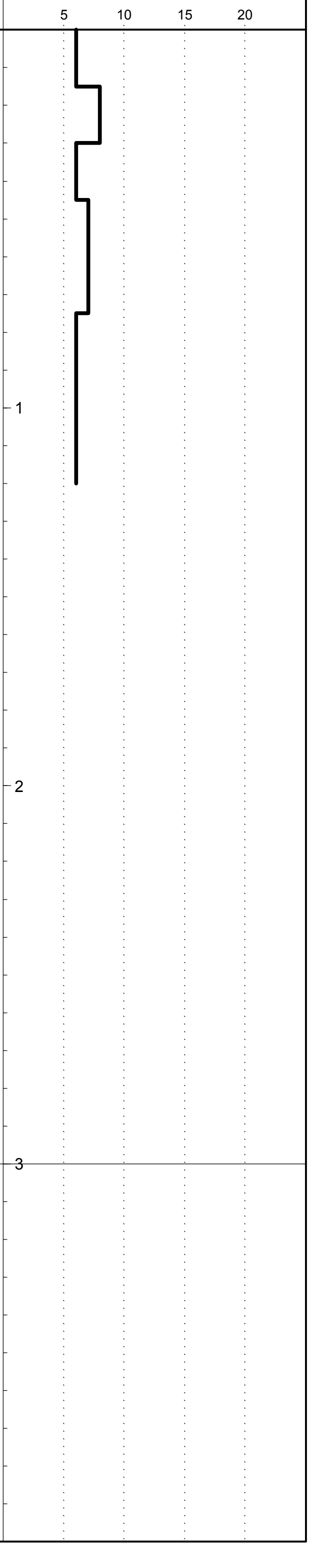
CLIENT: Camden Council
PROJECT: Proposed Residential Subdivision
LOCATION: Lot 4 Raby Road, Gledswood Hills

SURFACE LEVEL: 124.0 mAHD
EASTING: 295867
NORTHING: 6232186

PIT No: 9
PROJECT No: 76591.00
DATE: 11/12/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
124		TOPSOIL - light brown silty clay						
	0.2	SILTY CLAY - very stiff, red brown mottled grey silty clay, mc~pl			0.3			
				U_{50} D	0.5			
					0.7			
123	1	- grey mottled red brown with some iron indurated bands below 1.0m		D	1.0			
		- light grey, mc<pl below 1.5m		D	1.5			
				B	1.6			
122	2			D	2.0			
				D	2.5			
121	3 / 3.0	Pit discontinued at 3.0m - limit of investigation		D	3.0			

Dynamic Penetrometer Test (blows per 150mm)



RIG: JCB 3CX backhoe - 450mm bucket
LOGGED: MV
SURVEY DATUM: MGA94 Zone 56

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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Geotechnics / Environment / Groundwater

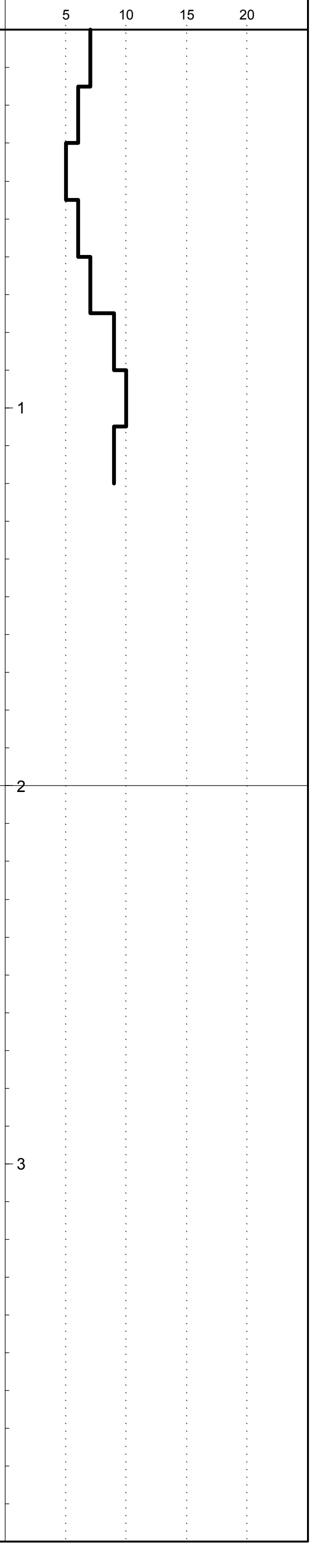
TEST PIT LOG

CLIENT: Camden Council
PROJECT: Proposed Residential Subdivision
LOCATION: Lot 4 Raby Road, Gledswood Hills

SURFACE LEVEL: 132.5 mAHD
EASTING: 296019
NORTHING: 6232086

PIT No: 10
PROJECT No: 76591.00
DATE: 11/12/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
		TOPSOIL - light brown silty clay							
	0.3	SILTY CLAY - very stiff, red brown silty clay, mc~pl		D	0.5				
	0.9	SILTY CLAY - very stiff, light grey and light brown silty clay with some iron indurated bands		D	1.0				
	1.4	SANDSTONE - low strength, slightly weathered, light brown and light grey fine grained sandstone with some clay bands - becoming medium strength below 1.7m		D	1.5				
	2.0	Pit discontinued at 2.0m - limit of investigation		D	2.0				



RIG: JCB 3CX backhoe - 450mm bucket **LOGGED:** MV **SURVEY DATUM:** MGA94 Zone 56

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

Appendix C

Laboratory Test Reports

Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9910 6200 fax 02 9910 6201
enquiries@envirolabservices.com.au
www.envirolabservices.com.au

CERTIFICATE OF ANALYSIS **102547**

Client:
Douglas Partners Pty Ltd Smeaton Grange
Unit 5/50 Topham Rd
Smeaton Grange
NSW 2567

Attention: Bradley Harris

Sample log in details:

Your Reference:	**76591.00, Land Capability Assessment**	
No. of samples:	58 Soils	
Date samples received / completed instructions received	13/12/13	/ 13/12/13

Analysis Details:
Please refer to the following pages for results, methodology summary and quality control data.
Samples were analysed as received from the client. Results relate specifically to the samples as received.
Results are reported on a dry weight basis for solids and on an as received basis for other matrices.
Please refer to the last page of this report for any comments relating to the results.

Report Details:

Date results requested by: / Issue Date:	20/12/13	/ 24/12/13
Date of Preliminary Report:	Not issued	

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Accredited for compliance with ISO/IEC 17025. **Tests not covered by NATA are denoted with *.**

Results Approved By:

Jacinta Hurst
Laboratory Manager

Miscellaneous Inorg - soil						
Our Reference:	UNITS	102547-1	102547-2	102547-3	102547-4	102547-5
Your Reference	-------------	1	1	1	1	1
Depth	------------	0.5	1.0	1.5	2.0	2.5
Date Sampled		11/12/2013	11/12/2013	11/12/2013	11/12/2013	11/12/2013
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	23/12/2013	23/12/2013	23/12/2013	23/12/2013	23/12/2013
Date analysed	-	23/12/2013	23/12/2013	23/12/2013	23/12/2013	23/12/2013
pH 1:5 soil:water	pH Units	5.4	4.9	4.8	5.0	5.4
Electrical Conductivity 1:5 soil:water	µS/cm	160	430	480	330	210
Chloride, Cl 1:5 soil:water	mg/kg	150	[NA]	[NA]	470	[NA]
Sulphate, SO4 1:5 soil:water	mg/kg	64	[NA]	[NA]	76	[NA]

Miscellaneous Inorg - soil						
Our Reference:	UNITS	102547-6	102547-7	102547-8	102547-9	102547-10
Your Reference	-------------	1	2	2	2	2
Depth	------------	3.0	0.5	1.0	1.5	2.0
Date Sampled		11/12/2013	11/12/2013	11/12/2013	11/12/2013	11/12/2013
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	23/12/2013	23/12/2013	23/12/2013	23/12/2013	23/12/2013
Date analysed	-	23/12/2013	23/12/2013	23/12/2013	23/12/2013	23/12/2013
pH 1:5 soil:water	pH Units	5.1	5.5	4.8	4.8	5.0
Electrical Conductivity 1:5 soil:water	µS/cm	430	180	300	600	480
Chloride, Cl 1:5 soil:water	mg/kg	[NA]	[NA]	[NA]	900	[NA]
Sulphate, SO4 1:5 soil:water	mg/kg	[NA]	[NA]	[NA]	84	[NA]

Miscellaneous Inorg - soil						
Our Reference:	UNITS	102547-11	102547-12	102547-13	102547-14	102547-15
Your Reference	-------------	2	2	3	3	3
Depth	------------	2.5	3.0	0.5	1.0	1.5
Date Sampled		11/12/2013	11/12/2013	11/12/2013	11/12/2013	11/12/2013
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	23/12/2013	23/12/2013	23/12/2013	23/12/2013	23/12/2013
Date analysed	-	23/12/2013	23/12/2013	23/12/2013	23/12/2013	23/12/2013
pH 1:5 soil:water	pH Units	5.1	5.2	5.5	5.7	6.7
Electrical Conductivity 1:5 soil:water	µS/cm	430	520	18	28	23
Chloride, Cl 1:5 soil:water	mg/kg	[NA]	[NA]	[NA]	27	[NA]
Sulphate, SO4 1:5 soil:water	mg/kg	[NA]	[NA]	[NA]	<10	[NA]

Miscellaneous Inorg - soil						
Our Reference:	UNITS	102547-16	102547-17	102547-18	102547-19	102547-20
Your Reference	-------------	3	3	3	4	4
Depth	------------	2.0	2.5	3.0	0.5	1.0
Date Sampled		11/12/2013	11/12/2013	11/12/2013	11/12/2013	11/12/2013
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	23/12/2013	23/12/2013	23/12/2013	23/12/2013	23/12/2013
Date analysed	-	23/12/2013	23/12/2013	23/12/2013	23/12/2013	23/12/2013
pH 1:5 soil:water	pH Units	9.1	8.2	8.6	5.3	4.9
Electrical Conductivity 1:5 soil:water	µS/cm	91	110	170	180	340
Chloride, Cl 1:5 soil:water	mg/kg	[NA]	20	[NA]	[NA]	[NA]
Sulphate, SO4 1:5 soil:water	mg/kg	[NA]	22	[NA]	[NA]	[NA]

Miscellaneous Inorg - soil						
Our Reference:	UNITS	102547-21	102547-22	102547-23	102547-24	102547-25
Your Reference	-------------	4	4	4	4	5
Depth	------------	1.5	2.0	2.5	3.0	0.5
Date Sampled		11/12/2013	11/12/2013	11/12/2013	11/12/2013	11/12/2013
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	23/12/2013	23/12/2013	23/12/2013	23/12/2013	23/12/2013
Date analysed	-	23/12/2013	23/12/2013	23/12/2013	23/12/2013	23/12/2013
pH 1:5 soil:water	pH Units	4.9	4.9	5.2	4.9	5.3
Electrical Conductivity 1:5 soil:water	µS/cm	350	340	360	450	250
Chloride, Cl 1:5 soil:water	mg/kg	200	[NA]	[NA]	[NA]	240
Sulphate, SO4 1:5 soil:water	mg/kg	140	[NA]	[NA]	[NA]	110

Miscellaneous Inorg - soil						
Our Reference:	UNITS	102547-26	102547-27	102547-28	102547-29	102547-30
Your Reference	-------------	5	5	5	5	5
Depth	------------	1.0	1.5	2.0	2.5	3.0
Date Sampled		11/12/2013	11/12/2013	11/12/2013	11/12/2013	11/12/2013
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	23/12/2013	23/12/2013	23/12/2013	23/12/2013	23/12/2013
Date analysed	-	23/12/2013	23/12/2013	23/12/2013	23/12/2013	23/12/2013
pH 1:5 soil:water	pH Units	5.2	5.3	5.0	4.9	5.2
Electrical Conductivity 1:5 soil:water	µS/cm	310	250	420	550	460
Chloride, Cl 1:5 soil:water	mg/kg	[NA]	[NA]	[NA]	[NA]	610
Sulphate, SO4 1:5 soil:water	mg/kg	[NA]	[NA]	[NA]	[NA]	160

Miscellaneous Inorg - soil						
Our Reference:	UNITS	102547-31	102547-32	102547-33	102547-34	102547-35
Your Reference	-------------	6	6	6	6	6
Depth	------------	0.5	1.0	1.5	2.0	2.5
Date Sampled		11/12/2013	11/12/2013	11/12/2013	11/12/2013	11/12/2013
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	23/12/2013	23/12/2013	23/12/2013	23/12/2013	23/12/2013
Date analysed	-	23/12/2013	23/12/2013	23/12/2013	23/12/2013	23/12/2013
pH 1:5 soil:water	pH Units	5.4	5.0	5.0	4.9	5.0
Electrical Conductivity 1:5 soil:water	µS/cm	160	390	440	520	430

Miscellaneous Inorg - soil						
Our Reference:	UNITS	102547-36	102547-37	102547-38	102547-39	102547-40
Your Reference	-------------	6	7	7	7	7
Depth	------------	3.0	0.5	1.0	1.5	2.0
Date Sampled		11/12/2013	11/12/2013	11/12/2013	11/12/2013	11/12/2013
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	23/12/2013	23/12/2013	23/12/2013	23/12/2013	23/12/2013
Date analysed	-	23/12/2013	23/12/2013	23/12/2013	23/12/2013	23/12/2013
pH 1:5 soil:water	pH Units	5.3	7.8	8.9	8.0	5.3
Electrical Conductivity 1:5 soil:water	µS/cm	460	41	520	690	570
Chloride, Cl 1:5 soil:water	mg/kg	510	[NA]	280	[NA]	770
Sulphate, SO4 1:5 soil:water	mg/kg	150	[NA]	30	[NA]	140

Miscellaneous Inorg - soil						
Our Reference:	UNITS	102547-41	102547-42	102547-43	102547-44	102547-45
Your Reference	-------------	7	7	8	8	8
Depth	------------	2.5	3.0	0.5	1.0	1.5
Date Sampled		11/12/2013	11/12/2013	11/12/2013	11/12/2013	11/12/2013
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	23/12/2013	23/12/2013	23/12/2013	23/12/2013	23/12/2013
Date analysed	-	23/12/2013	23/12/2013	23/12/2013	23/12/2013	23/12/2013
pH 1:5 soil:water	pH Units	5.0	4.9	5.2	4.9	4.8
Electrical Conductivity 1:5 soil:water	µS/cm	490	420	270	400	590
Chloride, Cl 1:5 soil:water	mg/kg	[NA]	[NA]	290	[NA]	[NA]
Sulphate, SO4 1:5 soil:water	mg/kg	[NA]	[NA]	140	[NA]	[NA]

Miscellaneous Inorg - soil						
Our Reference:	UNITS	102547-46	102547-47	102547-48	102547-49	102547-50
Your Reference	-------------	8	8	8	9	9
Depth	------------	2.0	2.5	3.0	0.5	1.0
Date Sampled		11/12/2013	11/12/2013	11/12/2013	11/12/2013	11/12/2013
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	23/12/2013	23/12/2013	23/12/2013	23/12/2013	23/12/2013
Date analysed	-	23/12/2013	23/12/2013	23/12/2013	23/12/2013	23/12/2013
pH 1:5 soil:water	pH Units	5.0	4.9	5.1	5.0	4.8
Electrical Conductivity 1:5 soil:water	µS/cm	510	610	560	230	430
Chloride, Cl 1:5 soil:water	mg/kg	[NA]	[NA]	[NA]	180	[NA]
Sulphate, SO4 1:5 soil:water	mg/kg	[NA]	[NA]	[NA]	170	[NA]

Miscellaneous Inorg - soil						
Our Reference:	UNITS	102547-51	102547-52	102547-53	102547-54	102547-55
Your Reference	-------------	9	9	9	9	10
Depth	------------	1.5	2.0	2.5	3.0	0.5
Date Sampled		11/12/2013	11/12/2013	11/12/2013	11/12/2013	11/12/2013
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	23/12/2013	23/12/2013	23/12/2013	23/12/2013	23/12/2013
Date analysed	-	23/12/2013	23/12/2013	23/12/2013	23/12/2013	23/12/2013
pH 1:5 soil:water	pH Units	4.7	4.5	4.6	4.6	5.3
Electrical Conductivity 1:5 soil:water	µS/cm	540	650	640	630	46
Chloride, Cl 1:5 soil:water	mg/kg	[NA]	800	[NA]	[NA]	[NA]
Sulphate, SO4 1:5 soil:water	mg/kg	[NA]	190	[NA]	[NA]	[NA]

Miscellaneous Inorg - soil				
Our Reference:	UNITS	102547-56	102547-57	102547-58
Your Reference	-------------	10	10	10
Depth	------------	1.0	1.5	2.0
Date Sampled		11/12/2013	11/12/2013	11/12/2013
Type of sample		Soil	Soil	Soil
Date prepared	-	23/12/2013	23/12/2013	23/12/2013
Date analysed	-	23/12/2013	23/12/2013	23/12/2013
pH 1:5 soil:water	pH Units	5.3	5.1	4.9
Electrical Conductivity 1:5 soil:water	µS/cm	82	190	300
Chloride, Cl 1:5 soil:water	mg/kg	[NA]	[NA]	400
Sulphate, SO4 1:5 soil:water	mg/kg	[NA]	[NA]	54

ESP/CEC						
Our Reference:	UNITS	102547-1	102547-7	102547-13	102547-19	102547-25
Your Reference	-------------	1	2	3	4	5
Depth	------------	0.5	0.5	0.5	0.5	0.5
Date Sampled		11/12/2013	11/12/2013	11/12/2013	11/12/2013	11/12/2013
Type of sample		Soil	Soil	Soil	Soil	Soil
Exchangeable Ca	meq/100g	3.3	2.1	0.9	1.2	0.1
Exchangeable K	meq/100g	0.5	0.2	0.2	0.4	0.3
Exchangeable Mg	meq/100g	12	13	4.5	11	10
Exchangeable Na	meq/100g	1.2	2.0	0.23	1.5	2.2
Cation Exchange Capacity	meq/100g	17	17	5.8	14	13
ESP	%	7.1	11.5	3.9	10.8	17.1

ESP/CEC						
Our Reference:	UNITS	102547-31	102547-37	102547-43	102547-49	102547-55
Your Reference	-------------	6	7	8	9	10
Depth	------------	0.5	0.5	0.5	0.5	0.5
Date Sampled		11/12/2013	11/12/2013	11/12/2013	11/12/2013	11/12/2013
Type of sample		Soil	Soil	Soil	Soil	Soil
Exchangeable Ca	meq/100g	0.3	21	1.7	1.1	1.0
Exchangeable K	meq/100g	0.3	0.3	0.4	0.4	0.4
Exchangeable Mg	meq/100g	9.7	14	12	9.6	6.2
Exchangeable Na	meq/100g	1.8	1.3	2.2	1.9	0.93
Cation Exchange Capacity	meq/100g	12	37	17	13	8.5
ESP	%	14.8	3.6	13.2	14.6	10.9

Method ID	Methodology Summary
Inorg-001	pH - Measured using pH meter and electrode in accordance with APHA 22nd ED, 4500-H+.
Inorg-002	Conductivity and Salinity - measured using a conductivity cell and dedicated meter, in accordance with APHA 22nd ED 2510 and Rayment & Lyons.
Inorg-081	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA 22nd ED, 4110 -B.
Metals-009	Determination of exchangeable cations and cation exchange capacity in soil based on Rayment and Lyons 2011.

QUALITY CONTROL Miscellaneous Inorg - soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			20/12/2013	102547-1	23/12/2013 || 23/12/2013	LCS-1	20/12/2013
Date analysed	-			20/12/2013	102547-1	23/12/2013 || 23/12/2013	LCS-1	20/12/2013
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	102547-1	5.4 || 5.5 || RPD: 2	LCS-1	101%
Electrical Conductivity 1:5 soil:water	µS/cm	1	Inorg-002	<1	102547-1	160 || 150 || RPD: 6	LCS-1	98%
Chloride, Cl 1:5 soil:water	mg/kg	10	Inorg-081	<10	102547-1	150 || 170 || RPD: 12	LCS-1	98%
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	<10	102547-1	64 || 63 || RPD: 2	LCS-1	118%

QUALITY CONTROL ESP/CEC	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Exchangeable Ca	meq/100g	0.1	Metals-009	<0.1	102547-13	0.9 || 1 || RPD: 11	LCS-1	119%
Exchangeable K	meq/100g	0.1	Metals-009	<0.1	102547-13	0.2 || 0.2 || RPD: 0	LCS-1	120%
Exchangeable Mg	meq/100g	0.1	Metals-009	<0.1	102547-13	4.5 || 5.1 || RPD: 12	LCS-1	115%
Exchangeable Na	meq/100g	0.1	Metals-009	<0.1	102547-13	0.23 || 0.24 || RPD: 4	LCS-1	115%
Cation Exchange Capacity	meq/100g	1	Metals-009	[NT]	102547-13	5.8 || 6.5 || RPD: 11	[NR]	[NR]
ESP	%	1	Metals-009	[NT]	102547-13	3.9 || 3.8 || RPD: 3	[NR]	[NR]

QUALITY CONTROL Miscellaneous Inorg - soil	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date prepared	-	102547-40	23/12/2013 || 23/12/2013	LCS-2	20/12/2013
Date analysed	-	102547-40	23/12/2013 || 23/12/2013	LCS-2	20/12/2013
pH 1:5 soil:water	pH Units	102547-40	5.3 || [N/T]	LCS-2	101%
Electrical Conductivity 1:5 soil:water	µS/cm	102547-40	570 || [N/T]	LCS-2	104%
Chloride, Cl 1:5 soil:water	mg/kg	102547-40	770 || 740 || RPD: 4	[NR]	[NR]
Sulphate, SO4 1:5 soil:water	mg/kg	102547-40	140 || 100 || RPD: 33	[NR]	[NR]

QUALITY CONTROL Miscellaneous Inorg - soil	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date prepared	-	102547-11	23/12/2013 || 23/12/2013	LCS-2	20/12/2013
Date analysed	-	102547-11	23/12/2013 || 23/12/2013	LCS-2	20/12/2013
pH 1:5 soil:water	pH Units	102547-11	5.1 || 5.2 || RPD: 2	LCS-2	101%
Electrical Conductivity 1:5 soil:water	µS/cm	102547-11	430 || 420 || RPD: 2	LCS-2	104%
Chloride, Cl 1:5 soil:water	mg/kg	[NT]	[NT]	[NR]	[NR]
Sulphate, SO4 1:5 soil:water	mg/kg	[NT]	[NT]	[NR]	[NR]

QUALITY CONTROL Miscellaneous Inorg - soil	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD
Date prepared	-	102547-21	23/12/2013 || 23/12/2013
Date analysed	-	102547-21	23/12/2013 || 23/12/2013
pH 1:5 soil:water	pH Units	102547-21	4.9 || 4.9 || RPD: 0
Electrical Conductivity 1:5 soil:water	µS/cm	102547-21	350 || 360 || RPD: 3
Chloride, Cl 1:5 soil:water	mg/kg	102547-21	200 || [N/T]
Sulphate, SO4 1:5 soil:water	mg/kg	102547-21	140 || [N/T]

QUALITY CONTROL Miscellaneous Inorg - soil	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD
Date prepared	-	102547-31	23/12/2013 || 23/12/2013
Date analysed	-	102547-31	23/12/2013 || 23/12/2013
pH 1:5 soil:water	pH Units	102547-31	5.4 || 5.4 || RPD: 0
Electrical Conductivity 1:5 soil:water	µS/cm	102547-31	160 || 170 || RPD: 6
Chloride, Cl 1:5 soil:water	mg/kg	[NT]	[NT]
Sulphate, SO4 1:5 soil:water	mg/kg	[NT]	[NT]

QUALITY CONTROL Miscellaneous Inorg - soil	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD
Date prepared	-	102547-41	23/12/2013 || 23/12/2013
Date analysed	-	102547-41	23/12/2013 || 23/12/2013
pH 1:5 soil:water	pH Units	102547-41	5.0 || 5.3 || RPD: 6
Electrical Conductivity 1:5 soil:water	µS/cm	102547-41	490 || 460 || RPD: 6
Chloride, Cl 1:5 soil:water	mg/kg	[NT]	[NT]
Sulphate, SO4 1:5 soil:water	mg/kg	[NT]	[NT]

QUALITY CONTROL Miscellaneous Inorg - soil	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD
Date prepared	-	102547-51	23/12/2013 || 23/12/2013
Date analysed	-	102547-51	23/12/2013 || 23/12/2013
pH 1:5 soil:water	pH Units	102547-51	4.7 || 4.7 || RPD: 0
Electrical Conductivity 1:5 soil:water	µS/cm	102547-51	540 || 520 || RPD: 4
Chloride, Cl 1:5 soil:water	mg/kg	[NT]	[NT]
Sulphate, SO4 1:5 soil:water	mg/kg	[NT]	[NT]

Report Comments:

Asbestos ID was analysed by Approved Identifier: Not applicable for this job
Asbestos ID was authorised by Approved Signatory: Not applicable for this job

INS: Insufficient sample for this test	PQL: Practical Quantitation Limit	NT: Not tested
NA: Test not required	RPD: Relative Percent Difference	NA: Test not required
<: Less than	>: Greater than	LCS: Laboratory Control Sample

Quality Control Definitions

Blank: This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.

Duplicate: This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.

Matrix Spike : A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.

LCS (Laboratory Control Sample) : This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.

Surrogate Spike: Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.
Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.
Spikes for Physical and Aggregate Tests are not applicable.
For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: <5xPQL - any RPD is acceptable; >5xPQL - 0-50% RPD is acceptable.
Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics and 10-140% for SVOC and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Douglas Partners
Geotechnics / Environment / Groundwater

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Determination of Emerson Class Number of Soil

Client:	**CAMDEN COUNCIL**	**Project No:**	76591.00
		Report No:	MAC13-319
Project:	Proposed Residential Subdivision	**Report Date:**	19/12/2013
Location:	Lot 4 Raby Road, Gledswood Hills	**Date of Test:**	19/12/2013
		Page:	1 of 1

Sample No.	Depth (m)	Description	Water Type	Water Temp	Class No.
3	0.5	SILTY CLAY – Red brown silty clay	Distilled	20°C	5
7	0.5	SILTY CLAY – Light brown silty clay	Distilled	20°C	5
8	0.5	SILTY CLAY – Red brown mottled grey silty clay	Distilled	20°C	5
10	0.5	SILTY CLAY – Red brown silty clay	Distilled	20°C	6
11	0.5	SILTY CLAY – Light brown silty clay	Distilled	20°C	5

Test Methods: AS 1289 3.8.1

Sampling Methods: Sampled By DP Engineering

Remarks:

NATA
ACCREDITED FOR TECHNICAL COMPETENCE

NATA Accredited Laboratory Number: 828

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.
Accredited for compliance with ISO/IEC 17025

Tested: AS
Checked: AJS

A J Sweetland
Laboratory Manager

Appendix D

Summary Table: Laboratory Tests and Assessments

Test Bore or Pit	Test Location East (m MGA56)	North (m MGA56)	RL (m AHD)	Sample ID	Sample Depth (m bgl)	pH (pH units)	Chloride Concentration (mg/kg)	Sulphate Concentration (mg/kg)	Resistivity By inversion of EC1:5 Ω.cm	Soil Condition [AS2159-2009]	Sample Aggressivity Class [AS2159-2009] Aggr. to Concrete - from sample pH	Aggr. to Concrete - from Sulphate conc.	Aggr. to Steel - from sample pH	Aggr. to Steel - from Chloride conc.	Aggr. to Steel - from sample Resistivity
1	295843.0	6233378.0	122.1	1/0.5	0.5	5.4	150	64	6250	B	Mild	Non-Aggressive	Non-Aggressive	Non-Aggressive	Non-Aggressive
				1/1.0	1.0	4.9			2326	B	Mild		Non-Aggressive		Non-Aggressive
				1/1.5	1.5	4.8			2083	B	Mild		Non-Aggressive		Non-Aggressive
				1/2.0	2.0	5	470	76	3030	B	Mild	Non-Aggressive	Non-Aggressive	Non-Aggressive	Non-Aggressive
				1/2.5	2.5	5.4			4762	B	Mild		Non-Aggressive		Non-Aggressive
.	.	.	.	1/3.0	3.0	5.1			2326	B	Mild		Non-Aggressive		Non-Aggressive
2	295632.0	6233301.0	114.9	2/0.5	0.5	5.5			5556	B	Mild		Non-Aggressive		Non-Aggressive
				2/1.0	1.0	4.8			3333	B	Mild		Non-Aggressive		Non-Aggressive
				2/1.5	1.5	4.8	900	84	1667	B	Mild	Non-Aggressive	Non-Aggressive	Non-Aggressive	Mild
				2/2.0	2.0	5			2083	B	Mild		Non-Aggressive		Non-Aggressive
				2/2.5	2.5	5.1			2326	B	Mild		Non-Aggressive		Non-Aggressive
.	.	.	.	2/3.0	3.0	5.2			1923	B	Mild		Non-Aggressive		Mild
3	295713.0	6233246.0	119.2	3/0.5	0.5	5.5			55556	B	Mild		Non-Aggressive		Non-Aggressive
				3/1.0	1.0	5.7	27	<10	35714	B	Non-Aggressive	Non-Aggressive	Non-Aggressive	Non-Aggressive	Non-Aggressive
				3/1.5	1.5	6.7			43478	B	Non-Aggressive		Non-Aggressive		Non-Aggressive
				3/2.0	2.0	9.1			10989	B	Non-Aggressive		Non-Aggressive		Non-Aggressive
				3/2.5	2.5	8.2	20	22	9091	B	Non-Aggressive	Non-Aggressive	Non-Aggressive	Non-Aggressive	Non-Aggressive
.	.	.	.	3/3.0	3.0	8.6			5882	B	Non-Aggressive		Non-Aggressive		Non-Aggressive
4	295753.0	6233185.0	116.4	4/0.5	0.5	5.3			5556	B	Mild		Non-Aggressive		Non-Aggressive
				4/1.0	1.0	4.9			2941	B	Mild		Non-Aggressive		Non-Aggressive
				4/1.5	1.5	4.9	200	140	2857	B	Mild	Non-Aggressive	Non-Aggressive	Non-Aggressive	Non-Aggressive
				4/2.0	2.0	4.9			2941	B	Mild		Non-Aggressive		Non-Aggressive
				4/2.5	2.5	5.2			2778	B	Mild		Non-Aggressive		Non-Aggressive
.	.	.	.	4/3.0	3.0	4.9			2222	B	Mild		Non-Aggressive		Non-Aggressive
5	295749.0	6232932.0	115.2	5/0.5	0.5	5.3	240	110	4000	B	Mild	Non-Aggressive	Non-Aggressive	Non-Aggressive	Non-Aggressive
				5/1.0	1.0	5.2			3226	B	Mild		Non-Aggressive		Non-Aggressive
				5/1.5	1.5	5.3			4000	B	Mild		Non-Aggressive		Non-Aggressive
				5/2.0	2.0	5			2381	B	Mild		Non-Aggressive		Non-Aggressive
				5/2.5	2.5	4.9			1818	B	Mild		Non-Aggressive		Mild
.	.	.	.	5/3.0	3.0	5.2	610	160	2174	B	Mild	Non-Aggressive	Non-Aggressive	Non-Aggressive	Non-Aggressive
6	295839.0	6232936.0	114.4	6/0.5	0.5	5.4			6250	B	Mild		Non-Aggressive		Non-Aggressive
				6/1.0	1.0	5			2564	B	Mild		Non-Aggressive		Non-Aggressive
				6/1.5	1.5	5			2273	B	Mild		Non-Aggressive		Non-Aggressive
				6/2.0	2.0	4.9			1923	B	Mild		Non-Aggressive		Mild
				6/2.5	2.5	5			2326	B	Mild		Non-Aggressive		Non-Aggressive
.	.	.	.	6/3.0	3.0	5.3	510	150	2174	B	Mild	Non-Aggressive	Non-Aggressive	Non-Aggressive	Non-Aggressive
7	295809.0	6232783.0	126.1	7/0.5	0.5	7.8			24390	B	Non-Aggressive		Non-Aggressive		Non-Aggressive
				7/1.0	1.0	8.9	280	30	1923	B	Non-Aggressive	Non-Aggressive	Non-Aggressive	Non-Aggressive	Mild
				7/1.5	1.5	8			1449	B	Non-Aggressive		Non-Aggressive		Mild
				7/2.0	2.0	5.3	770	140	1754	B	Mild	Non-Aggressive	Non-Aggressive	Non-Aggressive	Mild
				7/2.5	2.5	5			2041	B	Mild		Non-Aggressive		Non-Aggressive
.	.	.	.	7/3.0	3.0	4.9			2381	B	Mild		Non-Aggressive		Non-Aggressive
8	295841.0	6232441.0	117.9	8/0.5	0.5	5.2	290	140	3704	B	Mild	Non-Aggressive	Non-Aggressive	Non-Aggressive	Non-Aggressive
				8/1.0	1.0	4.9			2500	B	Mild		Non-Aggressive		Non-Aggressive
				8/1.5	1.5	4.8			1695	B	Mild		Non-Aggressive		Mild
				8/2.0	2.0	5			1961	B	Mild		Non-Aggressive		Mild
				8/2.5	2.5	4.9			1639	B	Mild		Non-Aggressive		Mild
.	.	.	.	8/3.0	3.0	5.1			1786	B	Mild		Non-Aggressive		Mild
9	295867.0	6232186.0	124.0	9/0.5	0.5	5	180	170	4348	B	Mild	Non-Aggressive	Non-Aggressive	Non-Aggressive	Non-Aggressive
				9/1.0	1.0	4.8			2326	B	Mild		Non-Aggressive		Non-Aggressive
				9/1.5	1.5	4.7			1852	B	Mild		Non-Aggressive		Mild
				9/2.0	2.0	4.5	800	190	1538	B	Moderate	Non-Aggressive	Non-Aggressive	Non-Aggressive	Mild
				9/2.5	2.5	4.6			1563	B	Mild		Non-Aggressive		Mild
.	.	.	.	9/3.0	3.0	4.6			1587	B	Mild		Non-Aggressive		Mild
10	296019.0	6232086.0	132.5	10/0.5	0.5	5.3			21739	B	Mild		Non-Aggressive		Non-Aggressive
				10/1.0	1.0	5.3			12195	B	Mild		Non-Aggressive		Non-Aggressive
				10/1.5	1.5	5.1			5263	B	Mild		Non-Aggressive		Non-Aggressive
.	.	.	.	10/2.0	2.0	4.9	400	54	3333	B	Mild	Non-Aggressive	Non-Aggressive	Non-Aggressive	Non-Aggressive

Test Bore or Pit	Test Location East (m MGA56)	Test Location North (m MGA56)	Test Location RL (m AHD)	Sample ID	Sample Depth (m bgl)	Exchangeable Sodium (Na) Concentration (meq/100g)	Cation Exchange Capacity (meq/100g)	Sodicity [Na/CEC] (%)	Sodicity Class [after DLWC]	Emerson Crumb Class Number	Dispersion? (from Emerson Class) [AS1289.3.8.1]	Soil Texture Group (for detailed soil logs see Report Appendix) [after DLWC]	Textural Factor (M) [after DLWC]	$EC_{1:5}$ [Lab.] (microS/cm)	EC_e [M x $EC_{1:5}$] (deciS/m)	Sample Salinity Class (Based on sample ECe) [Richards 1954]	Bulk ECe In Zone (m) 0 - 3 (dS/m)	Zone Salinity Class From Bulk ECe in Zone (m): 0 - 3 [Richards 1954]
1	295843.0	6233378.0	122.1	1/0.5	0.5	1.2	17	7	Sodic			Clay loam	9	160	1.4	Non-Saline	.	.
				1/1.0	1.0							Loam	10	430	4.3	Moderately Saline		
				1/1.5	1.5							Clay loam	9	480	4.3	Moderately Saline		
				1/2.0	2.0							Medium clay	7	330	2.3	Slightly Saline		
				1/2.5	2.5							Medium clay	7	210	1.5	Non-Saline		
.	.	.	.	1/3.0	3.0							Medium clay	7	430	3.0	Slightly Saline	2.7	Slightly Saline
2	295632.0	6233301.0	114.9	2/0.5	0.5	2	17	12	Sodic			Light medium clay	8	180	1.4	Non-Saline	.	.
				2/1.0	1.0							Medium clay	7	300	2.1	Slightly Saline		
				2/1.5	1.5							Clay loam	9	600	5.4	Moderately Saline		
				2/2.0	2.0							Clay loam	9	480	4.3	Moderately Saline		
				2/2.5	2.5							Light medium clay	8	430	3.4	Slightly Saline		
.	.	.	.	2/3.0	3.0							Light medium clay	8	520	4.2	Moderately Saline	3.3	Slightly Saline
3	295713.0	6233246.0	119.2	3/0.5	0.5	0.23	5.8	4	Non-Sodic	5	No	Clay loam	9	18	0.2	Non-Saline	.	.
				3/1.0	1.0							Clay loam	9	28	0.3	Non-Saline		
				3/1.5	1.5							Clay loam	9	23	0.2	Non-Saline		
				3/2.0	2.0							Medium clay	7	91	0.6	Non-Saline		
				3/2.5	2.5							Medium clay	7	110	0.8	Non-Saline		
.	.	.	.	3/3.0	3.0							Medium clay	7	170	1.2	Non-Saline	0.5	Non-Saline
4	295753.0	6233185.0	116.4	4/0.5	0.5	1.5	14	11	Sodic			Light medium clay	8	180	1.4	Non-Saline	.	.
				4/1.0	1.0							Light medium clay	8	340	2.7	Slightly Saline		
				4/1.5	1.5							Light medium clay	8	350	2.8	Slightly Saline		
				4/2.0	2.0							Loam	10	340	3.4	Slightly Saline		
				4/2.5	2.5							Clay loam	9	360	3.2	Slightly Saline		
.	.	.	.	4/3.0	3.0							Light medium clay	8	450	3.6	Slightly Saline	2.7	Slightly Saline
5	295749.0	6232932.0	115.2	5/0.5	0.5	2.2	13	17	Highly Sodic			Medium clay	7	250	1.8	Non-Saline	.	.
				5/1.0	1.0							Medium clay	7	310	2.2	Slightly Saline		
				5/1.5	1.5							Medium clay	7	250	1.8	Non-Saline		
				5/2.0	2.0							Medium clay	7	420	2.9	Slightly Saline		
				5/2.5	2.5							Loam	10	550	5.5	Moderately Saline		
.	.	.	.	5/3.0	3.0							Clay loam	9	460	4.1	Moderately Saline	2.8	Slightly Saline
6	295839.0	6232936.0	114.4	6/0.5	0.5	1.8	12	15	Sodic			Medium clay	7	160	1.1	Non-Saline	.	.
				6/1.0	1.0							Clay loam	9	390	3.5	Slightly Saline		
				6/1.5	1.5							Clay loam	9	440	4.0	Slightly Saline		
				6/2.0	2.0							Clay loam	9	520	4.7	Moderately Saline		
				6/2.5	2.5							Loam	10	430	4.3	Moderately Saline		
.	.	.	.	6/3.0	3.0							Light medium clay	8	460	3.7	Slightly Saline	3.3	Slightly Saline
7	295809.0	6232783.0	126.1	7/0.5	0.5	1.3	37	4	Non-Sodic	5	No	Loam	10	41	0.4	Non-Saline	.	.
				7/1.0	1.0							Medium clay	7	520	3.6	Slightly Saline		
				7/1.5	1.5							Medium clay	7	690	4.8	Moderately Saline		
				7/2.0	2.0							Medium clay	7	570	4.0	Slightly Saline		
				7/2.5	2.5							Medium clay	7	490	3.4	Slightly Saline		
.	.	.	.	7/3.0	3.0							Medium clay	7	420	2.9	Slightly Saline	3.0	Slightly Saline
8	295841.0	6232441.0	117.9	8/0.5	0.5	2.2	17	13	Sodic	5	No	Heavy clay	6	270	1.6	Non-Saline	.	.
				8/1.0	1.0							Medium clay	7	400	2.8	Slightly Saline		
				8/1.5	1.5							Light medium clay	8	590	4.7	Moderately Saline		
				8/2.0	2.0							Clay loam	9	510	4.6	Moderately Saline		
				8/2.5	2.5							Medium clay	7	610	4.3	Moderately Saline		
.	.	.	.	8/3.0	3.0							Loam	10	560	5.6	Moderately Saline	3.6	Slightly Saline
9	295867.0	6232186.0	124.0	9/0.5	0.5	1.9	13	15	Sodic			Medium clay	7	230	1.6	Non-Saline	.	.
				9/1.0	1.0							Medium clay	7	430	3.0	Slightly Saline		
				9/1.5	1.5							Medium clay	7	540	3.8	Slightly Saline		
				9/2.0	2.0							Clay loam	9	650	5.9	Moderately Saline		
				9/2.5	2.5							Clay loam	9	640	5.8	Moderately Saline		
.	.	.	.	9/3.0	3.0							Light clay	8.5	630	5.4	Moderately Saline	3.9	Slightly Saline
10	296019.0	6232086.0	132.5	10/0.5	0.5	0.93	8.5	11	Sodic	6	No	Medium clay	7	46	0.3	Non-Saline	.	.
				10/1.0	1.0							Light clay	8.5	82	0.7	Non-Saline		
				10/1.5	1.5							Medium clay	7	190	1.3	Non-Saline		
.	.	.	.	10/2.0	2.0							Medium clay	7	300	2.1	Slightly Saline	1.1	Non-Saline

Aggressivity Flags
- Very Severe
- Severe
- Moderate
- Mild
- Non-Aggressive

Sodicity Flags
- Highly Sodic
- Sodic
- Non-Sodic

Dispersion Flags
- Complete
- Some
- Dispersive
- No

Salinity Flags
- Highly Saline
- Very Saline
- Moderately Saline
- Slightly Saline
- Non-Saline