26 June 2020

Matt Brown
Perception Planning
Sent via email: matt@perceptionplanning.com.au

Our ref: 2219760-20348
Your ref:

Dear Matt

Proposed Residential Development Gundy Rd, Scone
Salinity Modelling

Background

During the DA application process there has been several meetings between our client, Council and DPI regarding potential salinity issues from the proposed development. This has included items for consideration from DPI where these items have been addressed or agreed to be conditioned.

With respect to the ground water modelling and potential recharge issues, further field testing was directed to be carried out, and the approach provided by GHD to date to assess this potential risk was to be agreed following provision of these results.

As part of the meeting with Mr Alan Nicholson (DPI) and Upper Hunter Shire Council on 11 November 2019 it was determined that further to the total catchment analysis that outlets to the highway, a localised analysis of the proposed subdivision with respect to salinity impact would also be considered.

Your email of 6 March 2020 provides notes of the discussion and provides more recent comments on the items.

Additional Field testing

With respect to the salinity issues, the main concern is the determination of the impact of the proposed subdivision and the methods used to assess the impact.

It was agreed in the meeting of November 2019 that additional site investigations including 6 boreholes would be carried out to provide confirmation on the previous estimated spatial distribution of salinity across the site. The EM survey provided profiles at 0.5m and 1.5m depth showing slight to moderate salinity distribution with a few high salinity levels near the exiting dam and outlet of the gully that traverses the area. The meeting agreed that the lots in these “hot spot” areas can be reviewed and the managed. Further testing at depth across the site was requested to confirm the uniformity and potential salinity levels.

The location of the bore holes were agreed during the abovementioned meeting.

The additional site investigation was carried out by Douglas Partners, and their report dated June 2020 is attached to the revised GHD report. The salinity results provided by Douglas Partners were correlated with the EM survey also carried out by Douglas Partners in 2019.

The investigation confirmed that the salinity distribution and salinity class based on EC values at 0.5m and 1.5m obtained in the EM survey of the site was consistent with information from the boreholes. The boreholes also provided salinity levels at greater depths of 3m, 4.5m and 6m. These results indicated a similar distribution of salinity class as obtained in the EM survey.

The results of salinity testing resulted in salinity class of **moderate** to **slight** to **non-saline** and was consistent with the previous mapping provided. This latest information is included in section 3.5 of the GHD report and the Douglas Partners additional fieldwork report is provided in the Appendix.

Impact Modelling

The proposed methodology for impact modelling was discussed at length. The absence of ground water encountered in the geotechnical investigations together with insufficient ground wells and data logging that is publically available in the area provides difficulty in establishing base ground water data for a ground water model to which salinity concentrations can be added. The drought conditions over the past 5 to 10 years also makes data collection with respect to ground water levels and fluctuating difficult.

As such, the proposed analysis model uses simulated surface water and infiltration rates and volumes over a 130-year storm event database to provide indicative ground water volumes contributing to recharge for comparison with existing and post developed conditions. This was carried out for the total catchment and smaller catchments.

The results of this modelling indicated that the increase in total water runoff post development for both surface and infiltration increases was 1% to 1.4%. Given the water movement is the conduit for mobilising the salts within the ground, and with consideration of the uniform spatial distribution of moderate to slight to non-saline conditions from the geotechnical investigations, the impact was considered low.

The water table in the vicinity of the site was measured during previous investigations at 8m below the ground surface.

Further Impact Modelling

The meeting discussed that following the results of the further field-testing; assessment of further modelling would be considered with peer review input.

It was proposed that using the recent field data at the site and typical values for urbanised areas will provide saline weighted total volumes at the site outlet and the outlet at the highway for percentage increase or decrease comparisons. This is discussed in section 4.3 of the report.

The recent geotechnical information based on Douglas Partners June 2020 report on the site indicates deep clays and confirms low permeability rates of (0.02 m/day).

Ground water was not encountered in the boreholes to 6 m depth across the site during these investigations. This is consistent with previous investigations that indicated water at depths of greater than 8m below the surface.

The additional geotechnical investigation information and proposed analysis using simulated ground water volumes determined from rainfall, infiltration and irrigation rates based on water usage data would form the basis of that analysis. In particular, comparisons of infiltration rates already adopted in the modelling to date would be compared with potential infiltration from landscape watering. The landscape infiltration rates would be based on water usage data to be provided by Council.

Saline weighted water volumes across the catchment for pre and post development assessment based on the simulated water data above will be provided.

As agreed, this approach is to be reviewed and confirmed as an acceptable methodology prior to undertaking the analysis.

The updated report attached outlined this in more detail and together with the additional geotechnical information is provided for review.

Summary

A summary of the key points from the meeting of 11 November is provided below.

1. **Discharge zone/recharge zone.**

   Information on the modelling and recharge from ground watering post development is discussed in section 2 and acknowledges recharge from landscape watering of urbanised areas.

2. **Soil sampling**

   The additional soil sampling locations were agreed and this has been carried out. It is provided in section 3.5 with a copy of the Douglas Partners report is included in the Appendix.

3. **Infiltration.**

   Infiltration potential from potential urbanisation is compared with the decrease in pervious area and potential increase from watering of landscape areas. This has been assessed in section 4. The amount of infiltration adapted in the model will be compared with water usage data to be provided by Council for the existing urbanised areas.

4. **Groundwater**

   The data provided in the report on ground water is all available public data. The absence of groundwater in the geotechnical investigations has also been reported. Investigations in 2012 on an adjacent site revealed ground water at 8m below the surface at that time. Data provided on monitoring wells in the areas of the site showed infrequent and inconsistent monitoring and therefore any fluctuation with ground water overtime could net be determined. The impact model considers potential ground water as a result of low-average or high rainfall and infiltration using 130 years of rainfall data. The infiltration rates will be compared with average water usage data from the urbanised areas. This is discussed in section 4

5. **EM survey**

   Additional testing has been carried out. The results provided by Douglas Partners indicate relative consistent results with the EM survey. The results show moderate to slight to non-saline levels. The proposed lots identified where the salinity is high will be reconfigured to avoid these areas.

6. **Water modelling**

   The water modelling is discussed in sections 3 and 4 of the report and the simulation adopted based on the data available. As discussed in the meeting, the additional modelling methodology was to be agreed by the parties following the additional fieldwork prior to undertaking that modelling. The fieldwork has been provided in section 3.5 and the approach to additional modelling based on those results discussed in section 4

7. **Salinity**

   The salinity impact results will be based on the modelling and will provide a profile of increased impacts as a percentage of the existing conditions and will be based on water recharge rates from urbanisation.

8. Construction

It was agreed that a construction management plan for construction of the subdivision as well as individual dwellings will be a condition of consent

9. Vegetation

A construction management plan will form part of detailed design and construction certification. The requirements of that plan are provided in section 8 of the report. This includes vegetation selection and management. Landscape plans have been provided by others as part of the documentation. A final vegetation management plan would be made a condition of consent.

10. Monitoring

Monitoring and locations of piezometers was provided in section 8.14 of the report. This will be part of the Construction management plan and be a condition of consent.

11. Salinity management

Salinity management measures are provided in the repot. Section 6 of the report outlines the management requirements including construction techniques and materials and salinity management. Section 8 provides more detail for requirement of the construction management plan that will be required as part of detailed design. The geotechnical and stormwater reports provided for the DA provides salinity management measures from stormwater runoff.

Regards

David Sparkes
Technical Director - Structural/Civil Engineering
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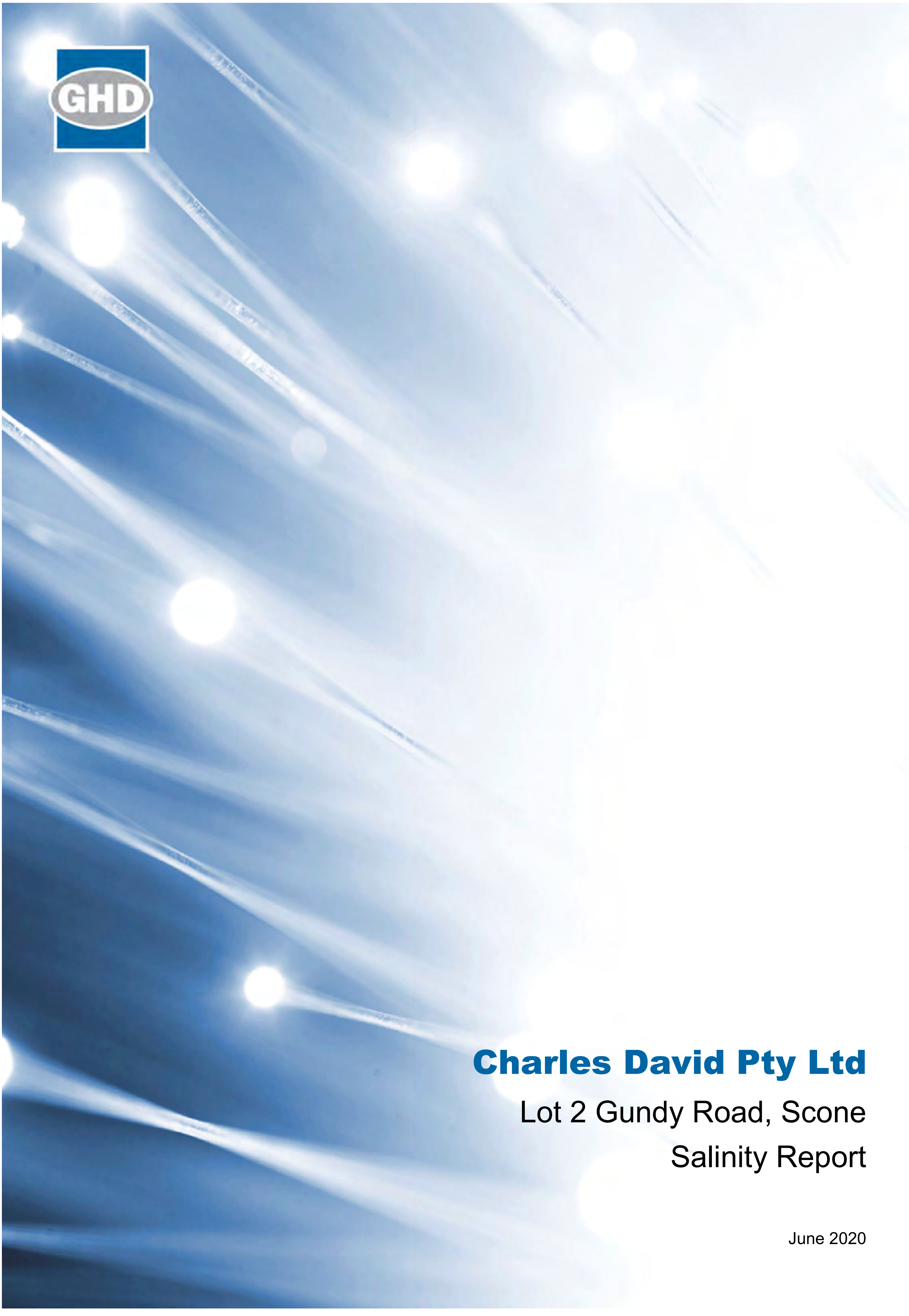
Attachment: Report



Charles David Pty Ltd

Lot 2 Gundy Road, Scone

Salinity Report

June 2020

WATER | ENERGY & RESOURCES | ENVIRONMENT | PROPERTY & BUILDINGS | TRANSPORTATION

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1. Introduction

GHD Pty Ltd (GHD) was commissioned by Charles David Pty Ltd (CD) to undertake a planning level salinity assessment of Lot 2 Gundy Road, Scone of approximately 58 Ha site for a proposed 423 lot subdivision.

The site is currently occupied by pasture land, and is mostly grass covered, with sparse tree growth along the northern edge. A natural drainage line, comprising some gully areas, is located (oriented in an east west direction) in the northern part of the site.

The site is defined by Councils DCP for the St Aubins Estate which has a zoning of RI general residential. The DCP provides constraints and road and lot layouts to be adopted for the development.

Following several meetings with Council and DPI additional site investigations and analysis has been carried out. This has been included in this updated report and revisions shown in italics for easy reference.

This report has been based on previous works carried out by GHD near the site as well as the following documents provided by CD:

- Proposed Site Masterplan.
- Councils DCP for the subdivision.
- Valley Civil Lab, Lot 2 Gundy Road Scone NSW Geotechnical Assessment Report P1303-R-001-Rev0, November 2017.
- Barker Ryan Stewart Stormwater Quality Report, 2471 New England Highway and Gundy Road Scone, November 2017.
- Geotechnical investigations for the adjacent Aged care site by Valley Geotechnical and GHD.
- EM survey of the site by Douglas Partners.
- *Salinity field testing across the site by Douglas Partners report 86959.01 dated June 2020*

1.1 Objectives

The objectives of this salinity assessment were to:

- Provide a preliminary model of the salinity related characteristics and constraints within the site.
- *The model is to be agreed in principle by DPI and Council then the results adopted.*
- Provide a description of the impact of the development on the salinity processes and of the salinity processes on the proposed development.
- Develop salinity management measures pertinent to the site and the proposed development.

GHD were engaged for the adjacent aged care site developed in 2014. This included geotechnical Investigations and salinity management report which was accepted by Upper Hunter Shire Council and Department of Industry.

1.2 Summary of study results

The findings of this planning level report indicate that there does not appear to be any major underlying salinity issues that would prevent development of the site with the approved DCP.

The following generalised salinity characteristics have been identified:

- The presence of soils recording a wide range of salinity concentrations, from non-saline to very saline.
- The site consists of predominately low salinity levels except for the area of the existing drainage gully.

These characteristics and the associated salinity constraints are presented and discussed within the Report.

Supplementary monitoring of water level depth/quality is anticipated for more detailed salinity management measures to be incorporated into the final design.

Provided the site is developed in accordance with the salinity management measures herein, there is expected to be low risk to adverse salinity affects downstream of the development.

1.3 Limitations

This Salinity Report (Report) :

1. Has been prepared by GHD Pty Ltd for Charles David Pty Ltd
2. May only be used and relied on by Charles David Pty Ltd
3. Must not be copied to, used by, or relied on by any person other than Charles David Pty Ltd without the prior written consent of GHD
4. May only be used for the purpose of salinity assessment and management (and must not be used for any other purpose)

GHD and its servants, employees and officers otherwise expressly disclaim responsibility to any person other than Charles David Pty Ltd arising from or in connection with this Report.

To the maximum extent permitted by law, all implied warranties and conditions in relation to the services provided by GHD and the Report are excluded unless they are expressly stated to apply in this Report.

The services undertaken by GHD in connection with preparing this Report:

- Were limited to those specifically detailed in section in this Report;
- Did not include GHD undertaking any testing specifically related to salinity, but has relied on previous salinity test data supplied to us

The opinions, conclusions and any recommendations in this Report are based on assumptions made by GHD when undertaking services and preparing the Report, including but not limited to:

- The data supplied to us is accurate
- The water levels measured during the site investigations are reasonably representative of the groundwater level across the site

GHD expressly disclaims responsibility for any error in, or omission from, this Report arising from or in connection with any of the Assumptions being incorrect.

Subject to the paragraphs in this section of the Report, the opinions, conclusions and any recommendations in this Report are based on reported conditions encountered and information reviewed at the time of preparation and may be relied on until [30/12/2019], after which time, GHD expressly disclaims responsibility for any error in, or omission from, this Report arising from or in connection with those opinions, conclusions and any recommendations.

2. Site setting

2.1 Description

The proposed site covers approximately 58 ha and is located on the southern side of Gundy Road, approximately 1 km from the intersection with the New England Highway at Scone NSW (refer to Figure 1 in the Appendix).

A 423 lot residential subdivision is proposed on the site with construction in 16 stages. Stages 1 to 3 are located on the northern side of a natural drainage line and stages 4 to 16 located on the southern side of the drainage line. The proposed road and lot layouts are in accordance with Councils approved DCP for the development.

The existing site is mostly grass covered and with sparse trees along the northern edge. A natural drainage line, comprising some gully areas, is located (oriented in an east west direction) along the northern edge. Site levels gently slope towards the north, at approximately 2 to 3 degrees.

2.2 Geology

Reference to the ‘Hunter Coalfield Geology’ 1:100 000 Geological Series Sheet (1993) covering the region shows that the site is underlain by bedrock of the late Permian Jerrys Plains Subgroup, of the Wittingham Coal Measures of the Singleton Supergroup, comprising coal seams, claystone, tuff, siltstone, sandstone and conglomerate formed in an upper delta plain or lower delta plain river environment. The site is close to the Hunter Thrust (to the east), which resulted in Carboniferous tuff and ignimbrite interbedded with conglomerate, sandstone and shale to the east of the thrust.

2.3 Soil landscape

Reference to the Singleton Soil Landscape Map indicates the site is covered by the Hunter (hu) soil landscape unit, which is characterised by alluvial plains and terraces of the Hunter River and its tributaries, featuring brown clays and black earths with reliefs up to 10 m and slope angles up to about 3%.

The site is located adjacent to the boundary with the Dartbrook (db) and Segenhoe (sg) soil landscapes. The Dartbrook unit comprises of calcareous shale and sandstone, and alluvium on smooth undulating rises and low hills with reliefs between 30-80 m and slope angles ranging between 3-6%. The Segenhoe unit features undifferentiated carboniferous sediments and Tertiary basalt colluvium and alluvium with undulating to rolling hills, reliefs up to 200 m and slope angles between 6-25%.

2.4 Catchment

The site is located at the south boundary to the Parsons Gully catchment (Refer Figure 2-1). The Parsons Gully catchment comprises some 3600 Ha which drains downstream near the Scone Golf Course. The site is located at the edge of the catchment discharge zone which includes the Scone High School, Strathearn Village and the and the New England Highway, Rail line and Zone Substation.

The catchment recharge zone, upstream of the site, consists of grass covered farm lands and tree covered topography.

Figure 2-2 below shows the site in relation to the topography and known ground water levels.

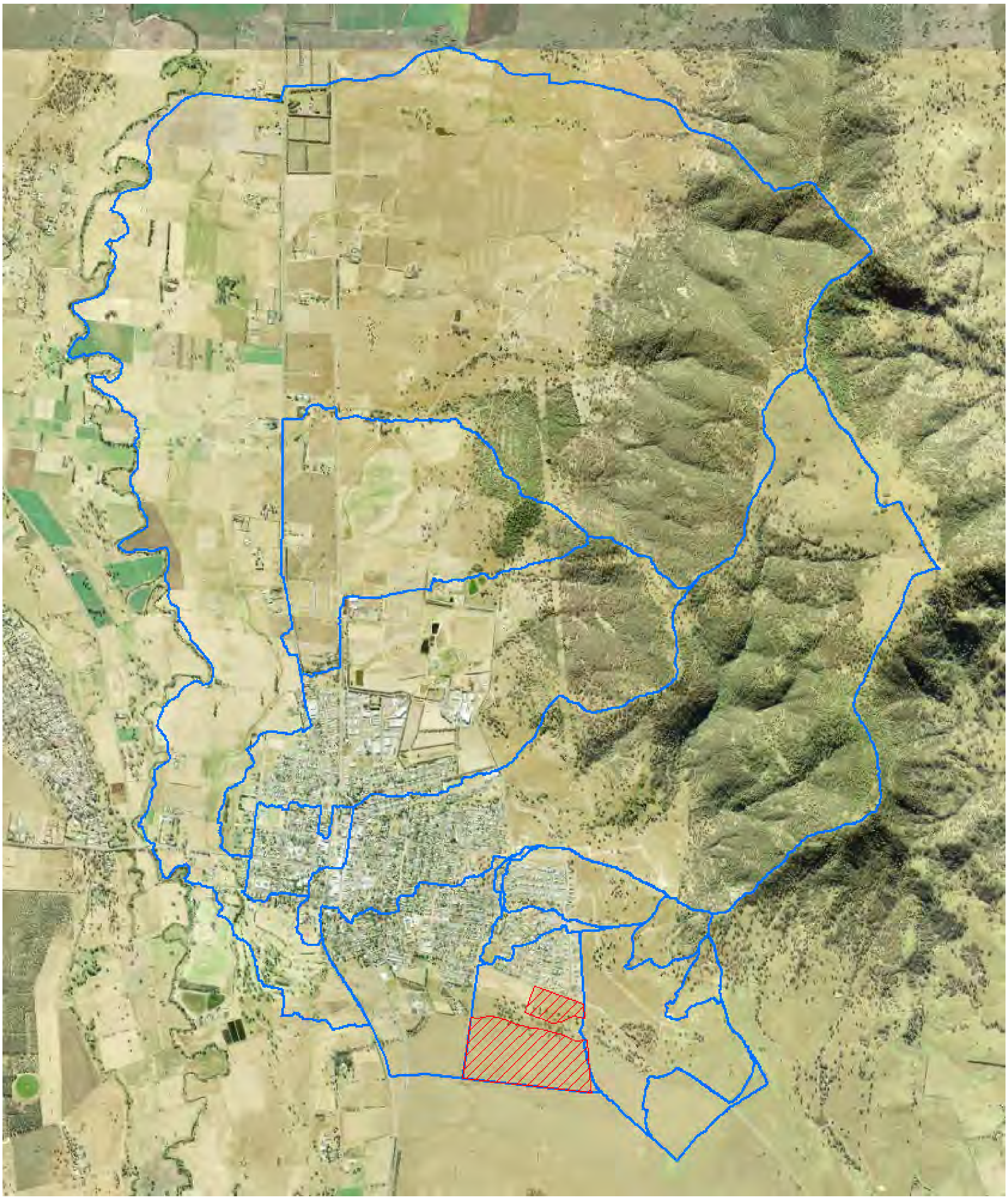


Figure 2-1 Catchment Plan

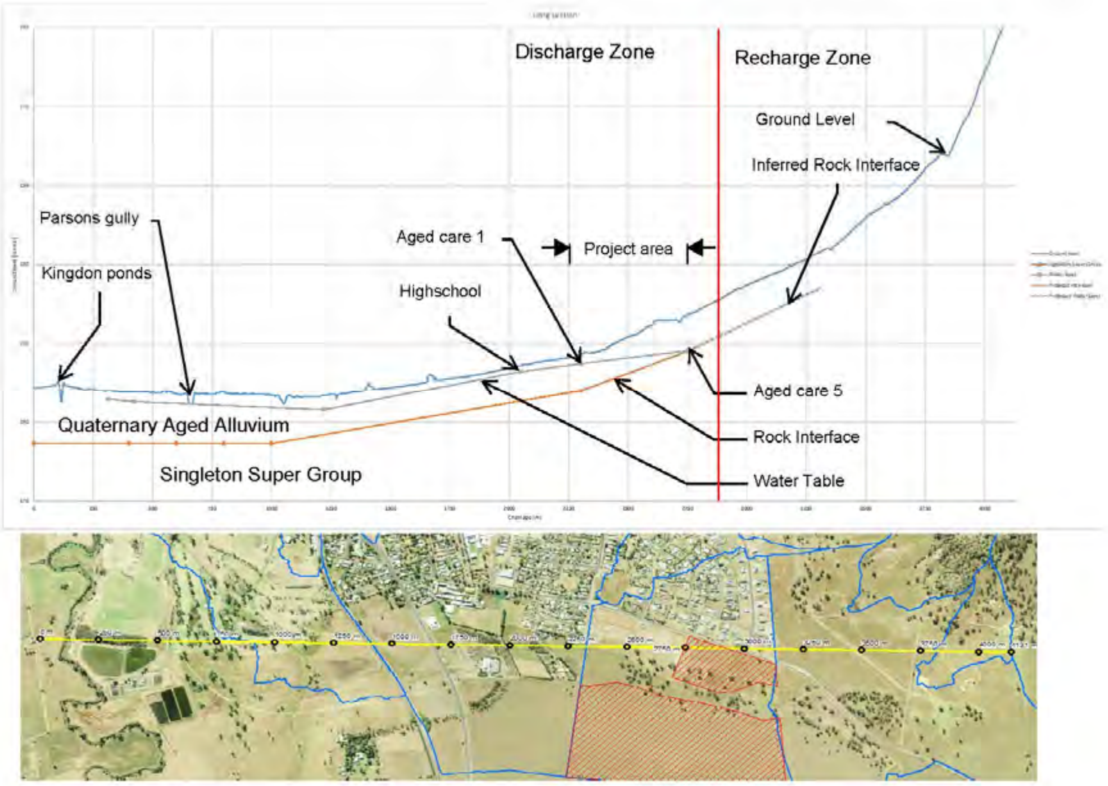


Figure 2-2 Local topography detail

2.5 Salinity potential

The Hunter River catchment, which the proposed development lies within is a recognised Dryland salinity zone. The existing site is located in the lower landscape of the local land form and consists of residual clays, overlying weathered rock. The depth of clays varies from 1 m to 3 m as shown in the Valley Civil Geotechnical Report. The geotechnical report fieldwork did not identify ground water within the depth of their investigation.

Reference to GHD geotechnical report carried out on the adjacent downstream property showed ground water at depth of 8 m at the time of the investigation at the interface with bedrock. Figure 2-2 above shows the water table from these investigations.

2.6 Preliminary model of salinity process

The site sits within the lower discharge area of an inland dryland salinity zone. Salt from rainwater infiltrate into the soils which are dispersive in nature and when subject to water infiltration from either rising ground water or stormwater runoff causes the salts to migrate within the ground water to lower parts of the catchment.

The existing landscape is within a bowl formation where infiltration of water in the upper catchment occurs from rain events. Based on geotechnical investigations and existing data from local piezometers and ground wells, the ground water at the site is deep seated at depth of 8 m.

The regional schematic below shows deep ground water from recharge further up the catchment at the bedrock interface with weathered rock. The site area is within the existing discharge zone of the catchment. Recharge to the area is from the upper catchment and can cause the deep seated ground water to vary in level, rising in wet periods. Recharge of ground water from landscape watering of urbanised areas can also occur.

The site soils consist of up to 6 m of very stiff clays of very low permeability that will limit any effects form surface water entering into the deep seated ground water as well as ground water rising beneath the site. Figure 2-2 shows the site in relation to the discharge zone.

The management of salinity for the proposed development will need to include management during construction as well as longer term management following development.

A construction management plan for construction approval will need to be prepared. During construction, any exposed soils will be stockpiled and covered to prevent salts leaching out and running off with surface water. Runoff will be collected and managed so that water is allowed to evaporate and remaining salts collected and disposed.

Post development, stormwater runoff management is described in the report by Barker Ryan Stewart. Water from impermeable roof and roadways will be collected and managed as part of Councils water quality management plan, this includes management of gross pollutants as well as bio-management of nutrients. The stormwater runoff management includes impermeable lined retention basins to ensure water does not infiltrate into the surrounding basin area (refer Section 2.4.2 of Barker report). the stormwater reports includes provision of onsite detention measures, isolated from any ground water, so that post development runoff rates match the existing runoff rates.

Stormwater infiltration to previous vegetation areas will be consistent with existing infiltration conditions. The existing residual soils will be covered with topsoil and vegetated to prevent erosion of topsoil and vegetated to prevent erosion of the topsoil. The top 200 mm of the residual soils will be treated with gypsum to enhance vegetation growth and stabilise the upper dispersive soils. The vegetation selected shall be drought tolerant species that do not require excessive watering. In ground drainage will capture excessive infiltration and be directed to the stormwater management systems.

The depth of the existing low permeability clays at the site (6 m) will limit any surface water infiltrating into the ground water. Additionally into the ground water. Additionally these clays will limit rising deep seated ground water.

3. Salinity investigation results

The following salinity investigations have been carried out by Valley Civil Lab as presented in their geotechnical report (P1303-R-001-Rev 0) dated November 2017, for the development.

3.1 Salinity readings - soil

The following is an extract from Valley Civil Lab's report:

"Salinity refers to the presence of excess salt in the soil which can be harmful to plants and restrict plant growth. The salinity of a soil is determined by the Electrical Conductivity (EC). Because salt separates into positively and negatively charges ions when dissolved in water, The EC of the water increased as salt increases. To determine the salinity of the soil, the EC is multiplied by a soil texture conversion factor to determine the final figure know and the Extract Electrical conductivity (ECe)

The salinity classes for soil (Taylor, Dryland Salinity, DLWC 1996) are as shown in Table 3-1 below.

Table 3-1 Soil Salinity Classes

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

The equivalent conductivity (ECe) readings recorded by Valley Civil Lab in their geotechnical investigation are presented in Table 3-2.

Table 3-2 Salinity Readings (Valley Civilab)

Bore hole	Sample Depth (m)	Extract Conductivity ECe (dS/m)	Material
BH8	0.5-0.6	*3.675*	Medium CLAY
	1.0-1.1	*3.332*	Medium CLAY
	1.2-1.3	*2.800*	Medium CLAY
BH12	0.1-0.2	*1.344*	Light Medium CLAY
	1.0-1.1	*2.538*	Clay Loam
	1.5-1.6	*10.080*	Medium CLAY
BH13	0.6-0.7	*6.097*	Medium CLAY
	1.0-1.1	*5.824*	Medium CLAY
	1.5-1.6	*4.046*	Medium CLAY
BH17	0.5-0.7	*1.664*	Light Medium CLAY
	1.5-1.8	*3.324*	Light CLAY
	2.0-3.0	*3.304*	Light Medium CLAY

The following comments are made on the results shown in Table 2 above:

- Clay with silt and sandy clay alluvium was recorded in the test holes.
- The recorded salinity concentrations varied with depth, but generally increased from near surface to about 1.0-1.5 m depth, then recorded a small decrease below about 1.5 m depths except for BH12 which was located in low part of the natural drainage line.
- The site soils recorded mainly slightly and moderately saline conditions.
- Very saline conditions were recorded in investigation holes in the lower (North western) corner of the proposed site corresponding with the low part of the natural drainage line..

3.2 Groundwater level readings

We note that ground water was not encountered within the depth of the geotechnical investigation. We have included levels from a geotechnical investigation carried out by GHD in 2012 for the adjacent site in Table 3 below.

Table 3-3 Groundwater Level Readings – GHD Geotechnical Investigation 2012

Borehole	Borehole depth (m)	Groundwater depth below ground surface (m)	Material
GHDBH1	9.2	8.9	BASALT
GHDBH2	9.2	7.9	CLAY

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

- Groundwater levels recorded during the GHD investigation period were at depths ranging from 7.9 to 8.9 m below the existing ground surface.
- The groundwater was observed to be at the interface of the very stiff to hard residual clay and extremely weathered basalt strata.
- Long term groundwater monitoring should be conducted, in order to verify the depths to groundwater recorded during the investigation.

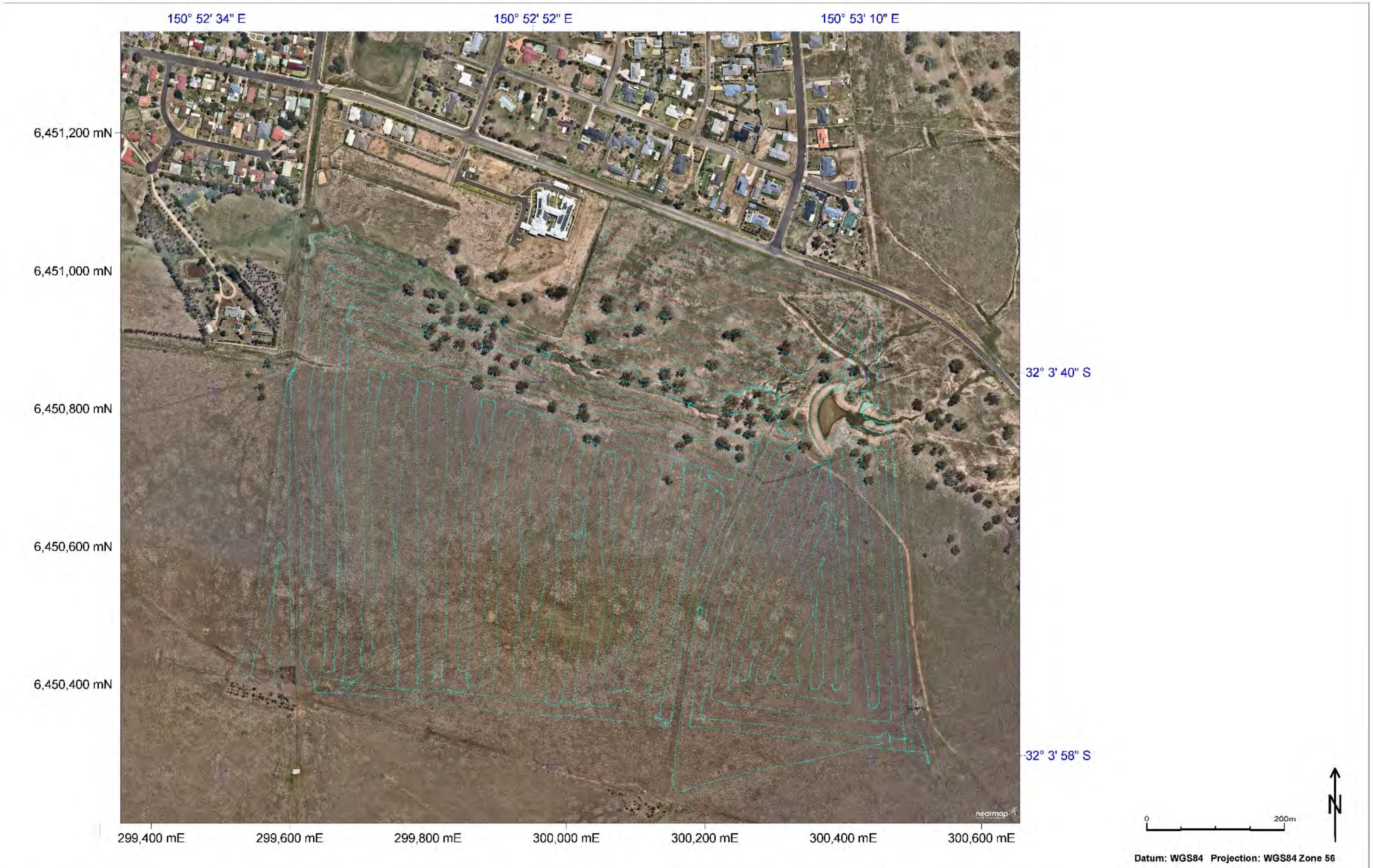
3.3 Water and salinity results from existing bores

During recent projects, a requirement of the development approval was for the installation of bores so that monitoring of ground water and levels of salinity could be obtaining. During the construction of the adjacent aged care facility, this was required. Bores also exist downstream at the High School and Golf Club.

Council has provided some of the data from these bores in recent years. This information together with recent geotechnical investigations provide the indicative ground water table levels shown in Figure 2-2 above.

3.4 EM Survey

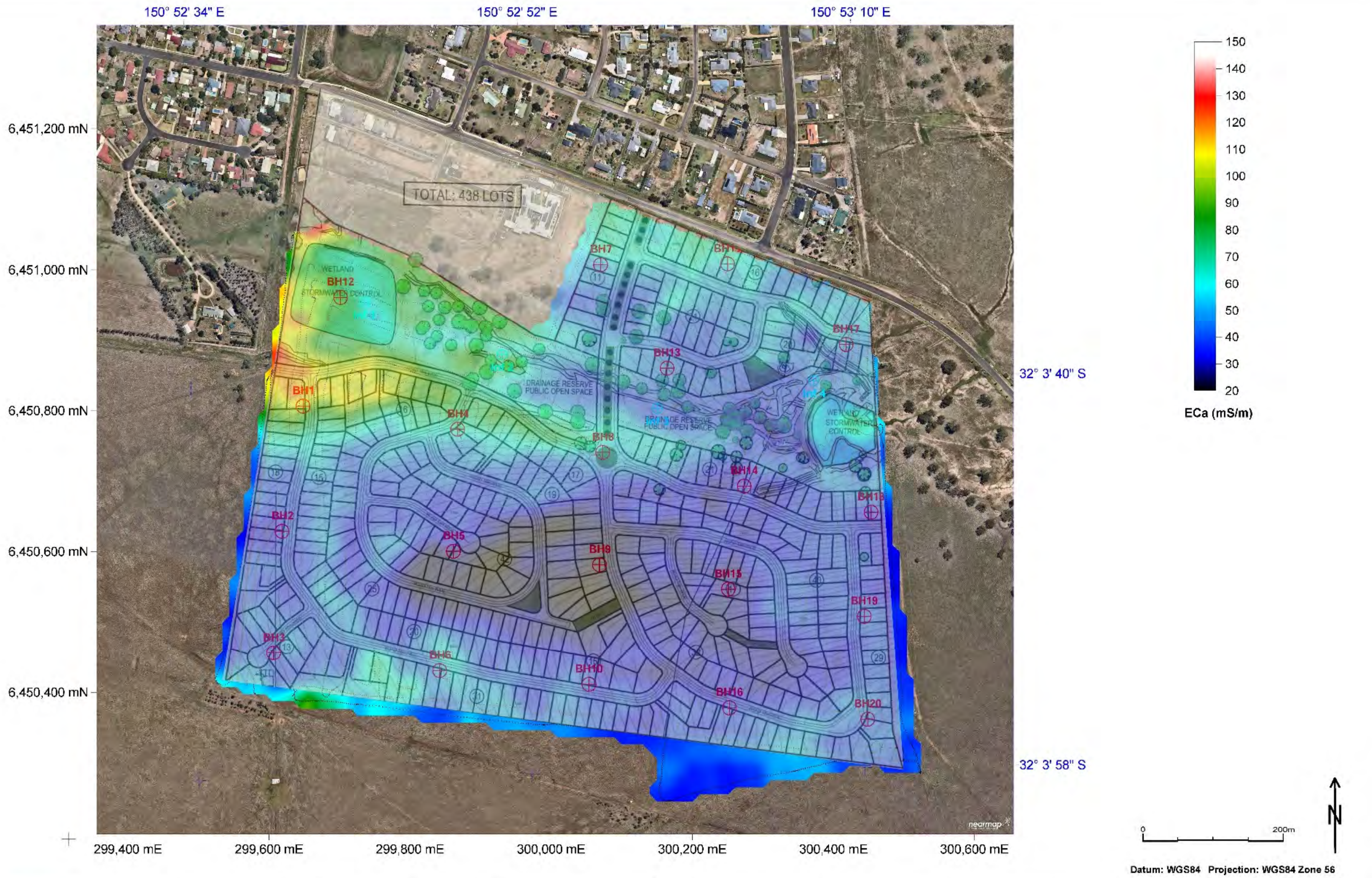
An EM survey of the site was carried out to assess the spatial condition of salinity. Images of EM conductivity maps are shown below. These are superimposed with the proposed development lot layout.



Douglas Partners
Geotechnics | Environment | Groundwater

CLIENT: GHD Pty Ltd
OFFICE: Sydney
SCALE: as shown
DRAWN BY: AJK
DATE: 18 Oct 2019
TITLE: Apparent Electrical Conductivity (ECa) - Survey Path
Geophysical Electromagnetic (EM) Survey
Scone, NSW
PROJECT No: 86959.00
DRAWING No: 1
REVISION: A

Figure 3-1 Path of survey



Douglas Partners
Geotechnics | Environment | Groundwater

CLIENT:	GHD Pty Ltd		
OFFICE:	Sydney	DRAWN BY:	AJK
SCALE:	as shown	DATE:	18 Oct 2019

TITLE:
Apparent Electrical Conductivity (ECa) - 2H coplanar coils
Geophysical Electromagnetic (EM) Survey - Path
Scone, NSW

PROJECT No:	86959.00
DRAWING No:	2
REVISION:	A

Figure 3-2 Conductivity at 0.5 m

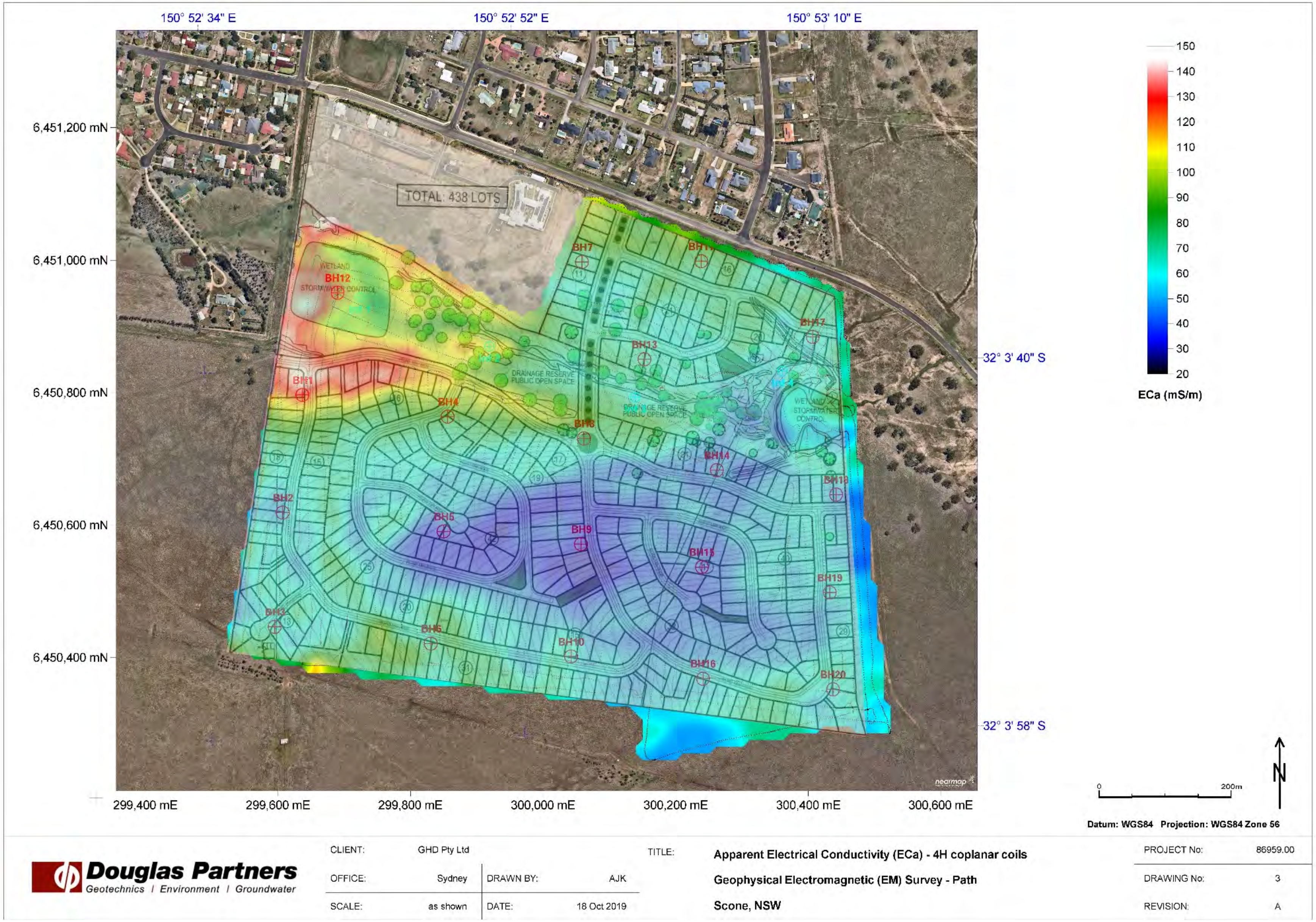


Figure 3-3 Conductivity at 1.5 m

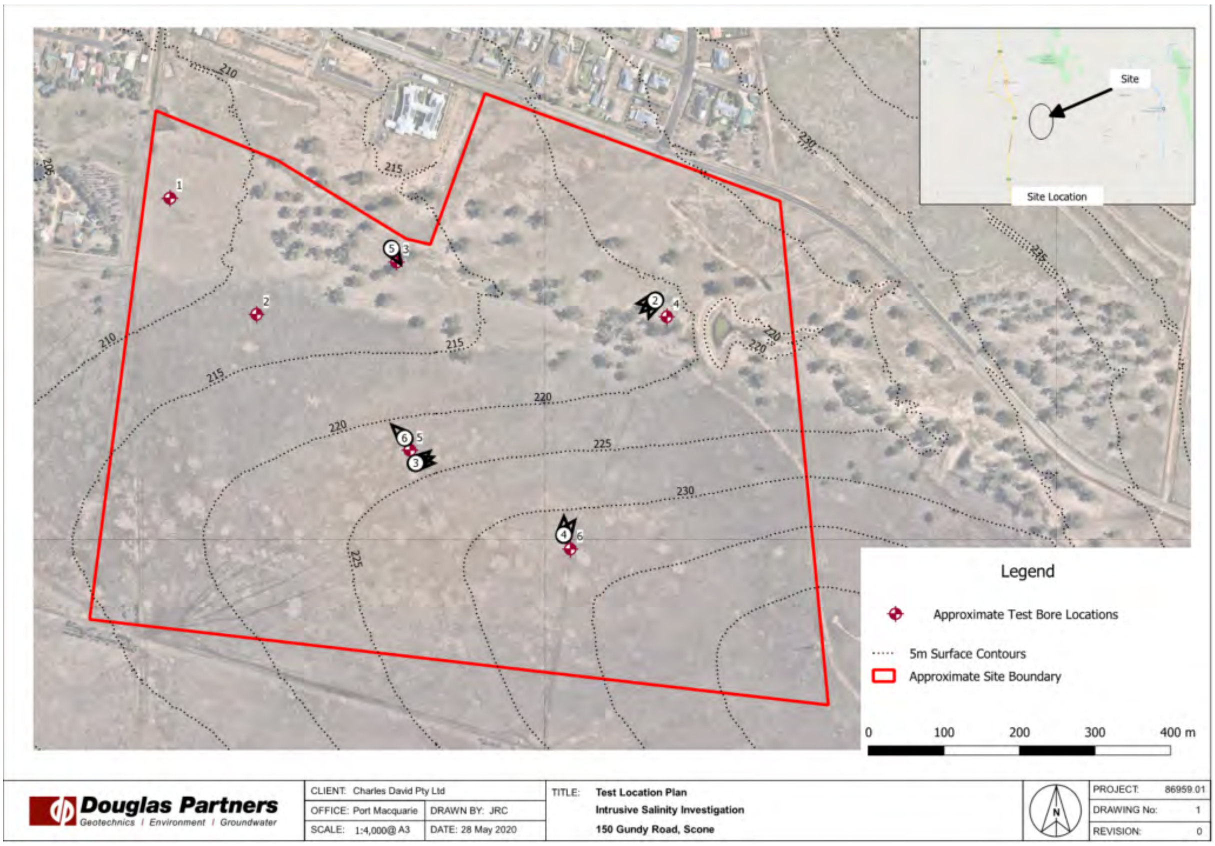
The survey shows that the site has low salinity with the top 1.5 m across the proposed development area. A local area of high salinity is located within the low natural drainage area that traverses the site as measured in the Valley Civil geotechnical investigation.

3.5 Detailed Salinity Survey and Boreholes

Following discussions with Council, it was agreed that further at depth survey of salinity be carried out to confirm the spatial distribution indicated from the EM survey results.

Douglas Partners carried out this work and a full copy of their report is provided in the Appendix.

The location of the site testing was agreed in the meeting with Council and is shown below.



Results of the testing is provided in the table below. Douglas reviewed these test results with their EM survey results for calibration and confirmed the ECa results above are consistent with the measured results. As such the Salinity classification is consistent for both sets of results.

The results show consistancy with the high localised salinity areas near the existing dam and site outlet and ***moderate*** *to* ***slight*** *to* ***non-saline*** *in the remainder of the site. The moderate classification provided I the results has ECe values of 4 and therefore were at the low end of the moderate class and the high end og the slightly saline class.*

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Table 2: Results of salinity laboratory testing

Bore	Depth	Description	pH	EC (µs/cm)	CEC (ppm)	ESP (%)	Texture[1]	Salinity Class[2]
1	0.5	Clay: brown	8.3	175	-	-	-	-
1	1.0-1.15	Clay: brown	8.0	1954	-	-	-	-
1	2.0	Clay: brown	7.9	1592	-	-	-	-
1	3.0	Clay: brown	8.3	529	-	-	-	-
1	4.0	Clay: brown	8.3	493	-	-	-	-
1	5.0	Clay: brown	8.7	450	-	-	-	-
1	6.0	Clay: brown	-	470	37	4	Light Clay	Moderate
2	0.05	Topsoil: brown silty clay	7.4	171	-	-	-	-
2	0.5	Clay: brown	8.0	319	-	-	-	-
2	1.0-1.45	Sandy Clay: grey white	8.0	1956	-	-	-	-
2	2.0	Sandy Clay: grey white	8.1	1763	-	-	-	-
2	2.5-2.95	Silty Clay: red brown	7.7	1806	-	-	-	-
2	3.5	Silty Clay: red brown	8.1	1348	-	-	-	-
2	4.0-4.45	Silty Clay: red brown	-	670	93	5	Medium Clay	Moderate
2	5.5-5.95	Silty Clay: red brown	8.1	736	-	-	-	-
3	0.5	Sandy Clay: brown	8.0	127	-	-	-	-
3	1.0	Sandy Clay: brown	8.4	109	-	-	-	-
3	2.0	Sandy Clay: brown	8.2	319	-	-	-	-
3	3.0	Sandy Clay: brown	-	250	38	1	Light Medium Clay	Slight

Factual Investigation, Intrusive Salinity Investigation
150 Gundy Road, Scone

89959.01.R.001.Rev0
June 2020

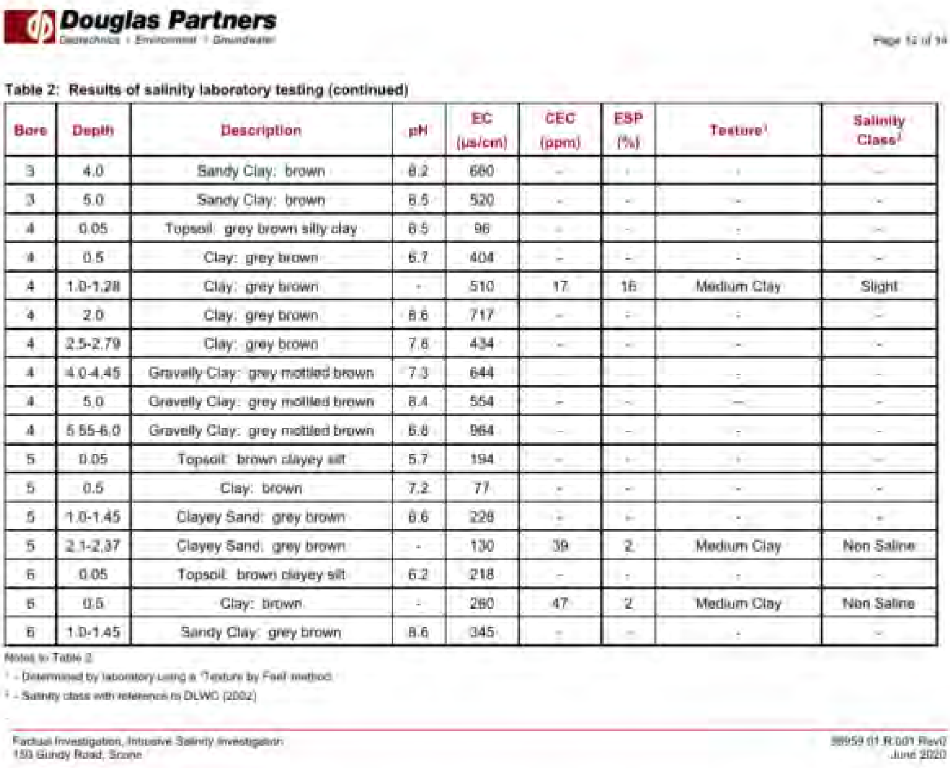

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Table 2: Results of salinity laboratory testing (continued)

Bore	Depth	Description	pH	EC (µs/cm)	CEC (ppm)	ESP (%)	Texture[1]	Salinity Class[2]
3	4.0	Sandy Clay: brown	8.2	680	-	-	-	-
3	5.0	Sandy Clay: brown	8.5	520	-	-	-	-
4	0.05	Topsoil: grey brown silty clay	8.5	96	-	-	-	-
4	0.5	Clay: grey brown	6.7	404	-	-	-	-
4	1.0-1.28	Clay: grey brown	-	510	17	16	Medium Clay	Slight
4	2.0	Clay: grey brown	8.6	717	-	-	-	-
4	2.5-2.79	Clay: grey brown	7.6	434	-	-	-	-
4	4.0-4.45	Gravelly Clay: grey mottled brown	7.3	644	-	-	-	-
4	5.0	Gravelly Clay: grey mottled brown	8.4	554	-	-	-	-
4	5.55-6.0	Gravelly Clay: grey mottled brown	6.8	964	-	-	-	-
5	0.05	Topsoil: brown clayey silt	5.7	194	-	-	-	-
5	0.5	Clay: brown	7.2	77	-	-	-	-
5	1.0-1.45	Clayey Sand: grey brown	8.6	228	-	-	-	-
5	2.1-2.37	Clayey Sand: grey brown	-	130	39	2	Medium Clay	Non Saline
6	0.05	Topsoil: brown clayey silt	6.2	218	-	-	-	-
6	0.5	Clay: brown	-	260	47	2	Medium Clay	Non Saline
6	1.0-1.45	Sandy Clay: grey brown	8.6	345	-	-	-	-

Notes to Table 2

[1] - Determined by laboratory using a 'Texture by Feel' method

[2] - Salinity class with reference to DLWC (2002)

Factual Investigation, Intrusive Salinity Investigation
150 Gundy Road, Scone

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4. Water balance

4.1 Water model

A Stormwater runoff and ground water model has been carried out to provide context of the proposed development within the catchment.

The site lies within the Parsons Gully sub-catchment of the area. The Parsons Gully catchment drains to the golf course area and includes rural landscape and the urbanised Scone town centre.

The development site is located on the south east fringe of the catchment within the lower landscape and within the catchment discharge zone. The below diagram shows the catchment and the location of the site and extent of proposed residential lots.

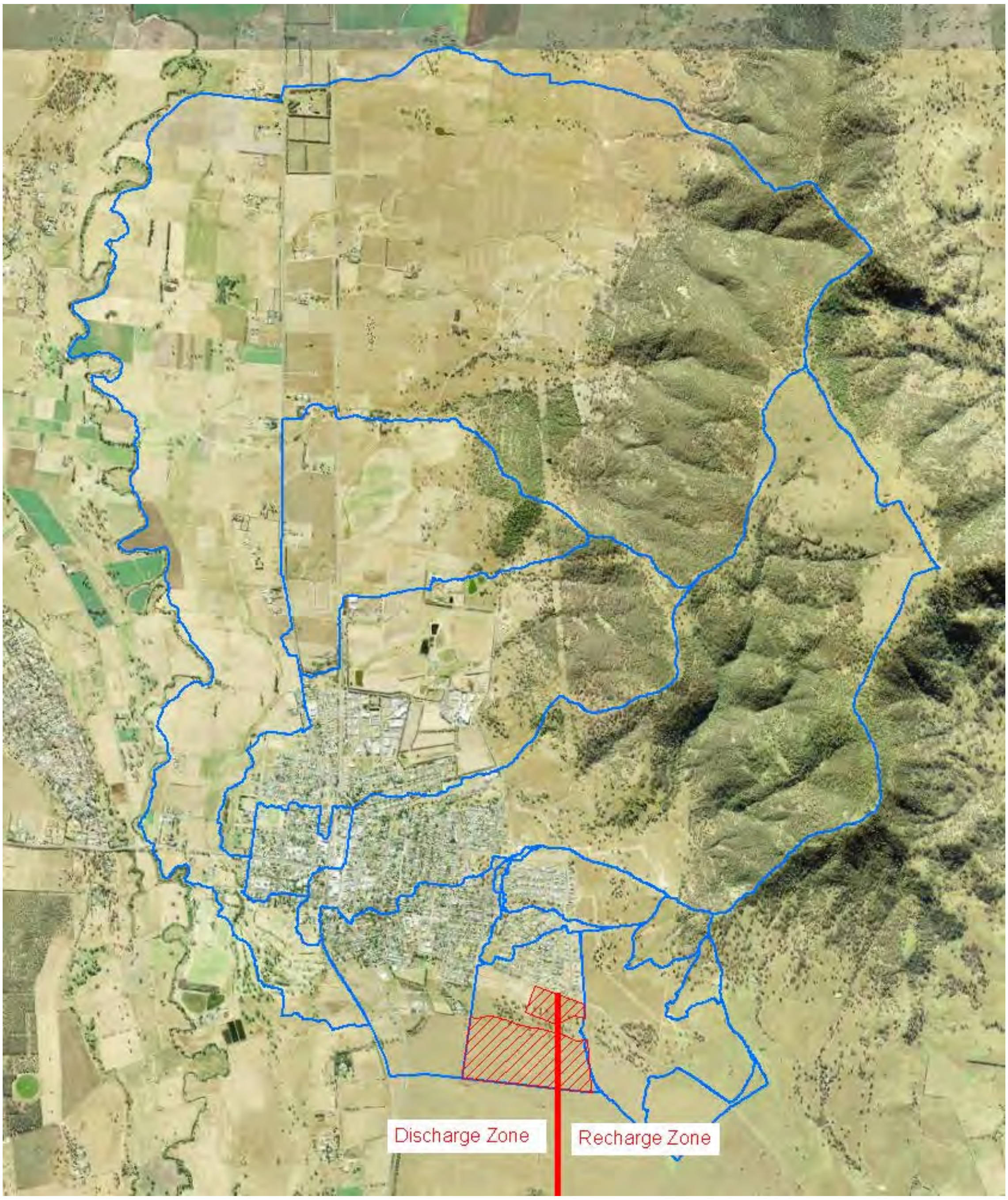


Figure 4-1 Catchment

The modelling has been carried out for the Parsons Gully catchment. Note however that the Kingdom Pond water course runs parallel to Parsons Gully and would also be contributing water to the golf course area and immediate surrounds. The Kingdom Ponds Catchment which has an area of 10-100 times larger than Parsons Gully.

The modelling was carried out for the existing catchment, including the urbanised areas of Scone Township.

The model was then re-run to include the urbanised area of the proposed lots. This included modelling the drainage course through the proposed development and proposed storages.

The modelling sampled the last 130 years of historical rainfall and evaporation at Scone to determine possible runoff outcomes. The model also included simulating ground infiltration.

Results below are for the following:

- 10th percentile = very dry rainfall year
- Mean = average rainfall year
- 90th percentile = very wet rainfall year

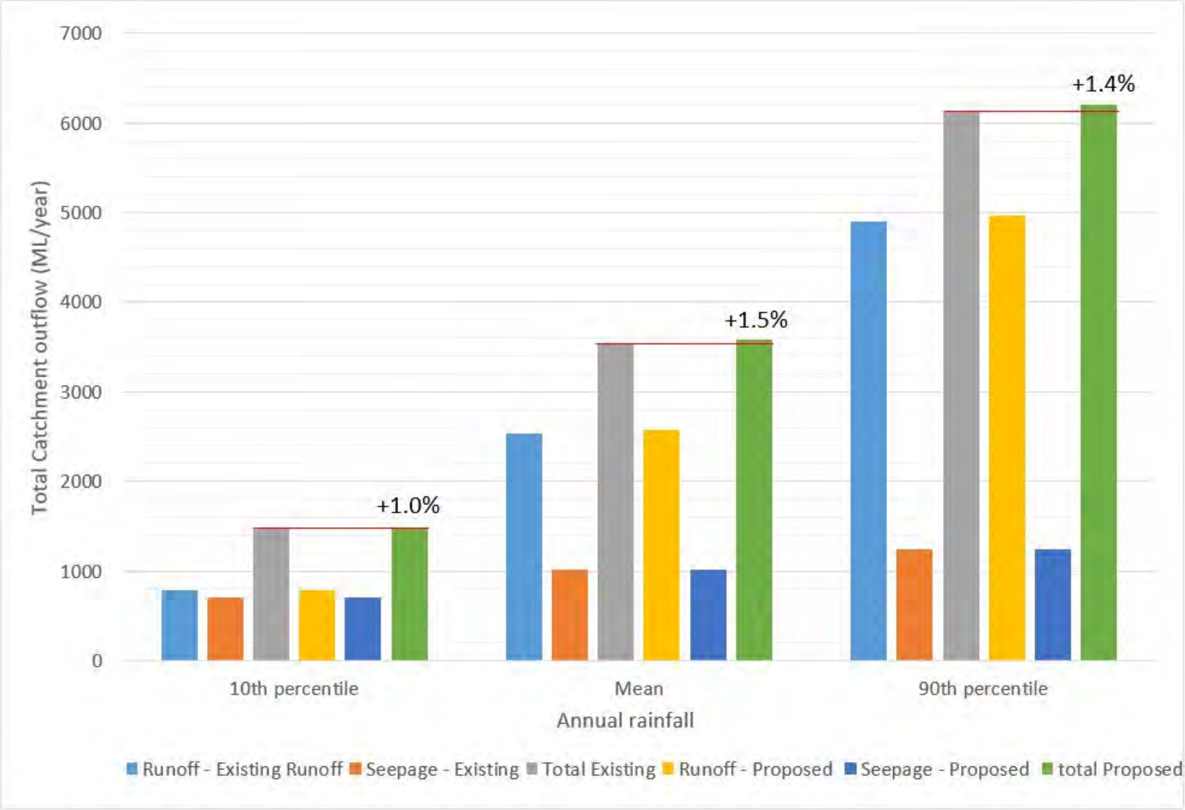


Figure 4-2 Results

As shown above, under all types of rainfall conditions, the proposed land development would only increase total runoff by approximately 1% to 1.5% of existing conditions. As shown, infiltration at the site decreases due to the urbanisation and runoff increases. The total effects however are less than 1.5%. when combined with runoff management control then the urbanisation will have minimal impact to the existing down stream conditions.

If the Kingdom Ponds area was also included which recharges the golf course and highway area then the above results would likely drop to a low fraction of existing conditions.

4.2 Infiltration

Reference to the constant head and falling head permeability tests for the soils at the site shows permeability of the heavy clay soils to be very low at levels of 4 x 10^{-8} m/s.

Other than the top 0.5 m to 1 m of top soil and proposed landscaping as part of the development, deep infiltration through the days will be slow. For comparison, at permeability rate of 2 x 10^{-7} m/s it would take many years for ponded surface water to reach the deep of ground water. Water within the top 1 m of landscape will be subject to transpiration and evaporation to further minimise deep infiltration.

Similarly, recharge to the development site form upper landscape via the ground water table will be low and therefore salinity issues with new construction will be from surface effects of the dwellings. Salinity management strategies as outlined further in the report are to be adopted.

4.3 Proposed refined smaller catchment modelling

Discussions with Council and DPI was carried out to determine an agreed model based on the above information. Separate correspondence dated February 2020 was provided for that proposed modelling and is presented here with further information from that discussion.

4.3.1 Proposed Residential Development Gundy Rd, Scone Salinity Modelling

Further to the meeting with Mr Alan Nicholson (DPI) and Upper Hunter Shire Council it was determined that further localised analysis of the proposed subdivision with respect to salinity impact was required.

It was agreed that a total catchment analysis was not required, but further information based on a localised catchment was of merit This local catchment is shown below.

The meeting determined that a proposed methodology would be provided for agreement in principle by Mr Alan Nicholson prior to carrying out any detailed analysis.

The below outlines the proposed methodology.

4.3.2 Catchment and Sub Catchments

The area of study will be reduced to the catchment shown below. This includes the proposed site as well as the main watercourse and downstream area of infrastructure (Substation and roadway).

Some fringe urbanised areas will be included in this catchment from the adjacent residential subdivisions.

The figure also shows the nominated sub catchments to be modelled. These have been determined based on the local topography, landuse and known salinity data.

The parcel of land for the proposed subdivision has been broken into sub catchments to reflect salinity levels based on recent Ec survey of the site.

4.3.3 Runoff Modelling

Runoff and infiltration modelling to provide surface and groundwater data will be carried out over the catchment for the pre-developed and proposed post developed site. Modelling will be based on rainfall events from previous 130 year data.

4.3.4 Salinity Modelling

One of the min areas of concern is the impact of urbanisation on portential ground water recharge and down stream effects.

The absence of ground water encountered in the geotechnical investigations and insufficient ground wells and data logging publically available in the area provides difficulty in establishing base ground water data for a ground water model to which salinity concentrations can be added.

Water balance by way of surface runoff and infiltration rates can be modelled to estimate the impact of urbanisation over the existing site and increase in infiltration from rainfall events or from irrigation of gardens and lawns. This is balanced with impervious areas created from roofs of buildings and hardstand road pavements where runoff from these areas will be collected and managed in the drainage system, detention and salinity collection basins at the outlet of the site.

Infiltration volumnes will also be compared with known water usage data on adjacent residential areas. The more conservative volumes will be used.

Salinity modelling will be based on the potential concentrations of salinity within the site from the fieldwork conducted to date. Saline weighted Infiltration rates from rainfall or irrigation will be compared with pre-exiting conditions to determine percentage changes.

4.3.4.1 Undeveloped – All rain events

Salinity values in the model will be based on typical values for urbanised areas for the existing residential areas and the current data for the proposed site and the specific High school and Aged Care site. Data from detailed site investigation carried out will also be used.

Surface runoff and ground water volumes at the outlet of the subdivision and the Highway will be assessed for weighted salinity and this used as the base case.

The salinity levels will be based on 1m soil horizons across the proposed site using average salinity levels for each of those horizons from the field date obtained by Douglas Partners.

4.3.4.2 Developed – All rain events

Developed simulation will be carried out with the proposed development complete. The developed area will include typical urban values from roofs and roads within the sub catchments as well as the site data for the landscaped areas.

Surface runoff and groundwater volumes will be assessed for weighted salinity and compared with the base case.

4.3.4.3 Dry Conditions – Simulation

A third analysis will be carried out assuming drought conditions. The simulation will include infiltration quantities of water likely to be used in the landscaped areas of the urban catchment from watering during dry conditions. This will be based on historical data of water usage from the adjacent residential areas.

Surface and groundwater volumes will be analysed and compared with the base case.

4.3.4.4 General Calibration

The modelling to be used will allow catchment and sub catchment results to be determined. The initial setup for the model will use the known available salinity data from the previous studies at the golf course at the bottom of the catchment to calibrate the model to existing conditions.

The model will allow indicative salinity levels to be input for each sub catchment and a salinity balance will be presented.

For ground water the model will consider infiltration form rainnfall events as well as infiltration from garden watering. The data for garden watering will be obtained by adopting average Council Water usage data for the adjacent existing residential areas and allowing and agreed percentage of that usage for simulating garden watering as mentioned above.

The results of the analysis will be provided with comment on the likely impact of the proposed development with respect to potential percentage increased salinity.

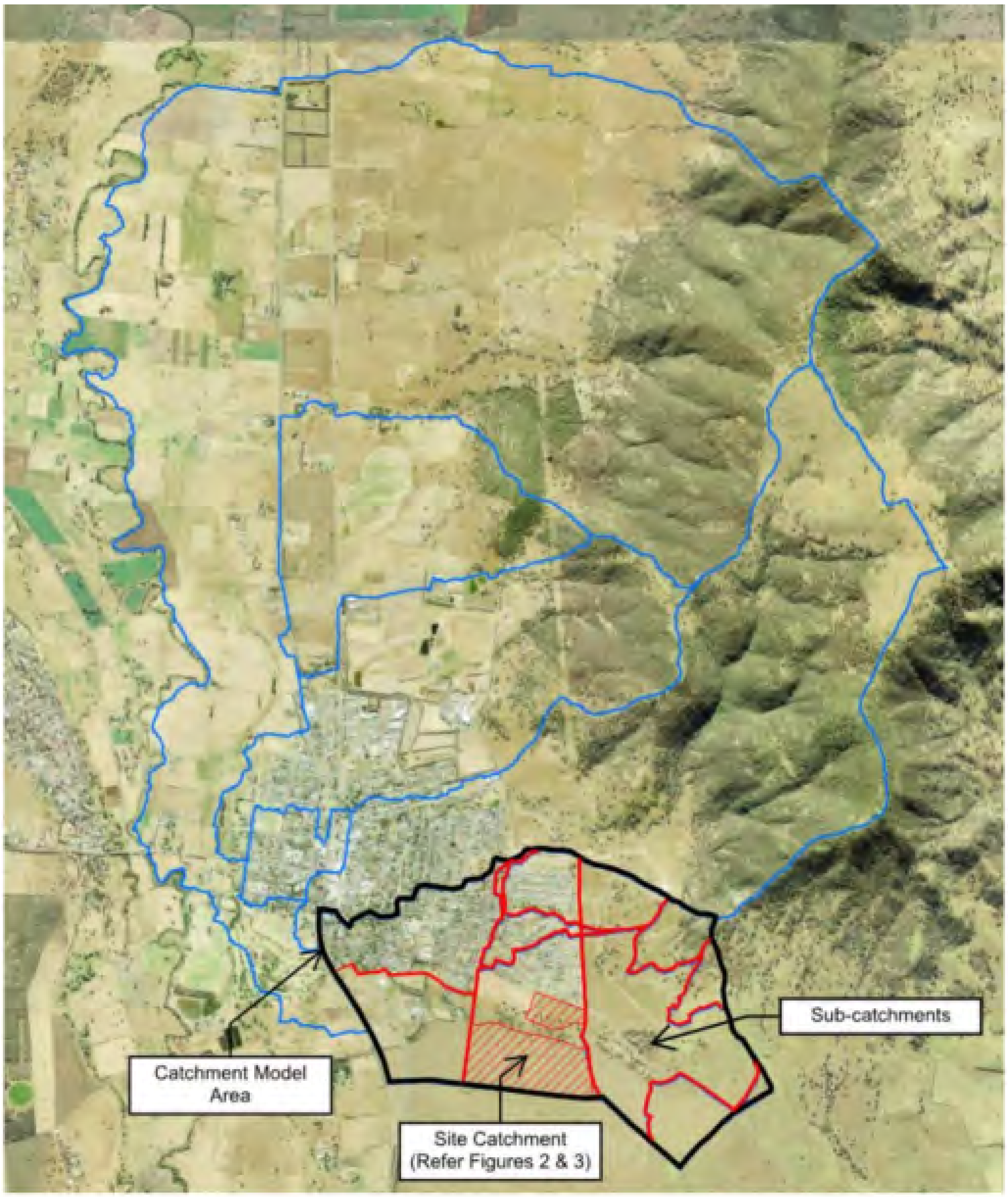


Figure 1 – Catchment Areas

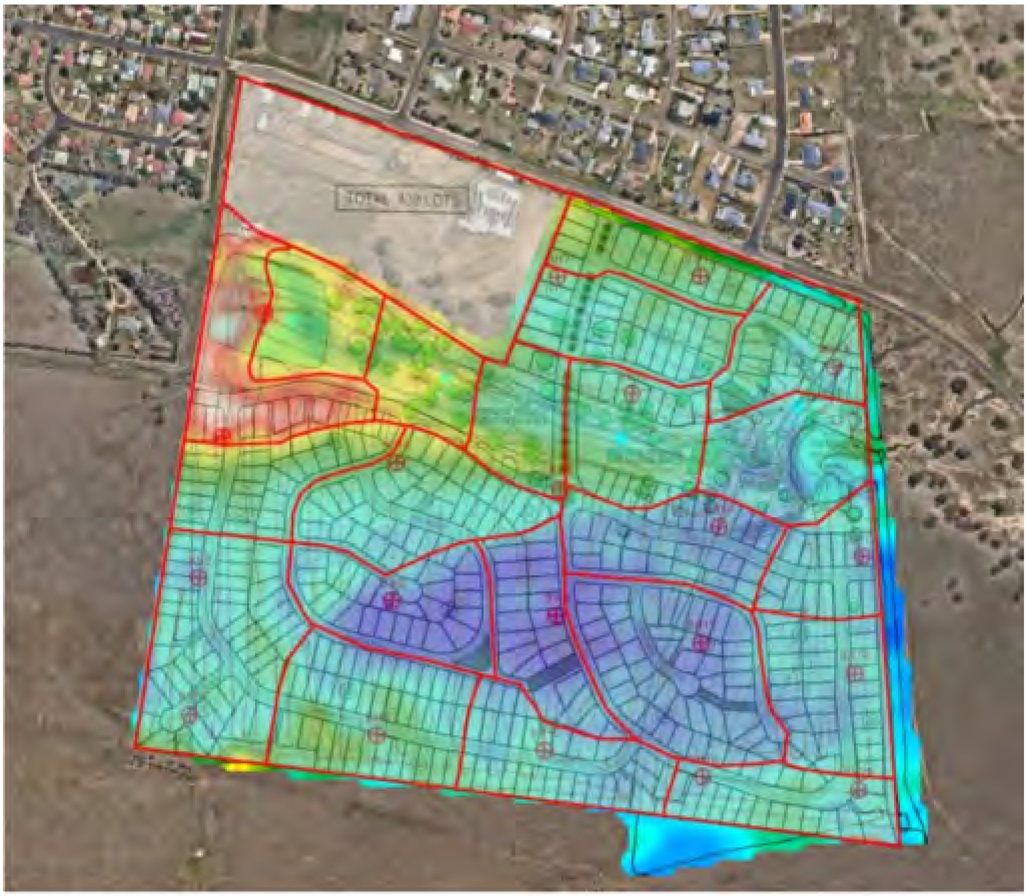


Figure 2 – Sub-catchments 1

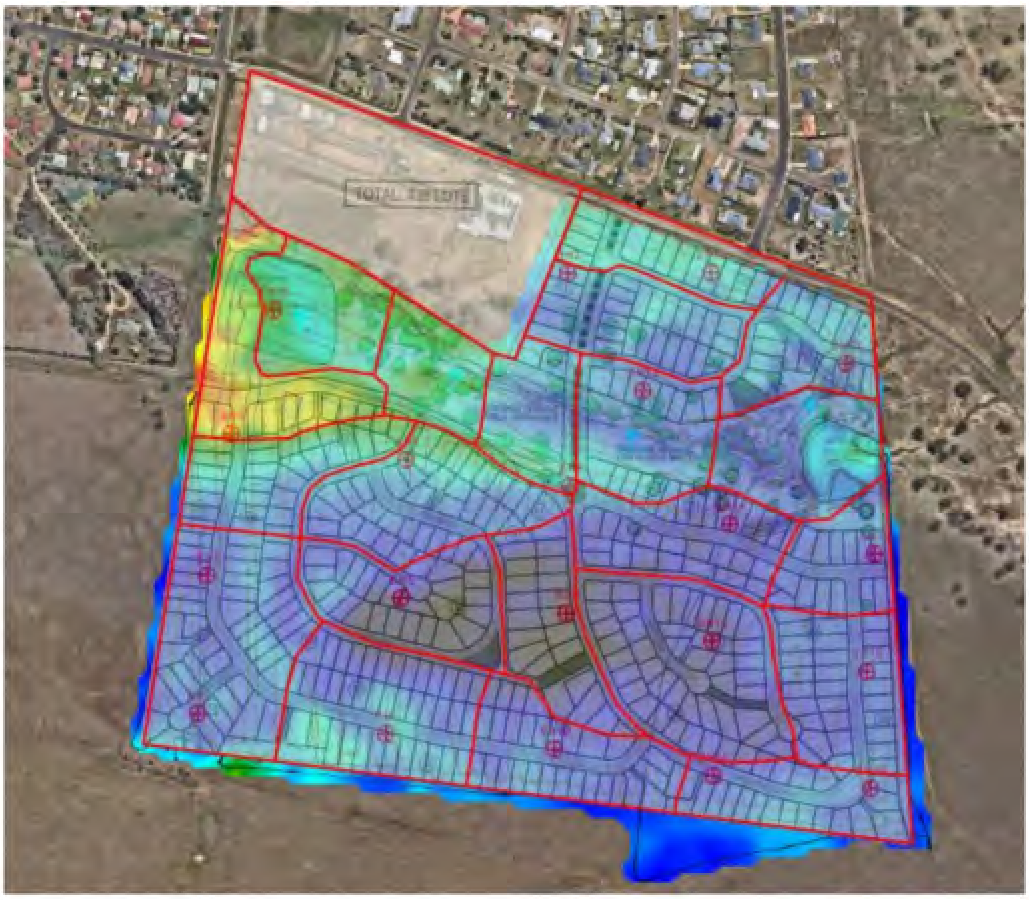


Figure 3 – Sub-catchments 2

5. Discussion

5.1 General

The soils conductivity (ECe) results confirm the ‘Dryland Salinity’ nature of the site, and the requirement to provide salinity management resources for the development. The cumulative surface water from the urbanisation will be managed as discussed in the stormwater quality report by Barker, Ryan and Stewart.

The field results from the Douglas report dated June indicated that the EM survey for the whole site is consistent with the specific bore hole testing.

*The salinity levels range from **non-saline** in the upper 1m of soil to **slightly saline** in the 2m to 3m depth and **moderate saline** below 4m depth. The moderate class has ECe values of 4 and is therefore at the interface of moderate and slightly class. Given the uniform distribution of saline soils across the site, and that the soils are in the slightly saline class, the change in downstream effects from surface development will be primarily dependent on the change in ground water volume from the development. This has been assessed as being less than 2% increase at the highway outlet.*

The consistency of the clay soils is of low permability and potential increased infilltration within the subdivision will be managed using drainage systems in the top 2m of ground. This will minimise any impact to recharge downstream from the subdivision

With respect to saline management, the runoff of stormwater will be managed via retention basins such that no increase in downstream runoff results from the proposed development nor contributes to the deep seated ground water table and recharge..

The depth of the water table indicates that increase in salinity from surface water effects is not likely.

5.2 Salinity

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

- Within the top soil horizons, mobilisation of salts can occur during a rainfall events. As the water seeps down through the regolith, salts are mobilised and leached downwards through the soil horizon. This is consistent with ‘non-saline’ to ‘moderately saline’ results obtained for the upper soil horizons. However, the volume of water from infiltration is low compared to possible deep ground water recharge events from the regional catchment. The gaining stream allows this recharge to cause the water table to rise and mobilises salts within the soils.
- Runoff from impervious areas will be managed via stormwater infrastructure and controlled at the outlet to match the pre developed conditions. This infrastructure will include saline management considerations and controls.
- Infiltration to pervious areas will be managed with appropriate vegetation and by stabilising the top layers of the existing dispersive soils.
- Areas for groundwater recharge are from higher in the landscape rather than from any localised infiltration from surface water at the site. Discharge areas are typically in the lower landscape. This is demonstrated with primarily ‘slightly saline’ results for the higher eastern side of the proposed site and ‘very saline’ results present on the lower north- western side

- Based on the geotechnical report, the depth of the water table indicates that saline effects at the site will be from rising water table rather than from surface infiltration. Areas covered by buildings and roadways will reduce the infiltration rates into the ground.

6. Salinity management

The proposed development is expected to involve:

- Cut and fill to form roadways and benched residential lots for housing
- Cut/fill benching up to approximately 0.6 m

The proposed development earthworks shall follow good salinity design strategies of cuts in the upper areas and filling in the lower areas.

Areas which will be covered by buildings and roads will reduce both infiltration to the (saline) groundwater table and concentration of salts near surface by evaporation.

6.1 Objectives

The objectives of salinity management at the site are:

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

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

Typically, management measures need to address:

- Earthworks to provide filling rather than cuts in lower landscape areas.
- Drainage to reduce recharge to the groundwater table.
- Use of saline resistant building materials.
- Adoption of saline resistant building techniques.
- Water management/landscaping.
- Appropriate design of services, including the potential for water leaks.

6.2 Management measures - general

Salinity response measures recommended for this site include:

- The provision of subsoil drains at the base of cuts. Also provide sub-soil drainage measures behind retaining walls (for the full depth of the wall).
- Provide adequate surface profile and drainage to avoid depressions or locations of run-off water accumulation/ponding.
- Durable building products in accordance with AS3700 ‘Masonry Structures’. In particular, the use of exposure class bricks and non-raked joints below the damp course layer, and utilising potable water for mortar and concrete mixing.
- Collect all roof and stormwater runoff, in order to reduce groundwater recharge that may affect off-site areas, which are located lower on the slope.
- Ensure all water carrying pipes/channels are constructed and maintained in order to minimise and leakage of water.
- Provide adequate ventilation beneath any suspended sub-floor areas.
- Maintain areas of established native vegetation where possible, and replant where necessary using drought tolerant and salt tolerant species.

- Minimise irrigation requirements by use of appropriate watering systems, mulching and by planting drought tolerant vegetation where possible/practical.

6.3 Off-Site Impacts of Saline Water and Re-Use of Excavated Soils

6.3.1 Background

Salinity is a naturally occurring part of the Australian landscape. It is present in the rainfall, circa 10-20kg/ha/yr at Scone, and it is stored in the soils and groundwater.

The management of such soils relates to possible adverse effects on buildings, infrastructure and plants.

Management measures to address the naturally occurring salinity include:

- Saline resistant materials
- Appropriate plants (native vegetation)
- Controls on drainage to avoid low areas that pond where the naturally occurring salts can accumulate due to migration in the water and concentration by evaporation
- Catching roof and road water to reduce recharge to the groundwater and hence *decrease* the flow of groundwater (which is typically saline in this area) off-site.

6.3.2 Groundwater Impacts

The proposed development should collect all runoff and route this to appropriate SUDS harvest tanks for beneficial reuse, or else release to stream flow through an appropriate stormwater/detention system.

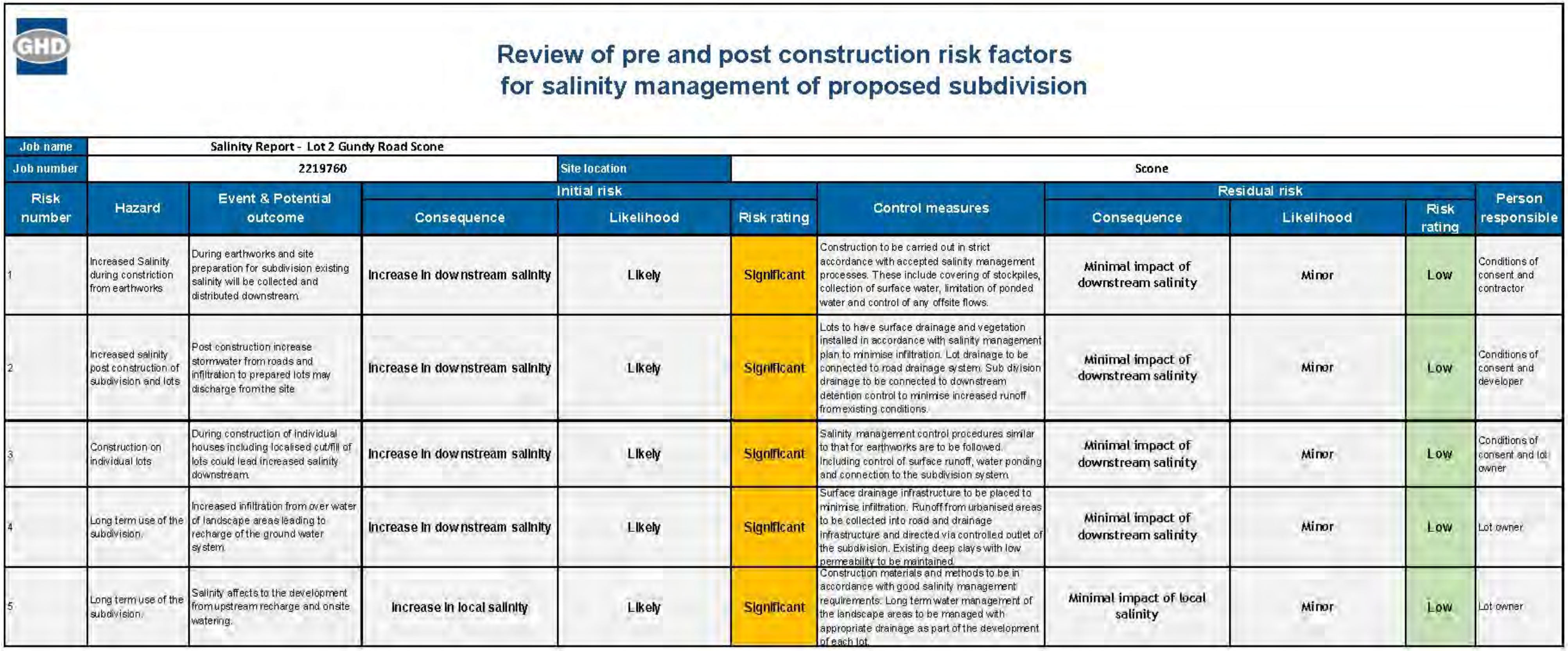
Accordingly the re-charge to the (saline) groundwater table will be reduced, leading to less off-site flow of this saline water, and therefore less salt impact downstream.

6.3.3 Excavated Soils

Based on the naturally occurring salinity concentrations, the excavated natural soils would be classed as VENM (Virgin Excavated Natural Materials) and from this aspect may be used either within the site area, or exported off-site. It would be normal practice to produce a cut to fill balance for the site.

7. Risk Assessment

The following risk assessment of key issues has been carried out the controls are to be adopted for the development.



Review of pre and post construction risk factors for salinity management of proposed subdivision

Job name Salinity Report - Lot 2 Gundy Road Scone

Job number 2219760 **Site location** Scone

Risk number	Hazard	Event & Potential outcome	Initial risk			Control measures	Residual risk			Person responsible
			Consequence	Likelihood	Risk rating		Consequence	Likelihood	Risk rating	
1	Increased Salinity during constriction from earthworks	During earthworks and site preparation for subdivision existing salinity will be collected and distributed downstream.	Increase in downstream salinity	Likely	Significant	Construction to be carried out in strict accordance with accepted salinity management processes. These include covering of stockpiles, collection of surface water, limitation of ponded water and control of any offsite flows.	Minimal impact of downstream salinity	Minor	Low	Conditions of consent and contractor
2	Increased salinity post construction of subdivision and lots	Post construction increase stormwater from roads and infiltration to prepared lots may discharge from the site	Increase in downstream salinity	Likely	Significant	Lots to have surface drainage and vegetation installed in accordance with salinity management plan to minimise infiltration. Lot drainage to be connected to road drainage system. Sub division drainage to be connected to downstream detention control to minimise increased runoff from existing conditions.	Minimal impact of downstream salinity	Minor	Low	Conditions of consent and developer
3	Construction on individual lots	During construction of individual houses including localised cut/fill of lots could lead increased salinity downstream.	Increase in downstream salinity	Likely	Significant	Salinity management control procedures similar to that for earthworks are to be followed. Including control of surface runoff, water ponding and connection to the subdivision system.	Minimal impact of downstream salinity	Minor	Low	Conditions of consent and lot owner
4	Long term use of the subdivision.	Increased infiltration from over water of landscape areas leading to recharge of the ground water system.	Increase in downstream salinity	Likely	Significant	Surface drainage infrastructure to be placed to minimise infiltration. Runoff from urbanised areas to be collected into road and drainage infrastructure and directed via controlled outlet of the subdivision. Existing deep clays with low permeability to be maintained.	Minimal impact of downstream salinity	Minor	Low	Lot owner
5	Long term use of the subdivision.	Salinity affects to the development from upstream recharge and onsite watering.	Increase in local salinity	Likely	Significant	Construction materials and methods to be in accordance with good salinity management requirements. Long term water management of the landscape areas to be managed with appropriate drainage as part of the development of each lot.	Minimal impact of local salinity	Minor	Low	Lot owner

Figure 7-1 Risk Assessment

8. Construction Management Plan (CMP)

A detailed salinity construction management plan (CMP) should form part of the detailed design phase of the project, to address the above mentioned issues both during construction and after development. The CMP shall address the construction staging and the control measures required at each stage and controls to remain in place at the completion of the project.

The plan should include ongoing management strategies and monitoring for the developed site.

The following items should form the basis of the CMP

8.1 Catchment profile

The site is bounded by Gundy road to the North, grass covered pasture land to the east and south and some existing residential developments to the north west. The site is the adjacent to the existing urban zone on Gundy road heading east from Scone.

The site consists of gently sloping lands at approximately 3 degrees from east to west and is located in the top part of the local catchment discharge area. Gundy road collects and diverts stormwater runoff from the north with only the parcel of land to the east directing stormwater to the site.

8.2 Site profile

The site profile consists of gently sloping ground to the natural drainage line that bisects the site. This shallow, poorly defined gully, is located to the south of stages 1 to 3 and to the north of stages 4 to 16. The site discharges to at the north west corner where the gully flattens very quickly and forms a delta with the downstream natural water course.

The site comprises predominately heavy clay soils overlying basalt. The Geotechnical investigations indicate that the soil profile is relatively uniform across the site.

8.3 Ground water levels and salinity levels

The geotechnical investigations revealed that ground water was not encounter in the top 3 m of all 19 test bore holes across the site. The test bore holes were spread uniformly across the site.

Earlier investigations on the adjacent aged care site included test bores to rock which indicated that the ground water was located some 8 m below the surface at the clay/rock interface at the time of the testing.

The recorded salinity concentrations varied with depth, but generally increased from near surface to about 1.0-1.5 m depth, then recorded a small decrease below about 1.5 m depths.

Below about 1.5 m, the site soils recorded mainly slightly and moderately saline conditions with Ece values less than 4 ds/cm.

Higher saline conditions were recorded in one investigation bore hole in the lower (north western) side of the proposed site. The EM Survey shows that the salinity levels are uniform across the site other than the high levels in the drainage gully.

It is considered therefore that the salinity levels for this development are low to moderate and well within being managed with normal and acceptable salinity management techniques.

8.4 Zone specific measures

The site is located in the upper landscape zone within dry land salinity environment. Current groundwater levels in this zone are assessed as being deeper than 4 m below the ground surface. Salinity related processes that could occur in this zone include:

- Waterlogging/evaporation due to changed drainage conditions that could lead to saline accumulation.
- Interception of potentially saline soils/seepages at permeability contrasts.
- Dispersive erosion on cut batters.
- Waterlogging/evaporation cycles above areas of compacted fill or in poorly drained: low spots".

Specific measures recommended for this zone include:

- The provision of subsoil drains on the upslope side of all cuts, roadways and compacted areas. Also, provide subsoil drainage measures behind retaining walls and the upslope side of any cuts around buildings.
- Provide adequate surface profile and drainage to avoid depression or locations of run-off water accumulating/ponding.
- Use a waterproofing membrane directly beneath concrete slab on ground with a free draining sub soil capillary break layer (typically fine to medium grained sand) beneath the slabs.
- Full width waterproof damp course to all walls.

8.5 Development/construction staging

The development is being carried out in construction stages. All salinity management measures outlined in this plan is to be used for all construction stages of the site.

Any area not subject to construction shall be maintained in its current vegetated condition. All stormwater runoff from the site not subject to construction activities shall be directed uninterrupted to the outlet of the site.

Stormwater runoff directed to any of the construction zones shall be intercepted and managed. Should any other parts of the site outside a construction area be disturbed during construction for any reason, then salinity management initiatives outlined in this plan shall also be applied to those parts of the site.

8.6 Stormwater runoff treatment facilities

Stormwater runoff treatment facilities to manage runoff are covered in this section and outline the construction requirements to manage runoff and to limit water ingress into the ground water system.

Bulk Earthworks

During bulk earthworks the construction zone should be provided with shallow berms to the upslope side of the area. These berms shall be vegetated and located such that any natural stormwater runoff up stream of the construction area is intercepted and diverted away for the construction zone.

The construction side of the berms shall be provided with shallow swales to intercept runoff from within the construction area. These swales shall be located to suit the construction activities and shall be directed to the outlet part of the construction zone. The swales shall be connected to a sedimentation basin and then to a salt basin.

During construction the swales shall be maintained and cleaned regularly to ensure stormwater runoff from the construction site is controlled.

The sedimentation basin and salt basin should also be maintained and cleaned regularly and any resulting salt deposits shall be collected and disposed off site.

Building Construction

During building construction all adjacent ground profiles shall be such that all stormwater runoff is directed away from building areas and into the swales noted above.

Care is to be taken to avoid creating local depressions where stormwater may pond during the construction. This may mean that the surrounding apron of buildings are regularly graded to eliminate depressions and to direct stormwater runoff to the drainage swales.

The management controls put in place will be specific to the construction of the main infrastructure (roads, services etc) and to the formation of the residential lots. Guidelines should be provided to new land owners for the construction of individual buildings.

Post construction

As soon as practical during and subsequent to the road and earthworks construction and installation of all in ground services and the completion of individual buildings the following shall be carried out:

- Collect all stormwater runoff and connect to the installed stormwater drainage system.
- Direct surface water to drain away from all buildings.
- Provide adequate surface profile and drainage to avoid depressions or locations of run-off water accumulation/ponding.
- Provide vegetation, gravel and hard paving to all exposed ground surfaces.
- Remove the drainage swales and berms, make good and vegetate the construction apron to blend with the natural grasses.

8.7 Water management and vegetation

Following construction works in order to minimise recharge to the ground water, stormwater from the developed site areas shall be collected and discharged into stormwater water management facilities. Ongoing water management initiatives are to include the following:

- Maintain areas of established native vegetation where possible, and replant where necessary using drought tolerant and salt tolerant species.
- Minimise irrigation requirements by use of appropriate watering systems, mulching and by planting drought tolerant vegetation where possible/practical.
- Use plants have deep root systems that are effective in lowering the water table.

8.8 Building materials

Building materials that are compatible with saline environments shall be used.

The following measures will minimise moisture from moving into building structures and will effectively break the salt cycle.

- A 50 mm (Min.) layer of sand placed under all slabs.
- 0.2 mm thick ‘high impact’ damp proof membrane (DPM) shall be installed on top of the sand layer and under the slab.
- The membrane must be installed as detailed in AS2870, and shall include requirements such as:
  - The membrane is lapped 200 mm at joints for continuity
  - The entire slab footprint is covered by the membrane
  - The membrane must extend to the outside face of external edge beam up to ground level
  - The membrane is continuous at penetrations; taped or sealed with a close-fitting sleeve
- 32 MPa grade concrete shall be the minimum grade used for construction.
- Exposure grade masonry and mortar shall be used under the level of the damp proof course (DPC). For continuity it is advised that the use of exposure grade masonry and mortar is considered for entire structure.
- Stainless steel wall ties and embedded masonry components shall be used.
- Install damp proof course (DPC) under all masonry walls above finished ground level. The waterproof membrane must be in accordance with BCA and other relevant Australian Standards, and must extend beyond external face of brickwork.
- External landscaping and garden beds must be kept at least 100 mm below the damp proof course level to ensure bridging of the DPC does not occur.
- Mortar joints below damp proof course layer must not be raked.
- Potable water shall be used for mortar and concrete mixing.
- Plastic membrane to be placed behind retaining walls to reduce risk of efflorescence.

8.9 Subsoil drain types

Subsoil drains are an important part of the groundwater management system. These are used to pick up subsoil water to minimise recharge of the groundwater. Construction requirements for the subsoil drainage system shall be as follows:

- Provide subsoil drains at the base of all cuts.
- Provide sub-soil drains behind retaining walls (for the full depth of the wall).
- Ensure all water carrying pipes/channels are constructed and maintained in order to minimise any leakage of water.
- The subsoil drainage system shall be provided with cleanout opening at 30 m centres.
- The subsoil drainage system shall me maintained and regularly flushed to ensure it is working adequately.
- The subsoil drainage system shall be connected to the main stormwater drainage system.

8.10 Filter requirements

Following the installation of the stormwater drainage system and completion of the construction works a sand filter should be installed at the outlet as part of the stormwater management system. This filter shall be regularly maintained and cleaned.

8.11 Cuts in dispersive clay

Any cutting required should be coordinated with bulk earthworks activities as mentioned above.

Sub soil drainage shall be installed at the base of the cuts and all stormwater runoff directed to the drainage swales.

8.12 Road embankment fill

The formation of the roadways will require some fill and will be carried out as part of the bulk earthworks. All topsoil and vegetation cut from the site for the formation of the roadways shall be stockpiled and covered to protect from rainfall and stormwater runoff.

Likewise all material stockpiled for the formation of the road embankment shall be adequately covered. Following formation of the road embankment and installation of the pavement, the base course shall be given a prime seal.

Subsoil drains shall be installed to each side of the road embankment.

8.13 Building platform fill

The formation of the building platforms will require some cut to fill as well as the build up of fill to form the building platform. As described above, the material shall be managed as outlined for the road embankment. Following formation of the platforms, all stormwater runoff should be directed away from the building platform footprint and all local depressions graded to eliminate any ponding of water.

Areas of the platform not covered by the building footprint are to be maintained and outlined earlier in the plan until they can be covered with either landscaping or paving.

8.14 Monitoring

As part of the construction, piezometric wells should to be installed around the site. These wells will be used by the Catchment Management Authority as part of their data collection in the area for ongoing long term monitoring of the depth of the water table and salinity levels.

The proposed wells are shown in the appendix and can be constructed in stages as the site is developed.

Once installed, they will add to a broader network of existing wells within the catchment for ongoing data collection.

Following construction of each, ongoing monitoring of the stormwater drainage system, and watering systems should be carried out on a regular basis during the first 12 months to ensure that it is working adequately. This monitoring will determine changes in water table levels and defects or leaks within the drainage system.

Saline samples should be taken at 3 month intervals in the first 12 months to monitor salt levels.

The long term monitoring program and saline testing should be developed by the CMA for the area making use of the piezometers as required.

9. References

1. Department of Land & Water Conservation, Dryland Salinity, (Scott Taylor 1996).
2. GHD, Strathearn Aged Care Facility – Stage 1 Geotechnical Investigation Report, Report 94888, September 2011.
3. Valley Civilab, Lot 2 Gundy Road, Scone NSW Geotechnical Assessment, Report P1303-R-001-Rev. 0, November 2017.
4. Littleboy, M., Piscopo, G., Beecham, R., Barnett, P., Newmann, L. and Alwood, N., Dryland Salinity Extent and Impacts – New South Wales, Technical Report for the National Land and Water Resources Audit, February 2001.
5. Soil Conservation Service of NSW, Soil Landscape Series Sheet 20272, Singleton.
6. Soil and Water Investigation Report and Salinity Management Plan – proposed redevelopment of Scone Golf Course (Upper Hunter Shire Council/Steve Eccles Consultancy).

Appendices

Appendix A – Site master plan and Geotechnical Reports

STAGE	LOTS
1	24
2	26
3	15
4	27
5	24
6	27
7	25
8	29
9	28
10	33
11	21
12	36
13	27
14	29
15	31
16	21
TOTAL	423

FIGURE 1

MM HYNDES BAILEY & Co.
REGISTERED SURVEYORS - TOWN PLANNING - CIVIL DESIGN
Surveying the Hunter since 1920

Ph: 02 65432475 Email: office @hbsurveys.com.au
GROUND FLOOR 108 Bridge Street (PO Box 26), MUSWELLBROOK NSW 2333

STAGING PLAN
PROPOSED SUBDIVISION
LOT 2 IN DP1169320, GUNDY ROAD SCONE

H.SCALE: 1:4000
A3
CONT. INT:
V.SCALE
DATUM:
DATE 16/11/2017
FILE: STAGE_001

CLIENT: CHARLES DAVID PTY LTD

LGA: UPPER HUNTER
PARISH: SCONE
COUNTY: BRISBANE

JOB REF: 217133
VER D

Geotechnical Site Investigation
Lot 2 Gundy Road, Scone NSW

Ref: P1303 – R – 001 – Rev.0

Written by: Matthew Lay (Senior Geotechnical Engineer)

Reviewed by: Nathan Roberts (Geotechnical Engineering Manager)

Approved by: Karl Dawes (General Manager)

Email: office@valleycivilab.com.au

Client: Casson PDS

Job Number	Report Type	Report Number	Revision Number	Author	Reviewer	Date
P1303	*R-*	*001*	*0*	*Matthew Lay*	*Nathan Roberts*	*20/11/2017*

20/11/2017

20/11/2017

Prepared for:

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Attention: **David Casson**

RE: **Proposed Subdivision,**
Lot 2 Gundy Road, Scone
Geotechnical Site Investigation Report

Dear Sir,

As requested by Casson PDS, Valley Civilab Pty Ltd have undertaken a geotechnical site investigation for the purpose of a Site Classification to AS 2870-2011 with Foundation Parameter Recommendations at Lot 2 Gundy Road, Scone NSW. The following report (Ref: P1303 – R – 001 – Rev.0) outlines the geotechnical conditions encountered at the site, including site classification, suitable foundation recommendations and bearing capacities, site salinity and infiltration rates.

If you have further questions or queries regarding the attached report, please contact the signatory below.

For and on behalf of
Valley Civilab Pty Ltd

Nathan Roberts
Geotechnical Engineering Manager
Bachelor of Engineering (Civil)

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Annex B – Borehole & DCP Logs

Annex C – Valley Civilab Laboratory Test Reports

Annex D – Reactivity Assessments

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Annex F – Soil Permeability Test Results

Annex G – BTF 18-2011- CSIRO - Foundation Maintenance and Footing Performance - A Homeowner's Guide

Annex H – Department of Land and Water Conservation's "*Site Investigations for Urban Salinity*" 2002

1. Introduction

At the request of Casson PDS, Valley Civilab Pty Ltd (VC) have carried out a geotechnical investigation for the purpose of a site classification, salinity assessment and infiltration testing for a proposed subdivision. The development consists of the construction of a new 423 lot subdivision. The purpose of the investigation was to provide recommendations on the following:

- Surface and Sub-surface conditions;
- Laboratory testing results;
- Site preparation;
- Excavation conditions;
- Suitability of site soils for fill and founding conditions;
- Site Classification to AS 2870-2011;
- Alternative footing types and foundation design parameters;
- Site salinity assessment;
- Permeability of in-situ soils.

2. Site Description

The site was located Lot 2 Gundy Road, Scone NSW. The site was bordered by Gundy Road and an aged care facility to the north, partially by Stock Route and residential development and partially by farmland to the west and by farmland to the east and south.

At the time of the investigation the site was undeveloped and had been in use and farmland.

Existing vegetation consisted primarily of short to long grass with some medium to large established trees along the drainage coarse running through the site.

Topographically the site slopes down towards a drainage coarse running east to west approximately 250m south of Gundy Road. The site slopes down towards this drainage coarse from Gundy Road at a maximum of 5^{o}. The site slopes down towards this drainage coarse from the north at up to 20^{o}.

No outcropping of rock was observed at the site although some rocks were observed on the surface.

A farm dam was located on the site within the drainage course.

3. Preliminary Site Investigation

3.1 Geological and Soil Landscape Setting

Reference to the 1:250,000 Singleton Geological Map indicates that the site is underlain by an undifferentiated landscape of the Maitland Group consisting of sandstone, siltstone and conglomerate.

Reference to the Singleton 1:250,000 Soil Landscapes Sheet indicates that the site is partially underlain by the Hunter soil landscape and partially by the Dartbrook soil landscape. The Hunter soil landscape is characterised by alluvial plains and terraces of the Hunter River and its tributaries. Local slopes are up to 3% on local reliefs of up to 10m. Soils for the landscape consist of brown clays and black earths on prior stream channels and on tributary flats, chernozems on prior stream channels adjacent to Dartbrook and Brays Hill soils landscapes, alluvial soils on levees and flats adjacent to the present river bed, red podzolic soils and lateritic podzolic soils on old terraces and non-calcic brown soils on terraces with yellow solodic soils in drainage lines.

The Dartbrook soil landscape is characterised by smooth undulating rises and low hills. Local slopes are generally 3-6% on local reliefs of 30-80m. Soil for the consist of brown clays and black earths on upper midslopes, euchrozems and non-calcic brown soils on mid to lower slopes, prairie soils on alluvial flats, red-brown earths on some upper slopes, chocolate soil red-brown earth intergrades on midslopes and chocolate soils on lower slopes.

3.2 Mine Subsidence

Reference to the Mine Subsidence Board’s Mine District Maps indicates that the site lies in an area of no known mine subsidence.

4. Methodology

Fieldwork was undertaken on the 26th and the 30th of October 2017 and consisted of:

- a visual assessment of the existing surface of the site and surrounding area;
- the drilling of twenty (20) boreholes (BH1-BH20) to depths of up to 3.0m;
- the driving of eighteen (18) Dynamic Cone Penetrometer probes at BH locations (DCP1-DCP3);
- the undertaking of four (4) Constant Head Permeability on site tests;
- recovery of undisturbed and disturbed soil samples for laboratory testing.

Laboratory testing consisted of:

- six (6) Shrink Swell Index tests;
- six (6) Atterberg Limit tests;
- six (6) Particle Size Distribution tests;
- five (5) Emmerson Crumb tests;
- twelve (12) Salinity Assessment Suites (consisting of pH, Electrical Conductivity and Cation Exchange Capacity)

5. Subsurface Conditions

The subsurface conditions encountered at the site have been summarised into the following units:

UNIT 1 – Topsoil:

- Clayey SILT, low plasticity, pale grey
- Silty CLAY, medium plasticity, dark grey

UNIT 2 – Alluvium:

- Silty Sandy CLAY or Silty CLAY, low-medium or high plasticity, dark grey/brown, brown/orange, dark grey

- Clayey SILT, low plasticity, pale brown
- Silty Gravelly CLAY, low to medium plasticity, pale brown/grey
- Sandy CLAY, high or medium plasticity, dark grey/brown

UNIT 3 – Residual:

- Silty CLAY, high plasticity, dark brown/mottled brown
- Clayey SILT, low plasticity, pale brown
- Clayey Sandy Gravelly SILT, low plasticity, pale brown
- Silty Sandy CLAY, low plasticity, pale brown/pale grey

UNIT 4 –Bedrock:

- Weathered SANDSTONE, fine grained, pale brown/white/pale red, trace of gravel

A summary of the soil subsurface unit profiles encountered in each borehole can be seen below in Table 5.1.

Table 5.1 – Summary of Soil and Subsurface Profile

Borehole	**Depth (m)**	**Depth (m)**			
		UNIT 1 top	**UNIT 2 all**	**UNIT 3 res**	**UNIT 4 rock**
BH1	1.7	-	-	0.0-1.3	1.3-1.7
BH2	1.5	-	-	0.0-1.0	1.0-1.5
BH3	1.5	-	-	0.0-0.7	0.7-1.5
BH4	2.0	-	-	0.0-1.0	1.0-2.0
BH5	1.5	-	-	0.0-0.7	0.7-1.5
BH6	1.4	-	-	0.0-0.9	0.9-1.4
BH7	3.0	0.0-0.1	0.1-3.0	-	-
BH8	1.7	-	-	0.0-1.3	1.3-1.7
BH9	1.5	-	-	0.0-0.8	0.8-1.5
BH10	2.0	-	-	0.0-1.3	1.3-2.0
BH11	3.0	-	-	0.0-3.0	-
BH12	3.0	-	-	0.0-3.0	-
BH13	2.0	-	-	0.0-1.4	1.4-2.0
BH14	2.6	0.0-0.05	0.05-2.6	-	-
BH15	3.0	-	-	0.0-1.2	1.2-3.0
BH16	3.0	-	-	0.0-1.1	1.1-3.0
BH17	3.0	0.0-0.15	0.15-3.0	-	-
BH18	3.0	-	0.0-1.2	1.2-3.0	3.0-2.5
BH19	3.0	-	-	0.0-3.0	-

BH20	3.0	-	-	0.0-3.0	-

Groundwater was not encountered at the site. Surfacewater was observed in a small dam near the northeast corner of the site. Refer to **Annex A** for the borehole location plan and **Annex B** for the detailed borelog report.

6. Laboratory Test Results

Undisturbed and disturbed soil samples were recovered from the boreholes. The samples were transported to Valley Civilab's NATA accredited soil testing laboratory for analysis. The laboratory test results are summarised below in **Table 6.1, Table 6.2, Table 6.3** and **Table 6.4** below.

Table 6.1 – Shrink Swell Index Tests Results

Borehole	Depth (m)	Soil Description	Iss (%)
BH3	0.4-0.6	Silty CLAY	5.4
BH4	0.5-0.7	Silty CLAY	4.6
BH11	1.5-1.7	Sandy Silty CLAY	2.5
BH13	0.4-0.7	Silty CLAY	1.9
BH16	0.5-0.8	Silty CLAY	4.8
BH18	0.6-0.8	Silty CLAY	4.6

Table 6.2 – Atterberg Limit Test Results

Borehole	Depth (m)	Soil Description	Plasticity Index (%)	Linear Shrinkage (%)
BH1	0.1-0.4	Silty CLAY	75	23.5
BH6	0.2-0.4	Silty CLAY	69	23
BH7	2.0-2.2	Silty CLAY	62	20
BH8	0.3-0.6	Silty CLAY	68	21.5
BH17	1.5-1.8	Sandy CLAY	36	13.5
BH20	0.5-0.7	Sandy Gravelly Clayey SILT	28	15.5

Table 6.3 – Particle Size Distribution Test Results

Borehole	Depth (m)	Percentage Passing 19mm (%)	Percentage Passing 1.18mm (%)	Percentage Passing 75μm (%)
BH1	0.1-0.4	100	99	87
BH2	2.0-2.2	100	92	68
BH8	0.3-0.6	100	96	78
BH12	0.1-0.4	100	98	81

BH17	1.5-1.8	100	94	61
BH14	0.4-0.7	100	95	62

Table 6.4 – Emmerson Crumb Test Results

Borehole	Depth (m)	Soil Description	Emmerson Class
BH3	0.3-0.4	Silty CLAY	Class 4
BH8	0.3-0.6	Silty CLAY	Class 5
BH12	0.1-0.4	Silty CLAY	Class 5
BH13	0.4-0.5	Silty CLAY	Class 2
BH18	0.6-0.8	Silty CLAY	Class 2

Laboratory test results from the soil sample can be found in **Annex C.**

6.1 Discussion of Laboratory Results

A review of the above laboratory results reflects the subsurface profile described in the borehole logs. The Particle Size Distribution and Atterberg Limit results both indicate that the samples collected are high plastic clay materials and would be suitable to be used as fill on site. The Emmerson Crumb results indicate that the site soils are moderately to highly dispersive and may create surface scouring issues both in the drainage flats and on the hill slopes. The dispersive classification of the soils may be lowered by the addition of gypsum if required.

7. Site Classification

7.1 Background Information

Site classification is based off the characteristic surface movements encountered at the site due to the moisture variations within the soil profile. Characteristic surface movements are estimated in accordance with AS2870-2011 "Residential Slabs & Footings". Surface movement calculation take into consideration the depth of the soil profile layers, the soil reactivity and the soil suction depth.

The site classification based on characteristic surface movements are summarised below in **Table 7.1**.

Table 7.1 – Summary of AS2870-2011 Characteristic Surface Movement & Site Classification

Characteristic surface movement (y_s) mm	Site Classification AS 2870-2011	Underlying Soil / Geology
0	Class A	SAND or ROCK site (non-reactive)
0 – 20mm	Class S	CLAY (slightly reactive)
20 – 40mm	Class M	CLAY (moderately reactive)
40 – 60mm	Class H1	CLAY (highly reactive)

60 – 75mm	Class H2	CLAY (highly reactive)
> 75mm	Class E	CLAY (extremely reactive)

Sites subjected to deep-seated moisture change are modified with the addition of "-D".

As defined by AS2870-2011 other sites should be classified as a Class P (Problem) site. These sites include sites with:

- inadequate bearing capacity
- expected excessive foundation settlement due to loading on the foundation
- significant moisture variations
- mine subsidence risk
- slope stability risk
- erosion issues
- greater than 0.8m of fill for sand sites and greater than 0.4m for other sites (in general)

7.2 Site Classification

The proposed development should be designed in accordance with AS2870-2011 "Residential Slabs and Footings". Based on the visual inspection, dynamic cone penetrometer tests and soil profile shown above in **Section 5**, the site classification is summarised below in **Table 7.2**.

Table 7.2 – Site Classification & Characteristic Surface Movements

Location	Site Classification	Site Reactivity	Characteristic Surface Movement
BH3	Class H2	Class H2	60 – 75mm
BH4	Class H2	Class H2	60 – 75mm
BH11	Class H1	Class H1	40 – 60mm
BH13	Class M	Class M	20 – 40mm
BH16	Class H2	Class H2	60 – 75mm
BH18	Class E	Class E	> 75mm

The above classifications have taken in to account varying reactivity's across the soil profile. Based on the results of the reactivity testing above, site classifications have been assigned to each stage and can be seen in **Table 7.3** below.

Table 7.3 – Site Classifications for Each Stage

Stage	Borehole	Site Classification	Characteristic Surface Movement
1, 2 and 3	BH11 and BH13	Class H1	40 – 60mm
4 and 8	BH18	Class E	> 75mm
6, 7, 15 and 16	BH16	Class H2	60 – 75mm

5, 10 and 11	BH4	Class H2	60 – 75mm
9, 12, 13 and 14	BH3	Class H2	60 – 75mm

The above site classifications only apply to the site as it currently lies and should be used only as a reference for the site. Individual lots must be reclassified after earthworks has been completed.

Classification of the site has not taken into account the effects of abnormal moisture conditions. If the site undergoes any earthworks operations, the site shall be reclassified in accordance with AS2870-2011.

7.3 Abnormal Moisture Effects

Abnormal moisture conditions in the foundation can be caused by the following:

- leaking water services
- prolonged periods of draught or heavy rainfall
- trenches or other man made water courses
- poor roof plumbing or obstruction to the roof plumbing system
- poor rainfall runoff control
- corroded gutters or downpipes

Abnormal moisture conditions specified above can cause adverse effects to the development's foundation such as:

- Erosion significantly effecting the lateral and founding support of the structure's footing system
- Saturation of the founding material which can cause a significant decrease in the strength of the founding material
- Shrinkage creating subsidence of the founding material and causing additional stresses within the building structure
- Swelling which creates an upward force in the footings which causes additional stresses within the building structure

7.4 Effects from Trees

The existence of trees within or adjacent to the building footprint can cause significant soil movement due to the following:

- Roots growing within the foundation and causing an upward force on footings
- Roots drawing in and absorbing the moisture below a footing system causing subsidence due to shrinkage of the soil volume

The site should take into account the tree score effect in accordance with and designed to AS2870-2011. The site was found to have a "Low" tree score effect and has been taken into consideration.

7.5 Footing Recommendations

The site is suitable for the use of both shallow and deep footing systems dependant on the development and structural bearing pressure required. Refer to **Section 7.5.1** and **7.5.2** below for bearing pressure parameters.

7.5.1 Shallow Footings

The maximum allowable bearing capacity of 100kPa for shallow level footings founded within soft to firm clay soils below topsoil or other deleterious material is recommended at the site.

If weathered rock is exposed at the base of the excavation of footings it is recommended that the rest of the footing system be piered / taken to bedrock to reduce the risk of differential settlement.

The footing systems must be designed by a structural engineer in accordance with engineering principles and AS 2870 - 2011 "Residential Slabs and Footings" for no less than the minimum requirements for the site classification and soil reactivity given as per **Section 7.2** above.

7.5.2 Deep Footings

The site is suitable for bored piers with an approximate Allowable End Bearing Pressures and Shaft Adhesion estimated below in **Table 7.4**.

Table 7.4 - Summary of Allowable End Bearing Pressures and Shaft Adhesion for Bored Piles

Soil Strata	**Typical Depth to unit across site (m) (3)**	**Allowable Shaft Adhesion (kPa)**	**Allowable End Bearing Pressure (kPa)**
Residual CLAYs	0.0	5	100
Alluvial CLAYs	0.0	5	100
Alluvial CLAYs	1.0	5	200
Weathered BEDROCK	Varying	10	500

Notes:

(1) AS2159 requires that the contribution of the pile shaft from ground surface to 1.5 piles diameters or 1m (whichever greater) shall be ignored;

(2) Assumes minimum embedment depth of 1 x pile diameter into the founding stratum and a total pile depth of at least 5 x pile diameters;

(3) The depth of the founding stratum may vary across the building area;

(4) Assumes a clean socket with roughness category of R2 or better as defined by Walker and Pells (1998);

(5) Allowable bearing capacities are based on a limiting settlement of 1% of the pile diameter and shaft adhesion values include a FOS of 2.5.

(6) It should also be considered that for piles designed to resist uplift (tension) loads we recommend a shaft adhesion value of 50% of the tabulated value to be adopted.

The bearing pressures presented above have been correlated from Dynamic Cone Penetration tests and should be considered as estimates only. Bearing pressures of all exposed foundation areas should be confirmed at the time of earthworks and prior to concrete pour by a qualified Geotechnical Engineer.

7.6 Footing Construction

All footings should be excavated, cleaned and inspected by a qualified Geotechnical Engineer. Concrete should be poured with minimal delay. If delays in pouring mass concrete footings is anticipated, a concrete blinding layer should be provided to protect the foundation material.

Should softening of exposed foundation occur, the effected material should be over excavated and backfilled to design footing level by engineered fill or mass concrete.

7.7 Ongoing Footing Maintenance

Foundations including effective site drainage are required to be maintained over the life of the development to ensure footing performance. Refer to **Annex G** for the following:

- BTF 18-2011- CSIRO - Foundation Maintenance and Footing Performance – A Homeowner's Guide.

8. Earthworks

Any earthworks conducted at the site should be controlled in accordance with AS3798-2007 and guided by the sections below.

8.1 Site Preparation

It is recommended that the following be undertaken were controlled filling is to be undertaken:

1) Remove all topsoil, root effected zones, material assessed as unsuitable and other deleterious zones (noting the stripped soil is not considered suitable as engineered fill but may be considered for landscaping purposes);
2) Exposed suitable foundation areas should then be ripped 300mm and re-compacted to 100% standard maximum dry density (SMDD) at ±2% of optimum moisture content (OMC);
3) The foundation area should then be proof rolled under the supervision of an experienced geotechnical consultant
4) any soft spots / heaving areas identified. If identified these areas should be over excavated under the direction of the geotechnical consultant and replaced with engineered fill

8.2 Controlled Fill

Any earthworks conducted at the site should be controlled in accordance with AS3798-2007. Based on the soil profile shown above in **Section 5**, visual observations and in-situ Dynamic

Cone Penetrometer testing, the material encountered at the site is deemed suitable for controlled fill. If the sub-surface conditions encountered at the site during construction differ from those discussed in **Section 5**, VC should be consulted to determine if the material is suitable for controlled fill. Similarly, any won material imported from external sites should consult VC to determine if the fill is suitable for controlled fill.

8.2.1 Compaction Criteria

Fill material should be compacted in near-horizontal uniform layers with a maximum compacted thickness of 300mm. It is important to ensure layers are placed in such a way that provides adequate drainage and prevent ponding during construction. The thickness of fill placed during construction should take into account the compaction equipment available.

The moisture of the fill material should be controlled within a specified range of OMC in order to achieve the compaction criteria. In general, soils should be compacted within a moisture range of ±2% of OMC.

For residential developments the following compaction criteria applies:

- Cohesive Soils – 95% Minimum Density Ratio (Standard Compactive Effort)
- Non-cohesive Soils – 70% Minimum Density Index

For road developments the following compaction criteria applies:

- General Fill – 98% Standard Maximum Dry Density
- Subgrade – 100% ± 2 Standard Maximum Dry Density Density

Refer to council development guidelines for compaction criteria for different traffic loading.

A suitably qualified geotechnical professional must be consulted to determine that the specified compaction has been achieved.

8.3 Excavations Conditions

Excavations within the fill, natural soils and extremely low to very low strength rock that was encountered during the investigations is thought to be achievable with conventional earthmoving equipment such excavators, backhoes and dozers. Very low to low strength rock may also require ripper tynes attached to excavator arms or dozers for effective excavation. Rock of low strength or greater may possibly require a 12 tonne excavator (or greater) with rock ripper or hydraulic rock hammer, depending on the degree of strength and fracturing in the rock. Excavations in rock would require minimising vibration to neighbouring residences and structures, else other methods may be required (for example pre-drilling the rock, rock sawing using diamond wire saw equipment, grinding or engaging a rock breaking and removal specialist).

Bored piers could be drilled using a 12 tonne excavator or greater with an attached auger. It is recommended that the bottom of bored pier holes should be cleaned out with the excavator fitted with a bucket attachment.

Excavations should be conducted in accordance with The Safe Work Australia "Excavation Work" Code of Practice March 2015. (http://www.safeworkaustralia.gov.au/sites/SWA/about/Publications/Documents/704/ExcavationWork2.pdf)

Excavations can seriously affect the stability of adjacent buildings. Careful consideration must be taken in order to prevent the collapse of partial collapse of adjacent structures.

Construction material and equipment should not be placed within the zone of influence of an excavation unless a suitably qualified geotechnical engineer has designed ground support structures to withstand these loads. The zone of influence is dependent on the material encountered at the site and is the area in which possible failures can occur.

Refer to Upper Hunter Shire Council's development guidelines before conducting any excavation works.

8.4 Batter Slopes

8.4.1 Temporary Batter Slopes

Temporary excavations in natural material or extremely low to very low strength rock may be near vertical provided that:

- The depth does not exceed 1.5m;
- They are open for no more than 24hrs;
- No surcharge loading is applied to the surface within 2.5m of the excavation;
- No one enters the excavation e.g. workers

All other temporary batter slopes during construction should not exceed 1H:1V in soils and 1H:4V in rock and benched, planned and managed in accordance with Safe Work Australia Excavation Work Code of Practice March 2015.

8.4.2 Permanent Batter Slopes

Recommended permanent batter slopes in general are as follows:

- 2H:1V in cohesive soils (e.g. clays) or extremely to very low weathered rock else retained by an engineered retaining wall;
- 3H:1V in non-cohesive soils (e.g. sands) else retained by an engineered retaining wall;
- 1H:1V in low strength rock or greater (permanent rock batters may be steepened to near vertical – subject to inspection by a qualified geotechnical engineer).

8.5 Retaining Walls

In general, design of retaining walls requires determination of the earth pressure coefficient. This depends on the nature of the wall such that:

- Where walls are not propped and some rotation of the wall away from the support soil is permissible, the active earth pressure coefficient (Ka) may be taken as 0.35 for fill and residual soil or 0.3 for extremely low to low strength rock;

- Where the walls can move towards the support soil either during or after construction, passive earth pressures would apply. A Passive Earth Pressure coefficient (Kp) may be taken as 2.5 for fill, residual soil or extremely low to low strength rock;
- Where the walls cannot move towards or away from the support soil then the design should be undertaken using an at rest coefficient (Ko) of 0.5.

For retaining walls surcharge loads from uphill structures should be considered and it is recommended that a minimum surcharge of 5kPa be adopted for this purpose. Retaining walls in excess of 1m high should be designed by a qualified structural engineer, with adequate subsurface and surface drainage provided behind the retaining wall.

9. Salinity Assessment

9.1 Laboratory Test Results

Eight (8) samples were recovered from the boreholes. The samples were transported to Lanfax Laboratories' NATA accredited soil testing laboratory for analysis.

The laboratory test results are summarised below in **Table 6.1** and **Table 6.2** below.

Table 9.1 – pH and Electrical Conductivity Testing Results

Borehole	Depth (m)	pH in Water	pH in Calcium Chloride	Electrical Conductivity (dS/m)
BH8	0.5-0.6	8.44	7.48	0.525
BH8	1.0-1.1	8.61	7.60	0.476
BH8	1.2-1.3	8.81	7.71	0.400
BH12	0.1-0.2	8.41	7.60	0.168
BH12	1.0-1.1	8.67	7.69	0.282
BH12	1.5-1.6	8.28	7.84	1.440
BH13	0.6-0.7	8.52	7.95	0.871
BH13	1.0-1.1	8.57	7.98	0.832
BH13	1.5-1.6	8.84	7.97	0.578
BH17	0.5-0.7	7.91	7.72	0.208
BH17	1.5-1.8	8.89	7.82	0.391
BH17	2.0-3.0	9.20	7.96	0.413

Table 9.2 – Cations Testing Results

Borehole	Depth (m)	Exchangeable Cations (cmol+/kg)				Cation Exch. Capacity (cmol+/kg)	Exch. Na Percent (%)
		Ca	K	MG	Na		
BH8	0.5-0.6	22.09	0.49	25.39	3.24	51.2	6.3
BH8	1.0-1.1	22.13	0.48	25.74	4.11	52.5	7.8

BH8	1.2-1.3	22.74	0.42	24.28	4.03	51.5	7.8
BH12	0.1-0.2	23.16	0.46	8.61	0.73	33.0	2.2
BH12	1.0-1.1	18.04	0.31	8.17	2.36	28.9	8.2
BH12	1.5-1.6	21.31	0.46	21.85	6.28	49.9	12.6
BH13	0.6-0.7	16.41	0.41	12.38	4.84	34.0	14.2
BH13	1.0-1.1	17.27	0.39	12.09	4.27	34.0	12.6
BH13	1.5-1.6	12.61	0.44	8.75	5.24	27.0	19.4
BH17	0.5-0.7	10.99	0.66	6.94	2.82	21.5	13.1
BH17	1.5-1.8	11.38	0.46	6.54	3.63	22.0	16.5
BH17	2.0-3.0	13.73	0.42	8.30	5.08	28.3	18.0

Laboratory test results from the soil sample can be found in **Annex E.**

9.2 Assessing the Site

To assess the site an assessment of salinity and sodicity is undertaken. The site was assessment was undertaken in accordance with details set out in the Department of Land and Water Conservation's "*Site Investigations for Urban Salinity*" 2002.

9.2.1 Salinity

Salinity refers to the presence of excess salt in the soil which can be harmful to plants and restrict plant growth. The salinity of a soil is determined by the Electrical Conductivity (EC). Because salt separates into positively and negatively charged ions when dissolved in water. The EC of the water increases as salt increases. To determine the salinity of the soil the EC is multiplied by a soil texture conversion factor to determine the final figure known as the extract Electrical Conductivity (ECe). Table 9.3 and **Table 9.4** below shows soil texture conversion factor and Table 9.4 shows the correlation between ECe and Salinity.

Table 9.3 - Factors for Converting EC (1:5) to ECe

Soil Texture Group	Multiplication Factors
Sands	17
Sandy Loams	14
Loams	10
Clay Loams	9
Light Clays	8.5
Light Medium Clays	8
Medium Clays	7
Heavy Clays	6

Table 9.4 - ECe Values of Soil Salinity Classes

Class	ECe (dS/m)	Comments
Non-Saline	<2	Salinity effects mostly negligible
Slightly Saline	2-4	Yields of very sensitive crops may be 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

9.2.2 Sodicity

Sodicity refers to the exchangeable sodium as a percentage of the cation exchange capacity. It is usually referred to the exchangeable sodium percentage (ESP). When wet, sodic soils disperse into small particles and clog pores decreasing the permeability of the soil. They can cause crusting within the soil layers and prevent movement of air and water, limiting plant growth. Sodic soils can also lead to gully and tunnel erosion. **Table 9.5** below shows the correlation between ESP and Sodicity Rating.

Table 9.5 - Sodicity Rating

ESP (%)	Sodicity Rating
<5	Non-sodic
5-15	Sodic
>15	Highly Sodic

9.3 Discussion of Results

Based on the laboratory results in **Table 6.1** and **Table 6.2** the site was assessed for salinity and sodicity. Based on the borehole logs and the samples recovered the soil types have been interpreted as below and corresponding conversion factors will apply. Using this soil texture factor ECe was determined. Salinity results for the site have been summarised in **Table 9.6** below.

Table 9.6 - Site Salinity

Borehole	Depth (m)	Soil Type	EC (dS/m)	ECe (dS/m)	Salinity
BH8	0.5-0.6	Medium Clay	0.525	3.675	Slightly Saline
BH8	1.0-1.1	Medium Clay	0.476	3.332	Slightly Saline
BH8	1.2-1.3	Medium Clay	0.400	2.800	Slightly Saline
BH12	0.1-0.2	Light Med. Clay	0.168	1.344	Non-Saline
BH12	1.0-1.1	Clay Loam	0.282	2.538	Slightly Saline
BH12	1.5-1.6	Medium Clay	1.440	10.080	Very Saline
BH13	0.6-0.7	Medium Clay	0.871	6.097	Moderately Saline
BH13	1.0-1.1	Medium Clay	0.832	5.824	Moderately Saline
BH13	1.5-1.6	Medium Clay	0.578	4.046	Moderately Saline

BH17	0.5-0.7	Light Med. Clay	0.208	1.664	Non-Saline
BH17	1.5-1.8	Light Clay	0.391	3.324	Slightly Saline
BH17	2.0-3.0	Light Med. Clay	0.413	3.304	Slightly Saline

Table 9.6 indicates varying salinity across the site at varying depths. However the majority of samples indicate slightly saline to moderately saline soils across the site.

Sodicity results for the site have been summarised in **Table 9.7** below.

Table 9.7 - Site Sodicity

Borehole	Depth (m)	Exch. Na Percent (%)	Sodicity
BH8	0.5-0.6	6.3	Sodic
BH8	1.0-1.1	7.8	Sodic
BH8	1.2-1.3	7.8	Sodic
BH12	0.1-0.2	2.2	Sodic
BH12	1.0-1.1	8.2	Sodic
BH12	1.5-1.6	12.6	Sodic
BH13	0.6-0.7	14.2	Sodic
BH13	1.0-1.1	12.6	Sodic
BH13	1.5-1.6	19.4	High Sodic
BH17	0.5-0.7	13.1	Sodic
BH17	1.5-1.8	16.5	High Sodic
BH17	2.0-3.0	18.0	High Sodic

Table 9.7 indicates that the site is sodic to highly sodic. The sodicity of the soils will limit the permeability of site soils and may also limit the growth of plants. Care should be taken if vegetation is to be added. The application of gypsum may be used to decrease the sodicity of the soils if required however this must be undertaken under the supervision of a qualified Geotechnical Engineer.

10. Constant Head Permeability Test

The soil permeability of the silty sandy clay and silt clays along the existing drainage course were tested in accordance with AS/NZ1547:2012 "On-Site Domestic Wastewater Management" Appendix G Soil Permeability Measurement – Constant Head Test. The Talsma-Hallam permeameter described with AS/NZ1547:2012 “On-site Domestic Wastewater Management, Appendix G Soil Permeability Measurement – Constant Head Test” is suitable for a soil permeability range of 0.0009 to 2.9m/day.

The drop in water level in the reservoir was recorded until the change in drop became steady. Steady state was achieved when the drop was +/- 10% of the previous drops.

10.1 Soil Permeability

Four (4) permeability tests were undertaken and the “steady state” soil permeability can be seen in **Table 10.1** below.

Table 10.1 - Constant Head Permeability Test Results

Location	Soil Type	Saturated Hydraulic Conductivity (m/day)
Inf 1	Silty Sandy CLAY	0.0202
Inf 2	Silty CLAY	0.0202
Inf 3	Silty CLAY	0.0222
Inf 4	Silty CLAY	0.0181

The soil permeability testing results and calculations can be seen in **Annex F**.

11. Report Limitations

The geotechnical data and recommendations within the above report are subjected to the specific sampling and testing that was undertaken at the time of the current investigation. It should be noted that underlying site soil conditions can vary significantly across a site and the environment can change overtime. If conditions encountered during construction are different to those contained in this report Valley Civilab should be contacted immediately for site reassessment.

If you have any further questions about this report, please contact the undersigned.

For and on behalf of

Valley Civilab Pty Ltd

Reported by	Reviewed by
Matthew Lay	**Nathan Roberts**
Senior Geotechnical Engineer	*Geotechnical Engineering Manager*
Bachelor of Engineering (Civil)	**Bachelor of Engineering (Civil)**

Annex A

VALLEY CIVILAB
Geotechnical & Environmental Services

Geotechnical Investigation
Gundy Road, Scone NSW
VC Ref: P1303

Notes:
(1) The scale bar is approximate.
(2) Base layer sourced from Six Maps (August 13, 2012). Scone, NSW.
56 H 300056m E, 6450831m S. Department of Finance, Services and Innovation.
Accessed October 26, 2017. Overlay sourced from MM Hyndes Bailey & Co.

Figure 1 - Locality Plan

LEGEND

⊕ Bore hole
⊕ Infiltration Test

Scale (m)
0 85 170

N
W E
S

Annex B

VALLEY CIVILAB

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Proposed Subdivision
LOCATION : Gundy Road, Scone

HOLE NO : BH1
FILE / JOB NO : P1303
SHEET : 1 OF 1

POSITION : E: 299639.0, N: 6450800.0 (MGA94 Zone 56)
SURFACE ELEVATION :
ANGLE FROM HORIZONTAL : 90°
RIG TYPE : Drill Rig
MOUNTING : Trailer
CONTRACTOR :
DRILLER :
DATE STARTED : 30/10/2017
DATE COMPLETED : 30/10/2017
DATE LOGGED : 30/10/2017
LOGGED BY : ML
CHECKED BY : ML

DRILLING

DCP AS 1289.6.3.2-1997 Depth (m)	Blows	CBR	LAB SOAKED CBR	SAMPLES & FIELD TESTS
0.00 - 0.10	1			
0.10 - 0.20	2			0.10m D
0.20 - 0.30	1			
0.30 - 0.40	2			0.40m
0.40 - 0.50	3			
0.50 - 0.60	4			
0.60 - 0.70	5			
0.70 - 0.80	6			
0.80 - 0.90	8			
0.90 - 1.00	13			
1.00 - 1.10	Terminated			

PENETRATION: VE E F H

MATERIAL

DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
0.0 - 1.30m	CH	Silty CLAY, high plasticity, dark brown/mottled brown	M	S to F	RESIDUAL SOIL
1.30m - 1.70m		Weathered SANDSTONE, fine grained, pale brown/white/pale red, trace of fine to medium gravel	D		ROCK
1.70m		Hole Terminated at 1.70 m Refusal			

PAVEMENT CONDITION / REMARK

METHOD

N Natural Exposure
E Existing Excavation
BH Backhoe Bucket
B Bulldozer Blade
R Ripper

PENETRATION

VE E F H VH
No Resistance

WATER

10 Oct., 73 Water Level on Date shown
▶ water inflow
◀ water outflow

SAMPLES & FIELD TESTS

U - Undisturbed Sample
D - Disturbed Sample
B - Bulk Disturbed Sample
MC - Moisture Content
PP - Pocket Penetrometer (UCS kPa)
VS - Vane Shear; P-Peak, R-Remouded (uncorrected kPa)
PBT - Plate Bearing Test

CLASSIFICATION SYMBOLS & SOIL DESCRIPTION
Based on Unified Classification System

MOISTURE

D - Dry
M - Moist
W - Wet

CONSISTENCY/ RELATIVE DENSITY

VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

See Explanatory Notes for details of abbreviations & basis of descriptions.

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NON-CORE DRILL HOLE - GEOLOGICAL LOG

VALLEY CIVILAB

PROJECT : Proposed Subdivision
LOCATION : Gundy Road, Scone

HOLE NO : BH2
FILE / JOB NO : P1303
SHEET : 1 OF 1

POSITION : E: 299614.5, N: 6450624.0 (MGA94 Zone 56) SURFACE ELEVATION : ANGLE FROM HORIZONTAL : 90°

RIG TYPE : Drill Rig MOUNTING : Trailer CONTRACTOR : DRILLER :

DATE STARTED : 30/10/2017 DATE COMPLETED : 30/10/2017 DATE LOGGED : 30/10/2017 LOGGED BY : ML CHECKED BY : ML

DRILLING

DCP AS 1289.6.3.2-1997 Depth (m)	Blows	CBR	LAB SOAKED CBR	SAMPLES & FIELD TESTS
0.00 - 0.10	0			
0.10 - 0.20	1			
0.20 - 0.30	1			
0.30 - 0.40	2			
0.40 - 0.50	2			
0.50 - 0.60	2			
0.60 - 0.70	4			
0.70 - 0.80	7			
0.80 - 0.90	10			
0.90 - 1.00	17			
1.00 - 1.10	Terminated			

MATERIAL

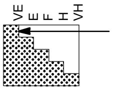
DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
0.0 - 1.00m	CH	Silty CLAY, high plasticity, dark brown/mottled brown	M	S to F	RESIDUAL SOIL
1.00m - 1.50m		Weathered SANDSTONE, fine grained, pale brown/white/pale red, trace of fine to medium gravel	D		ROCK
1.50m		Hole Terminated at 1.50 m Refusal			

PAVEMENT CONDITION / REMARK

METHOD

N	Natural Exposure
E	Existing Excavation
BH	Backhoe Bucket
B	Bulldozer Blade
R	Ripper

PENETRATION



WATER

10 Oct., 73 Water Level on Date shown
▶ water inflow
◀ water outflow

SAMPLES & FIELD TESTS

U - Undisturbed Sample
D - Disturbed Sample
B - Bulk Disturbed Sample
MC - Moisture Content
PP - Pocket Penetrometer (UCS kPa)
VS - Vane Shear; P-Peak, R-Remouded (uncorrected kPa)
PBT - Plate Bearing Test

CLASSIFICATION SYMBOLS & SOIL DESCRIPTION

Based on Unified Classification System

MOISTURE

D - Dry
M - Moist
W - Wet

CONSISTENCY/ RELATIVE DENSITY

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard
VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

See Explanatory Notes for details of abbreviations & basis of descriptions.

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NON-CORE DRILL HOLE - GEOLOGICAL LOG

VALLEY CIVILAB

PROJECT : Proposed Subdivision
LOCATION : Gundy Road, Scone

HOLE NO : BH3
FILE / JOB NO : P1303
SHEET : 1 OF 1

POSITION : E: 299606.4, N: 6450451.0 (MGA94 Zone 56)
SURFACE ELEVATION :
ANGLE FROM HORIZONTAL : 90°
RIG TYPE : Drill Rig
MOUNTING : Trailer
CONTRACTOR :
DRILLER :
DATE STARTED : 30/10/2017
DATE COMPLETED : 30/10/2017
DATE LOGGED : 30/10/2017
LOGGED BY : ML
CHECKED BY : ML

DRILLING

DCP AS 1289.6.3.2-1997

Depth (m)	Blows	CBR	LAB SOAKED CBR
0.00 - 0.10	0		
0.10 - 0.20	1		
0.20 - 0.30	1		
0.30 - 0.40	4		
0.40 - 0.50	6		
0.50 - 0.60	11		
0.60 - 0.70	15		
0.70 - 0.80	Terminated		

SAMPLES & FIELD TESTS

0.30m	D
0.40m	U
0.60m	

MATERIAL

DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
0.0	CH	Silty CLAY, high plasticity, dark brown/mottled brown	M	S to F	RESIDUAL SOIL
0.70m		Weathered SANDSTONE, fine grained, pale brown/white/pale red, trace of fine to medium gravel	D		ROCK
1.50m		Hole Terminated at 1.50 m Refusal			

PAVEMENT CONDITION / REMARK

METHOD
- N Natural Exposure
- E Existing Excavation
- BH Backhoe Bucket
- B Bulldozer Blade
- R Ripper

PENETRATION
VE E F H VH
No Resistance

WATER
10 Oct., 73 Water Level on Date shown
water inflow
water outflow

SAMPLES & FIELD TESTS
- U - Undisturbed Sample
- D - Disturbed Sample
- B - Bulk Disturbed Sample
- MC - Moisture Content
- PP - Pocket Penetrometer (UCS kPa)
- VS - Vane Shear; P-Peak, R-Remouded (uncorrected kPa)
- PBT - Plate Bearing Test

CLASSIFICATION SYMBOLS & SOIL DESCRIPTION
Based on Unified Classification System

MOISTURE
- D - Dry
- M - Moist
- W - Wet

CONSISTENCY/ RELATIVE DENSITY

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard
VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

See Explanatory Notes for details of abbreviations & basis of descriptions.

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH4
FILE / JOB NO : P1303
SHEET : 1 OF 1

PROJECT : Proposed Subdivision
LOCATION : Gundy Road, Scone

POSITION : E: 299856.4, N: 6450772.0 (MGA94 Zone 56)
SURFACE ELEVATION :
ANGLE FROM HORIZONTAL : 90°
RIG TYPE : Drill Rig
MOUNTING : Trailer
CONTRACTOR :
DRILLER :
DATE STARTED : 30/10/2017
DATE COMPLETED : 30/10/2017
DATE LOGGED : 30/10/2017
LOGGED BY : ML
CHECKED BY : ML

DRILLING

DCP AS 1289.6.3.2-1997

Depth (m)	Blows	CBR
0.00 - 0.10	1	
0.10 - 0.20	1	
0.20 - 0.30	2	
0.30 - 0.40	1	
0.40 - 0.50	2	
0.50 - 0.60	2	
0.60 - 0.70	3	
0.70 - 0.80	4	
0.80 - 0.90	4	
0.90 - 1.00	6	
1.00 - 1.10	10	
1.10 - 1.20	17	
1.20 - 1.30	Terminated	

SAMPLES & FIELD TESTS

0.30m	D
0.40m	
0.50m	U
0.70m	

MATERIAL

DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
0.0	CH	Silty CLAY, high plasticity, dark brown	M	S to F	RESIDUAL SOIL
1.00m		Weathered SANDSTONE, fine grained, pale brown/white, trace of fine to coarse gravel	D		ROCK
2.00m		Hole Terminated at 2.00 m Refusal			

PAVEMENT CONDITION / REMARK

METHOD

N	Natural Exposure
E	Existing Excavation
BH	Backhoe Bucket
B	Bulldozer Blade
R	Ripper

PENETRATION

VE E F H VH

No Resistance

WATER

10 Oct., 73 Water Level on Date shown
▶ water inflow
◀ water outflow

SAMPLES & FIELD TESTS

U	-	Undisturbed Sample
D	-	Disturbed Sample
B	-	Bulk Disturbed Sample
MC	-	Moisture Content
PP	-	Pocket Penetrometer (UCS kPa)
VS	-	Vane Shear; P-Peak, R-Remouded (uncorrected kPa)
PBT	-	Plate Bearing Test

CLASSIFICATION SYMBOLS & SOIL DESCRIPTION
Based on Unified Classification System

MOISTURE

D	-	Dry
M	-	Moist
W	-	Wet

CONSISTENCY/ RELATIVE DENSITY

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard
VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

See Explanatory Notes for details of abbreviations & basis of descriptions.

VALLEY CIVILAB

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Proposed Subdivision
LOCATION : Gundy Road, Scone

HOLE NO : BH5
FILE / JOB NO : P1303
SHEET : 1 OF 1

POSITION : E: 299854.9, N: 6450601.0 (MGA94 Zone 56) SURFACE ELEVATION : ANGLE FROM HORIZONTAL : 90°
RIG TYPE : Drill Rig MOUNTING : Trailer CONTRACTOR : DRILLER :
DATE STARTED : 30/10/2017 DATE COMPLETED : 30/10/2017 DATE LOGGED : 30/10/2017 LOGGED BY : ML CHECKED BY : ML

DRILLING

DCP AS 1289.6.3.2-1997

Depth (m)	Blows	CBR	LAB SOAKED CBR	SAMPLES & FIELD TESTS
0.00 - 0.10	1			
0.10 - 0.20	2			
0.20 - 0.30	1			
0.30 - 0.40	2			
0.40 - 0.50	3			
0.50 - 0.60	4			
0.60 - 0.70	10			
0.70 - 0.80	15			
0.80 - 0.90	Terminated			

PENETRATION: VE E F H

MATERIAL

DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
0.0 - 0.70m	CH	Silty CLAY, high plasticity, dark brown	D to M	S to F	RESIDUAL SOIL
0.70m - 1.50m		Weathered SANDSTONE, fine grained, pale brown/white/trace of fine to coarse gravel	D		ROCK
1.50m		Hole Terminated at 1.50 m Refusal			

DEPTH (m): 0.0, 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6

PAVEMENT CONDITION / REMARK

METHOD

N	Natural Exposure
E	Existing Excavation
BH	Backhoe Bucket
B	Bulldozer Blade
R	Ripper

PENETRATION

VE E F H VH — No Resistance

WATER

10 Oct., 73 Water Level on Date shown
▶ water inflow
◀ water outflow

SAMPLES & FIELD TESTS

U	- Undisturbed Sample
D	- Disturbed Sample
B	- Bulk Disturbed Sample
MC	- Moisture Content
PP	- Pocket Penetrometer (UCS kPa)
VS	- Vane Shear; P-Peak, R-Remouded (uncorrected kPa)
PBT	- Plate Bearing Test

CLASSIFICATION SYMBOLS & SOIL DESCRIPTION

Based on Unified Classification System

MOISTURE

D	- Dry
M	- Moist
W	- Wet

CONSISTENCY/ RELATIVE DENSITY

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard
VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

See Explanatory Notes for
details of abbreviations
& basis of descriptions.

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VALLEY CIVILAB

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Proposed Subdivision
LOCATION : Gundy Road, Scone

HOLE NO : BH6
FILE / JOB NO : P1303
SHEET : 1 OF 1

POSITION : E: 299841.2, N: 6450433.0 (MGA94 Zone 56)
SURFACE ELEVATION :
ANGLE FROM HORIZONTAL : 90°
RIG TYPE : Drill Rig
MOUNTING : Trailer
CONTRACTOR :
DRILLER :
DATE STARTED : 30/10/2017
DATE COMPLETED : 30/10/2017
DATE LOGGED : 30/10/2017
LOGGED BY : ML
CHECKED BY : ML

DRILLING							MATERIAL					
VE E F H PENETRATION	DCP AS 1289.6.3.2-1997 Depth (m)	Blows	CBR	LAB SOAKED CBR	SAMPLES & FIELD TESTS	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
	0.00 - 0.10	2				0.0			Silty CLAY, high plasticity, dark brown			RESIDUAL SOIL
	0.10 - 0.20	2										
	0.20 - 0.30	3			0.20m D	0.2						
	0.30 - 0.40	2										
	0.40 - 0.50	4			0.40m	0.4		CH		M	F	
	0.50 - 0.60	8										
	0.60 - 0.70	13				0.6						
	0.70 - 0.80	Terminated										
						0.8						
								0.90m	Weathered SANDSTONE, fine grained, pale brown/white, trace of fine to coarse gravel			ROCK
						1.0						
										D		
						1.2						
						1.4		1.40m	Hole Terminated at 1.40 m Refusal			

PAVEMENT CONDITION / REMARK

METHOD

N	Natural Exposure
E	Existing Excavation
BH	Backhoe Bucket
B	Bulldozer Blade
R	Ripper

PENETRATION

VE E F H VH

No Resistance

WATER

10 Oct., 73 Water Level on Date shown
▶ water inflow
◀ water outflow

SAMPLES & FIELD TESTS

U	- Undisturbed Sample
D	- Disturbed Sample
B	- Bulk Disturbed Sample
MC	- Moisture Content
PP	- Pocket Penetrometer (UCS kPa)
VS	- Vane Shear; P-Peak, R-Remouded (uncorrected kPa)
PBT	- Plate Bearing Test

CLASSIFICATION SYMBOLS & SOIL DESCRIPTION

Based on Unified Classification System

MOISTURE

D	- Dry
M	- Moist
W	- Wet

CONSISTENCY/ RELATIVE DENSITY

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard
VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

See Explanatory Notes for details of abbreviations & basis of descriptions.

VALLEY CIVILAB

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Proposed Subdivision
LOCATION : Gundy Road, Scone

HOLE NO : BH7
FILE / JOB NO : P1303
SHEET : 1 OF 1

POSITION : E: 300051.2, N: 6451008.8 (MGA94 Zone 56)
SURFACE ELEVATION :
ANGLE FROM HORIZONTAL : 90°
RIG TYPE : Drill Rig
MOUNTING : Trailer
CONTRACTOR :
DRILLER :
DATE STARTED : 30/10/2017
DATE COMPLETED : 30/10/2017
DATE LOGGED : 30/10/2017
LOGGED BY : MB
CHECKED BY : ML

DRILLING

DCP AS 1289.6.3.2-1997

Depth (m)	Blows	CBR
0.00 - 0.10	6	
0.10 - 0.20	8	
0.20 - 0.30	10	
0.30 - 0.40	10	
0.40 - 0.50	10	
0.50 - 0.60	Terminated	

SAMPLES & FIELD TESTS

From	Type	To
0.50m	D	0.70m
1.20m	D	1.40m
2.00m	B D	2.20m
2.70m	D	2.90m

MATERIAL

DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
0.0 – 0.10m	ML	Clayey SILT, low plasticity, pale grey	D		TOPSOIL
0.10m – 1.00m	CH	Silty Sandy CLAY, high plasticity, dark grey/brown; coarse grained sand	D	VSt	ALLUVIUM
1.00m – 1.50m	CL-CI	Silty Sandy CLAY, low to medium plasticity, brown/orange; fine to medium grained sand	D	St	
1.50m – 2.50m	CH	Silty CLAY, high plasticity, brown/orange, trace of coarse grained sand	D	St to VSt	
2.50m – 3.00m	CI	Sandy Silty CLAY, medium plasticity, brown/orange; fine to coarse grained sand		VSt	
3.00m		Hole Terminated at 3.00 m Terminated			

PAVEMENT CONDITION / REMARK

METHOD

- N Natural Exposure
- E Existing Excavation
- BH Backhoe Bucket
- B Bulldozer Blade
- R Ripper

PENETRATION

VE E F H VH

No Resistance

WATER

10 Oct., 73 Water Level on Date shown
► water inflow
◄ water outflow

SAMPLES & FIELD TESTS

- U - Undisturbed Sample
- D - Disturbed Sample
- B - Bulk Disturbed Sample
- MC - Moisture Content
- PP - Pocket Penetrometer (UCS kPa)
- VS - Vane Shear; P-Peak, R-Remouded (uncorrected kPa)
- PBT - Plate Bearing Test

CLASSIFICATION SYMBOLS & SOIL DESCRIPTION

Based on Unified Classification System

MOISTURE

- D - Dry
- M - Moist
- W - Wet

CONSISTENCY/ RELATIVE DENSITY

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard
VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

See Explanatory Notes for details of abbreviations & basis of descriptions.

VALLEY CIVILAB

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Proposed Subdivision
LOCATION : Gundy Road, Scone

HOLE NO : BH8
FILE / JOB NO : P1303
SHEET : 1 OF 1

POSITION : E: 300062.4, N: 6450746.3 (MGA94 Zone 56)
SURFACE ELEVATION :
ANGLE FROM HORIZONTAL : 90°
RIG TYPE : Drill Rig
MOUNTING : Trailer
CONTRACTOR :
DRILLER :
DATE STARTED : 30/10/2017
DATE COMPLETED : 30/10/2017
DATE LOGGED : 30/10/2017
LOGGED BY : ML
CHECKED BY : ML

DRILLING

DCP AS 1289.6.3.2-1997 Depth (m)	Blows	CBR	LAB SOAKED CBR
0.00 - 0.10	3		
0.10 - 0.20	4		
0.20 - 0.30	4		
0.30 - 0.40	5		
0.40 - 0.50	4		
0.50 - 0.60	5		
0.60 - 0.70	6		
0.70 - 0.80	4		
0.80 - 0.90	4		
0.90 - 1.00	7		
1.00 - 1.10	10		
1.10 - 1.20	Terminated		

SAMPLES & FIELD TESTS

From	Sample	To
0.30m	D	0.60m
1.00m	D	1.10m
1.20m	D	1.30m

MATERIAL

DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
0.0	CH	Silty CLAY, high plasticity, dark brown/brown, with medium to coarse gravel at 1.1mbgl	M	St to VSt	ALLUVIUM / RESIDUAL SOIL
1.30m		Weathered SANDSTONE, fine grained, pale brown, trace of fine to coarse gravel	D		ROCK
1.70m		Hole Terminated at 1.70 m Refusal			

PAVEMENT CONDITION / REMARK

METHOD

N	Natural Exposure
E	Existing Excavation
BH	Backhoe Bucket
B	Bulldozer Blade
R	Ripper

PENETRATION

VE E F H VH — No Resistance

WATER

10 Oct., 73 Water Level on Date shown
▶ water inflow
◀ water outflow

SAMPLES & FIELD TESTS

U - Undisturbed Sample
D - Disturbed Sample
B - Bulk Disturbed Sample
MC - Moisture Content
PP - Pocket Penetrometer (UCS kPa)
VS - Vane Shear; P-Peak, R-Remouded (uncorrected kPa)
PBT - Plate Bearing Test

CLASSIFICATION SYMBOLS & SOIL DESCRIPTION

Based on Unified Classification System

MOISTURE

D - Dry
M - Moist
W - Wet

CONSISTENCY/ RELATIVE DENSITY

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard
VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

See Explanatory Notes for details of abbreviations & basis of descriptions.

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Proposed Subdivision
LOCATION : Gundy Road, Scone

HOLE NO : BH9
FILE / JOB NO : P1303
SHEET : 1 OF 1

POSITION : E: 300061.8, N: 6450587.8 (MGA94 Zone 56) SURFACE ELEVATION : ANGLE FROM HORIZONTAL : 90°

RIG TYPE : Drill Rig MOUNTING : Trailer CONTRACTOR : DRILLER :

DATE STARTED : 30/10/2017 DATE COMPLETED : 30/10/2017 DATE LOGGED : 30/10/2017 LOGGED BY : ML CHECKED BY : ML

DRILLING

DCP AS 1289.6.3.2-1997

Depth (m)	Blows	CBR	LAB SOAKED CBR	SAMPLES & FIELD TESTS
0.00 - 0.10	2			
0.10 - 0.20	2			
0.20 - 0.30	1			
0.30 - 0.40	2			
0.40 - 0.50	5			
0.50 - 0.60	10			
0.60 - 0.70	14			
0.70 - 0.80	Terminated			

PENETRATION: VE E F H

MATERIAL

DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
0.0 – 0.80m	CH	Silty CLAY, high plasticity, dark brown	M	F	RESIDUAL SOIL
0.80m – 1.50m		Weathered SANDSTONE, fine grained, pale brown, trace of fine to coarse gravel	D		ROCK
1.50m		Hole Terminated at 1.50 m Refusal			

PAVEMENT CONDITION / REMARK

METHOD

N	Natural Exposure
E	Existing Excavation
BH	Backhoe Bucket
B	Bulldozer Blade
R	Ripper

PENETRATION

VE E F H VH — No Resistance

WATER

10 Oct., 73 Water Level on Date shown
▶ water inflow
◀ water outflow

SAMPLES & FIELD TESTS

U	-	Undisturbed Sample
D	-	Disturbed Sample
B	-	Bulk Disturbed Sample
MC	-	Moisture Content
PP	-	Pocket Penetrometer (UCS kPa)
VS	-	Vane Shear; P-Peak, R-Remouded (uncorrected kPa)
PBT	-	Plate Bearing Test

CLASSIFICATION SYMBOLS & SOIL DESCRIPTION
Based on Unified Classification System

MOISTURE

D	-	Dry
M	-	Moist
W	-	Wet

CONSISTENCY/ RELATIVE DENSITY

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard
VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

See Explanatory Notes for details of abbreviations & basis of descriptions.

VALLEY CIVILAB

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Proposed Subdivision
LOCATION : Gundy Road, Scone

HOLE NO : BH10
FILE / JOB NO : P1303
SHEET : 1 OF 1

POSITION : E: 300051.0, N: 6450419.0 (MGA94 Zone 56)
SURFACE ELEVATION :
ANGLE FROM HORIZONTAL : 90°
RIG TYPE : Drill Rig
MOUNTING : Trailer
CONTRACTOR :
DRILLER :
DATE STARTED : 30/10/2017
DATE COMPLETED : 30/10/2017
DATE LOGGED : 30/10/2017
LOGGED BY : ML
CHECKED BY : ML

DRILLING

PENETRATION: VE E F H VH

DCP AS 1289.6.3.2-1997 Depth (m)	Blows	CBR	LAB SOAKED CBR	SAMPLES & FIELD TESTS
0.00 - 0.10	4			
0.10 - 0.20	3			
0.20 - 0.30	3			
0.30 - 0.40	3			
0.40 - 0.50	4			
0.50 - 0.60	7			
0.60 - 0.70	6			
0.70 - 0.80	7			
0.80 - 0.90	7			
0.90 - 1.00	9			
1.00 - 1.10	10			
1.10 - 1.20	10			
1.20 - 1.30	14			
1.30 - 1.40	Terminated			

MATERIAL

DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
0.0	ML	Clayey SILT, low plasticity, pale brown	D	F	RESIDUAL SOIL
0.20m	CH	Silty CLAY, high plasticity, dark brown, trace of coarse gravel at 1.0mbgl	M	F	
1.30m		Weathered SANDSTONE, fine grained, pale brown, trace of fine to coarse gravel	M		ROCK
2.00m		Hole Terminated at 2.00 m Refusal			

PAVEMENT CONDITION / REMARK

METHOD

N	Natural Exposure
E	Existing Excavation
BH	Backhoe Bucket
B	Bulldozer Blade
R	Ripper

PENETRATION

VE E F H VH
No Resistance

WATER

10 Oct., 73 Water Level on Date shown
water inflow
water outflow

SAMPLES & FIELD TESTS

U	- Undisturbed Sample
D	- Disturbed Sample
B	- Bulk Disturbed Sample
MC	- Moisture Content
PP	- Pocket Penetrometer (UCS kPa)
VS	- Vane Shear; P-Peak, R-Remouded (uncorrected kPa)
PBT	- Plate Bearing Test

CLASSIFICATION SYMBOLS & SOIL DESCRIPTION
Based on Unified Classification System

MOISTURE

D	- Dry
M	- Moist
W	- Wet

CONSISTENCY/ RELATIVE DENSITY

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard
VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

See Explanatory Notes for details of abbreviations & basis of descriptions.

VALLEY CIVILAB

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Proposed Subdivision
LOCATION : Gundy Road, Scone

HOLE NO : BH11
FILE / JOB NO : P1303
SHEET : 1 OF 1

POSITION : E: 300230.0, N: 6451015.5 (MGA94 Zone 56)
SURFACE ELEVATION :
ANGLE FROM HORIZONTAL : 90°
RIG TYPE : Drill Rig
MOUNTING : Trailer
CONTRACTOR :
DRILLER :
DATE STARTED : 30/10/2017
DATE COMPLETED : 30/10/2017
DATE LOGGED : 30/10/2017
LOGGED BY : MB
CHECKED BY : ML

DRILLING

DCP AS 1289.6.3.2-1997

Depth (m)	Blows	CBR
0.00 - 0.10	4	
0.10 - 0.20	3	
0.20 - 0.30	7	
0.30 - 0.40	10	
0.40 - 0.50	10	
0.50 - 0.60	6/50	
0.60 - 0.70	Terminated	

SAMPLES & FIELD TESTS

Depth	Sample
1.50m - 1.70m	U

MATERIAL

DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
0.0 - 0.60m	CI	Sandy Silty CLAY, medium plasticity, dark grey; fine to coarse grained sand	D	St	ALLUVIUM
0.60m - 0.80m	CI	Sandy Silty CLAY, medium plasticity, brown with fine white powder (salt); fine to coarse grained sand	D	H	
0.80m - 3.00m	CL-CI	Sandy Silty CLAY, low to medium plasticity, dark grey/brown/orange, trace of fine angular gravel	D	St to VSt	
3.00m		Hole Terminated at 3.00 m Terminated			

PAVEMENT CONDITION / REMARK

METHOD

N Natural Exposure
E Existing Excavation
BH Backhoe Bucket
B Bulldozer Blade
R Ripper

PENETRATION

VE E F H VH — No Resistance

WATER

10 Oct., 73 Water Level on Date shown
water inflow
water outflow

SAMPLES & FIELD TESTS

U - Undisturbed Sample
D - Disturbed Sample
B - Bulk Disturbed Sample
MC - Moisture Content
PP - Pocket Penetrometer (UCS kPa)
VS - Vane Shear; P-Peak, R-Remouded (uncorrected kPa)
PBT - Plate Bearing Test

CLASSIFICATION SYMBOLS & SOIL DESCRIPTION

Based on Unified Classification System

MOISTURE

D - Dry
M - Moist
W - Wet

CONSISTENCY/ RELATIVE DENSITY

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard
VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

See Explanatory Notes for details of abbreviations & basis of descriptions.

VALLEY CIVILAB

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Proposed Subdivision
LOCATION : Gundy Road, Scone

HOLE NO : BH12
FILE / JOB NO : P1303
SHEET : 1 OF 1

POSITION : E: 299678.0, N: 6450960.1 (MGA94 Zone 56)
SURFACE ELEVATION :
ANGLE FROM HORIZONTAL : 90°
RIG TYPE : Drill Rig
MOUNTING : Trailer
CONTRACTOR :
DRILLER :
DATE STARTED : 30/10/2017
DATE COMPLETED : 30/10/2017
DATE LOGGED : 30/10/2017
LOGGED BY : ML
CHECKED BY : ML

DRILLING

DCP AS 1289.6.3.2-1997 Depth (m)	Blows	CBR	LAB SOAKED CBR
0.00 - 0.10	4		
0.10 - 0.20	3		
0.20 - 0.30	3		
0.30 - 0.40	10		
0.40 - 0.50	11		
0.50 - 0.60	Terminated		

PENETRATION: VE E F H

SAMPLES & FIELD TESTS
0.10m B 0.40m
0.50m D 0.60m
1.50m D 1.60m

MATERIAL

DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
0.0	CH	Silty CLAY, high plasticity, dark brown, with fine to medium grained sand	M	St	ALLUVIUM
0.50m	ML	Clayey SILT, low plasticity, pale brown	D	VSt	
0.70m	CH	Silty CLAY, high plasticity, dark brown, trace of fine to coarse grained sand, becoming brown/dark brown at approximately 1.2mbgl	D M	St	
3.00m		Hole Terminated at 3.00 m Terminated			

DEPTH (m) scale: 0.0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0

PAVEMENT CONDITION / REMARK

METHOD
- N Natural Exposure
- E Existing Excavation
- BH Backhoe Bucket
- B Bulldozer Blade
- R Ripper

PENETRATION
VE E F H VH
No Resistance

WATER
10 Oct., 73 Water Level on Date shown
water inflow
water outflow

SAMPLES & FIELD TESTS
- U - Undisturbed Sample
- D - Disturbed Sample
- B - Bulk Disturbed Sample
- MC - Moisture Content
- PP - Pocket Penetrometer (UCS kPa)
- VS - Vane Shear; P-Peak, R-Remouded (uncorrected kPa)
- PBT - Plate Bearing Test

CLASSIFICATION SYMBOLS & SOIL DESCRIPTION
Based on Unified Classification System

MOISTURE
- D - Dry
- M - Moist
- W - Wet

CONSISTENCY/ RELATIVE DENSITY

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard
VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

See Explanatory Notes for details of abbreviations & basis of descriptions.

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Proposed Subdivision
LOCATION : Gundy Road, Scone

HOLE NO : BH13
FILE / JOB NO : P1303
SHEET : 1 OF 1

POSITION : E: 300148.9, N: 6450866.6 (MGA94 Zone 56) SURFACE ELEVATION : ANGLE FROM HORIZONTAL : 90°

RIG TYPE : Drill Rig MOUNTING : Trailer CONTRACTOR : DRILLER :

DATE STARTED : 30/10/2017 DATE COMPLETED : 30/10/2017 DATE LOGGED : 30/10/2017 LOGGED BY : ML CHECKED BY : ML

DRILLING

DCP AS 1289.6.3.2-1997

Depth (m)	Blows	CBR
0.00 - 0.10	6	
0.10 - 0.20	7	
0.20 - 0.30	10	
0.30 - 0.40	13	
0.40 - 0.50	15	
0.50 - 0.60	Terminated	

SAMPLES & FIELD TESTS

From	To	Sample
0.40m	0.60m	D U
0.60m	0.70m	D
1.00m	1.10m	D
1.50m	1.60m	D

MATERIAL

DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
0.0 - 0.30m	ML	Clayey SILT, low plasticity, pale brown	D	St	ALLUVIUM
0.30m - 1.40m	CH	Silty CLAY, high plasticity, brown/dark brown, trace of fine to medium grained sand, trace of fine to coarse gravel	D to M	St to VSt	
1.40m - 2.00m		Weathered SANDSTONE, fine grained, pale brown, trace of fine to coarse gravel	D		ROCK
2.00m		Hole Terminated at 2.00 m Refusal			

PAVEMENT CONDITION / REMARK

METHOD

N	Natural Exposure
E	Existing Excavation
BH	Backhoe Bucket
B	Bulldozer Blade
R	Ripper

PENETRATION

VE E F H VH — No Resistance

WATER

10 Oct., 73 Water Level on Date shown
▶ water inflow
◀ water outflow

SAMPLES & FIELD TESTS

U	-	Undisturbed Sample
D	-	Disturbed Sample
B	-	Bulk Disturbed Sample
MC	-	Moisture Content
PP	-	Pocket Penetrometer (UCS kPa)
VS	-	Vane Shear; P-Peak, R-Remouded (uncorrected kPa)
PBT	-	Plate Bearing Test

CLASSIFICATION SYMBOLS & SOIL DESCRIPTION

Based on Unified Classification System

MOISTURE

D	-	Dry
M	-	Moist
W	-	Wet

CONSISTENCY/ RELATIVE DENSITY

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard
VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

See Explanatory Notes for details of abbreviations & basis of descriptions.

NON-CORE DRILL HOLE - GEOLOGICAL LOG

VALLEY CIVILAB

PROJECT : Proposed Subdivision
LOCATION : Gundy Road, Scone

HOLE NO : BH14
FILE / JOB NO : P1303
SHEET : 1 OF 1

POSITION : E: 300262.2, N: 6450703.6 (MGA94 Zone 56)	SURFACE ELEVATION :	ANGLE FROM HORIZONTAL : 90°
RIG TYPE : Drill Rig	MOUNTING : Trailer	CONTRACTOR : DRILLER :
DATE STARTED : 30/10/2017 DATE COMPLETED : 30/10/2017	DATE LOGGED : 30/10/2017	LOGGED BY : MB CHECKED BY : ML

DRILLING							MATERIAL					
PENETRATION VE E F H	DCP Depth (m)	DCP Blows	DCP CBR	LAB SOAKED CBR	SAMPLES & FIELD TESTS	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
						0.0		CI	0.05m TOPSOIL: Silty CLAY, medium plasticity, dark grey	D	St	TOPSOIL
								CL-CI	Silty CLAY, low to medium plasticity, dark grey, trace of medium sub-angular gravel	D	St	ALLUVIUM
						0.5		CL-CI	0.40m Silty Gravelly CLAY, low to medium plasticity, pale brown/ grey; angular to sub-rounded fine to medium gravel	D	VSt	
						1.0						
						1.5		CL	1.50m Silty CLAY, low plasticity, trace of fine to medium gravel	D	VSt	
						2.0						
						2.5			2.60m Hole Terminated at 2.60 m Refusal			

PAVEMENT CONDITION / REMARK

METHOD

N	Natural Exposure
E	Existing Excavation
BH	Backhoe Bucket
B	Bulldozer Blade
R	Ripper

PENETRATION

VE E F H VH — No Resistance

WATER

10 Oct., 73 Water Level on Date shown
▶ water inflow
◀ water outflow

SAMPLES & FIELD TESTS

U	- Undisturbed Sample
D	- Disturbed Sample
B	- Bulk Disturbed Sample
MC	- Moisture Content
PP	- Pocket Penetrometer (UCS kPa)
VS	- Vane Shear; P-Peak, R-Remouded (uncorrected kPa)
PBT	- Plate Bearing Test

CLASSIFICATION SYMBOLS & SOIL DESCRIPTION

Based on Unified Classification System

MOISTURE

D	- Dry
M	- Moist
W	- Wet

CONSISTENCY/ RELATIVE DENSITY

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard
VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

See Explanatory Notes for details of abbreviations & basis of descriptions.

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Proposed Subdivision
LOCATION : Gundy Road, Scone

HOLE NO : BH15
FILE / JOB NO : P1303
SHEET : 1 OF 1

POSITION : E: 300243.5, N: 6450558.6 (MGA94 Zone 56) SURFACE ELEVATION : ANGLE FROM HORIZONTAL : 90°
RIG TYPE : Drill Rig MOUNTING : Trailer CONTRACTOR : DRILLER :
DATE STARTED : 30/10/2017 DATE COMPLETED : 30/10/2017 DATE LOGGED : 30/10/2017 LOGGED BY : MB CHECKED BY : ML

DRILLING

DCP AS 1289.6.3.2-1997

Depth (m)	Blows	CBR
0.00 - 0.10	6	
0.10 - 0.20	5	
0.20 - 0.30	6	
0.30 - 0.40	6	
0.40 - 0.50	10	
0.50 - 0.60	14	
0.60 - 0.70	Terminated	

MATERIAL

DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
0.0 - 0.35m	CH	Silty CLAY, high plasticity, dark grey, with fine to coarse sand	D - M	VSt	RESIDUAL SOIL
0.35m - 1.20m	ML	Clayey Sandy Gravelly SILT, low plasticity, pale brown; sub-angular to sub-rounded gravel	D	VSt	
1.20m - 3.00m		Weathered SANDSTONE, fine to coarse grained, pale brown	D	VD	
3.00m		Hole Terminated at 3.00 m Terminated			

PAVEMENT CONDITION / REMARK

METHOD

N	Natural Exposure
E	Existing Excavation
BH	Backhoe Bucket
B	Bulldozer Blade
R	Ripper

PENETRATION

VE E F H VH — No Resistance

WATER

10 Oct., 73 Water Level on Date shown
▶ water inflow
◀ water outflow

SAMPLES & FIELD TESTS

U - Undisturbed Sample
D - Disturbed Sample
B - Bulk Disturbed Sample
MC - Moisture Content
PP - Pocket Penetrometer (UCS kPa)
VS - Vane Shear; P-Peak, R-Remouded (uncorrected kPa)
PBT - Plate Bearing Test

CLASSIFICATION SYMBOLS & SOIL DESCRIPTION

Based on Unified Classification System

MOISTURE

D - Dry
M - Moist
W - Wet

CONSISTENCY/ RELATIVE DENSITY

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard
VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

See Explanatory Notes for details of abbreviations & basis of descriptions.

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Proposed Subdivision
LOCATION : Gundy Road, Scone

HOLE NO : BH16
FILE / JOB NO : P1303
SHEET : 1 OF 1

POSITION : E: 300249.9, N: 6450391.3 (MGA94 Zone 56)
SURFACE ELEVATION :
ANGLE FROM HORIZONTAL : 90°
RIG TYPE : Drill Rig
MOUNTING : Trailer
CONTRACTOR :
DRILLER :
DATE STARTED : 30/10/2017
DATE COMPLETED : 30/10/2017
DATE LOGGED : 30/10/2017
LOGGED BY : MB
CHECKED BY : ML

DRILLING

PENETRATION VE E F H	DCP AS 1289.6.3.2-1997 Depth (m)	Blows	CBR	LAB SOAKED CBR	SAMPLES & FIELD TESTS
	0.00 - 0.10	1			
	0.10 - 0.20	1			
	0.20 - 0.30	2			
	0.30 - 0.40	2			
	0.40 - 0.50	3			0.50m
	0.50 - 0.60	5			U
	0.60 - 0.70	6			
	0.70 - 0.80	9			0.80m
	0.80 - 0.90	11			
	0.90 - 1.00	7/50			
	1.00 - 1.10	Terminated			

MATERIAL

DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
0.0		CH	Silty CLAY, high plasticity, dark grey, trace of fine sub-rounded gravel, becoming dark grey/dark brown at 0.6mbgl	D to M	S	RESIDUAL SOIL
				D	VSt to H	
1.10m			Extremely Weathered SANDSTONE, pale grey/red/brown, with medium angular gravel	D		
3.00m			Hole Terminated at 3.00 m Terminated			

DEPTH (m) scale: 0.0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0

PAVEMENT CONDITION / REMARK

METHOD

N	Natural Exposure
E	Existing Excavation
BH	Backhoe Bucket
B	Bulldozer Blade
R	Ripper

PENETRATION

VE E F H VH
No Resistance

WATER

10 Oct., 73 Water Level on Date shown
▶ water inflow
◀ water outflow

SAMPLES & FIELD TESTS

U	- Undisturbed Sample
D	- Disturbed Sample
B	- Bulk Disturbed Sample
MC	- Moisture Content
PP	- Pocket Penetrometer (UCS kPa)
VS	- Vane Shear; P-Peak, R-Remouded (uncorrected kPa)
PBT	- Plate Bearing Test

CLASSIFICATION SYMBOLS & SOIL DESCRIPTION
Based on Unified Classification System

MOISTURE

D	- Dry
M	- Moist
W	- Wet

CONSISTENCY/ RELATIVE DENSITY

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard
VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

See Explanatory Notes for
details of abbreviations
& basis of descriptions.

VCL 2.02.2 LIB.GLB Log IS AU PAVEMENTS 2 VCL 2.02.GPJ <<DrawingFile>> 20/11/2017 11:44 10.0.000 Datgel Lab and In Situ Tool - DGD | Lib: VCL 2.02.2 2016-04-08 Prj: VCL 2.02 2016-04-04

VALLEY CIVILAB

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Proposed Subdivision
LOCATION : Gundy Road, Scone

HOLE NO : BH17
FILE / JOB NO : P1303
SHEET : 1 OF 1

POSITION : E: 300400.4, N: 6450906.2 (MGA94 Zone 56) SURFACE ELEVATION : ANGLE FROM HORIZONTAL : 90°
RIG TYPE : Drill Rig MOUNTING : Trailer CONTRACTOR : DRILLER :
DATE STARTED : 30/10/2017 DATE COMPLETED : 30/10/2017 DATE LOGGED : 30/10/2017 LOGGED BY : MB CHECKED BY : ML

DEPTH (m)	SAMPLES & FIELD TESTS	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
0.0 – 0.15m		ML	TOPSOIL: Clayey SILT, low plasticity, dark grey	D - M		TOPSOIL
0.15m – 1.00m	0.50m D 0.70m	CI-CH	CLAY, medium to high plasticity, dark grey, with fine to coarse grained sand	D	St	ALLUVIUM
1.00m – 2.00m	1.50m B 1.60m D 1.80m	CH	Sandy CLAY, high plasticity, dark grey/brown; fine to coarse grained sand	D	VSt	
2.00m – 3.00m	2.00m D 3.00m	CI	Sandy CLAY, medium plasticity, brown; fine grained sand	D	VSt	
3.00m			Hole Terminated at 3.00 m Terminated			

DRILLING: PENETRATION (VE E F H), DCP (Depth (m), Blows, CBR), LAB SOAKED CBR, SAMPLES & FIELD TESTS

PAVEMENT CONDITION / REMARK

METHOD

- N Natural Exposure
- E Existing Excavation
- BH Backhoe Bucket
- B Bulldozer Blade
- R Ripper

PENETRATION

VE E F H VH — No Resistance

WATER

10 Oct., 73 Water Level on Date shown
▶ water inflow
◀ water outflow

SAMPLES & FIELD TESTS

- U - Undisturbed Sample
- D - Disturbed Sample
- B - Bulk Disturbed Sample
- MC - Moisture Content
- PP - Pocket Penetrometer (UCS kPa)
- VS - Vane Shear; P-Peak, R-Remouded (uncorrected kPa)
- PBT - Plate Bearing Test

CLASSIFICATION SYMBOLS & SOIL DESCRIPTION

Based on Unified Classification System

MOISTURE

- D - Dry
- M - Moist
- W - Wet

CONSISTENCY/ RELATIVE DENSITY

- VS - Very Soft
- S - Soft
- F - Firm
- St - Stiff
- VSt - Very Stiff
- H - Hard
- VL - Very Loose
- L - Loose
- MD - Medium Dense
- D - Dense
- VD - Very Dense

See Explanatory Notes for details of abbreviations & basis of descriptions.

VCL 2.02.2 LIB.GLB Log IS AU PAVEMENTS 2 VCL 2.02.GPJ <<DrawingFile>> 20/11/2017 11:44 10.0.000 Datgel Lab and In Situ Tool - DGD | Lib: VCL 2.02.2 2016-04-08 Prj: VCL 2.02 2016-04-04

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH18
FILE / JOB NO : P1303
SHEET : 1 OF 1

PROJECT : Proposed Subdivision
LOCATION : Gundy Road, Scone

POSITION : E: 300441.0, N: 6450672.4 (MGA94 Zone 56)
SURFACE ELEVATION :
ANGLE FROM HORIZONTAL : 90°
RIG TYPE : Drill Rig
MOUNTING : Trailer
CONTRACTOR :
DRILLER :
DATE STARTED : 30/10/2017
DATE COMPLETED : 30/10/2017
DATE LOGGED : 30/10/2017
LOGGED BY : MB
CHECKED BY : ML

DRILLING

DCP AS 1289.6.3.2-1997

Depth (m)	Blows	CBR	LAB SOAKED CBR	SAMPLES & FIELD TESTS
0.00 - 0.10	4			
0.10 - 0.20	5			
0.20 - 0.30	4			
0.30 - 0.40	9			
0.40 - 0.50	8			
0.50 - 0.60	10			0.60m
0.60 - 0.70	9			B U
0.70 - 0.80	Terminated			0.80m

PENETRATION: VE E F H

MATERIAL

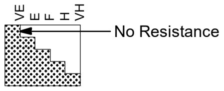
DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
0.0 - 0.80m	CH	Silty CLAY, high plasticity, dark grey/black, with fine to coarse grained sand	M	VSt	ALLUVIUM
0.80m - 1.20m	CH	Silty CLAY, high plasticity, dark grey/black, trace of coarse grained sand	D to M	VSt	
1.20m - 2.50m	CL	Silty Sandy CLAY, low plasticity, pale brown/pale grey, fine to coarse grained sand	D	VSt	RESIDUAL SOIL
2.50m - 3.00m		Extremely weathered SANDSTONE	D	VD	
3.00m		Hole Terminated at 3.00 m Terminated			

PAVEMENT CONDITION / REMARK

METHOD

N	Natural Exposure
E	Existing Excavation
BH	Backhoe Bucket
B	Bulldozer Blade
R	Ripper

PENETRATION



WATER

10 Oct., 73 Water Level on Date shown
► water inflow
◄ water outflow

SAMPLES & FIELD TESTS

U	-	Undisturbed Sample
D	-	Disturbed Sample
B	-	Bulk Disturbed Sample
MC	-	Moisture Content
PP	-	Pocket Penetrometer (UCS kPa)
VS	-	Vane Shear; P-Peak, R-Remouded (uncorrected kPa)
PBT	-	Plate Bearing Test

CLASSIFICATION SYMBOLS & SOIL DESCRIPTION
Based on Unified Classification System

MOISTURE

D	-	Dry
M	-	Moist
W	-	Wet

CONSISTENCY/ RELATIVE DENSITY

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard
VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

See Explanatory Notes for details of abbreviations & basis of descriptions.

NON-CORE DRILL HOLE - GEOLOGICAL LOG

VALLEY CIVILAB

PROJECT : Proposed Subdivision
LOCATION : Gundy Road, Scone

HOLE NO : BH19
FILE / JOB NO : P1303
SHEET : 1 OF 1

POSITION : E: 300435.0, N: 6450524.0 (MGA94 Zone 56) SURFACE ELEVATION : ANGLE FROM HORIZONTAL : 90°

RIG TYPE : Drill Rig MOUNTING : Trailer CONTRACTOR : DRILLER :

DATE STARTED : 30/10/2017 DATE COMPLETED : 30/10/2017 DATE LOGGED : 30/10/2017 LOGGED BY : MB CHECKED BY : ML

DRILLING

DCP AS 1289.6.3.2-1997

Depth (m)	Blows	CBR	LAB SOAKED CBR	SAMPLES & FIELD TESTS
0.00 - 0.10	2			
0.10 - 0.20	4			
0.20 - 0.30	5			
0.30 - 0.40	8			
0.40 - 0.50	6/50			
0.50 - 0.60	Terminated			

MATERIAL

DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
0.0	CI-CH	Silty Sandy CLAY, medium to high plasticity, dark grey; fine to medium grained sand	D	St	RESIDUAL SOIL
0.25m	CI-CH	Silty Sandy CLAY, pale grey, low plasticity; fine grained sand with fine sub-angular to sub-rounded gravel	D	VSt to H	
3.00m		Hole Terminated at 3.00 m Terminated			

PAVEMENT CONDITION / REMARK

METHOD

N	Natural Exposure
E	Existing Excavation
BH	Backhoe Bucket
B	Bulldozer Blade
R	Ripper

PENETRATION

VE E F H VH

No Resistance

WATER

10 Oct., 73 Water Level on Date shown

▶ water inflow

◀ water outflow

SAMPLES & FIELD TESTS

U	Undisturbed Sample
D	Disturbed Sample
B	Bulk Disturbed Sample
MC	Moisture Content
PP	Pocket Penetrometer (UCS kPa)
VS	Vane Shear; P-Peak, R-Remouded (uncorrected kPa)
PBT	Plate Bearing Test

CLASSIFICATION SYMBOLS & SOIL DESCRIPTION

Based on Unified Classification System

MOISTURE

D	Dry
M	Moist
W	Wet

CONSISTENCY/ RELATIVE DENSITY

VS	Very Soft
S	Soft
F	Firm
St	Stiff
VSt	Very Stiff
H	Hard
VL	Very Loose
L	Loose
MD	Medium Dense
D	Dense
VD	Very Dense

See Explanatory Notes for details of abbreviations & basis of descriptions.

VALLEY CIVILAB

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Proposed Subdivision
LOCATION : Gundy Road, Scone

HOLE NO : BH20
FILE / JOB NO : P1303
SHEET : 1 OF 1

POSITION : E: 300444.6, N: 6450382.6 (MGA94 Zone 56)   SURFACE ELEVATION :   ANGLE FROM HORIZONTAL : 90°
RIG TYPE : Drill Rig   MOUNTING : Trailer   CONTRACTOR :   DRILLER :
DATE STARTED : 30/10/2017   DATE COMPLETED : 30/10/2017   DATE LOGGED : 30/10/2017   LOGGED BY : MB   CHECKED BY : ML

DRILLING

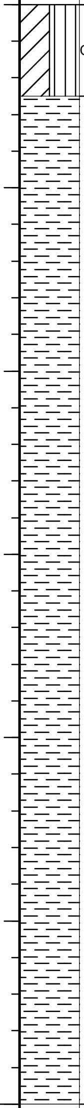
DCP AS 1289.6.3.2-1997

Depth (m)	Blows	CBR	LAB SOAKED CBR
0.00 - 0.10	4		
0.10 - 0.20	4		
0.20 - 0.30	6		
0.30 - 0.40	6		
0.40 - 0.50	10		
0.50 - 0.60	10		
0.60 - 0.70	Terminated		

SAMPLES & FIELD TESTS: 0.50m B 0.70m

PENETRATION: VE E F H

MATERIAL



DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
0.0	CI-CH	Silty CLAY, medium to high plasticity, dark grey, trace of roots	D - M	VSt	RESIDUAL SOIL
0.25m	ML	Sandy Gravelly Clayey SILT, low plasticity, pale grey; fine to coarse grained sand; fine to medium gravel, becoming softer with coarse sub-angular gravel at 1.5mbgl	D	H	
1.5			D	St	
3.00m		Hole Terminated at 3.00 m Terminated			

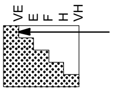
Depth scale: 0.0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0

PAVEMENT CONDITION / REMARK

METHOD

N	Natural Exposure
E	Existing Excavation
BH	Backhoe Bucket
B	Bulldozer Blade
R	Ripper

PENETRATION



WATER

10 Oct., 73 Water Level on Date shown
water inflow
water outflow

SAMPLES & FIELD TESTS

U	-	Undisturbed Sample
D	-	Disturbed Sample
B	-	Bulk Disturbed Sample
MC	-	Moisture Content
PP	-	Pocket Penetrometer (UCS kPa)
VS	-	Vane Shear; P-Peak, R-Remouded (uncorrected kPa)
PBT	-	Plate Bearing Test

CLASSIFICATION SYMBOLS & SOIL DESCRIPTION
Based on Unified Classification System

MOISTURE

D	-	Dry
M	-	Moist
W	-	Wet

CONSISTENCY/ RELATIVE DENSITY

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard
VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

See Explanatory Notes for details of abbreviations & basis of descriptions.

VALLEY CIVILAB
Geotechnical & Environmental Services

Annex C

VALLEY CIVILAB
Geotechnical & Environmental Services

Shrink Swell Index Report

Client :	**David Casson - Casson Planning & Development Services**	Report Number:	**P1303 - 1/1**
Address :	**5 Stanstead Close, Scone, NSW, 2337**	Report Date :	**7/11/2017**
Project Name :	**Geotechnical Investigation - Scone**	Order Number :	
Project Number :	**P1303**	Test Method :	**AS1289.7.1.1**
Location:	**Lot 2 Gundy Road , Scone**		**Page 1 of 2**

Sample Number :	S17-5384	S17-5385	S17-5386	S17-5387
Test Number :				
Sampling Method :	AS1289.1.3.1	AS1289.1.3.1	AS1289.1.3.1	AS1289.1.3.1
Sampled By :	Mathew Lay	Mathew Lay	Mathew Lay	Mathew Lay
Date Sampled :	30/10/2017	30/10/2017	30/10/2017	30/10/2017
Date Tested :	1/11/2017	1/11/2017	1/11/2017	1/11/2017
Material Type :	existing	existing	existing	existing
Material Source :	Tube Sample	Tube Sample	Tube Sample	Tube Sample
Sample Location :	Client PO; Sample Taken BH3 -0.4m/-0.6m	Client PO; Sample Taken BH4 -0.5m/-0.7m	Client PO; Sample Taken BH11 -1.5m/-1.7m	Client PO; Sample Taken BH13 -0.4m/-0.7m
Inert Material Estimate (%) :	15	15	10	10
PP before (kPa) :	600+	600+	600+	600+
PP after (kPa) :	170	150	180	150
Shrinkage Moisture Content (%) :	28	27.6	26.9	18.1
Shrinkage (%) :	**6.1**	**5.9**	**4.2**	**2.3**
Swell Moisture Content Before (%) :	26.3	26.2	25.6	21.5
Swell Moisture Content After (%) :	44.9	40.1	33.7	30.7
Swell (%) :	**7.2**	**4.7**	**0.8**	**2.2**
Unit Weight (t/m³) :	-	-	-	-
Shrink Swell Index Iss (%) :	**5.4**	**4.6**	**2.5**	**1.9**
Visual Classification :	refer to attached borelogs	refer to attached borelogs	refer to attached borelogs	refer to attached borelogs
Cracking :	Minor	Minor	Major	Nil
Crumbling :	Major	Minor	Nil	Nil
Remarks :				

NATA
WORLD RECOGNISED ACCREDITATION

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

APPROVED SIGNATORY

Richard Badior - Senior Geotechnical Officer
NATA Accreditation Number
14975

Shrink Swell Index Report

Client :	**David Casson - Casson Planning & Development Services**	Report Number:	**P1303 - 1/1**
Address :	**5 Stanstead Close, Scone, NSW, 2337**	Report Date :	**7/11/2017**
Project Name :	**Geotechnical Investigation - Scone**	Order Number :	
Project Number :	**P1303**	Test Method :	**AS1289.7.1.1**
Location:	**Lot 2 Gundy Road , Scone**	**Page 2 of 2**	

Sample Number :	S17-5388	S17-5389		
Test Number :				
Sampling Method :	AS1289.1.3.1	AS1289.1.3.1		
Sampled By :	Mathew Lay	Mathew Lay		
Date Sampled :	30/10/2017	30/10/2017		
Date Tested :	1/11/2017	1/11/2017		
Material Type :	existing	existing		
Material Source :	Tube Sample	Tube Sample		
Sample Location :	Client PO; Sample Taken BH16 -0.5m/-0.8m	Client PO; Sample Taken BH18 -0.6m/-0.8m		
Inert Material Estimate (%) :	15	15		
PP before (kPa) :	600+	600+		
PP after (kPa) :	150	150		
Shrinkage Moisture Content (%) :	27.7	29.3		
Shrinkage (%) :	**5.2**	**5.9**		
Swell Moisture Content Before (%) :	29.3	29.8		
Swell Moisture Content After (%) :	44.2	34.4		
Swell (%) :	**6.7**	**4.5**		
Unit Weight (t/m³) :	-	-		
Shrink Swell Index Iss (%) :	**4.8**	**4.6**		
Visual Classification :	refer to attached borelogs	refer to attached borelogs		
Cracking :	Minor	Minor		
Crumbling :	Major	Minor		
Remarks :				

NATA
WORLD RECOGNISED ACCREDITATION

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APPROVED SIGNATORY

Richard Badior - Senior Geotechnical Officer
NATA Accreditation Number
14975

VALLEY CIVILAB
Geotechnical & Environmental Services

Atterberg Limits Report

Client :	**David Casson - Casson Planning & Development Services**	Report Number:	**P1303 - 3/1**
Address :	**5 Stanstead Close, Scone, NSW, 2337**	Report Date :	**16/11/2017**
Project Name :	**Geotechnical Investigation - Scone**	Order Number :	
Project Number :	**P1303**	Test Method :	**AS1289.3.1.2, 3.2.1, 3.3.1, 3.4.1**
Location:	**Lot 2 Gundy Road , Scone**		**Page 1 of 2**

Sample Number :	S17-5336	S17-5342	S17-5343	S17-5344
Test Number :				
Date Sampled :	30/10/2017	30/10/2017	30/10/2017	30/10/2017
Date Tested :	9/11/2017	9/11/2017	13/11/2017	9/11/2017
Sampled By :	Mathew Lay	Mathew Lay	Mathew Lay	Mathew Lay
Sampling Method :	AS1289.1.2.1	AS1289.1.2.1	AS1289.1.2.1	AS1289.1.2.1
Material Source :	On-site	On-site	On-site	On-site
Material Type :	Soil	Soil	Soil	Soil
Sample Location :	BH1_0.1-0.4m	BH6_0.2-0.4m	BH7_2.0-2.2m	BH8_0.3-0.6m
Lot Number :				
Moisture Method :	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1
Sample History :	Oven Dried	Oven Dried	Oven Dried	Oven Dried
Sample Preparation :	Dry	Dry	Dry	Dry
Notes :	Some Curling Occured	Some Curling Occured	Some Curling Occured	Some Curling Occured
Mould Length (mm) :	125.5	125	150	125
Liquid Limit (%) :	96	90	81	89
Plastic Limit (%) :	21	21	19	21
Plasticity Index (%) :	75	69	62	68
Linear Shrinkage (%) :	23.5	23	20	21.5
SPECIFICATION DETAILS				
Specification Number :				
Liquid Limit - Max :				
Plasticity Index - Max :				
Linear Shrinkage - Max :				
Remarks :	-			

NATA
WORLD RECOGNISED ACCREDITATION

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APPROVED SIGNATORY

JWyatt

James Wyatt - Technician - Quarry Materials
NATA Accreditation Number :
14975

VALLEY/CIVILAB
Geotechnical & Environmental Services

Atterberg Limits Report

Client :	**David Casson - Casson Planning & Development Services**	Report Number:	**P1303 - 3/1**
Address :	**5 Stanstead Close, Scone, NSW, 2337**	Report Date :	**16/11/2017**
Project Name :	**Geotechnical Investigation - Scone**	Order Number :	
Project Number :	**P1303**	Test Method :	**AS1289.3.1.2, 3.2.1, 3.3.1, 3.4.1**
Location:	**Lot 2 Gundy Road , Scone**		**Page 2 of 2**

Sample Number :	S17-5347	S17-5349		
Test Number :				
Date Sampled :	30/10/2017	30/10/2017		
Date Tested :	9/11/2017	13/11/2017		
Sampled By :	Mathew Lay	Mathew Lay		
Sampling Method :	AS1289.1.2.1	AS1289.1.2.1		
Material Source :	On-site	On-site		
Material Type :	Soil	Soil		
Sample Location :	BH17_1.5-1.8m	BH20_0.5-0.7m		
Lot Number :				
Moisture Method :	AS1289.2.1.1	AS1289.2.1.1		
Sample History :	Oven Dried	Oven Dried		
Sample Preparation :	Dry	Dry		
Notes :	Some Curling Occured	No Cracking or Crumbling		
Mould Length (mm) :	125	150		
Liquid Limit (%) :	49	53		
Plastic Limit (%) :	13	25		
Plasticity Index (%) :	36	28		
Linear Shrinkage (%) :	13.5	15.5		
SPECIFICATION DETAILS				
Specification Number :				
Liquid Limit - Max :				
Plasticity Index - Max :				
Linear Shrinkage - Max :				
Remarks :	-			

NATA
WORLD RECOGNISED ACCREDITATION

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APPROVED SIGNATORY

James Wyatt - Technician - Quarry Materials
NATA Accreditation Number :
14975

VALLEY CIVILAB
Geotechnical & Environmental Services

Particle Size Distribution Report

Client : **David Casson - Casson Planning & Development Services**
Address : **5 Stanstead Close, Scone, NSW, 2337**
Project Name : **Geotechnical Investigation - Scone**
Project Number : **P1303**
Location: **Lot 2 Gundy Road , Scone**

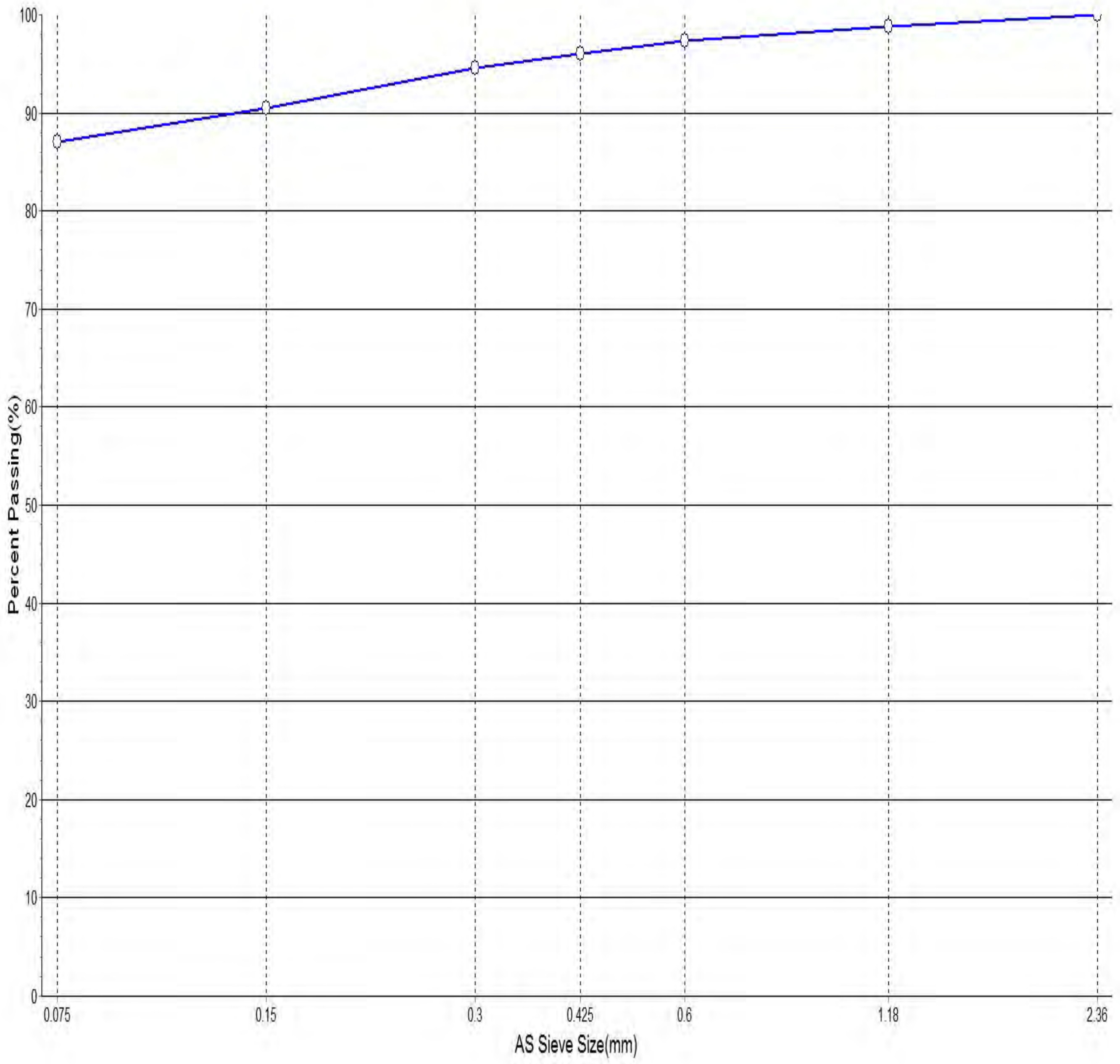
Report Number: **P1303 - 2/1**
Report Date : **16/11/2017**
Order Number :
Test Method : **AS1289.3.6.1**
Page 1 of 6

Sample Number : S17-5336
Sampling Method : AS1289.1.2.1
Sampled By : Mathew Lay
Date Sampled : 30/10/2017
Date Tested : 9/11/2017
Material Type : Soil
Material Source : On-site
Remarks :

SAMPLE LOCATION
BH1_0.1-0.4m

Test Number :
Lot Number :
Specification Number :

AS Sieve Size(mm)	Percent Passing	Specification Limits
100		
75		
63		
53		
37.5		
26.5		
19.0		
16.0		
13.2		
9.5		
6.7		
4.75		
2.36	**100**	
1.18	**99**	
0.600	**97**	
0.425	**96**	
0.300	**95**	
0.150	**90**	
0.075	**87**	



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APPROVED SIGNATORY

James Wyatt - Technician - Quarry Materials
NATA Accreditation Number
14975

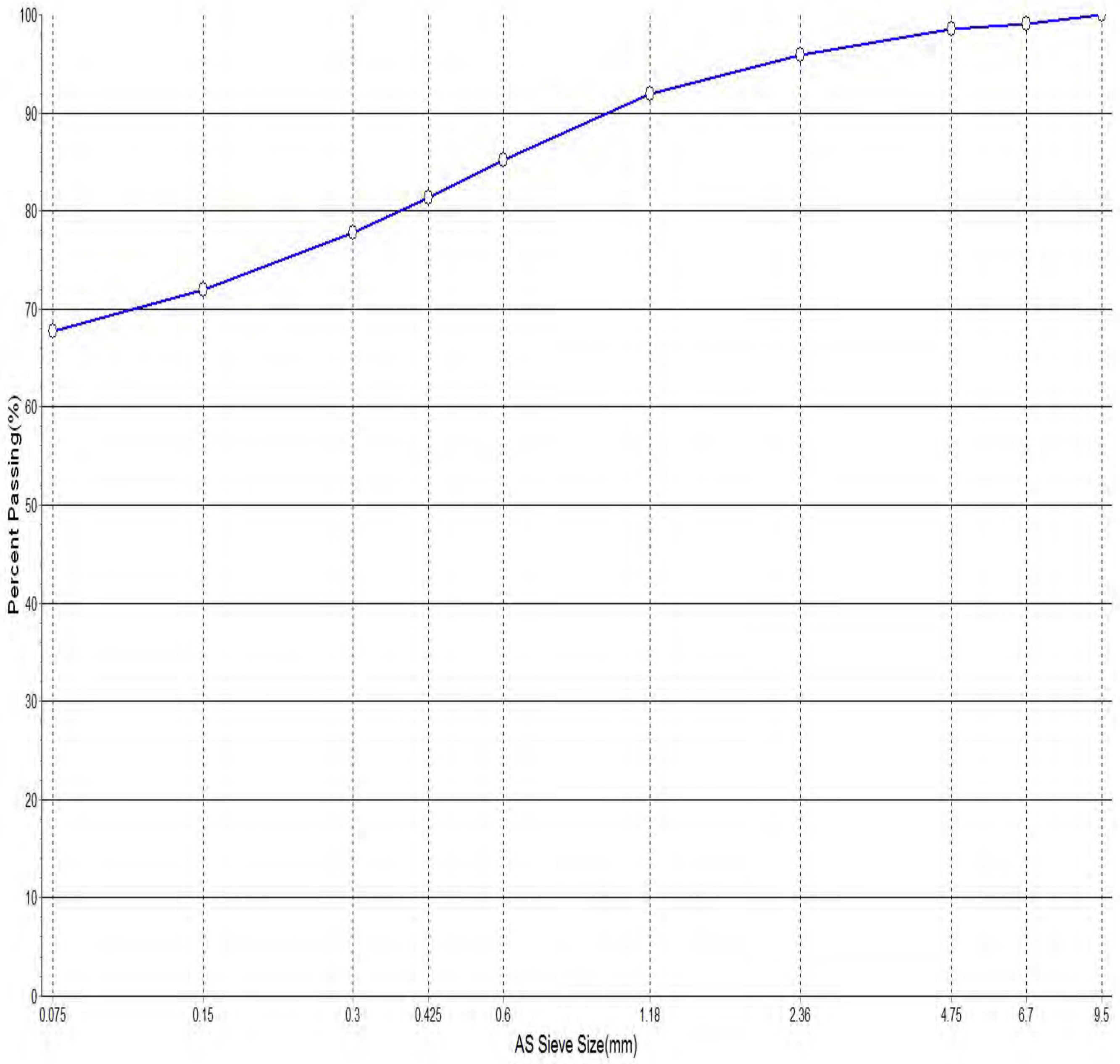
Particle Size Distribution Report

Client :	**David Casson - Casson Planning & Development Services**	Report Number:	**P1303 - 2/1**
Address :	**5 Stanstead Close, Scone, NSW, 2337**	Report Date :	**16/11/2017**
Project Name :	**Geotechnical Investigation - Scone**	Order Number :	
Project Number :	**P1303**	Test Method :	**AS1289.3.6.1**
Location:	**Lot 2 Gundy Road , Scone**		**Page 2 of 6**

Sample Number :	S17-5343
Sampling Method :	AS1289.1.2.1
Sampled By :	Mathew Lay
Date Sampled :	30/10/2017
Date Tested :	9/11/2017
Material Type :	Soil
Material Source :	On-site
Remarks :	

SAMPLE LOCATION	
BH7_2.0-2.2m	
Test Number :	
Lot Number :	
Specification Number :	

AS Sieve Size(mm)	Percent Passing	Specification Limits
100		
75		
63		
53		
37.5		
26.5		
19.0		
16.0		
13.2		
9.5	**100**	
6.7	**99**	
4.75	**98**	
2.36	**96**	
1.18	**92**	
0.600	**85**	
0.425	**81**	
0.300	**78**	
0.150	**72**	
0.075	**68**	



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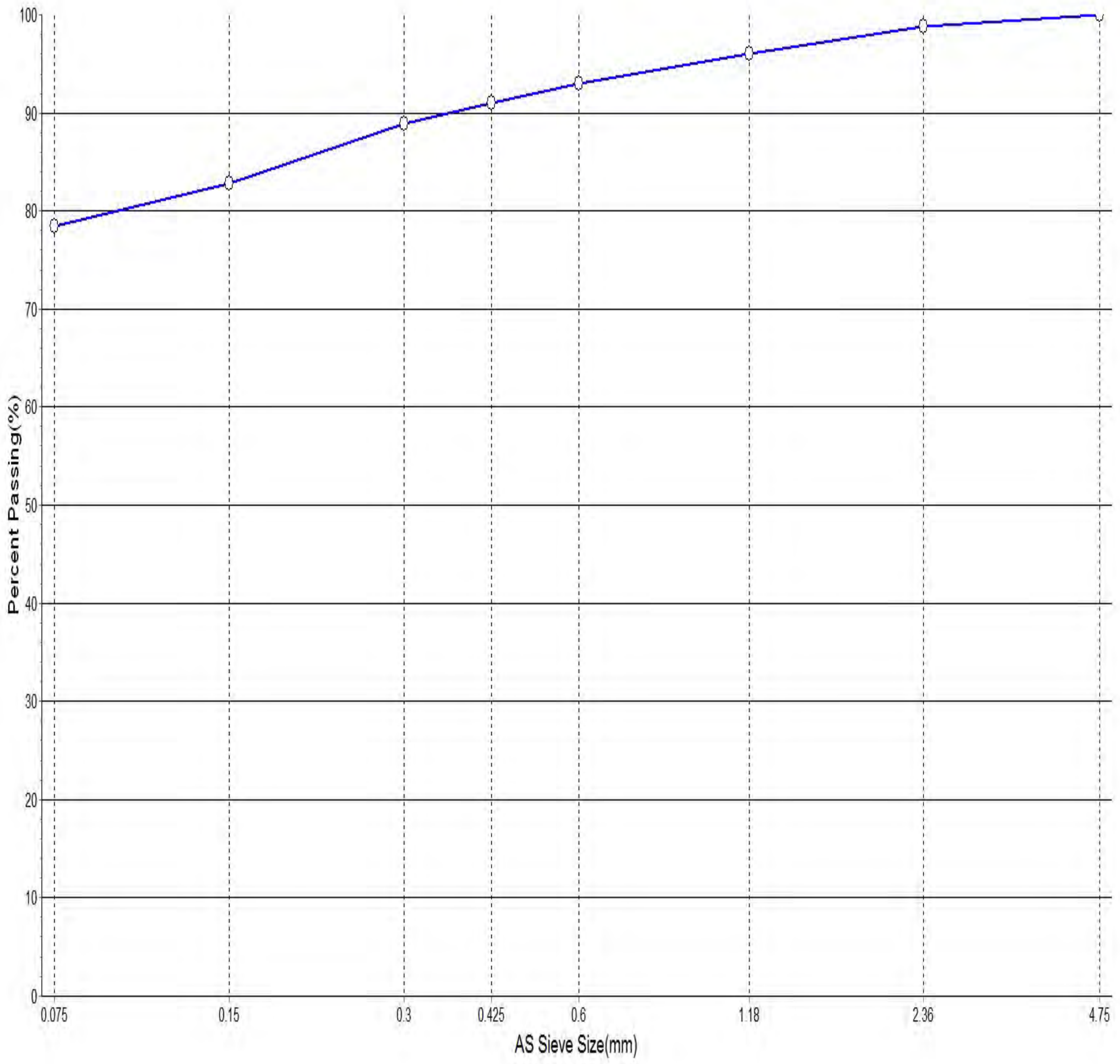
NATA Accreditation Number
14975

Particle Size Distribution Report

Client :	**David Casson - Casson Planning & Development Services**	Report Number:	**P1303 - 2/1**
Address :	**5 Stanstead Close, Scone, NSW, 2337**	Report Date :	**16/11/2017**
Project Name :	**Geotechnical Investigation - Scone**	Order Number :	
Project Number :	**P1303**	Test Method :	**AS1289.3.6.1**
Location:	**Lot 2 Gundy Road , Scone**		**Page 3 of 6**

Sample Number :	S17-5344	SAMPLE LOCATION	
Sampling Method :	AS1289.1.2.1	**BH8_0.3-0.6m**	
Sampled By :	Mathew Lay		
Date Sampled :	30/10/2017		
Date Tested :	9/11/2017		
Material Type :	Soil	Test Number :	
Material Source :	On-site	Lot Number :	
Remarks :		Specification Number :	

AS Sieve Size(mm)	Percent Passing	Specification Limits
100		
75		
63		
53		
37.5		
26.5		
19.0		
16.0		
13.2		
9.5		
6.7		
4.75	**100**	
2.36	**99**	
1.18	**96**	
0.600	**93**	
0.425	**91**	
0.300	**89**	
0.150	**83**	
0.075	**78**	



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APPROVED SIGNATORY

JWyatt

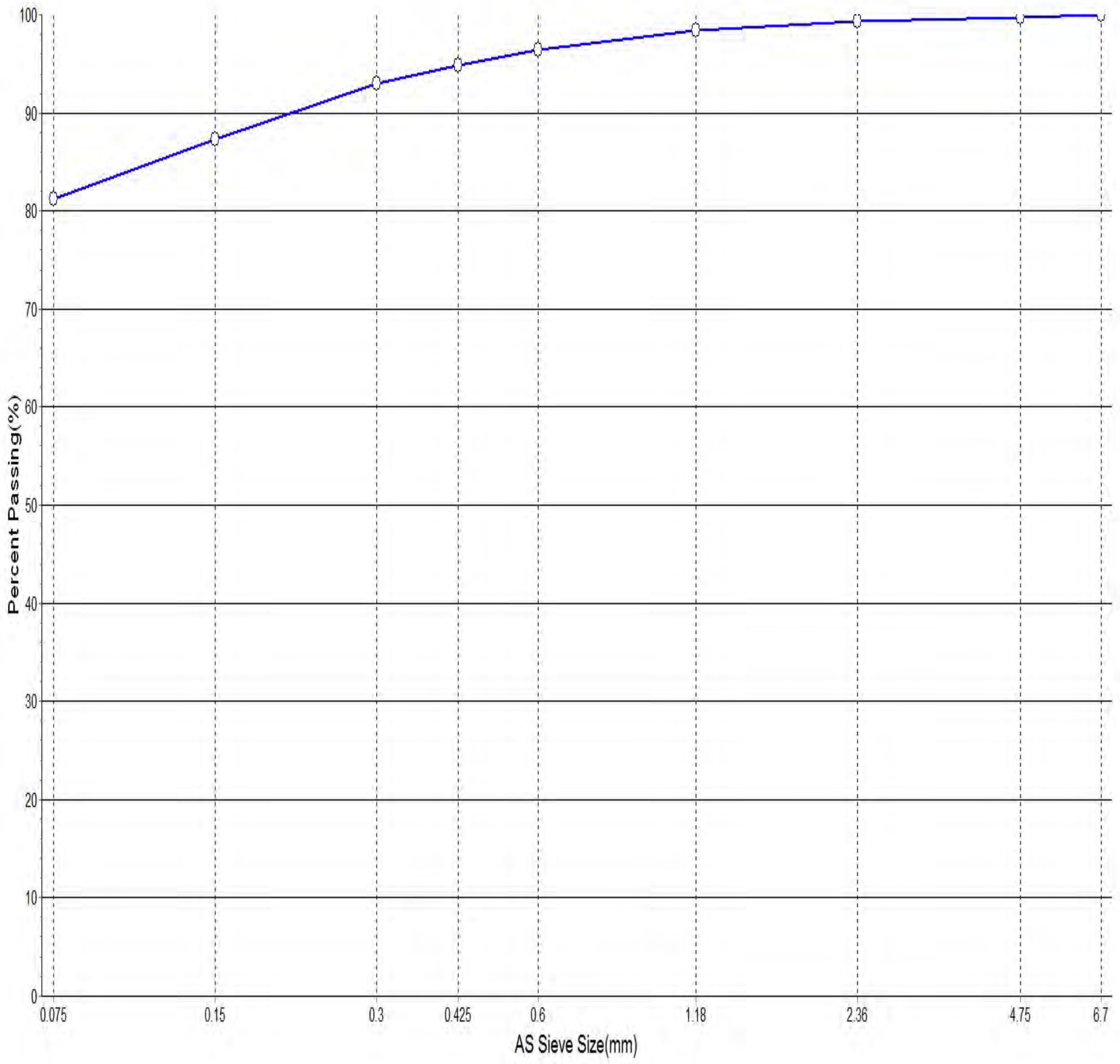
James Wyatt - Technician - Quarry Materials
NATA Accreditation Number
14975

Particle Size Distribution Report

Client :	**David Casson - Casson Planning & Development Services**	Report Number:	**P1303 - 2/1**
Address :	**5 Stanstead Close, Scone, NSW, 2337**	Report Date :	**16/11/2017**
Project Name :	**Geotechnical Investigation - Scone**	Order Number :	
Project Number :	**P1303**	Test Method :	**AS1289.3.6.1**
Location:	**Lot 2 Gundy Road , Scone**		**Page 4 of 6**

Sample Number :	S17-5345	SAMPLE LOCATION	
Sampling Method :	AS1289.1.2.1	**BH12_0.1-0.4m**	
Sampled By :	Mathew Lay		
Date Sampled :	30/10/2017		
Date Tested :	9/11/2017		
Material Type :	Soil	Test Number :	
Material Source :	On-site	Lot Number :	
Remarks :		Specification Number :	

AS Sieve Size(mm)	Percent Passing	Specification Limits
100		
75		
63		
53		
37.5		
26.5		
19.0		
16.0		
13.2		
9.5		
6.7	**100**	
4.75	**100**	
2.36	**99**	
1.18	**98**	
0.600	**96**	
0.425	**95**	
0.300	**93**	
0.150	**87**	
0.075	**81**	



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NATA Accreditation Number
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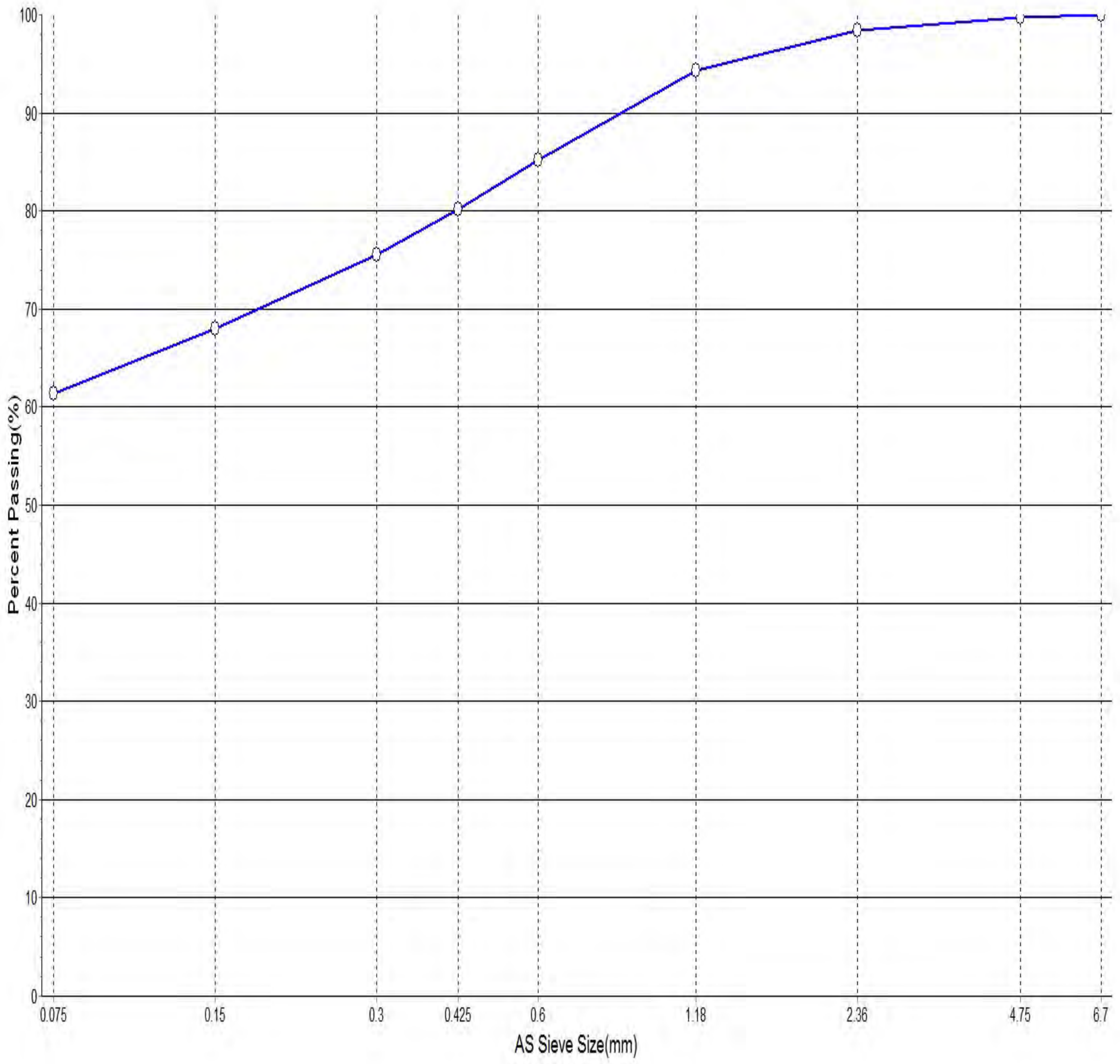
Particle Size Distribution Report

Client :	**David Casson - Casson Planning & Development Services**	Report Number:	**P1303 - 2/1**
Address :	**5 Stanstead Close, Scone, NSW, 2337**	Report Date :	**16/11/2017**
Project Name :	**Geotechnical Investigation - Scone**	Order Number :	
Project Number :	**P1303**	Test Method :	**AS1289.3.6.1**
Location:	**Lot 2 Gundy Road , Scone**		**Page 5 of 6**

Sample Number :	S17-5347	SAMPLE LOCATION	
Sampling Method :	AS1289.1.2.1	**BH17_1.5-1.8m**	
Sampled By :	Mathew Lay		
Date Sampled :	30/10/2017		
Date Tested :	9/11/2017		
Material Type :	Soil	Test Number :	
Material Source :	On-site	Lot Number :	
Remarks :		Specification Number :	

AS Sieve Size(mm)	Percent Passing	Specification Limits
100		
75		
63		
53		
37.5		
26.5		
19.0		
16.0		
13.2		
9.5		
6.7	**100**	
4.75	**100**	
2.36	**98**	
1.18	**94**	
0.600	**85**	
0.425	**80**	
0.300	**76**	
0.150	**68**	
0.075	**61**	



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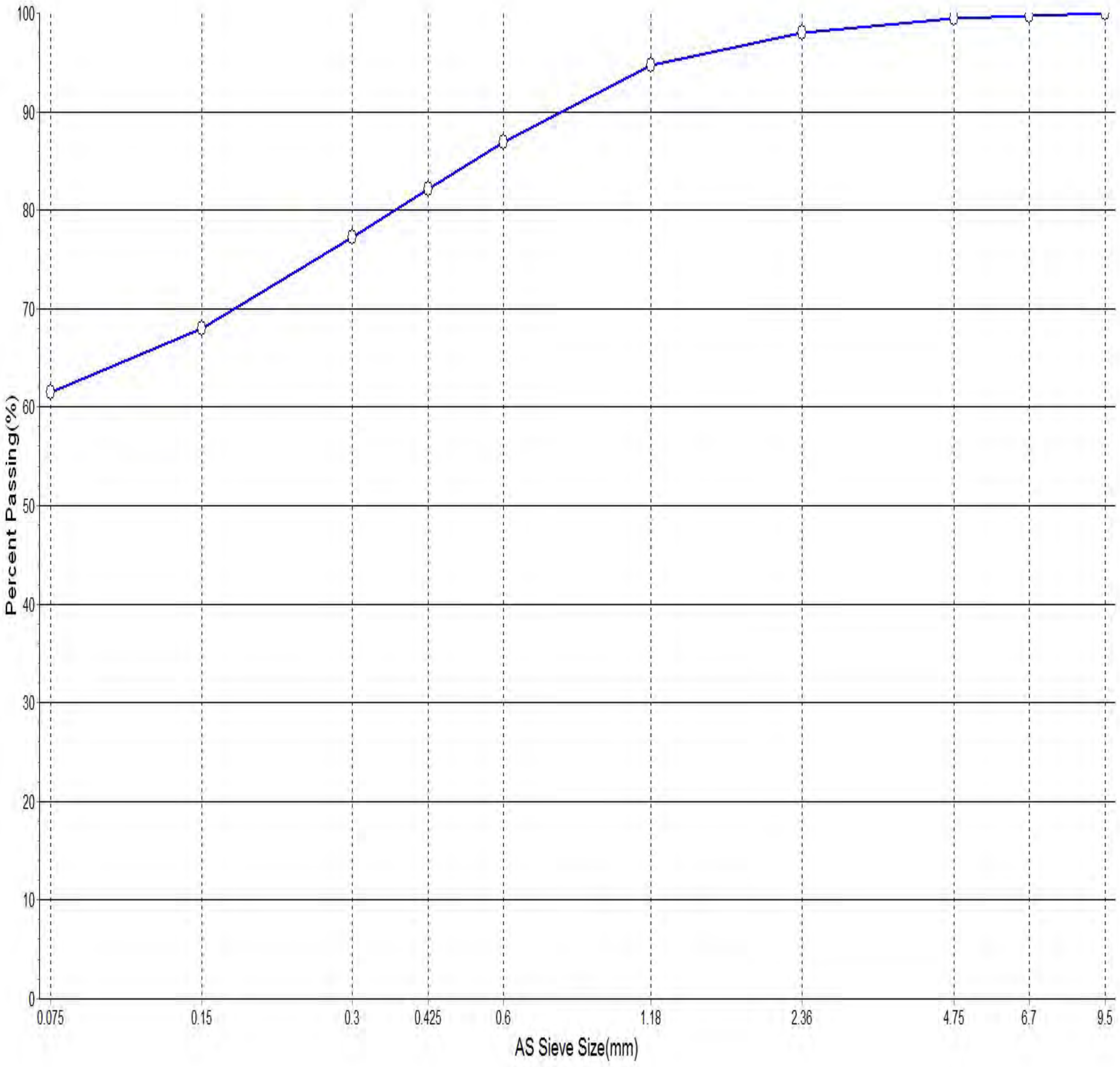
VALLEY CIVILAB
Geotechnical & Environmental Services

Particle Size Distribution Report

Client :	**David Casson - Casson Planning & Development Services**	Report Number:	**P1303 - 2/1**
Address :	**5 Stanstead Close, Scone, NSW, 2337**	Report Date :	**16/11/2017**
Project Name :	**Geotechnical Investigation - Scone**	Order Number :	
Project Number :	**P1303**	Test Method :	**AS1289.3.6.1**
Location:	**Lot 2 Gundy Road , Scone**		**Page 6 of 6**

Sample Number :	S17-5350	SAMPLE LOCATION	
Sampling Method :	AS1289.1.2.1	**BH140.4-0.7m**	
Sampled By :	Mathew Lay		
Date Sampled :	30/10/2017		
Date Tested :	9/11/2017		
Material Type :	Soil	Test Number :	
Material Source :	On-site	Lot Number :	
Remarks :		Specification Number :	

AS Sieve Size(mm)	Percent Passing	Specification Limits
100		
75		
63		
53		
37.5		
26.5		
19.0		
16.0		
13.2		
9.5	**100**	
6.7	**100**	
4.75	**100**	
2.36	**98**	
1.18	**95**	
0.600	**87**	
0.425	**82**	
0.300	**77**	
0.150	**68**	
0.075	**62**	



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NATA Accreditation Number
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VALLEY CIVILAB
Geotechnical & Environmental Services

Emerson Class Report

Client :	**David Casson - Casson Planning & Development Services**	Report Number:	**P1303 - 4/1**
Address :	**5 Stanstead Close, Scone, NSW, 2337**	Report Date :	**16/11/2017**
Project Name :	**Geotechnical Investigation - Scone**	Order Number :	
Project Number :	**P1303**	Test Method :	**AS1289.3.8.1**
Location:	**Lot 2 Gundy Road , Scone**	**Page 1 of 2**	

Sample Number :	S17-5341	S17-5344	S17-5345	S17-5346
Test Number :				
Sampling Method :	AS1289.1.2.1	AS1289.1.2.1	AS1289.1.2.1	AS1289.1.2.1
Date Sampled :	30/10/2017	30/10/2017	30/10/2017	30/10/2017
Date Tested :	16/11/2017	16/11/2017	16/11/2017	16/11/2017
Material Type :	Soil	Soil	Soil	Soil
Material Source :	On-site	On-site	On-site	On-site
Lot Number :				
Sample Location :	BH4_0.3-0.4m	BH8_0.3-0.6m	BH12_0.1-0.4m	BH13_0.4-0.5m
Primary Water Type :	Distilled Water	Distilled Water	Distilled Wtaer	Distilled Water
Primary Soil Description :	CLAY, dark brown	CLAY, dark brown	CLAY, grey	CLAY, brown
Primary Temperature :	28	24	24	25
Primary Emerson Class Number :	**Class 4**	**Class 5**	**Class 5**	**Class 2**
Secondary Water Type :				
Secondary Soil Description :				
Secondary Temperature :				
Secondary Emerson Class Number :				
Remarks :				

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NATA Accreditation Number
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Emerson Class Report

Client :	**David Casson - Casson Planning & Development Services**	Report Number:	**P1303 - 4/1**
Address :	**5 Stanstead Close, Scone, NSW, 2337**	Report Date :	**16/11/2017**
Project Name :	**Geotechnical Investigation - Scone**	Order Number :	
Project Number :	**P1303**	Test Method :	**AS1289.3.8.1**
Location:	**Lot 2 Gundy Road , Scone**	**Page 2 of 2**	

Sample Number :	S17-5348			
Test Number :				
Sampling Method :	AS1289.1.2.1			
Date Sampled :	30/10/2017			
Date Tested :	16/11/2017			
Material Type :	Soil			
Material Source :	On-site			
Lot Number :				
Sample Location :	BH18_0.6-0.8m			
Primary Water Type :	Distilled Wtaer			
Primary Soil Description :	CLAY, brown			
Primary Temperature :	25			
Primary Emerson Class Number :	**Class 2**			
Secondary Water Type :				
Secondary Soil Description :				
Secondary Temperature :				
Secondary Emerson Class Number :				
Remarks :				

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APPROVED SIGNATORY

James Wyatt - Technician - Quarry Materials
NATA Accreditation Number
14975

Annex D

Site Reactivity Assessment

The following is a calculation of the Charactersitic Surface Movement and Site Reactivity as per AS2870-2011 "Residential Slabs and Footings"

Client: Casson PDS
Site Address: Lot 2 Gundy Road, Scone
Job No: P1303
Fieldwork Date: 30/10/2017
Fieldwork By: ML
Location: BH3

Hs = 3 m

Δu (pF) = 1.2 m

Layer	Hs (m)	Δu (pF) (m)	Iss (%)	α	Iss x Δu x α	Average Iss x Δu x α	Δys (mm)
1	0.00	1.20	5.40	1.00	6.48	5.72	40.07
	0.70	0.92	5.40	1.00	4.97		
2	0.70	0.92	3.00	1.00	2.76	2.28	18.24
	1.50	0.60	3.00	1.00	1.80		
3	1.50	0.60	2.00	1.70	2.04	1.49	11.14
	2.25	0.30	2.00	1.55	0.93		
4	2.25	0.30	2.00	1.55	0.93	0.47	3.49
	3.00	0.00	2.00	1.40	0.00		

Characteristic Surface Movement (Ys) = 72.93

Indicative Values For Classification	
Classification	**Ys (mm)**
Class S	<20
Class M	20 to 40
Class H1	40 to 60
Class H2	60 to 75
Class E	>75

Site Classification

The site is classified in accordance with AS2870-2011 as a

Class H2

Undetaken by: ML
Date: 20/11/2017

Checked by: NWR
Date: 20/11/2017

Site Reactivity Assessment

The following is a calculation of the Charactersitic Surface Movement and Site Reactivity as per AS2870-2011 "Residential Slabs and Footings"

Client: Casson PDS
Site Address: Lot 2 Gundy Road, Scone
Job No: P1303
Fieldwork Date: 30/10/2017
Fieldwork By: ML
Location: BH4

Hs = 3 m

Δu (pF) = 1.2 m

Layer	Hs (m)	Δu (pF) (m)	Iss (%)	α	Iss x Δu x α	Average Iss x Δu x α	Δys (mm)
1	0.00	1.20	4.60	1.00	5.52	4.60	46.00
	1.00	0.80	4.60	1.00	3.68		
2	1.00	0.80	3.00	1.00	2.40	2.10	10.50
	1.50	0.60	3.00	1.00	1.80		
3	1.50	0.60	2.00	1.70	2.04	1.49	11.14
	2.25	0.30	2.00	1.55	0.93		
4	2.25	0.30	2.00	1.55	0.93	0.47	3.49
	3.00	0.00	2.00	1.40	0.00		

Characteristic Surface Movement (Ys) = 71.13

Indicative Values For Classification	
Classification	**Ys (mm)**
Class S	<20
Class M	20 to 40
Class H1	40 to 60
Class H2	60 to 75
Class E	>75

Site Classification

The site is classified in accordance with AS2870-2011 as a

Class H2

Undetaken by: ML
Date: 20/11/2017

Checked by: NWR
Date: 20/11/2017

Site Reactivity Assessment

The following is a calculation of the Charactersitic Surface Movement and Site Reactivity as per AS2870-2011 "Residential Slabs and Footings"

Client: Casson PDS
Site Address: Lot 2 Gundy Road, Scone
Job No: P1303
Fieldwork Date: 30/10/2017
Fieldwork By: ML
Location: BH11

Hs = 3 m

∆u (pF) = 1.2 m

Layer	Hs (m)	∆u (pF) (m)	Iss (%)	α	Iss x Δu x α	Average Iss x Δu x α	Δys (mm)
1	0.00	1.20	3.00	1.00	3.60	3.12	24.96
	0.80	0.88	3.00	1.00	2.64		
2	0.80	0.88	2.50	1.00	2.20	1.85	12.95
	1.50	0.60	2.50	1.00	1.50		
3	1.50	0.60	2.50	1.70	2.55	1.86	13.92
	2.25	0.30	2.50	1.55	1.16		
4	2.25	0.30	2.50	1.55	1.16	0.58	4.36
	3.00	0.00	2.50	1.40	0.00		

Characteristic Surface Movement (Ys) = 56.19

Indicative Values For Classification	
Classification	**Ys (mm)**
Class S	<20
Class M	20 to 40
Class H1	40 to 60
Class H2	60 to 75
Class E	>75

Site Classification

The site is classified in accordance with AS2870-2011 as a

Class H1

Undetaken by: ML
Date: 20/11/2017

Checked by: NWR
Date: 20/11/2017

Site Reactivity Assessment

The following is a calculation of the Charactersitic Surface Movement and Site Reactivity as per AS2870-2011 "Residential Slabs and Footings"

Client: Casson PDS
Site Address: Lot 2 Gundy Road, Scone
Job No: P1303
Fieldwork Date: 30/10/2017
Fieldwork By: ML
Location: BH13

Hs = 3 m

∆u (pF) = 1.2 m

Layer	Hs (m)	∆u (pF) (m)	Iss (%)	α	Iss x Δu x α	Average Iss x Δu x α	Δys (mm)
1	0.00	1.20	1.00	1.00	1.20	1.16	2.32
	0.20	1.12	1.00	1.00	1.12		
2	0.20	1.12	1.90	1.00	2.13	1.63	21.24
	1.50	0.60	1.90	1.00	1.14		
3	1.50	0.60	1.00	1.70	1.02	0.74	5.57
	2.25	0.30	1.00	1.55	0.47		
4	2.25	0.30	1.00	1.55	0.47	0.23	1.74
	3.00	0.00	1.00	1.40	0.00		

Characteristic Surface Movement (Ys) = 30.87

Indicative Values For Classification	
Classification	**Ys (mm)**
Class S	<20
Class M	20 to 40
Class H1	40 to 60
Class H2	60 to 75
Class E	>75

Site Classification

The site is classified in accordance with AS2870-2011 as a

Class M

Undetaken by: ML
Date: 20/11/2017

Checked by: NWR
Date: 20/11/2017

Site Reactivity Assessment

The following is a calculation of the Charactersitic Surface Movement and Site Reactivity as per AS2870-2011 "Residential Slabs and Footings"

Client: Casson PDS
Site Address: Lot 2 Gundy Road, Scone
Job No: P1303
Fieldwork Date: 30/10/2017
Fieldwork By: ML
Location: BH16

Hs = 3 m

∆u (pF) = 1.2 m

Layer	Hs (m)	∆u (pF) (m)	Iss (%)	α	Iss x ∆u x α	Average Iss x ∆u x α	∆ys (mm)
1	0.00	1.20	4.80	1.00	5.76	4.70	51.74
	1.10	0.76	4.80	1.00	3.65		
2	1.10	0.76	3.00	1.00	2.28	2.04	8.16
	1.50	0.60	3.00	1.00	1.80		
3	1.50	0.60	2.00	1.70	2.04	1.49	11.14
	2.25	0.30	2.00	1.55	0.93		
4	2.25	0.30	2.00	1.55	0.93	0.47	3.49
	3.00	0.00	2.00	1.40	0.00		

Characteristic Surface Movement (Ys) = 74.53

Indicative Values For Classification	
Classification	**Ys (mm)**
Class S	<20
Class M	20 to 40
Class H1	40 to 60
Class H2	60 to 75
Class E	>75

Site Classification

The site is classified in accordance with AS2870-2011 as a

Class H2

Undetaken by: ML
Date: 20/11/2017

Checked by: NWR
Date: 20/11/2017

Site Reactivity Assessment

The following is a calculation of the Charactersitic Surface Movement and Site Reactivity as per AS2870-2011 "Residential Slabs and Footings"

Client: Casson PDS
Site Address: Lot 2 Gundy Road, Scone
Job No: P1303
Fieldwork Date: 30/10/2017
Fieldwork By: ML
Location: BH18

Hs = 3 m

∆u (pF) = 1.2 m

Layer	**Hs (m)**	**∆u (pF) (m)**	**Iss (%)**	**α**	**Iss x Δu x α**	**Average Iss x Δu x α**	**Δys (mm)**
1	0.00	1.20	4.60	1.00	5.52	4.42	52.99
	1.20	0.72	4.60	1.00	3.31		
2	1.20	0.72	4.60	1.00	3.31	3.04	9.11
	1.50	0.60	4.60	1.00	2.76		
3	1.50	0.60	4.60	1.70	4.69	3.04	30.36
	2.50	0.20	4.60	1.50	1.38		
4	2.50	0.20	2.00	1.50	0.60	0.30	1.50
	3.00	0.00	2.00	1.40	0.00		

Characteristic Surface Movement (Ys) = 93.96

Indicative Values For Classification	
Classification	**Ys (mm)**
Class S	<20
Class M	20 to 40
Class H1	40 to 60
Class H2	60 to 75
Class E	>75

Site Classification

The site is classified in accordance with AS2870-2011 as a

Class E

Undetaken by: ML
Date: 20/11/2017

Checked by: NWR
Date: 20/11/2017

Annex E

Phone Office/Lab (02) 6775 1157

email: lanfaxlabs@bigpond.com.au
Website: http://www.lanfaxlabs.com.au
Lab address: 493 Old Inverell Road
Postal address: PO Box 4690 Armidale NSW 2350
Director: Dr Robert Patterson FIEAust, CPSS(3), CPAg
Soil Scientists and Environmental Engineers

Lanfax Laboratories
ABN 72 212 385 096
Quality Assurance and Quality Control by Approved Methods

Analysis of Soil Sample for Wastewater System Design

Client... Valley Civilab PO Box 284, Thornton NSW 2322

Date...14th November 2017

Soil sample received 6th November 2017
Sample date: 30th October 2017 *Analysis completed*. 14th November 2017
Source of soil: Property – location of proposed on-site application area

RESULTS – P1303

	Valley Civilab - NOV17													
Site Location	**Exc.Al+H**	**Ca**		**K**		**Mg**		**Na**		**Base Sat.**	**ESP**	**CEC**	**Ca/Mg**	
Sample ID	**cmol+/kg**	**mg/kg**	**cmol+/kg**	**mg/kg**	**cmol+/kg**	**mg/kg**	**cmol+/kg**	**mg/kg**	**cmol+/kg**	**%**	**%**	**cmol+/kg**	**ratio**	
ValleyCivilab-BH8, 0.5-0.6	0.0	4427	22.09	193	0.49	3086	25.39	746	3.24	100.0	6.3	51.2	0.9	Vall
ValleyCivilab-BH8, 1.0-1.1	0.1	4435	22.13	186	0.48	3128	25.74	944	4.11	99.8	7.8	52.5	0.9	Vall
ValleyCivilab-BH8, 1.2-1.3	0.0	4558	22.74	165	0.42	2951	24.28	926	4.03	100.0	7.8	51.5	0.9	Vall
ValleyCivilab-BH12, 0.1-0.2	0.0	4642	23.16	179	0.46	1047	8.61	167	0.73	100.0	2.2	33.0	2.7	Valle
ValleyCivilab-BH12,1.0-1.1	0.0	3616	18.04	121	0.31	993	8.17	541	2.36	100.0	8.2	28.9	2.2	Valle
ValleyCivilab-BH12, 1.5-1.6	0.0	4270	21.31	181	0.46	2656	21.85	1444	6.28	100.0	12.6	49.9	1.0	Valle
ValleyCivilab-BH13, 0.6-0.7	0.0	3288	16.41	160	0.41	1505	12.38	1112	4.84	100.0	14.2	34.0	1.3	Valle
ValleyCivilab-BH13, 1.0-1.1	0.0	3461	17.27	153	0.39	1469	12.09	982	4.27	100.0	12.6	34.0	1.4	Valle
ValleyCivilab-BH13, 1.5-1.6	0.0	2527	12.61	173	0.44	1064	8.75	1205	5.24	100.0	19.4	27.0	1.4	Valle
ValleyCivilab-BH17, 0.5-0.7	0.1	2203	10.99	257	0.66	844	6.94	648	2.82	99.6	13.1	21.5	1.6	Valle
ValleyCivilab-BH17, 1.5-1.8	0.0	2281	11.38	181	0.46	795	6.54	836	3.63	100.0	16.5	22.0	1.7	Valle
ValleyCivilab-BH17, 2.0-3.0	0.7	2752	13.73	165	0.42	1009	8.30	1167	5.08	97.5	18.0	28.3	1.6	Valle

Valley Civilab - NOV17				
Site Location	**pHw**	**pHca**	**EC**	**Emerson class**
Sample ID	**units**	**units**	**uS/cm**	**in SAR5, EC 1 dS/m**
ValleyCivilab-BH8, 0.5-0.6	8.44	7.48	525	ERR
ValleyCivilab-BH8, 1.0-1.1	8.61	7.60	476	ERR
ValleyCivilab-BH8, 1.2-1.3	8.81	7.71	400	ERR
ValleyCivilab-BH12, 0.1-0.2	8.41	7.60	168	ERR
ValleyCivilab-BH12,1.0-1.1	8.67	7.69	282	ERR
ValleyCivilab-BH12, 1.5-1.6	8.28	7.84	1440	ERR
ValleyCivilab-BH13, 0.6-0.7	8.52	7.95	871	ERR
ValleyCivilab-BH13, 1.0-1.1	8.57	7.98	832	ERR
ValleyCivilab-BH13, 1.5-1.6	8.84	7.97	578	ERR
ValleyCivilab-BH17, 0.5-0.7	7.91	7.72	208	ERR
ValleyCivilab-BH17, 1.5-1.8	8.89	7.82	391	ERR
ValleyCivilab-BH17, 2.0-3.0	9.20	7.96	413	ERR

Methods: Rayment & Lyons 2011
pH Method 4A1 (water) 4B1 ($CaCl_2$)
EC Method 3A1
Exchangeable acidity (H^+, Al^{3+}) Method 15 G1
Cation Exchange Capacity Method 15D3 plus exchangeable acidity
Exchangeable sodium percentage ratio sodium to ECEC

RPatterson

Dr Robert Patterson FIEAust, CPSS(3), CPAg
Soil Scientist and Environmental Enginee

VALLEY CIVILAB
Geotechnical & Environmental Services

Annex F

CONSTANT HEAD PERMABILITY TEST - RESULTS

Client: Casson PDS
Location: Lot 2 Gundy Road, Scone
Job No: P1303 **Test Location:** Inf 1
Date: 26/10/2017 **Logged By:** Matt Lay

Constant head permeability test was undertaken as per Appendix G of AS/NZ1547 "On-site Domestic Wastewater Management"

Radius of tube (cm) = 2.7
Cross Sectional Area of Tube (cm^2) = 22.90221

Time (min)	Time (sec)	Level in Tube (cm)	Change in time (sec)	Drop in Level (cm)	Flowrate (Q) (cm^3/min)
0	0	34			
1	60	34.1	60	0.1	2.29
2	120	34.2	60	0.1	2.29
3	180	34.2	60	0	0.00
4	240	34.3	60	0.1	2.29
5	300	34.4	60	0.1	2.29
10	600	35.1	300	0.7	3.21
15	900	35.9	300	0.8	3.66
20	1200	36.6	300	0.7	3.21
30	1800	38	600	1.4	3.21
40	2400	39.2	600	1.2	2.75
50	3000	40.2	600	1	2.29
60	3600	41.2	600	1	2.29

Average Flowrate (cm^3/min) = 2.29

CONSTANT HEAD PERMABILITY TEST - CALCULATIONS

Client: Casson PDS
Location: Lot 2 Gundy Road, Scone
Job No: P1303 **Test Location:** Inf 1
Date: 26/10/2017 **Logged By:** Matt Lay

Constant head permeability test was undertaken as per Appendix G of AS/NZ1547 "On-site Domestic Wastewater Management"

Saturated hydraulic conductivity of the soil (K_{sat}) was determined using the following formula

$$K_{sat} = \frac{4.4Q[\{0.5 \sinh^{-1}(H/2r)\} - \{[(r/H)^2+0.25]^\wedge 0.5\} + \{r/H\}]}{\{2 \times \pi \times H^2\}} \quad \text{(cm/min)}$$

where:

4.4 = correction factor for a systematic under-estimate of soil permeability in the mathematical derivation of the equation

H = depth of water in the test hole (cm)
r = radius of the test hole (cm)
Q = rate of flow of water from the reservoir (cm^3/min)
π = 3.141592654

Data from fieldwork conducted:

H = 25 (cm)
r = 4.5 (cm)

From the Constant Head Permeability Test - Results sheet:

Q = 2.29 (cm^3/min)

Saturated Hydraulic Conductivity is:

K_{sat} = 0.0014 (cm/min)

= 0.0202 (m/day)

CONSTANT HEAD PERMABILITY TEST - RESULTS

Client: Casson PDS
Location: Lot 2 Gundy Road, Scone
Job No: P1303 **Test Location:** Inf 2
Date: 26/10/2017 **Logged By:** Matt Lay

Constant head permeability test was undertaken as per Appendix G of AS/NZ1547 "On-site Domestic Wastewater Management"

Radius of tube (cm) = 2.7
Cross Sectional Area of Tube (cm^2) = 22.90221

Time (min)	**Time (sec)**	**Level in Tube (cm)**	**Change in time (sec)**	**Drop in Level (cm)**	**Flowrate (Q) (cm^3/min)**
0	0	40			
1	60	40.1	60	0.1	2.29
2	120	40.2	60	0.1	2.29
3	180	40.3	60	0.1	2.29
4	240	40.4	60	0.1	2.29
5	300	40.5	60	0.1	2.29
10	600	41.4	300	0.9	4.12
15	900	42.4	300	1	4.58
20	1200	43.6	300	1.2	5.50
30	1800	44.6	600	1	2.29
40	2400	45.5	600	0.9	2.06
50	3000	46.5	600	1	2.29
60	3600	47.5	600	1	2.29

Average Flowrate (cm^3/min) = 2.29

CONSTANT HEAD PERMABILITY TEST - CALCULATIONS

Client: Casson PDS
Location: Lot 2 Gundy Road, Scone
Job No: P1303 **Test Location:** Inf 2
Date: 26/10/2017 **Logged By:** Matt Lay

Constant head permeability test was undertaken as per Appendix G of AS/NZ1547 "On-site Domestic Wastewater Management"

Saturated hydraulic conductivity of the soil (K_{sat}) was determined using the following formula

$$K_{sat} = \frac{4.4Q[\ \{0.5 \sinh^{-1}(H/2r)\} - \{[(r/H)^2+0.25]\text{^}0.5\} + \{r/H\}]}{\{2 \times \pi \times H^2\}} \qquad \text{(cm/min)}$$

where:

4.4 = correction factor for a systematic under-estimate of soil permeability in the mathematical derivation of the equation
H = depth of water in the test hole (cm)
r = radius of the test hole (cm)
Q = rate of flow of water from the reservoir (cm^3/min)
π = 3.141592654

Data from fieldwork conducted:

H = 25 (cm)
r = 4.5 (cm)

From the Constant Head Permeability Test - Results sheet:

Q = 2.29 (cm^3/min)

Saturated Hydraulic Conductivity is:

K_{sat} = 0.0014 (cm/min)

= 0.0202 (m/day)

CONSTANT HEAD PERMABILITY TEST - RESULTS

Client: Casson PDS
Location: Lot 2 Gundy Road, Scone
Job No: P1303 **Test Location:** Inf 3
Date: 26/10/2017 **Logged By:** Matt Lay

Constant head permeability test was undertaken as per Appendix G of AS/NZ1547 "On-site Domestic Wastewater Management"

Radius of tube (cm) = 2.7
Cross Sectional Area of Tube (cm^2) = 22.90221

Time (min)	Time (sec)	Level in Tube (cm)	Change in time (sec)	Drop in Level (cm)	Flowrate (Q) (cm^3/min)
0	0	37			
1	60	37.1	60	0.1	2.29
2	120	37.2	60	0.1	2.29
3	180	37.2	60	0	0.00
4	240	37.3	60	0.1	2.29
5	300	37.4	60	0.1	2.29
10	600	38.1	300	0.7	3.21
15	900	38.7	300	0.6	2.75
20	1200	39.4	300	0.7	3.21
30	1800	40.6	600	1.2	2.75
40	2400	41.7	600	1.1	2.52
50	3000	42.8	600	1.1	2.52
60	3600	43.9	600	1.1	2.52

Average Flowrate (cm^3/min) = 2.52

CONSTANT HEAD PERMABILITY TEST - CALCULATIONS

Client: Casson PDS

Location: Lot 2 Gundy Road, Scone

Job No: P1303 **Test Location:** Inf 3

Date: 26/10/2017 **Logged By:** Matt Lay

Constant head permeability test was undertaken as per Appendix G of AS/NZ1547 "On-site Domestic Wastewater Management"

Saturated hydraulic conductivity of the soil (K_{sat}) was determined using the following formula

$$K_{sat} = \frac{4.4Q[\{0.5 \sinh^{-1}(H/2r)\} - \{[(r/H)^2+0.25]\text{^}0.5\} + \{r/H\}]}{\{2 \times \pi \times H^2\}} \quad \text{(cm/min)}$$

where:

4.4 = correction factor for a systematic under-estimate of soil permeability in the mathematical derivation of the equation

H = depth of water in the test hole (cm)

r = radius of the test hole (cm)

Q = rate of flow of water from the reservoir (cm^3/min)

π = 3.141592654

Data from fieldwork conducted:

H = 25 (cm)

r = 4.5 (cm)

From the Constant Head Permeability Test - Results sheet:

Q = 2.52 (cm^3/min)

Saturated Hydraulic Conductivity is:

K_{sat} = 0.0015 (cm/min)

= 0.0222 (m/day)

CONSTANT HEAD PERMABILITY TEST - RESULTS

Client: Casson PDS
Location: Lot 2 Gundy Road, Scone
Job No: P1303 **Test Location:** Inf 4
Date: 26/10/2017 **Logged By:** Matt Lay

Constant head permeability test was undertaken as per Appendix G of AS/NZ1547 "On-site Domestic Wastewater Management"

Radius of tube (cm) = 2.7
Cross Sectional Area of Tube (cm^2) = 22.90221

Time (min)	Time (sec)	Level in Tube (cm)	Change in time (sec)	Drop in Level (cm)	Flowrate (Q) (cm^3/min)
0	0	45			
1	60	45.1	60	0.1	2.29
2	120	45.3	60	0.2	4.58
3	180	45.4	60	0.1	2.29
4	240	45.5	60	0.1	2.29
5	300	45.5	60	0	0.00
10	600	46.1	300	0.6	2.75
15	900	46.8	300	0.7	3.21
20	1200	47.5	300	0.7	3.21
30	1800	48.6	600	1.1	2.52
40	2400	49.6	600	1	2.29
50	3000	50.5	600	0.9	2.06
60	3600	51.4	600	0.9	2.06

Average Flowrate (cm^3/min) = 2.06

CONSTANT HEAD PERMABILITY TEST - CALCULATIONS

Client: Casson PDS
Location: Lot 2 Gundy Road, Scone
Job No: P1303 **Test Location:** Inf 4
Date: 26/10/2017 **Logged By:** Matt Lay

Constant head permeability test was undertaken as per Appendix G of AS/NZ1547 "On-site Domestic Wastewater Management"

Saturated hydraulic conductivity of the soil (K_{sat}) was determined using the following formula

$$\mathbf{K_{sat} = \frac{4.4Q[\ \{0.5\ \sinh^{-1}(H/2r)\} - \{[(r/H)^2+0.25]^\wedge 0.5\} + \{r/H\}]}{\{2 \times \pi \times H^2\}}} \quad \text{(cm/min)}$$

where:

4.4 = correction factor for a systematic under-estimate of soil permeability in the mathematical derivation of the equation

H	=	depth of water in the test hole	(cm)
r	=	radius of the test hole	(cm)
Q	=	rate of flow of water from the reservoir	(cm^3/min)
π	=	3.141592654	

Data from fieldwork conducted:

H = 25 (cm)
r = 4.5 (cm)

From the Constant Head Permeability Test - Results sheet:

Q = 2.06 (cm^3/min)

Saturated Hydraulic Conductivity is:

K_{sat} = 0.0013 (cm/min)

= 0.0181 (m/day)

Annex G

Foundation Maintenance and Footing Performance:

A Homeowner's Guide

PUBLISHING

BTF 18-2011
replaces
Information
Sheet 10/91

Buildings can and often do move. This movement can be up, down, lateral or rotational. The fundamental cause of movement in buildings can usually be related to one or more problems in the foundation soil. It is important for the homeowner to identify the soil type in order to ascertain the measures that should be put in place in order to ensure that problems in the foundation soil can be prevented, thus protecting against building movement.

This Building Technology File is designed to identify causes of soil-related building movement, and to suggest methods of prevention of resultant cracking in buildings.

Soil Types

The types of soils usually present under the topsoil in land zoned for residential buildings can be split into two approximate groups – granular and clay. Quite often, foundation soil is a mixture of both types. The general problems associated with soils having granular content are usually caused by erosion. Clay soils are subject to saturation and swell/shrink problems.

Classifications for a given area can generally be obtained by application to the local authority, but these are sometimes unreliable and if there is doubt, a geotechnical report should be commissioned. As most buildings suffering movement problems are founded on clay soils, there is an emphasis on classification of soils according to the amount of swell and shrinkage they experience with variations of water content. The table below is Table 2.1 from AS 2870-2011, the Residential Slab and Footing Code.

Causes of Movement

Settlement due to construction

There are two types of settlement that occur as a result of construction:

- Immediate settlement occurs when a building is first placed on its foundation soil, as a result of compaction of the soil under the weight of the structure. The cohesive quality of clay soil mitigates against this, but granular (particularly sandy) soil is susceptible.
- Consolidation settlement is a feature of clay soil and may take place because of the expulsion of moisture from the soil or because of the soil's lack of resistance to local compressive or shear stresses. This will usually take place during the first few months after construction, but has been known to take many years in exceptional cases.

These problems are the province of the builder and should be taken into consideration as part of the preparation of the site for construction. Building Technology File 19 (BTF 19) deals with these problems.

Erosion

All soils are prone to erosion, but sandy soil is particularly susceptible to being washed away. Even clay with a sand component of say 10% or more can suffer from erosion.

Saturation

This is particularly a problem in clay soils. Saturation creates a bog-like suspension of the soil that causes it to lose virtually all of its bearing capacity. To a lesser degree, sand is affected by saturation because saturated sand may undergo a reduction in volume, particularly imported sand fill for bedding and blinding layers. However, this usually occurs as immediate settlement and should normally be the province of the builder.

Seasonal swelling and shrinkage of soil

All clays react to the presence of water by slowly absorbing it, making the soil increase in volume (see table below). The degree of increase varies considerably between different clays, as does the degree of decrease during the subsequent drying out caused by fair weather periods. Because of the low absorption and expulsion rate, this phenomenon will not usually be noticeable unless there are prolonged rainy or dry periods, usually of weeks or months, depending on the land and soil characteristics.

The swelling of soil creates an upward force on the footings of the building, and shrinkage creates subsidence that takes away the support needed by the footing to retain equilibrium.

Shear failure

This phenomenon occurs when the foundation soil does not have sufficient strength to support the weight of the footing. There are two major post-construction causes:

- Significant load increase.
- Reduction of lateral support of the soil under the footing due to erosion or excavation.

In clay soil, shear failure can be caused by saturation of the soil adjacent to or under the footing.

GENERAL DEFINITIONS OF SITE CLASSES

Class	Foundation
A	Most sand and rock sites with little or no ground movement from moisture changes
S	Slightly reactive clay sites, which may experience only slight ground movement from moisture changes
M	Moderately reactive clay or silt sites, which may experience moderate ground movement from moisture changes
H1	Highly reactive clay sites, which may experience high ground movement from moisture changes
H2	Highly reactive clay sites, which may experience very high ground movement from moisture changes
E	Extremely reactive sites, which may experience extreme ground movement from moisture changes

Notes

1. Where controlled fill has been used, the site may be classified A to E according to the type of fill used.
2. Filled sites. Class P is used for sites which include soft fills, such as clay or silt or loose sands; landslip; mine subsidence; collapsing soils; soil subject to erosion; reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise.
3. Where deep-seated moisture changes exist on sites at depths of 3 m or greater, further classification is needed for Classes M to E (M-D, H1-D, H2-D and E-D).

Tree root growth
Trees and shrubs that are allowed to grow in the vicinity of footings can cause foundation soil movement in two ways:

- Roots that grow under footings may increase in cross-sectional size, exerting upward pressure on footings.
- Roots in the vicinity of footings will absorb much of the moisture in the foundation soil, causing shrinkage or subsidence.

Unevenness of Movement

The types of ground movement described above usually occur unevenly throughout the building's foundation soil. Settlement due to construction tends to be uneven because of:

- Differing compaction of foundation soil prior to construction.
- Differing moisture content of foundation soil prior to construction.

Movement due to non-construction causes is usually more uneven still. Erosion can undermine a footing that traverses the flow or can create the conditions for shear failure by eroding soil adjacent to a footing that runs in the same direction as the flow.

Saturation of clay foundation soil may occur where subfloor walls create a dam that makes water pond. It can also occur wherever there is a source of water near footings in clay soil. This leads to a severe reduction in the strength of the soil which may create local shear failure.

Seasonal swelling and shrinkage of clay soil affects the perimeter of the building first, then gradually spreads to the interior. The swelling process will usually begin at the uphill extreme of the building, or on the weather side where the land is flat. Swelling gradually reaches the interior soil as absorption continues. Shrinkage usually begins where the sun's heat is greatest.

Effects of Uneven Soil Movement on Structures

Erosion and saturation
Erosion removes the support from under footings, tending to create subsidence of the part of the structure under which it occurs. Brickwork walls will resist the stress created by this removal of support by bridging the gap or cantilevering until the bricks or the mortar bedding fail. Older masonry has little resistance. Evidence of failure varies according to circumstances and symptoms may include:

- Step cracking in the mortar beds in the body of the wall or above/below openings such as doors or windows.
- Vertical cracking in the bricks (usually but not necessarily in line with the vertical beds or perpends).

Isolated piers affected by erosion or saturation of foundations will eventually lose contact with the bearers they support and may tilt or fall over. The floors that have lost this support will become bouncy, sometimes rattling ornaments etc.

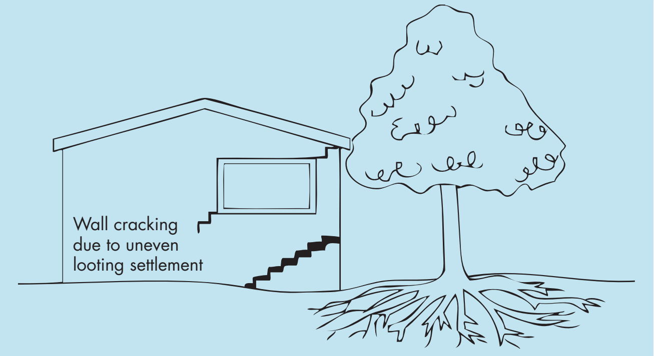
Seasonal swelling/shrinkage in clay
Swelling foundation soil due to rainy periods first lifts the most exposed extremities of the footing system, then the remainder of the perimeter footings while gradually permeating inside the building footprint to lift internal footings. This swelling first tends to create a dish effect, because the external footings are pushed higher than the internal ones.

The first noticeable symptom may be that the floor appears slightly dished. This is often accompanied by some doors binding on the floor or the door head, together with some cracking of cornice mitres. In buildings with timber flooring supported by bearers and joists, the floor can be bouncy. Externally there may be visible dishing of the hip or ridge lines.

As the moisture absorption process completes its journey to the innermost areas of the building, the internal footings will rise. If the spread of moisture is roughly even, it may be that the symptoms will temporarily disappear, but it is more likely that swelling will be uneven, creating a difference rather than a disappearance in symptoms. In buildings with timber flooring supported by bearers and joists, the isolated piers will rise more easily than the strip footings or piers under walls, creating noticeable doming of flooring.

As the weather pattern changes and the soil begins to dry out, the external footings will be first affected, beginning with the locations where the sun's effect is strongest. This has the effect of lowering the external footings. The doming is accentuated and cracking reduces or disappears where it occurred because of dishing, but other cracks open up. The roof lines may become convex.

Trees can cause shrinkage and damage



Doming and dishing are also affected by weather in other ways. In areas where warm, wet summers and cooler dry winters prevail, water migration tends to be toward the interior and doming will be accentuated, whereas where summers are dry and winters are cold and wet, migration tends to be toward the exterior and the underlying propensity is toward dishing.

Movement caused by tree roots
In general, growing roots will exert an upward pressure on footings, whereas soil subject to drying because of tree or shrub roots will tend to remove support from under footings by inducing shrinkage.

Complications caused by the structure itself
Most forces that the soil causes to be exerted on structures are vertical – i.e. either up or down. However, because these forces are seldom spread evenly around the footings, and because the building resists uneven movement because of its rigidity, forces are exerted from one part of the building to another. The net result of all these forces is usually rotational. This resultant force often complicates the diagnosis because the visible symptoms do not simply reflect the original cause. A common symptom is binding of doors on the vertical member of the frame.

Effects on full masonry structures
Brickwork will resist cracking where it can. It will attempt to span areas that lose support because of subsided foundations or raised points. It is therefore usual to see cracking at weak points, such as openings for windows or doors.

In the event of construction settlement, cracking will usually remain unchanged after the process of settlement has ceased.

With local shear or erosion, cracking will usually continue to develop until the original cause has been remedied, or until the subsidence has completely neutralised the affected portion of footing and the structure has stabilised on other footings that remain effective.

In the case of swell/shrink effects, the brickwork will in some cases return to its original position after completion of a cycle, however it is more likely that the rotational effect will not be exactly reversed, and it is also usual that brickwork will settle in its new position and will resist the forces trying to return it to its original position. This means that in a case where swelling takes place after construction and cracking occurs, the cracking is likely to at least partly remain after the shrink segment of the cycle is complete. Thus, each time the cycle is repeated, the likelihood is that the cracking will become wider until the sections of brickwork become virtually independent.

With repeated cycles, once the cracking is established, if there is no other complication, it is normal for the incidence of cracking to stabilise, as the building has the articulation it needs to cope with the problem. This is by no means always the case, however, and monitoring of cracks in walls and floors should always be treated seriously.

Upheaval caused by growth of tree roots under footings is not a simple vertical shear stress. There is a tendency for the root to also exert lateral forces that attempt to separate sections of brickwork after initial cracking has occurred.

The normal structural arrangement is that the inner leaf of brickwork in the external walls and at least some of the internal walls (depending on the roof type) comprise the load-bearing structure on which any upper floors, ceilings and the roof are supported. In these cases, it is internally visible cracking that should be the main focus of attention, however there are a few examples of dwellings whose external leaf of masonry plays some supporting role, so this should be checked if there is any doubt. In any case, externally visible cracking is important as a guide to stresses on the structure generally, and it should also be remembered that the external walls must be capable of supporting themselves.

Effects on framed structures
Timber or steel framed buildings are less likely to exhibit cracking due to swell/shrink than masonry buildings because of their flexibility. Also, the doming/dishing effects tend to be lower because of the lighter weight of walls. The main risks to framed buildings are encountered because of the isolated pier footings used under walls. Where erosion or saturation causes a footing to fall away, this can double the span which a wall must bridge. This additional stress can create cracking in wall linings, particularly where there is a weak point in the structure caused by a door or window opening. It is, however, unlikely that framed structures will be so stressed as to suffer serious damage without first exhibiting some or all of the above symptoms for a considerable period. The same warning period should apply in the case of upheaval. It should be noted, however, that where framed buildings are supported by strip footings there is only one leaf of brickwork and therefore the externally visible walls are the supporting structure for the building. In this case, the subfloor masonry walls can be expected to behave as full brickwork walls.

Effects on brick veneer structures
Because the load-bearing structure of a brick veneer building is the frame that makes up the interior leaf of the external walls plus perhaps the internal walls, depending on the type of roof, the building can be expected to behave as a framed structure, except that the external masonry will behave in a similar way to the external leaf of a full masonry structure.

Water Service and Drainage

Where a water service pipe, a sewer or stormwater drainage pipe is in the vicinity of a building, a water leak can cause erosion, swelling or saturation of susceptible soil. Even a minuscule leak can be enough to saturate a clay foundation. A leaking tap near a building can have the same effect. In addition, trenches containing pipes can become watercourses even though backfilled, particularly where broken rubble is used as fill. Water that runs along these trenches can be responsible for serious erosion, interstrata seepage into subfloor areas and saturation.

Pipe leakage and trench water flows also encourage tree and shrub roots to the source of water, complicating and exacerbating the problem. Poor roof plumbing can result in large volumes of rainwater being concentrated in a small area of soil:

- Incorrect falls in roof guttering may result in overflows, as may gutters blocked with leaves etc.
- Corroded guttering or downpipes can spill water to ground.
- Downpipes not positively connected to a proper stormwater collection system will direct a concentration of water to soil that is directly adjacent to footings, sometimes causing large-scale problems such as erosion, saturation and migration of water under the building.

Seriousness of Cracking

In general, most cracking found in masonry walls is a cosmetic nuisance only and can be kept in repair or even ignored. The table below is a reproduction of Table C1 of AS 2870-2011.

AS 2870-2011 also publishes figures relating to cracking in concrete floors, however because wall cracking will usually reach the critical point significantly earlier than cracking in slabs, this table is not reproduced here.

Prevention/Cure

Plumbing
Where building movement is caused by water service, roof plumbing, sewer or stormwater failure, the remedy is to repair the problem. It is prudent, however, to consider also rerouting pipes away from the building where possible, and relocating taps to positions where any leakage will not direct water to the building vicinity. Even where gully traps are present, there is sometimes sufficient spill to create erosion or saturation, particularly in modern installations using smaller diameter PVC fixtures. Indeed, some gully traps are not situated directly under the taps that are installed to charge them, with the result that water from the tap may enter the backfilled trench that houses the sewer piping. If the trench has been poorly backfilled, the water will either pond or flow along the bottom of the trench. As these trenches usually run alongside the footings and can be at a similar depth, it is not hard to see how any water that is thus directed into a trench can easily affect the foundation's ability to support footings or even gain entry to the subfloor area.

Ground drainage
In all soils there is the capacity for water to travel on the surface and below it. Surface water flows can be established by inspection during and after heavy or prolonged rain. If necessary, a grated drain system connected to the stormwater collection system is usually an easy solution.

It is, however, sometimes necessary when attempting to prevent water migration that testing be carried out to establish watertable height and subsoil water flows. This subject is referred to in BTF 19 and may properly be regarded as an area for an expert consultant.

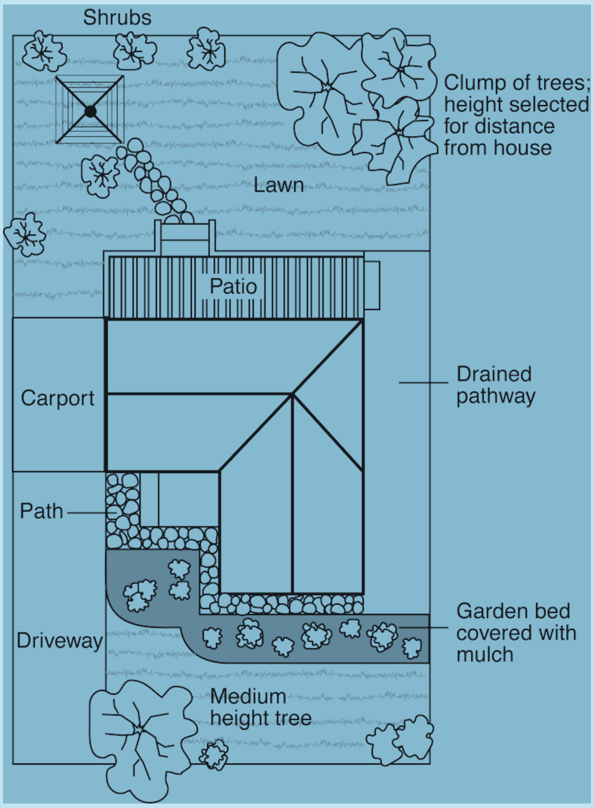
Protection of the building perimeter
It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

For this reason, particularly where problems exist or are likely to occur, it is recommended that an apron of paving be installed around as much of the building perimeter as necessary. This paving should

CLASSIFICATION OF DAMAGE WITH REFERENCE TO WALLS

Description of typical damage and required repair	Approximate crack width limit (see Note 3)	Damage category
Hairline cracks	<0.1 mm	0
Fine cracks which do not need repair	<1 mm	1
Cracks noticeable but easily filled. Doors and windows stick slightly.	<5 mm	2
Cracks can be repaired and possibly a small amount of wall will need to be replaced. Doors and windows stick. Service pipes can fracture. Weathertightness often impaired.	5–15 mm (or a number of cracks 3 mm or more in one group)	3
Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows. Window and door frames distort. Walls lean or bulge noticeably, some loss of bearing in beams. Service pipes disrupted.	15–25 mm but also depends on number of cracks	4

Gardens for a reactive site



extend outwards a minimum of 900 mm (more in highly reactive soil) and should have a minimum fall away from the building of 1:60. The finished paving should be no less than 100 mm below brick vent bases.

It is prudent to relocate drainage pipes away from this paving, if possible, to avoid complications from future leakage. If this is not practical, earthenware pipes should be replaced by PVC and backfilling should be of the same soil type as the surrounding soil and compacted to the same density.

Except in areas where freezing of water is an issue, it is wise to remove taps in the building area and relocate them well away from the building – preferably not uphill from it (see BTF 19).

It may be desirable to install a grated drain at the outside edge of the paving on the uphill side of the building. If subsoil drainage is needed this can be installed under the surface drain.

Condensation

In buildings with a subfloor void such as where bearers and joists support flooring, insufficient ventilation creates ideal conditions for condensation, particularly where there is little clearance between the floor and the ground. Condensation adds to the moisture already present in the subfloor and significantly slows the process of drying out. Installation of an adequate subfloor ventilation system, either natural or mechanical, is desirable.

Warning: Although this Building Technology File deals with cracking in buildings, it should be said that subfloor moisture can result in the development of other problems, notably:

- Water that is transmitted into masonry, metal or timber building elements causes damage and/or decay to those elements.
- High subfloor humidity and moisture content create an ideal environment for various pests, including termites and spiders.
- Where high moisture levels are transmitted to the flooring and walls, an increase in the dust mite count can ensue within the living areas. Dust mites, as well as dampness in general, can be a health hazard to inhabitants, particularly those who are abnormally susceptible to respiratory ailments.

The garden

The ideal vegetation layout is to have lawn or plants that require only light watering immediately adjacent to the drainage or paving edge, then more demanding plants, shrubs and trees spread out in that order.

Overwatering due to misuse of automatic watering systems is a common cause of saturation and water migration under footings. If it is necessary to use these systems, it is important to remove garden beds to a completely safe distance from buildings.

Existing trees

Where a tree is causing a problem of soil drying or there is the existence or threat of upheaval of footings, if the offending roots are subsidiary and their removal will not significantly damage the tree, they should be severed and a concrete or metal barrier placed vertically in the soil to prevent future root growth in the direction of the building. If it is not possible to remove the relevant roots without damage to the tree, an application to remove the tree should be made to the local authority. A prudent plan is to transplant likely offenders before they become a problem.

Information on trees, plants and shrubs

State departments overseeing agriculture can give information regarding root patterns, volume of water needed and safe distance from buildings of most species. Botanic gardens are also sources of information. For information on plant roots and drains, see Building Technology File 17.

Excavation

Excavation around footings must be properly engineered. Soil supporting footings can only be safely excavated at an angle that allows the soil under the footing to remain stable. This angle is called the angle of repose (or friction) and varies significantly between soil types and conditions. Removal of soil within the angle of repose will cause subsidence.

Remediation

Where erosion has occurred that has washed away soil adjacent to footings, soil of the same classification should be introduced and compacted to the same density. Where footings have been undermined, augmentation or other specialist work may be required. Remediation of footings and foundations is generally the realm of a specialist consultant.

Where isolated footings rise and fall because of swell/shrink effect, the homeowner may be tempted to alleviate floor bounce by filling the gap that has appeared between the bearer and the pier with blocking. The danger here is that when the next swell segment of the cycle occurs, the extra blocking will push the floor up into an accentuated dome and may also cause local shear failure in the soil. If it is necessary to use blocking, it should be by a pair of fine wedges and monitoring should be carried out fortnightly.

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Geotechnical & Environmental Services

Annex H

SITE INVESTIGATIONS for URBAN SALINITY

LOCAL GOVERNMENT
SALINITY INITIATIVE

First published 2002
Department of Land and Water Conservation
22-33 Bridge Street
Sydney NSW 2000

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LAND & WATER
CONSERVATION

Contents

Site Investigations for Urban Salinity - Introduction

Introduction

It is increasingly recognised that salinity is an issue that needs to be considered when planning urban land use. This booklet provides a methodology which looks at how to assess and quantify the impact of salinity on a proposed urban development as well as the impact of the development on the salt and water processes. The last step of the methodology is to use the collected information to tailor the design, construction and maintenance of the site to minimise undesirable impacts.

Salinity affected site (photo DLWC SALIVA library)

While salinity should be integrated into natural resource management decision processes, it is presented here as a discrete issue to highlight the ways in which it can affect development and vice versa.

Salt and it's Effects

Salts in soil come from sources such as:

- weathering of rock and soil
- soils formed on old sea beds
- salt lakes or other saline soils
- the ocean via wind and rain

Surface and ground water can dissolve and mobilise these salts often leading to their accumulation in other areas. Over time a balance is reached between water movement and salt. Ecosystems develop that are adapted to the salt in soil and ground water.

Development can change the movement of surface and ground water thus carrying the salt to other areas. Concentrations of salt and certain kinds of salt can affect plant growth, soil chemistry and structure as well as the lifespan of materials such as bitumen, concrete, masonry and metal. This means that both ecosystems and aspects of any development can be affected. The design of development should keep this in mind.

The processes that move salt through the landscape are a complex interaction between geology, climate, soil, water balance and vegetation. Therefore there is no one prescriptive list of tests to determine the impact of salinity prior to development. Rather any investigation should develop an understanding of processes and interactions peculiar to the site combined with the likely impacts of the proposed development.

Not only can the management, design and construction of the development then take these impacts into account but the new understanding arising from the experience can be used in future investigations and developments.

Measuring Salinity

Because salt separates into positively and negatively charged ions when dissolved in water, the electrical conductivity of the water increases as the amount of salt increases. To test the electrical conductivity of soil one part of soil is mixed with 5 parts of water. The result is then multiplied by the soil texture conversion factor to give the final figure. This result is known as extract electrical conductivity (ECe) and is given in deciSiemens per metre (dS/m).

Salinity affected site (photo DLWC SALIVA library)

More information on units of measure and conversion factors are discussed in Appendix 1.

Saline Soil

A saline soil is defined as a soil that contains sufficient soluble salt to adversely affect plant growth and/or land use. A soil is often considered saline if it has an ECe of 4 dS/m. This is the level at which many crops are affected. However more sensitive plants may show effects at 1 or 2 dS/m. The response is also associated with other factors including pH and the relative amounts of the various cations (positively charged ions) present in the soil such as sodium, calcium, magnesium and potassium.

The use of an arbitrary ECe reading for determining the impact of salinity on buildings and infrastructure is also an oversimplification. The impact of salts on building material is related to the amount of salt and water present, the types of salts present, chemical and physical reactions with the building materials and the amount of wetting and drying occurring. This booklet therefore lists a range of possible tests and parameters that can be used to understand the salinity processes on development sites.

Salinity affected site (photo DLWC SALIVA library)

Phases and Scale of Survey

This booklet suggests that a site should be assessed in four phases as follows:

- In the first phase, walk the site and collect any existing information. This will enable you to work out what information is missing and therefore what further tests and research are needed.
- In phase two, conduct a detailed site analysis by methods such as digging soil test pits and installing piezometers.
- The third phase is the laboratory analysis of selected soil and water samples and interpretation of results.
- The fourth phase is selection of appropriate management and evaluation techniques to suit the salt and water processes and the development.

Salinity affected site (photo DLWC SALIVA library)

PHASE ONE: INITIAL SITE INVESTIGATION AND DESKTOP REVIEW

This phase consists of

- a detailed 'desktop review' of the site and general vicinity,
- an initial site walk.

By collecting as much existing information as possible you can to start to identify the amount and types of salts present, the soil conditions, and the processes that are likely to be happening on the site. This information is used to tailor phase 2 of the site investigation for the development in question, the specific site and the level of current knowledge and understanding. Phase 2 will consist of collecting all the missing pieces to the puzzle, confirming the theories developed in phase 1 .

Broad scale and Existing Information Sources

There are various information sources that are useful in estimating the amount and type of salts in an area as well as the water movements. For example:

- Climate data such as rainfall and evaporation patterns,
- Landuse and vegetation history,
- Geological maps,
- Urban capability maps and reports,
- Soil landscape maps and derivatives,
- FLAG modelling (Fuzzy Landscape Analysis Geographical Information System),
- National Dryland Salinity Program tools (www.ndsp.gov.au) including maps classifying groundwater systems into local, intermediate or regional systems,
- SALIS (NSW Soil and Landscape Information System),
- DLWC Groundwater database,

(These broad scale investigation tools are further explained in a separate booklet of the Local Government Salinity Initiative package.)

SALIS

The NSW Soil and Land Information System (SALIS) is a database available from DLWC. It contains soil data from a wide range of sites and sources and is therefore a useful reference point. Site profile information is publicly available and free of charge on the internet (www.spade.dlwc.nsw.gov.au). Consultants requesting bulk data will incur a fee.

DLWC recommends that all soil profile descriptions, gathered as part of an investigation, are recorded on the data cards of SALIS. The cards should then be mailed to:

SALIS Coordinator
Soil and Land Information System
Department of Land and Water Conservation,
Level 4 Macquarie Tower
10 Valentine Avenue (PO Box 3720)
Parramatta 2174

The data can then be entered onto the central database. Credit is given for submitting the cards and this is offset against any cost of obtaining other site profile information held on the system. Soil data cards are available from the SALIS Coordinator at the above address or 'phone: 9895 7988.

Groundwater Database

DLWC also maintains a state wide groundwater database and provides information from the developing database to the public and to private companies for a fee that covers the time it takes an officer to extract and provide the information. The data available can include bore location, construction details, bore depth, rock/ sediment type, standing water level, yield, salinity etc however the level of information for each bore varies. Requests for raw data should be directed to the Regional Resource Information Manager in each DLWC region. Hydro-geological information may also be obtained from the DLWC regional hydro-geologists.

The Water Management Act requires all groundwater piezometers and bores to be registered with DLWC. In many cases, for example high and low yield bores, a licence is also required prior to construction of the bore. Drillers operating in NSW must also hold a valid driller's licence to help ensure correct construction of bores. Information thus obtained, as well as from other sources is being entered into the groundwater database.

Defining Landforms

At this stage in the investigation the broad distribution of geomorphic landform units should also be identified for the site. Geomorphic landform units are areas that are characterised by having similar physical and soil forming processes, examples are hill crests, side slopes and foot slopes **(Figure 1**). Landform will help determine the possible location of salt outbreaks and accumulations in the landscape. These may also be influenced by other geological and structural factors such as dykes and rock bars.

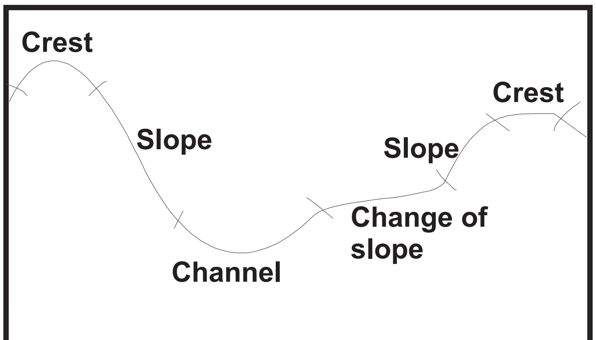


Fig 1 Examples of landform units

Other Information to Collect

Other information collected at this stage should include observations of possible salinity outbreaks and electrical conductivity readings of water bodies such as dams and creeks with a field EC meter.

Indicators of salinity outbreaks on a site include:

- Bare soil patches,
- Salt crystals present on the surface,
- 'Puffiness' of soil when dry, or greasy, on some soils if wet,
- Black staining on some soils,
- Presence of indicator vegetation species,
- Die back of trees,
- Staining and marking of house foundations.

If salinity is suspected, the soil can be tested using a field meter to measure the conductivity of a 1:5 soil:water extract to confirm the presence of salt. The results will be less accurate than a laboratory test but may help design the in-depth soil survey.

Salinity affected site near residential developement (photo DLWC)

The salinity level of water on the landscape can also be measured, but caution is needed in interpreting the results of tests on water in creeks, seeps of free water in soils etc. As Taylor (1996) points out:

> " A measurement of the electrical conductivity of water, for example in a seepage, bore or stream, is referred to as an EC w. Measuring surface water provides a reference only and indicates that, at a given point in time, a specific location was suffering from the measured degree of salinity.
>
> As massive variations in water quality can occur in the short term, measurements on water samples cannot be used to infer soil salinities at that site for a variety of reasons. These include the levels of water through flow in the soil, the time since rain, the permeability and porosity of the soil, and the position sampled. For example backwater or pools subject to concentration mechanisms such as evaporation often show higher readings than a flowing creek."

Collect local geology and soils information
(photo; DLWC SALIVA library)

How Many Samples?

Most projects involving intensive development such as urban or industrial projects, require detailed site design and layout and therefore are mapped at a large scale, ie 1:10 000, 1:5 000 or larger. In order to produce a soil map at a similar scale more samples are required than for a development at a smaller scale eg 1:25 000.

The number of samples should enable identification of the soils and landscapes that have different salinity hazards and require different management options. The most intensive land use of the area will also determine the minimum level of testing. Often on a large site there are many different uses and this will mean that different intensities of testing are needed. For example in a site survey for a residential subdivision, open space may be surveyed at a scale of 1:25 000 while residential areas are surveyed at a scale of 1:10 000 or 1:5 000. Table 1 lists typically required scales for different types of development and land use.

Table One also gives a range of samples as a guide for the initial site investigation, phase 1, and detailed site investigation, phase 2. Phase 2 includes soil profile analysis as well as laboratory analysis.

The questions that should be considered when determining which end of the range of samples is appropriate include:

- Do the landscape and soil characteristics vary across the site?
- How much local information about the salt and water processes already exists?
- What is the proposed type of development? For example landuses that don't involve irrigation, effluent disposal, or tree clearing may be less likely to mobilise any salt present and therefore may require fewer investigations.
- What is the cost of sampling relative to the cost of the development? For example $500 worth of soil sampling may not be warranted for a $500 shed, however it may be warranted to determine if a sulphate resistant cement is required for a $150,000 house.
- Are there other types of investigations that could be undertaken? For example an Electro-Magnetic Induction (EMI) survey may be used with only a few soil tests to validate the EMI survey. Alternatively, soil sampling may show there is little salt present but more groundwater information is required because the groundwater is saline, rapidly rising or close to the surface.

Scale of Mapping	**Distance at scale of mapping**	**Typical Land Use Types**	**Intial site investigation**	**Detailed Profile Descriptions**	**Laboratory Analysis of Soil Profiles**
1:25 000	1 cm = 250 m	Open space	6-18 per km^2	1.5-3 per km^2	0.2-1 per 2 km^2 (> 1 per type profile)
1:10 000	1 cm = 100 m	Intensive agriculture, low intensity construction	0.5-1.0 per ha	10- 20 per km^2	0.5 –4 per km^2 (> 1 per type profile)
1:5 000	1 cm = 50 m	Moderately intensive construction, waste and effluent disposal	2-4 per ha (0.5 – 1 per 0.25 ha)	0.5-1 per ha	0.2-1 per 5 ha (> 1 per type profile)
1: 1 000	1 cm = 10 m	Highly intensive construction, dams, waste and effluent disposal	50-100 per ha (0.5 – 1 per 100 m^2)	10-20 per ha	0.5-4 per ha (>1 per type profile)

Note: 1 km^2 = 100 ha
1 ha = 10 000 m^2
Table developed from "Soil and Landscape Issues In Environmental Impact" (DLWC 1997) and Is similar to requirements in "Managing Urban Stormwater Soils And Construction" (Blue Book) Dept of Housing 1998

Table 1 Recommended Levels of Site Description

PHASE TWO: DETAILED SITE INVESTIGATION

This phase consists of a detailed site analysis. A soil and groundwater sampling regime should be designed using information from the initial site walk and desktop review. For example how many soil and groundwater samples are needed, where should they be collected from, how should they be analysed. The information collection should be designed to lead to a better understanding of the physical processes operating on the site and to build a picture of the impact of the development on the site and vice versa. If the information collected in phase one shows there is little salt or groundwater hazard or that the processes on the site are already well understood then there will be less work in this second phase.

Outlined below is a list of standard soil and landscape information that should be collected for each soil profile site. Much of this data would normally be collected for geo-technical surveys and in the design of sediment and erosion control plans as described in the "Blue Book" (Dept of Housing 1998). The number of soil profiles required will vary depending on the level of existing information, the scale, intensity and type of the development plus the variability of the landscape. Column 5 of Table 1 provides a recommended range for the number of soil profiles required for a detailed site investigation. Usually there is at least one soil profile for each landform unit. The site profiles selected from the various landform units across the site should form transects. This will enable a three-dimensional picture of the subsoil profiles to be created.

Landscape Description

Topography

- Slope gradient and description (eg slope steepness, slope length, waxing, waning, convex, concave),
- Aspect,
- Elevation,
- Landform pattern (a general geomorphic description of the area such as plain, low hills, mountains),
- Landform element (which part of the landform pattern ie crest, mid-slope),
- Landform process (eg, aeolian, alluvial, residual, erosional).

This information is obtained from topographic maps and by site inspection and will give an understanding of the physical processes operating on the site.

Lithology

- Type of parent material and substrate,
- Degree of weathering.

This analysis can provide information on possible sources of salt and is obtained by site inspection and or from geological maps. Usually the advice of a specialist geologist or soil scientist is required to identify those geological formations most likely to be associated with saline outbreaks. Salt can come from sources other than rocks (eg aeolian dust, ancient sea incursions), so it is necessary to view the complete picture when predicting the potential for the development of salinity. McDonald et al (1990) provides information related to lithology.

Site Condition

- Ground cover (%),
- Existing degradation (eg erosion, salinity),
- Any indicators of salinity.

This information is obtained by site inspection and air photo interpretation and provides information of the extent of salinity outbreaks at the surface and any other site management problems.

Hydrology

- Run on and run off details,
- Drainage and permeability,
- Depth to water table (if in the soil profile).

This information is obtained by desktop review and site inspection and provides information on water movement on the site and under the site.

Inspecting the soil (photo; NSW Ag Image Library)

Soils

All major soil horizons should be described for the following properties:

- Depth of layer and total depth,
- Colour (Munsell - standard method of applying colour to soils) and mottling (yellow and grey blotching indicating periodic water logging),
- Field pH,
- Field texture (relative amounts of clay and sand which indicates how porous the soil will be and how much water it will hold as well as other soil properties),
- Soil water status (how moist the soil is),
- Structure (arrangement of soil particles and size, shape and condition of peds (crumbs) indicates how easily water will move through the soil and likely rooting depth for plants),
- Fabric (appearance of soil using x 10 hand lens),
- Coarse fragments (amount and size),
- Quantity of roots (important for water infiltration into the soil and will give an indication of the rooting depth of soils. Rooting depth is important for predicting the potential for deep drainage),
- Presence of hard pans (hard and often impervious layers that prevent water infiltration and lead to possible water logging).

Survey details such as Map Grid of Australia Reference, location, date, nature of exposure (eg, auger, batter, gully, etc), name of surveyor should also be recorded. McDonald et al (1990) provides information and guidelines on soil descriptions.

The depth to which the soil profile is described should be the greater of the following:

- 3 m or
- distance to solid bedrock (if less than 3 m); or
- depth of potential physical and/or chemical impact from the proposed development (eg depth of disturbance for an underground pipeline).

The depth of 3 m was selected as it is the depth to which a backhoe can reach. A backhoe, in 2002, costs approximately $170 to $200 plus $80 per hour of operation. On average around 1.5 to 2 soil profiles can be described in an hour.

Salinity affected site (photo DLWC SALIVA library)

Laboratory Analysis

Laboratory analysis of soils should be carried out on carefully selected representative soil profiles to provide a full description of physical and chemical soil properties for each identified landform unit. The number of profiles selected for laboratory analysis should normally be around 5 to 20% of all soil profiles (see Column 6 Table 1).

There should be at least one laboratory analysis conducted for each of the major soil horizons found in each landform unit. If distinct soil horizons are not present then the soils should be sampled at 20 cm, 0.5m, 1.0m, 1.5m, 2.0m, 2.5m and 3.0m. When there is a surface expression of salinity such as salt crystals on the soil, then the top 2cm of soil should be tested separately.

Each sample generally should contain a minimum of 1.5 kg of soil in a cotton bag with clear labelling (giving site number, depth interval, etc), and this should be sent to a laboratory soon after collection. Air-dry soil samples as soon as possible after collection to ensure reliable results from analysis. The “bulking” of topsoil samples is recommended. This is where six or more similar sub-samples within a 10m radius of the soil profile being described are thoroughly mixed together. “Bulking” gives more reliable test results of the topsoil. However, “bulking” **should not** be done for subsoils.

Laboratories often have an accreditation system such as National Association of Testing Authorities (NATA) or to ISO 9000 for the specific test or for the management system of the laboratory. These types of accreditation systems help ensure the reliability of the test results and reports. Full documentation of the sampling and testing methodology, including the equipment and tests used, should be specified in the results sheet. All original laboratory data should be readily available to the consent authority upon request. Where possible, the soil samples should be retained until after the development project has been completed in case further analysis is required.

Soil Tests for Urban Salinity

The soils tests listed below are divided into two broad categories. The first suite of tests provide information on water movement through the soil and possible impediments to drainage. The second suite helps determine how corrosive soil and groundwater on the development site will be to building materials and infrastructure. The two suites of tests are interrelated as the water movement through the landscape determines where the salts are concentrated and hence the most corrosive.

'Corrosion' here refers to deterioration and removal by chemical attack. In corrosive environments such as areas with saline soil and groundwater, building and infrastructure design, construction and maintenance may need to be modified to ensure the required service life and durability is achieved.

The cost of tests for water movement and corrosivity listed below, in 2002, are around $150 (including GST) per soil sample. If there are no soil horizons present and samples are collected at 20cm, 0.5m, 1.0m, 1.5m, 2.0m, 2.5m, and 3.0m the cost is $1050 (7 x $150) per soil profile. Consider whether this cost is justified in determining the number of soil profiles analysed in this way. Field testing techniques can often be used to estimate if many of these properties require more accurate laboratory analysis.

Tests for Water Movement

The purpose of this suite of tests is to use measurable indicators to infer how water moves through the soil and landscape. Areas that are likely to concentrate water are also likely to concentrate salts.

Permeability - is the rate at which water moves through the soil. Generally, the lower the permeability the more prone the soil can be to water logging. Permeability is determined by various soil properties including texture, structure, compaction, sodicity and presence of impermeable layers or crusts.

Cation Exchange Capacity (CEC)- indicates the soil's capacity to store the available positively charged cations such as sodium (Na), calcium (Ca), magnesium (Mg) and potassium (K). It is dependent on the amount and type of clay and organic matter present in the soil. The reason for the inclusion of CEC is that it is required for assessing sodicity.

Sodicity - is the level of exchangeable sodium in the soil. It relates to the likely dispersion on wetting and to shrink/swell properties. Sodic soils are prone to:

- very severe surface crusting,
- very low infiltration and hydraulic conductivity,
- very hard dense subsoils,
- severe gully erosion and tunnel erosion,
- restricted root growth and shallow rooting depths for plants.

Hard when dry and slow to wet up, sodic soils are boggy/soft when wet.

Sodicity or exchangeable sodium percentage (ESP) is the amount of exchangeable sodium as a percentage of the CEC

ESP = [Exchangeable sodium / CEC] x 100

Examine the characteristics of the soil profile
(photo; DLWC SALIVA library)

Dispersibility - is the susceptibility of soil aggregates to structural breakdown into individual particles. Using the Emmerson Aggregate (Crumb) Test (EAT or ECT) a comparable measure of the susceptibility of soil aggregates to structural breakdown into individual particles in water is determined. Dispersible soils greatly limit water movement through the soil resulting in poor drainage and water logging. There is an Australian Standard for the Emmerson aggregate test, AS 1289.3.8.1 - 1997.

Tests for Corrosivity

The purpose of this suite of tests is to identify how corrosive an environment is to concrete and steel. The tests are based on Australian Standards 2159: 1995 Piling - Design and Installation. The Standard has two classes of soil conditions:-,

(A) - high permeability soils below groundwater,
(B) - low permeability soils and all soils above groundwater.

In an urban environment additional sources of water, such as leaking pipes and excessive irrigation, can transport and concentrate salt and often cause the groundwater table to rise. Compaction or cut and fill often result in perched water tables creating a secondary groundwater table close to the surface. It could therefore be argued that the precautionary approach would be to use the more conservative classifications listed for soil condition A (see Appendix 2).

The corrosion potential of a soil on concrete is dependent on the level of sulphate, soil pH, and chloride (for reinforcement). It has been noted in AS 2159 that the presence of magnesium and ammonium ions can increase the aggressiveness of sulphate on concrete. This Standard does not quantify this effect, however the German Standard, DIN 4030 Assessment of Water, Soil and Gases for their Aggressiveness on Concrete, includes tests for magnesium and ammonium. Part of the German Standard has been reproduced in Appendix 3. The German Standard should be used as a guide only as German soils, conditions, and building techniques are different to those in Australia.

AS 2159 also gives values for the corrosion potential of an environment on steel based on soil pH, chloride and resistivity. A brief description of each of these factors follows:

Sulphates - are negatively charged particles (anions) which are corrosive to building materials, particularly concrete. Sulphates react with the hydrated calcium aluminate in concrete. The products of the reaction have a greater volume than the original material, producing physical stress in the concrete. The concentration of sulphate needs to be expressed as a percentage weight of the soil to be compared directly to AS 2159.

Soil pH - measures acidity or alkalinity of a soil and is important in determining the corrosivity of the soil to building materials. Acids combine with the calcium hydroxide component of cement to form soluble calcium compounds. These can be leached from the concrete increasing its porosity and decreasing its strength. (See Australian Standards 1289.4.3.1:1997 Soil Chemical tests - Determination of the pH value of the soil - Electrometric method). The pH will be expressed as pH units and should range between 1.0 (extremely acidic) and 14.0 (extremely alkaline), with 7.0 being neutral.

Chlorides - are negatively charged ions (anions) which are corrosive to building material, particularly steels. In concrete, chlorides react with the steel reinforcement causing it to corrode and expand putting physical stress on the concrete. Salt crystals also can cause mechanical damage as they expand in voids in concrete and brickwork. The concentration of chloride should be expressed as parts per million (ppm) or milligrams per litre (mg/L) in water to be compared directly to AS 2159.

Resistivity - is a measure of the impedance of electrical current in a soil and is important in determining the corrosiveness of soil on steel. Corrosion in metals involves an electrochemical change of the metal. For corrosion to proceed a medium, the electrolyte, is needed to transfer ions. Resistivity measures the strength of the electrolyte, in this case soil. (See Australian Standards 1289.4.4.1:1997 Soil Chemical tests - Determination of the Electrical Resistivity of a Soils Methods for Sands and Granular Materials). Resistivity should be in measured in ohm.cm to be compared directly to AS 2159.

Salinity - though not useful in the assessment of corrosivity provides important information for landscaping. Salinity refers to the presence of excessive salt, which is toxic to most plants. The salt tolerance of plants varies from species to species and stages of growth. Salinity is determined by the electrical conductivity of a soil water extract corrected for texture (see Appendix 1). The two most common laboratory methods are EC (1:2) (one part soil to two parts water) and EC (1:5) (one part soil to five parts water). The different tests will give different EC values that are then converted to ECe using a correction factor of soil texture, so ensure all results are cleared labelled.

Groundwater Tests for Salinity

Larger projects may require the installation of piezometer(s) to measure the groundwater depth before and after development especially if no data is available in the immediate vicinity of the site. The cost of drilling a groundwater bore in 2002 is approximately $600 to hire the drill rig and $1000 per shallow bore, depending on depth.

Preliminary site and desktop investigations should be used to determine if a piezometer or several piezometers are needed, at what depth and where. The results can help confirm groundwater conceptual models. For example the level of groundwater in a recharge site where water is entering the groundwater system will show more short term response to fluctuations in weather than a discharge point where water is leaving the groundwater system. The chemistry of the groundwater will also reflect the rocks and soil that the groundwater has passed through.

Collect local groundwater information
(photo; DLWC SALIVA library)

There may be several layers of groundwater under a particular site therefore piezometers of different depths may be needed. For example a regional groundwater system where water is entering the ground 50 or 60 km away may be under a local groundwater system where water is entering 1km away. Knowing whether the different systems exist, whether they interact with each other and whether they are rising will help determine if management options are appropriate on the site or elsewhere as well as the type of management option appropriate for the situation.

If a piezometer is installed, observations should be made of the characteristics of each layer in the soil profile as piezometers allow soil measurements and observations to a greater depth than allowable using a backhoe. For example

- Depth,
- ECe
- pH,
- Soil texture and colour,
- Moisture content,

should be recorded for the different soil horizons.

"Specifications and Methods For the Construction of Departmental Groundwater Monitoring Bores in NSW" produced in 1998 by the DLWC Groundwater Drilling Unit in Dubbo is one publication that details construction methods for bores.
Once piezometers are installed a chemical analysis of the groundwater can be undertaken to indicate the likely impact the groundwater may have on the soil, vegetation or man made structures. It is common to test for EC, pH, sodium, calcium, potassium, magnesium, sulphate, carbonates and chlorides. Groundwater chemical analysis will also help determine if the groundwater from different depths and different bores come from a common source or different sources.

Groundwater movement is often complex. Often numerous sources of information over long periods are required to confidently predict processes. Therefore it is important that any site information is compared with any existing information and that new information is recorded in a publicly available database for future use.

Salinity affected site (photo DLWC SALIVA library)

PHASE THREE: PRESENTATION AND INTERPRETATION OF RESULTS

The third phase of the site investigation involves presenting all the results in a clear and logical manner and comparing the results to various standards, technical manuals and reference documents.

Presenting the Data

All test results should be clearly presented in tables with the units of measurement clearly shown. Any conversion factors used should also be given as there are often numerous industry standards. This is very important for the correct interpretation and verification of theories relating to what is happening on the site and selection of suitable management options. For example if salinity readings are expressed as EC rather than ECe the result will be underestimated by a factor of 14 for a sandy loam or 6 for a heavy clay. Alternatively EC in decisiemens per metre is a 100 times less than EC in millisiemens per metre but is the same as millisiemens per centimetre.

A map showing the distribution of soil and landform types and soil profile sites over the development site helps relate results to the development layout and visualisation of changes across the site. Soil and landform types that may require different management can then be distinguished. In some cases, consideration could be given to preparing two maps, with one highlighting the main soil landscape units and the other highlighting the areas with similar constraints and management requirements.

The main features that should be included on the site map are:

- soil and landform units,
- drainage lines,
- locations of all site observations, site profile descriptions and analyses,
- legend, scale and north direction.

It is also useful for the map to include topographic contours and vegetation.

The site profile results for the site should be displayed as transects across the site. (see **figure 2** as an example). This will help build up a three dimensional picture of soil and salt distribution in the landscape. It will also assist in assessing the impact the development will have on the salt and water processes of the landscape as well as the impact the landscape may have on the development.

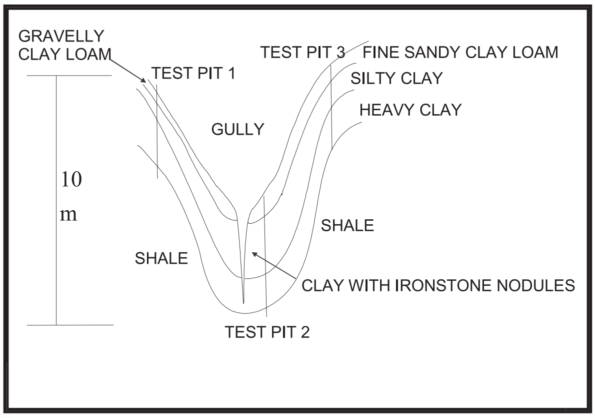


Fig 2 Example of a soil profile transect

It is useful to present results from the different soil horizons in a soil profile as a graph. For example EC on the X axis and sample depth on the Y axis. A decreasing EC with depth might suggest the soil profile was taken from a discharge site, while a steady low EC might indicate a recharge site. A zone in the profile where EC is higher may indicate the depth of a seasonal watertable or a zone of low permeability.

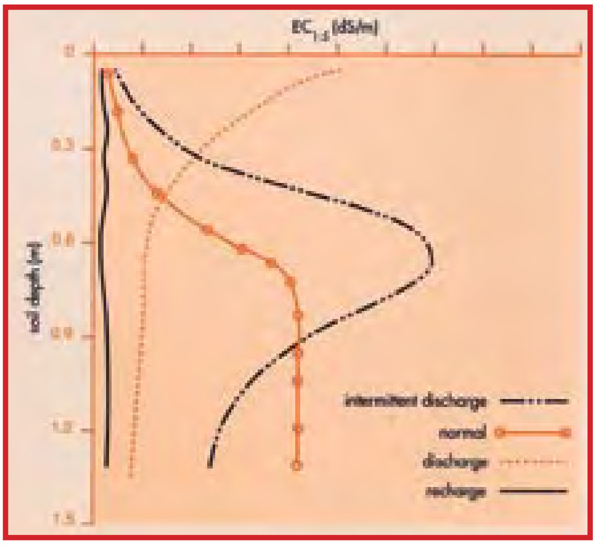


Figure 3 Typical Salt Profile shapes associated with recharged, discharge , normal and intermittent areas(Qld DNR 1997)

Results should also be assessed relative to what was observed in the field. If a salt scald was observed in the field with salt crystals on the surface then the soil test should indicate high levels of salt. If it does not then there may have been a problem with the labelling of samples, presentation of results etc.

Interpreting the Data


Salinity affected site (photo NSW Ag Image Library)


Salinity affected site (photo DLWC SALIVA library)

Permeability of soils will determine how quickly and easily rain, applied effluent, irrigation, and contaminants penetrate into the soil profile and possibly raise and/or contaminate the groundwater system.

Water movement should be considered at several scales. For example the permeability of the various layers of the subsoils can vary. Water flow can therefore be concentrated or confined to particular soil layers. Water movement along these layers is known as through flow or lateral flow. Through flow can be indicated by the soil being paler in colour than the layer above or below. If construction compacts or intercepts this layer, it can interfere with through flow and possibly create a discharge area upslope. This may be at a single house scale, street or suburb scale. On a larger scale groundwater may be moving from recharge areas to discharge areas 1km to over 50km apart.

An example of types of permeability rates is :

Texture	**Structure**	**Infiltration**	**Permeability (mm/h)**
Sand	Apedal	Very Rapid	>120 can be measured >250
Sandy Loam	Weekly pedal Apedal	Very rapid Rapid	>120 60-120
Loam	Peds evident Weakly pedal Apedal	Rapid Mod. Rapid Mod. rapid	60-120 20-60 20-60
Clay Loam	Peds evident Weakly pedal Apedal	Mod. rapid Moderate Slow	20-60 5-20 2.5-5
Light clay	Highly pedal Peds evident Weakly pedal	Moderate Slow Very slow	5-20 2.5-5 <2.5
Medium to heavy clay	Highly pedal Peds evident Weakly pedal	Slow Very slow Very slow	2.5-20* <2.5 <2.5
Clay	Sodic and saline Sodic Highly sodic	Moderate Very slow Extreme	8.0 <2.5 <1.0

* Strongly structured polyhedral subsoils e.g. Krasnozem

Sodicity is expressed as the amount of exchangeable sodium as a percentage of the Cation Exchange Capacity or ESP %. Various ranges are used to rank ESP % as non sodic, sodic or highly sodic. One example is:

ESP %	Rating
< 5	Non-sodic
5-15	Sodic
> 15	Highly sodic

When wet, sodic soils lose their structure and disperse into very small particles, the small particles fill the pore spaces in the soil effectively blocking them. This impermeable layer can severely impede water movement.

The depth and thickness of the layer of sodic material will determine the effect on development. For example a thin sodic layer deep in the soil profile may not cause a problem if the surface layers of soil are not removed and infiltration of water or effluent is designed to suit the site conditions. Excessive water entering the profile may be prevented from draining further by the sodic layer and result in tunnelling soil erosion. Gullying or tunnelling can be an issue if the sodic subsoil is exposed to rainfall, or construction leads to an outlet developing for water ponded above a sodic layer. With a sodic layer at the surface however, erosion is an issue. Plants may have problems establishing if erosion has removed the nutrients and the sodic crust is preventing air and water entering the soil profile. Stability for structures may also be an issue especially if the layer is thick.

Calcium, mostly in the form of gypsum, is often added to sodic soil to address the balance between sodium and calcium in the soil.

Dispersibility of soils is not always related to sodicity. Soils with poor soil structure, low amounts of organic matter and low sodium levels can also be highly dispersive. The sugars in the organic matter help bind soil together.

The Emmerson Aggregate Test can be used to rank soil dispersibility into classes from 1 to 8. Air dried soil is placed in water. As the water is absorbed air becomes trapped within some pores spaces. The pressure of this air can be enough in some soils to make it disperse. This type of dispersion is called slaking and refers to Emmerson aggregate classes 1 to 6. Those soils that don't slake are put into classes depending on whether they swell (class 7) or not (class 8).

Once the soil is immersed in water, dispersion can continue due to the stresses between the charged particles present. If these charged particles are readily dissolvable within water eg sodium or there is a large total number of salts present then dispersion will be greater. The reactions are used to classify soils into class 1 to 6. Class 1 and 2 soils can result in tunnelling erosion. Class 3 are stable and don't leak if compacted when wet. Class 4,5 and 6 however are highly aggregated materials and are less likely to hold water even when compacted.

Dispersible soils should be taken into account in the design of sediment and erosion control plans but also in terms of water and salt movements in the landscape. Dispersible soils can be managed by maintaining vegetation cover and possibly adding organic matter, gypsum and lime depending on the Emmerson aggregate class result.

Salinity affected site (photo DLWC SALIVA library)

Corrosivity test results can be compared with such sources as:

- AS 2159 (1995) Piling -Design and Installation. Extracts of this are given in Appendix Two.
- The German Standard DIN 4030 Assessment of Water, Soil and Gases for their Aggressiveness to Concrete. An extract of this is given in Appendix Three.
- The manufacturers specifications for various products and materials.

By understanding the salt and water processes on the site the likelihood of changes over time to results of testing can be estimated. In some cases the site may need to be managed carefully to ensure a particular outcome. The management options chosen may vary across the site. Ongoing monitoring of the site may also be necessary to determine success.

PHASE FOUR: MANAGEMENT AND EVALUATION

In the final report, the results presented in phase three need to be interpreted in terms of the current conditions on the site and what is likely to occur in the future. This latter component can only be undertaken if there has been sufficient investigation (phase one and two) to obtain an adequate understanding of the processes occurring on the site and in the area. Soil sampling alone might show that there is little salt present on the site. However, mobilisation and concentration of this small amount of salt may lead to salinity issues in the future. Alternatively, there may be a saline groundwater under the site that is intercepted by plant roots or deep constructions, or the groundwater may be rising to the surface due to offsite causes.

Urban developement encroaching on agricultural land
(photo NSW Ag Image Library)

The issue of cumulative impacts should also be addressed. Lots of small changes brought about by numerous developments can result in a significant impact in the longer term. Often simple management options and a precautionary approach can limit these cumulative impacts. This is usually more cost effective than trying to address a problem after it has occurred.

Questions that should be considered in phase four include:

- **How will the proposed development alter the above ground and below ground water movement on the site as well as the salt store?**

  Particular consideration should be given to:
  - water sensitive urban design principles of infiltrating surface water into the ground,
  - the use of stormwater detention ponds and wetlands,
  - the watering of lawns in residences and open space,
  - cut and fill techniques of construction,
  - compacting and disturbing soils in road and building construction,
  - the building of service trenches,
  - exposure of saline or sodic soils.

- ***What will be the impact of the altered water and salt movement on the development and environment, on and off site, if left unmanaged ?***

  Particular attention should be given to:
  - the change in concentrations of salts, particularly chloride and sulphate ions, that can have a corrosive effect on construction materials of roads and buildings,
  - capillary action drawing water and salt upwards,
  - wetting and drying effects on soil and building materials concentrating salts,
  - AS 2159 Supp 1 -1996 Piling - Design and installation - Guidelines Section 4 and AS 3600 Supp1 -1994 Concrete Structures Commentary Section C4 for additional information on designing for durability,
  - The effect of change in water movement and salt on flora, fauna and water quality. Impact on flora in particular may have a compounding effect. Death or removal of deep rooted, perennial vegetation may lead to lower rates of removal of groundwater by transpiration and thus a rise in the groundwater level.

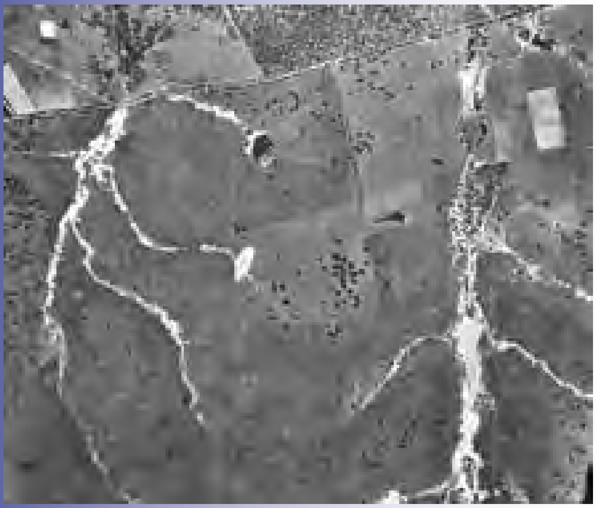
- ***What management options and strategies are proposed to mitigate the effects of altered water and salt movement?***

  To minimise the impact of the development on the water and salt processes on the site, possible management options might include:
  - minimising water infiltration,
  - the use of landscaping using native plants,
  - sealing stormwater detention ponds,
  - retention of deep rooted vegetation,
  - minimising soil disturbance such as compaction and cut and fill.

To minimise the impact of the water and salt processes on the development, possible management options may include:-

- careful installation of damp proof courses,
- water proofing the slab,
- good site drainage,
- the use of higher strength concrete with thicker cover and exposure class masonry,

(These building issues are further explained in a separate booklet of the Local Government Salinity Initiative package.)



Aerial photo showing salinity indicators
(Land Property Information)

Aerial photo showing salinity affected in rural areas
(Land Property Information)

Alternatively management could also be tailored to the particular soil and water processes of different parts of the site. Appropriate management options for recharge areas include:-

- Minimising infiltration of stormwater,
- Minimising on site sewer disposal,
- Use of local provenance native vegetation in landscaping to minimise the need for irrigation,
- Lawns linked to moisture probes and only watered to match the plants requirements,
- Planting of deep rooted native trees to increase water use,
- Retaining native vegetation where possible,
- Stormwater detention ponds and water features lined to reduce infiltration.

Urban developement encroaching on agricultural land
(photo NSW Ag Image Library)

Appropriate management options for areas with shallow water tables are the same as for recharge areas in conjunction with:-

- Damp proof courses correctly installed and maintained in buildings,
- Well drained building sites,
- Utility trenches designed so they do not concentrate saline groundwater flow,
- Minimised disturbance of drainage lines,
- Minimised cut and fill so saline or sodic subsoils are not exposed or groundwater intercepted,
- Soils replaced in their original order if excavations are undertaken,
- Sediment and erosion control plans that take into account saline and sodic soils.

Management options for permanent, periodic or historical discharge sites could include:-

- Use of appropriate construction materials and techniques to salt proof buildings and infrastructure,
- Use of salt tolerant vegetation in landscaping,
- Treating sodic soils with gypsum before landscaping,
- Rehabilitating salt scalds,
- Drainage and treatment of the collected salt water,

- Use of pier and beam construction. This has several advantages over slab construction namely;-
  - Allowing evaporation to occur at the soil surface,
  - Limiting the amount of building material in contact with salt or water,
  - Allowing any damage to be more easily observed,
  - Limiting the need for cut and fill and thus exposure of sodic or highly saline subsoil or disturbance to natural drainage.


Salinity affected site (photo DLWC SALIVA library)

- ***What degree of certainty is there that the proposed strategies will mitigate the effects of altered water and salt movement?***

A monitoring and evaluation system should be developed for the site, which is appropriate for the degree of certainty and the possible ramifications if they are wrong. For example, during construction evidence of localised perched water tables and unexpected changes in soil characteristics should be noted and taken into consideration. If piezometers have been installed to gain an understanding of the processes on the site these should continue to be monitored. Often groundwater movement is very slow so that the impacts of the development or remedial measures will not be apparent for numerous years. Care should therefore be taken to place peizometers where they can remain during and after development.


Salinity affected site (photo DLWC SALIVA library)

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APPENDIX ONE: UNITS USED TO EXPRESS SALINITY

From Taylor (1996) pages 9,10 and 25

Units Used to Express Salinity

The Department of Conservation and Land Management has adopted the Australian Laboratory Handbook of Soil and Water Chemical Methods (Rayment & Higginson 1992) standard of dS/m (deciSiemens per metre) as the unit of measurement of electrical conductivity and, hence, salinity. This is an inferred measure of the amount of salt in water or in a soil:water suspension. This measurement does not account for the effects of different ions in the solution.

Many other departments and private consultants use a number of different measures for various reasons including historical precedents, compatibility with international groups or simply personal preference. For example, the Western Australian Department of Agriculture commonly uses units of ppm (parts per million).

Measurement of the individual ionic components in a solution is generally in mmol/L (millimols per litre). Measurement of soluble salts in a soil may be expressed in terms of mg/kg (milligrams per kilogram).

A range of conversions between different units of electrical conductivity and other parameters follows. The measure of mol/L (moles of salt per litre) has been left out due to the lack of common use outside the ranks of soil chemists and technicians and because of the extra complications of using differing molecular weights and involved formulae.

MEASUREMENT CONVERSIONS TO DECISIEMENS PER METRE (dS/m)

- **dS/m = mmho/cm = mS/cm**
  (deciSiemens per metre = millimhos per centimetre and milliSiemens per centimetre)
- **dS/m x 100 = mS/m**
  (deciSiemens per metre by 100 = milliSiemens per metre)
- **dS/m x 1 000 = µS/cm**
  (deciSiemens per metre by 1000 = microSiemens per centimetre; µS/cm is a widely used measure in water samples and is commonly called an "EC Unit")
- **dS/m x 640 = ppm = mg/L = µg/ml** (approximately)
  (deciSiemens per metre by 640 = parts per million AND milligrams per litre AND micrograms per millilitre. These express total dissolved salts)
  Note: The conversion from dS/m to ppm can vary markedly depending on the salts present. To highlight this, for each of the single salt solutions shown, an EC of **1 dS/m** at 25°C is equal to the following concentrations in parts per million (mg/L):

$MgCl_2$	400ppm
$CaCl_2$	465
NaCl	500
Na_2SO_4	630
$MgSO_4$	710
$CaSO_4$	800
$NaHCO_3$	970

(Source: Richards, 1954)

The figure of 640 is used as an accepted average.

- **dS/m x – 0.36 = OP** in bars (OP = osmotic potential), multiply bars by 100 for kilopascals (kPa)
- **dS/m x 10.96 = meq/L of NaCl** (milliequivalents per litre of *sodium chloride* – varies with type of salt)

Other Conversions

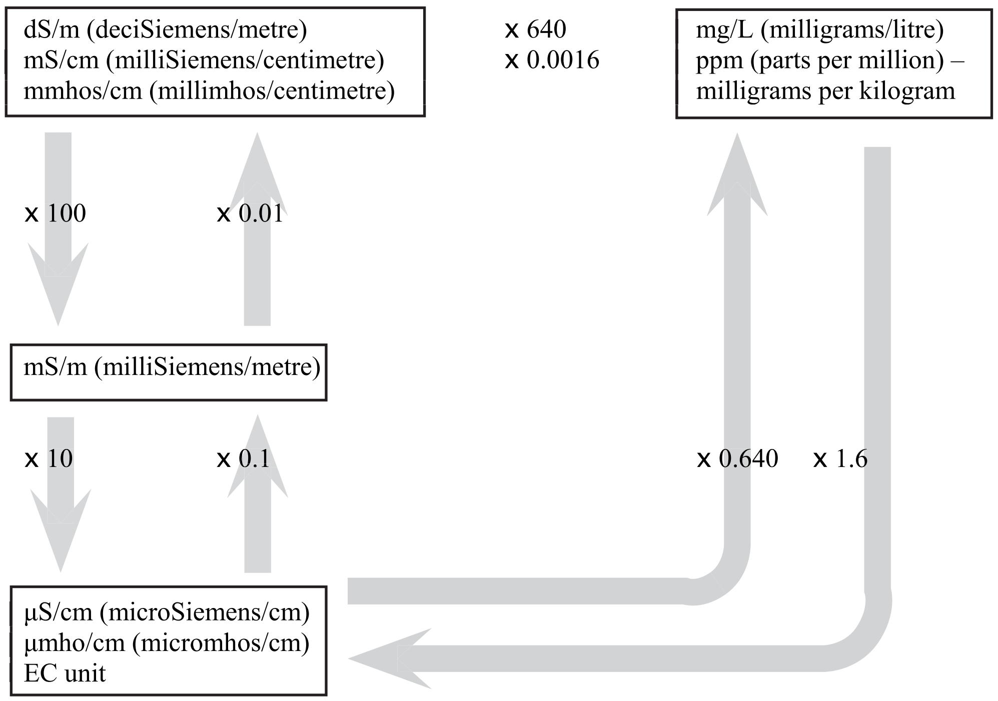
- **EC 1:5 (dS/m) x 0.34 = total soluble salts (TSS) as g/100g of soil (%)**
  (% TSS estimated from the EC in d/Sm of a 1:5 suspension at 25°C)
  this assumes salt content at 640 mg/L, (for NaCl assume 500 mg/L and use 0.25)
- **mhos/cm = 1 000 x mmhos/cm** (dS/m)
  (mhos per centimetre = 1 000 millimhos per centimetre (or dS/m)
- **mmhos/cm = 1 000 x µmhos/cm**
  (millihos per centimetre = 1 000 micromhos per centimetre)
- **µmhos/cm = µS/cm**
  (micromhos per centimetre = microSiemens per centimetre)

The following older measures may still be referred to by some clients. They are inserted here due to several requests of extension staff.

- **grains per imperial gallon[1] = 14.28 ppm**
  (a measure previously used and still referred to by some landholders, it is weight of salt in grains, remaining after evaporation of all water in one imperial gallon)
- **grains per US gallon[2] = 17.10 ppm**
  (as above but for the US gallon)

Many conversions are factors of ten. Parts per million (which equals mg/L etc.), and osmotic potential are the main exceptions. For quick reference, Figure 3.1 which depicts the more common measures and their conversions has been included.

FIGURE 3.1 – COMMON EC MEASUREMENT CONVERSIONS



FOR EXAMPLE: 8 dS/m

8dS/m = 800mS/m = 8000µS/cm = 5120mg/L
8mmho/cm = 8000µmho/cm = 5120ppm
= 8000 EC units

Source: Adapted from B. G. Williams and B. Wild (pers comm)

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[1] **4.546 litres = 1 imperial gallon**

[2] **3.785 litres = 1 US gallon**

TABLE 6.1 FACTORS FOR CONVERTING EC (1:5) TO EC$_e$

Soil Texture Group[8]	Multiplication Factors[9]
Sands have very little or no coherence and cannot be rolled into a stable ball. Individual sand grains adhere to the fingers.	17[10]
Sandy loams have some coherence and can be rolled into a stable ball but not to a thread. Sand grains can be felt during manipulation.	14
Loams can be rolled into a thick thread, but this will break up before it is 3-4 mm thick. The soil ball is easy to manipulate and has a smooth spongy feel with no obvious sandiness.	10
Clay Loam can be easily rolled to a thread 3-4 mm thick but will have a number of fractures along its length. The soil is becoming plastic, capable of being moulded into a stable shape.	9
Light clays can be rolled to a thread 3-4 mm thick without fracture. Plastic behaviour evident, smooth feel with some resistance to rolling out.	8.5
Light medium clay is plastic and smooth to the touch and will form a ribbon of 7.5cm.	8
Medium clay handles like plasticine, forms rods without fracture, has some resistance to ribboning shear, ribbons to 7.5cm or more.	7
Heavy clays can be rolled to a thread 3-4 mm thick and formed into a ring in the palm of the hand without fracture. They are smooth and very plastic with a moderate to strong resistance to rolling out.	6

Source: Multiple sources (see below)

TABLE 6.2: EC$_e$ VALUES OF SOIL SALINITY CLASSES

Class	EC$_e$ (dS/m)	Comments
Non – saline	<2	Salinity effects mostly negligible
Slightly saline	2-4	Yields of very sensitive crops may be 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

Source: Richards, (1954)

WATER SAMPLES

A measurement of the electrical conductivity of water, for example in a seepage, bore or stream, is referred to as an EC$_w$. Measuring surface water provides a reference only and indicates that, at a given point in time, a specific location was suffering from the measured degree of salinity.

As massive variations in water quality can occur in the short term, measurements on water samples cannot be used to infer soil salinities at that site for a variety of reasons. These include the levels of water throughflow in the soil, the time since rain, the permeability and porosity of the soil, and the position sampled. For example, still backwaters or pools subject to concentration mechanisms such as evaporation often show higher readings than a flowing creek.

It has been suggested that there is a relationship between the electrical conductivity measured in water, the EC$_w$, and the electrical conductivity of the soil, the EC$_e$, under irrigation. When dealing with dryland salinity however, any relationship is determined by many factors. Water salinity is of interest for other reasons such as quality for drinking, irrigation and stock use (Figure 6.3).

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[8] Soils are classified for texture on the degree to which moist soil can be rolled out in the palm of the hand. Take a small quantity of soil and knead with water until a homogeneous ball is obtained. Remove large pieces of grit and organic matter. Small clay peds should be crushed and worked in with the rest of the soil. The feel, behaviour and resistance of the soil to the manipulation during this process is important. Keep the soil ball moist so that it just fails to stick to the fingers. See Northcote (1979) for more complete soil texture information. Texture groups from: - Soil Conservation Service - Riverina, "Instructions for use of TPS conductivity meter and guidelines for interpretation of salinity values." (undated field guide)

[9] Unless indicated otherwise, these conversion factors are estimates derived from testing of soils by soil chemists from the NSW Department of Agriculture. Factors vary within broad bands for each texture unit and have been interpreted to derive the factors shown. (P. Slavich, pers. comm.)

[10] Yo and Shaw (1990)

APPENDIX TWO:
EXTRACT FROM AUSTRALIAN STANDARDS 2159 – 2009 PILING – DESIGN AND INSTALLATION

AS 2159-1995 has been reviewed and is superseded by AS 2159-2009.
Any reference to AS 2159-1995 in the text of this document should now be referred to AS 2159-2009.

The Tables related to this Appendix are extracts from AS 2159 – 2009 Piling – Design and Installation and are found in AS 2159 – 2009, Section 6, Durability Design between pages 38 and 46. These Tables should be used in conjunction with the associated text and Notes of Section 6 (Parts 6.1 to 6.6) to ensure Durability Design criteria are assessed within the intended context.

The printed hard copies of this Appendix contain reproductions of Tables 6.4.2 (A), Tables 6.4.2 (B), Tables 6.4.2 (C) with Notes, Tables 6.4.3 with Notes, Tables 6.5.2 (A), Tables 6.5.2 (B), Tables 6.5.2 (C) with Notes, and Tables 6.5.3 with Notes from AS 2159 – 2009 Piling – Design and Installation. Reproduced with permission from SAI Global under licence 1005-c012-3.

Salinity affected site (photo DLWC SALIVA library)

Salinity affected site (photo DLWC SALIVA library)

APPENDIX THREE: EXTRACT FROM GERMAN STANDARD DIN 4030 CORROSIVITY ASSESSMENT FOR CONCRETE

Parameter Checked	**Degree of Aggressiveness**		
	Low	**High**	**Extremely High**
pH Value	6.5 to 5.5	Below 5.5 up tp 4.5	Lees than 4.5
Carbonic acid (CO_2) in mg/L (heyer marble test)	15 to 40	Over 40 up to 100	Over 100
Ammonium (NH_4^+) (mg/L)	15 to 30	Over 40 up to 100	Over 100
Magnesium (Mg^{2+}) (mg/L)	300 to 1000	Over 1000 up to 3000	Over 3000
Sulphate (SO_4^{2-}) (mg/L)	200 to 600	Over 600 up to 3000	Over 3000

Table 4: Limiting values for assessing the degree of aggressiveness of water of mainly natural origin

Salinity affected site (photo DLWC)

Author

Adam Lillicrap DLWC, Sian McGhie DLWC

Acknowledgments

Greg Chapman DLWC, Susan Crick DLWC, Rob Muller DLWC, Brian Murphy DLWC
Katrine O'Flaherty NSW Ag, Scott Taylor DLWC, Andrew Wooldridge DLWC
to name just a few.

Report on
Factual Investigation

Intrusive Salinity Investigation
150 Gundy Road, Scone

Prepared for
Charles David Pty Limited

Project 86959.01
June 2020

Integrated Practical Solutions

Document History

Document details

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The undersigned, on behalf of Douglas Partners Pty Ltd, confirm that this document and all attached drawings, logs and test results have been checked and reviewed for errors, omissions and inaccuracies.

	Signature	Date
Author		1 June 2020
Reviewer		1 June 2020

Table of Contents

Report on Factual Investigation
Intrusive Salinity Investigation
150 Gundy Road, Scone

1. Introduction

This report presents the results of an intrusive salinity investigation at 150 Gundy Road, Scone. The investigation was commissioned via a signed services order dated 5 May 2020 by Beverley Martin of Charles David Pty Limited and was undertaken with reference to Douglas Partners Pty Ltd (DP) proposal PMQ200034 dated 4 May 2020.

It is understood that the investigation was required to collect samples for salinity testing to supplement the electromagnetic profiling previously undertaken at the site by DP to assist with the planning of the proposed development.

The aim of the investigation was to provide the following information:

- Subsurface soil and groundwater profile at each test location; and
- Factual data on the salinity profile (from laboratory testing) of the soils encountered during the investigation.

The investigation included the drilling of six boreholes and laboratory testing of selected samples. The details of the field work are presented in this report, together with the results of laboratory testing.

2. Site Description

The site is located at Lot 2 DP1169320, 150 Gundy Road, Scone. The site covers an area of approximately 48 hectares as shown in Figure 1, below.

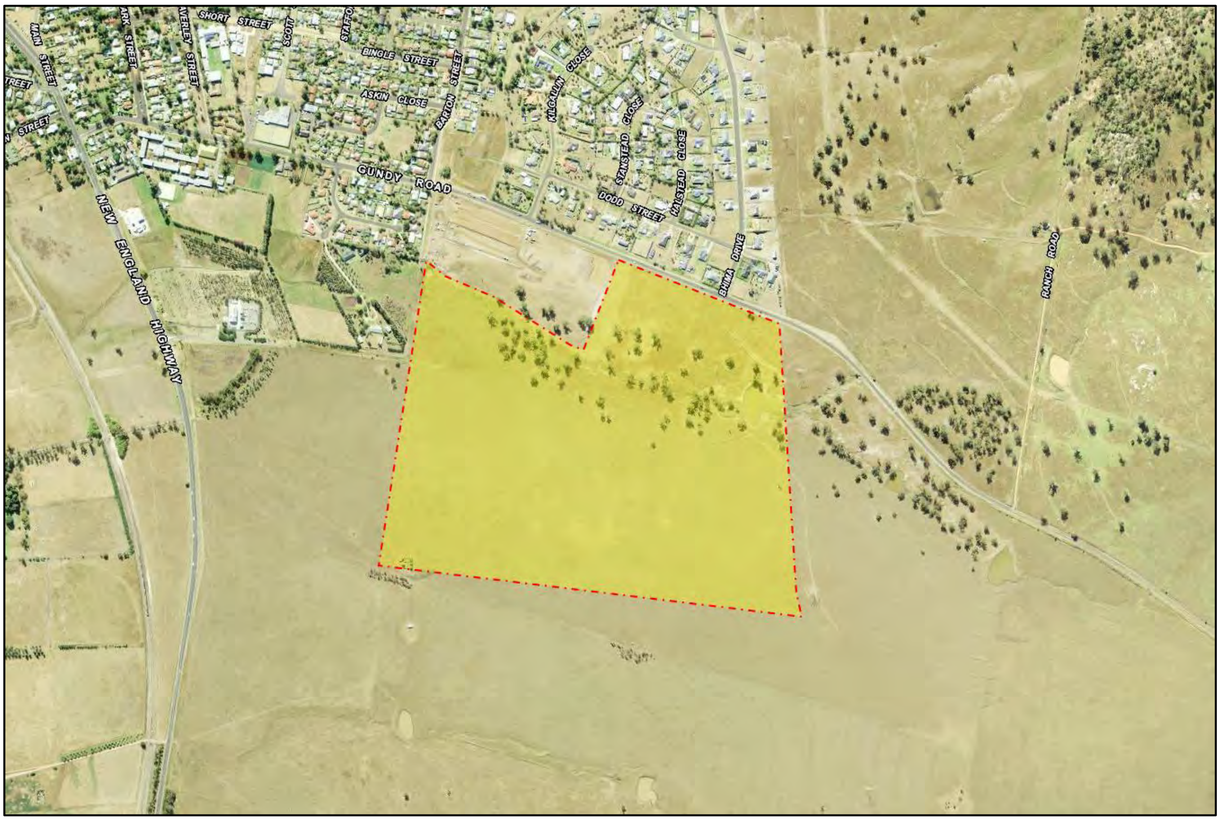


Figure 1: Aerial image of site with approximate boundary in red (image courtesy of SixMaps)

At the time of the investigation the site consisted of grassed paddock which slope down to the north in the southern part of the site and to the south in the northern part of the site. A drainage gully runs east to west through the site where the two slopes meet in the approximate northern third of the site with semi-mature to mature trees lining the gully. An existing dam is situated near the eastern boundary within the drainage gully.

The following photos show parts of the site during the investigation.

Figure 2: View from Bore 4 looking south to west

Figure 3: View from near Bore 5 looking west to north west

Figure 4: View form Bore 6 looking north to north west

Figure 5: Drill Rig on Bore 3 looking south

Figure 6: Looking north-west from approximate Bore 5 location

3. Regional Geology, Soil Landscape and Salinity Mapping

3.1 Regional Geology

With reference to the 1:100,000 scale NSW Hunter Coalfields Geology mapping (refer to Figure 7, below) indicates the site is underlain by the Whittingham Coal measures which typically comprises sandstone, siltstone, laminate, coal, claystone, tuff and conglomerate.

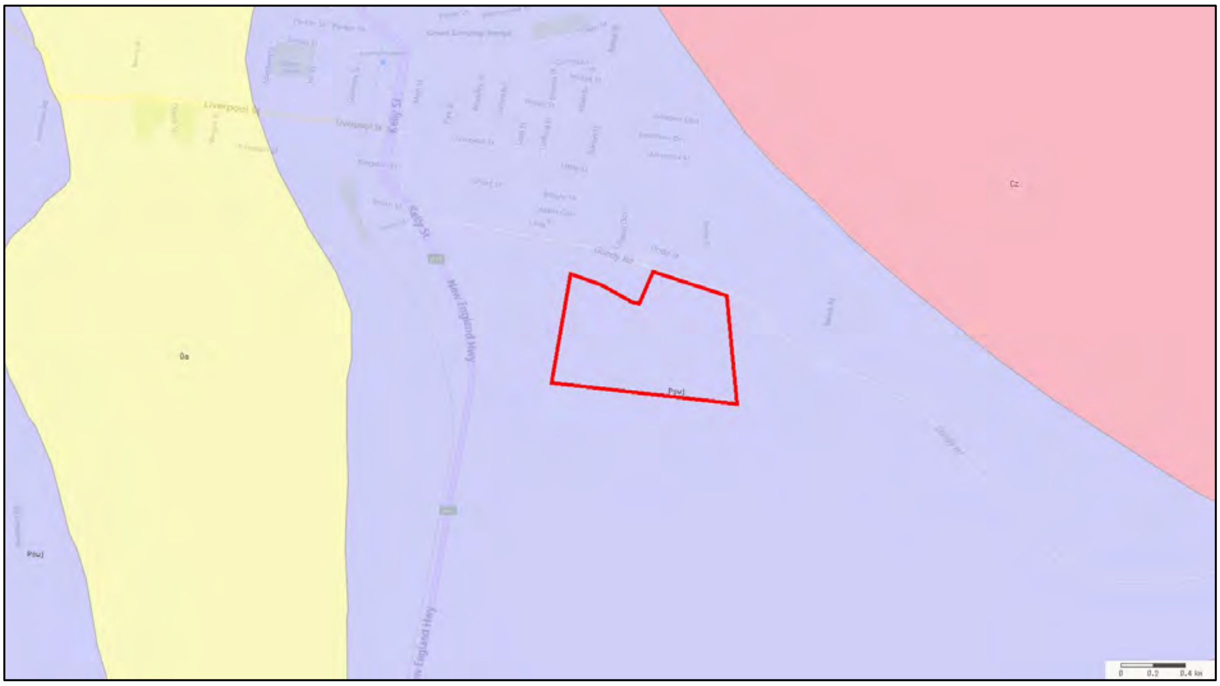


Figure 7: NSW Hunter Region Coalfields Geology map with approximate site location (red line)

3.2 Soil Landscape

Reference to the Singleton 1:250,000 scale Soil Landscape Sheet (Figure 8) indicates that the site is mapped as comprising alluvial soils of the Hunter landscape (pink shading) and brown clays of the Dartbrook landscape (brown shading).

The Hunter landscape is characterised by “level plains and river terraces of the Hunter River”. The soils within this landscape are characterised as “brown clays and clack earths on prior stream channels and on tributary flats, with chernozems on prior stream channels. Alluvial soils occur on levees and flats adjacent to the present river channel”.

The Dartbrook landscape is characterised by “undulating rises and low hills”. The soils within this landscape are characterised as “brown clays with some black earths on upper to midslopes, euchrozems and non-calcic brown soils on mid to lower slopes and prairie soils on the alluvial flats”.

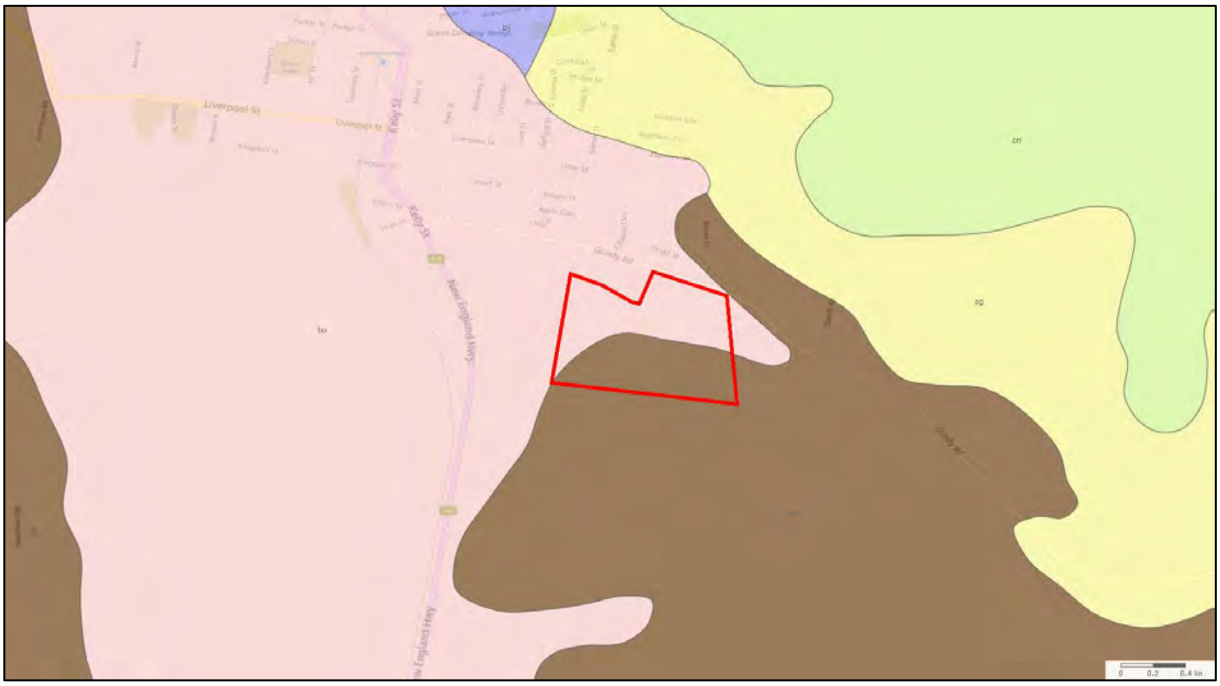


Figure 8: Soil Landscape Map with approximate site boundary (red outline)

3.3 Salinity mapping

Reference to the NSW Central Resource for Sharing and Enabling Environmental Data (SEED) information system eSPADE indicates that soils in the surrounding area have shown no salting evident within available soil profiles.

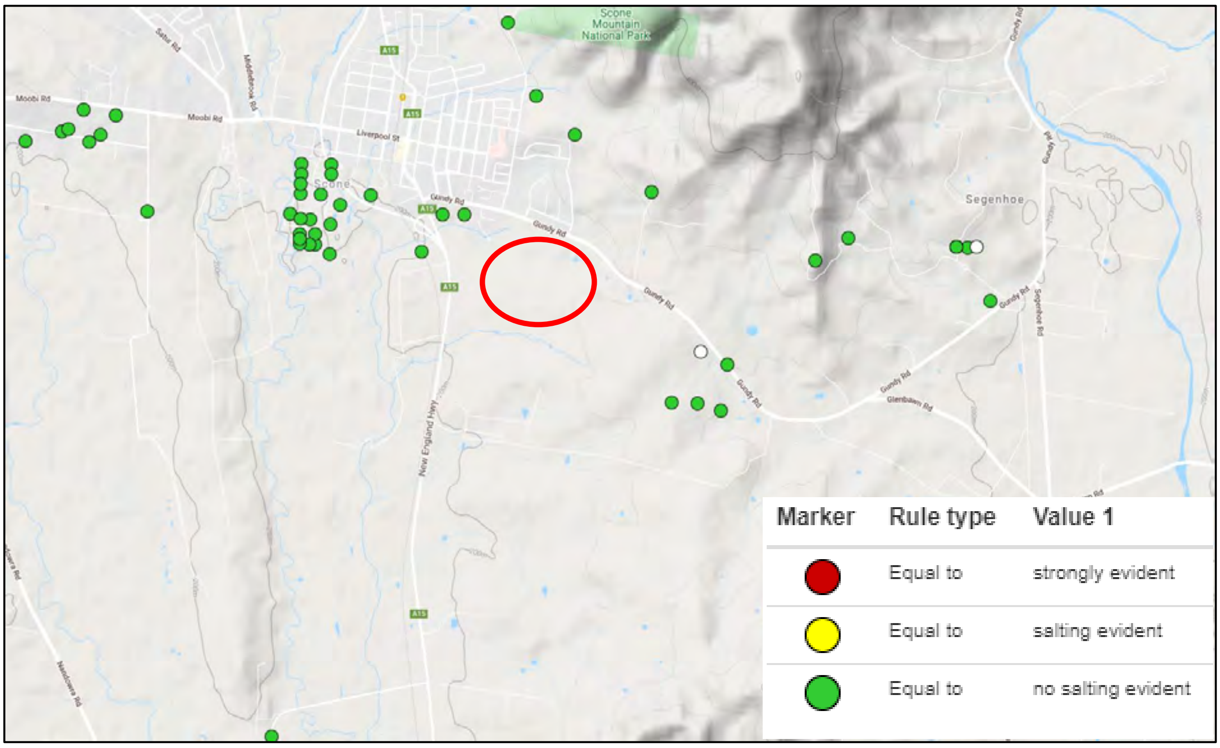


Figure 9: Soil profiles with salinity potential with approximate site location (red outline)

The following figures from eSPADE show modelled soil properties for soils 0.3 m to 1 m below the ground surface for Cation exchange capacity (CEC), electrical conductivity (EC) and exchangeable sodium percentage (ESP).

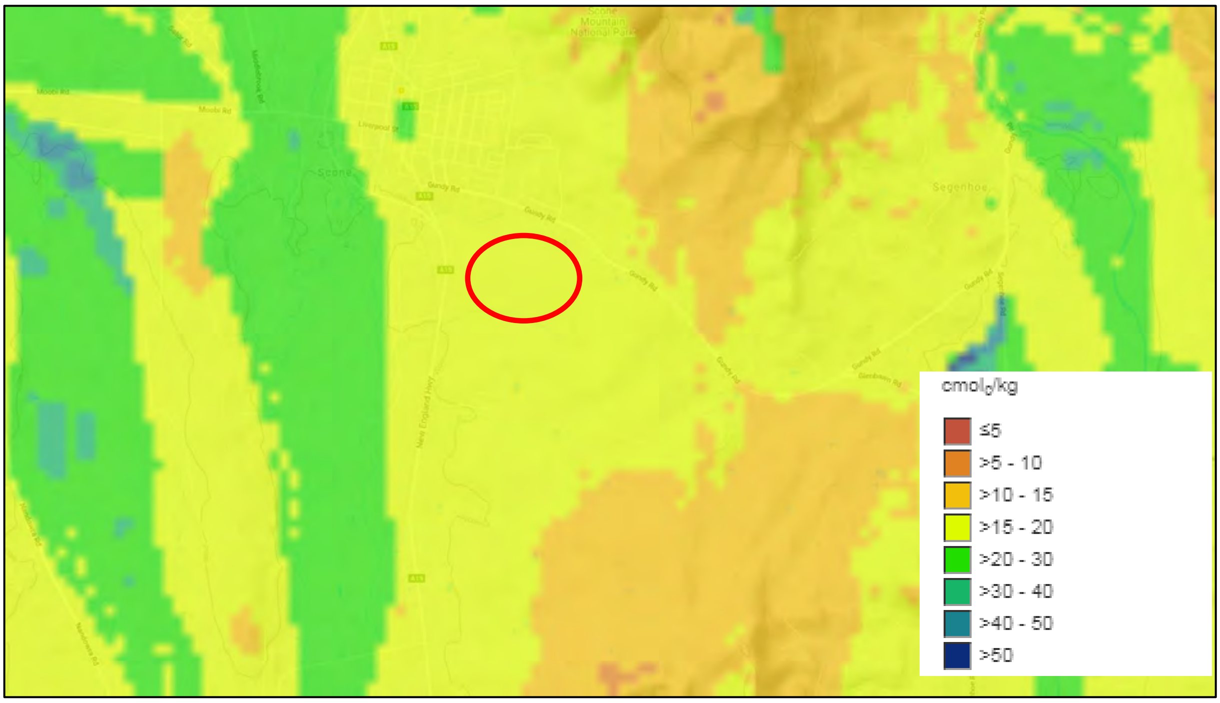


Figure 10: Modelled cation exchange capacity with approximate site location (red outline)

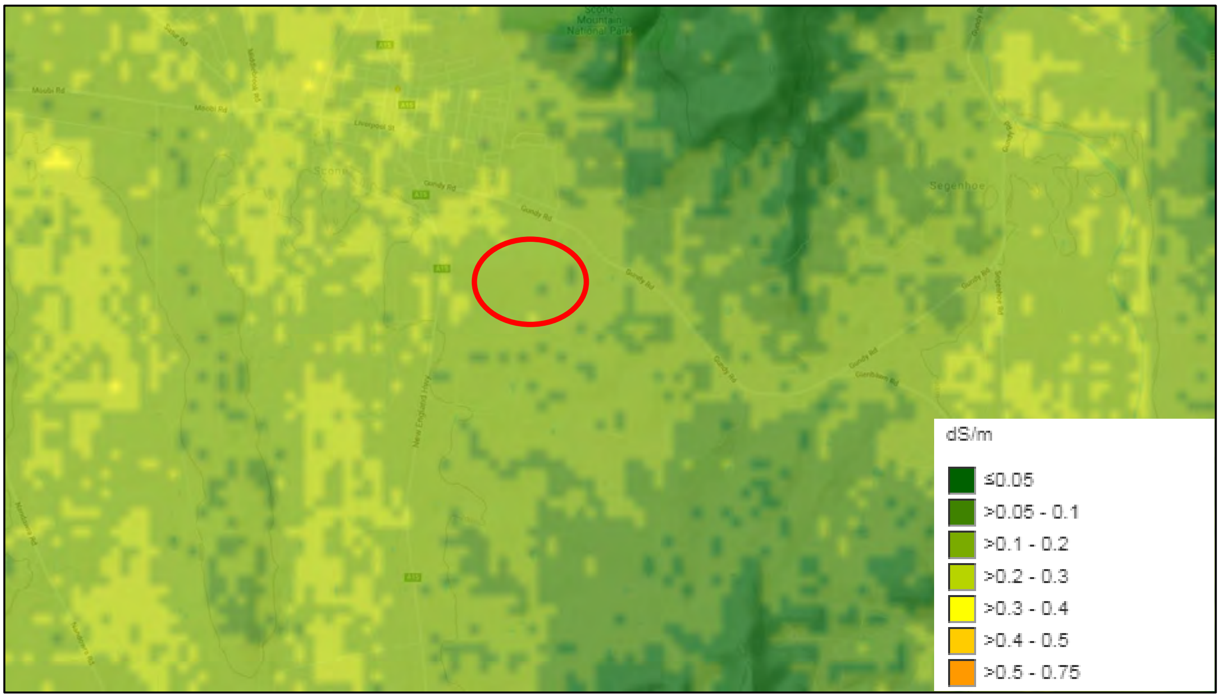


Figure 11: Modelled electrical conductivity with approximate site location (red outline)

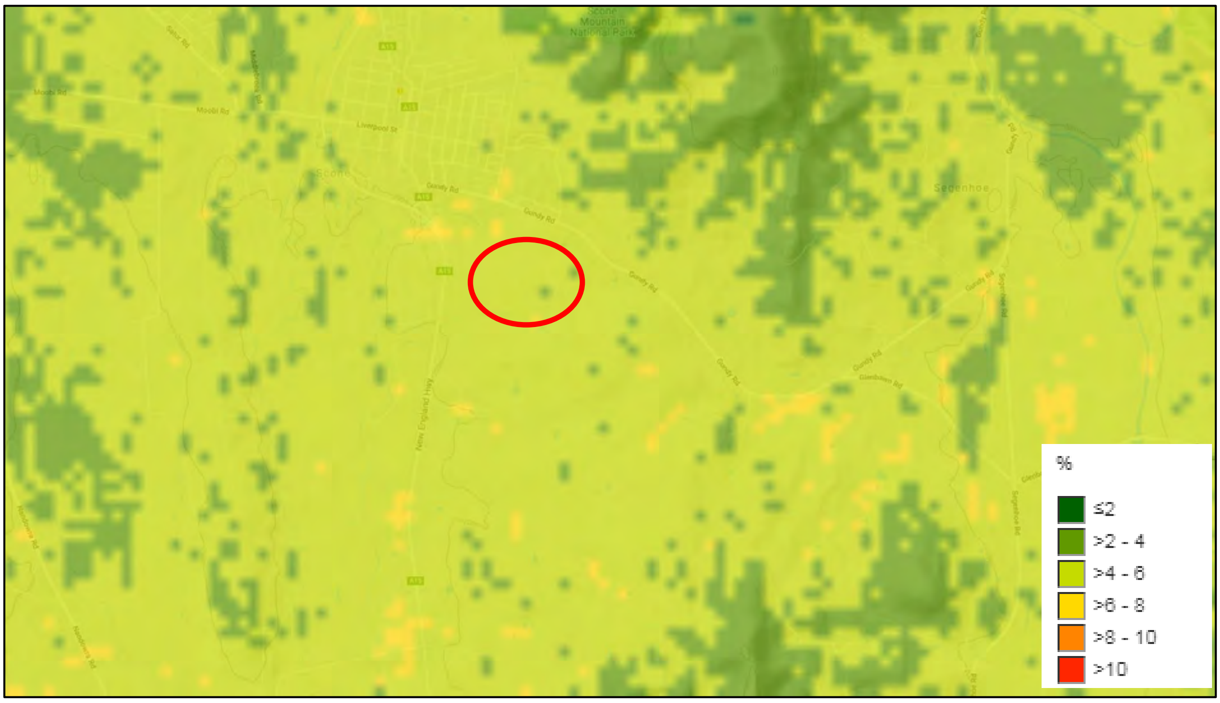


Figure 12: Modelled exchangeable sodium percentage with approximate site location (red outline)

4. Field Work

4.1 Methods

The fieldwork was carried out on 7 May 2020 and comprised the drilling of six (6) boreholes (Bores 1 to 6).

The bores were drilled by a truck-mounted drilling rig using 100 mm diameter solid flight augers and included Standard penetration tests (SPTs). The SPTs were generally carried out at 1.5 m depth intervals in the bores to provide information on the strength consistency and relative density of the subsurface profile.

The bores were set out by geotechnical engineer from DP who logged the subsurface profile in each bore and took regular samples for laboratory testing and identification purposes. The approximate locations of the boreholes are shown on Drawing 1 in Appendix D. The boreholes were backfilled using the spoil generated during the excavation process.

The locations of the bores were recorded using a hand held GPS which generally has an accuracy of ±5 m depending on satellite coverage and surrounding site conditions. The surface levels for the bores were obtained by interpolating surface contour data obtained from the NSW Government Spatial Services department. The location and surface levels of the bores are presented on the borehole logs in Appendix B.

4.2 Results

The subsurface conditions encountered at the test locations are presented in detail in the borehole logs in Appendix B. These should be read in conjunction with the accompanying notes in Appendix A, which explain the descriptive terms and classification methods used in the logs.

The subsurface conditions encountered within the bores are summarised in Table 1.

Table 1: Summary of Subsurface Conditions

Depth (m)		Stratum	Description
From	To		
Surface (0.0)	0.1 / 0.3	Topsoil	Generally brown, silty clay and clayey silt, abundant rootlets, M<Wp
0.1 / 0.3	0.7 / >6.0	Clay	Generally very stiff to hard, brown, trace fine grained sand or gravel, M<Wp (encountered in all bores except Bore 3)
0.2 / 0.7	>6.0	Sandy Clay / Silty Clay	Generally very stiff to hard, grey white, red brown, grey brown, brown, M<Wp (encountered in Bores 2 and 3 only)
0.7 / 0.8	1.9 / 2.37	Clayey Sand / Sandy Clay	Generally hard, dense to very dense, grey brown, trace gravel, M<Wp, dry, possible weathered rock (encountered in Bores 5 and 6 only)

Notes to Table 1:

M = Moisture content of soil W_p = Plastic limit of soil

Bore 4 encountered a grey mottled brown, gravelly clay from 4 m to 6 m depth.

Groundwater was not observed in any of the bores during the investigation. It should be noted that groundwater levels are affected by factors such as climatic conditions and soil permeability and will therefore vary with time.

5. Laboratory Testing

Laboratory testing was undertaken at DP Port Macquarie and Envirolab Service Pty Ltd, both NATA registered laboratories. Thirty (30) samples were analysed for pH and electrical conductivity (EC) in the DP Port Macquarie lab.

Six samples were analysed by Envirolab for the following:

- Cation Exchange capacity (CEC) and Exchangeable Sodium Percent (ESP); and
- Texture and Salinity Classification (which includes EC & ECe).

Detailed laboratory report sheets are attached in Appendix C and the results are summarised in Table 2 below.

Table 2: Results of salinity laboratory testing

Bore	Depth	Description	pH	EC (µs/cm)	CEC (ppm)	ESP (%)	Texture[1]	Salinity Class[2]
1	0.5	Clay: brown	8.3	175	-	-	-	-
1	1.0-1.15	Clay: brown	8.0	1954	-	-	-	-
1	2.0	Clay: brown	7.9	1592	-	-	-	-
1	3.0	Clay: brown	8.3	529	-	-	-	-
1	4.0	Clay: brown	8.3	493	-	-	-	-
1	5.0	Clay: brown	8.7	450	-	-	-	-
1	6.0	Clay: brown	-	470	37	4	Light Clay	Moderate
2	0.05	Topsoil: brown silty clay	7.4	171	-	-	-	-
2	0.5	Clay: brown	8.0	319	-	-	-	-
2	1.0-1.45	Sandy Clay: grey white	8.0	1956	-	-	-	-
2	2.0	Sandy Clay: grey white	8.1	1763	-	-	-	-
2	2.5-2.95	Silty Clay: red brown	7.7	1806	-	-	-	-
2	3.5	Silty Clay: red brown	8.1	1348	-	-	-	-
2	4.0-4.45	Silty Clay: red brown	-	670	93	5	Medium Clay	Moderate
2	5.5-5.95	Silty Clay: red brown	8.1	736	-	-	-	-
3	0.5	Sandy Clay: brown	8.0	127	-	-	-	-
3	1.0	Sandy Clay: brown	8.4	109	-	-	-	-
3	2.0	Sandy Clay: brown	8.2	319	-	-	-	-
3	3.0	Sandy Clay: brown	-	250	38	1	Light Medium Clay	Slight

Table 2: Results of salinity laboratory testing (continued)

Bore	Depth	Description	pH	EC (µs/cm)	CEC (ppm)	ESP (%)	Texture[1]	Salinity Class[2]
3	4.0	Sandy Clay: brown	8.2	660	-	-	-	-
3	5.0	Sandy Clay: brown	8.5	520	-	-	-	-
4	0.05	Topsoil: grey brown silty clay	6.5	96	-	-	-	-
4	0.5	Clay: grey brown	6.7	404	-	-	-	-
4	1.0-1.28	Clay: grey brown	-	510	17	16	Medium Clay	Slight
4	2.0	Clay: grey brown	8.6	717	-	-	-	-
4	2.5-2.79	Clay: grey brown	7.8	434	-	-	-	-
4	4.0-4.45	Gravelly Clay: grey mottled brown	7.3	644	-	-	-	-
4	5.0	Gravelly Clay: grey mottled brown	8.4	554	-	-	--	-
4	5.55-6.0	Gravelly Clay: grey mottled brown	6.8	964	-	-	-	-
5	0.05	Topsoil: brown clayey silt	5.7	194	-	-	-	-
5	0.5	Clay: brown	7.2	77	-	-	-	-
5	1.0-1.45	Clayey Sand: grey brown	8.6	228	-	-	-	-
5	2.1-2.37	Clayey Sand: grey brown	-	130	39	2	Medium Clay	Non Saline
6	0.05	Topsoil: brown clayey silt	6.2	218	-	-	-	-
6	0.5	Clay: brown	-	260	47	2	Medium Clay	Non Saline
6	1.0-1.45	Sandy Clay: grey brown	8.6	345	-	-	-	-

Notes to Table 2:

[1] – Determined by laboratory using a "Texture by Feel' method

[2] – Salinity class with reference to DLWC (2002)

.

It should be noted that the salinity class provided in Table 2 above for selected samples has been provided by Envirolab and is limited to their interpretation of the results for these samples alone. Interpretation of the factual results of soil testing, as provided above, should be undertaken to determine the risk of salinity and salinity levels within the soil profile based on all the results in Table 2 and not just the laboratory determined salinity class for selected samples. DP could assist with this interpretation, if required

6. Limitations

Douglas Partners (DP) has prepared this report for this project at 150 Gundy Road, Cone with reference to DP's proposal PMQ200034 dated 4 May 2020 and acceptance received from Beverley Martin of Charles David Pty Ltd dated 5 May 2020. The work was carried out under DP's Conditions of Engagement. This report is provided for the exclusive use of Charles David Pty Ltd and GHD Pty Ltd 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.

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 scope for work for this investigation/report did not include the assessment of surface or sub-surface materials or groundwater for contaminants, within or adjacent to the site. Should evidence of filling of unknown origin be noted in the report, and in particular the presence of building demolition materials, it should be recognised that there may be some risk that such filling may contain contaminants and hazardous building materials.

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 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
Sampling Methods
Soil Descriptions
Symbols and Abbreviations

About this Report

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.

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.

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 generally based on Australian Standard AS1726:2017, Geotechnical Site Investigations. 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	19 - 63
Medium gravel	6.7 - 19
Fine gravel	2.36 – 6.7
Coarse sand	0.6 - 2.36
Medium sand	0.21 - 0.6
Fine sand	0.075 - 0.21

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

The proportions of secondary constituents of soils are described as follows:

In fine grained soils (>35% fines)

Term	Proportion of sand or gravel	Example
And	Specify	Clay (60%) and Sand (40%)
Adjective	>30%	Sandy Clay
With	15 – 30%	Clay with sand
Trace	0 - 15%	Clay with trace sand

In coarse grained soils (>65% coarse)
- with clays or silts

Term	Proportion of fines	Example
And	Specify	Sand (70%) and Clay (30%)
Adjective	>12%	Clayey Sand
With	5 - 12%	Sand with clay
Trace	0 - 5%	Sand with trace clay

In coarse grained soils (>65% coarse)
- with coarser fraction

Term	Proportion of coarser fraction	Example
And	Specify	Sand (60%) and Gravel (40%)
Adjective	>30%	Gravelly Sand
With	15 - 30%	Sand with gravel
Trace	0 - 15%	Sand with trace gravel

The presence of cobbles and boulders shall be specifically noted by beginning the description with ‘Mix of Soil and Cobbles/Boulders’ with the word order indicating the dominant first and the proportion of cobbles and boulders described together.

Soil Descriptions

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
Friable	Fr	-

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	Density Index (%)
Very loose	VL	<15
Loose	L	15-35
Medium dense	MD	35-65
Dense	D	65-85
Very dense	VD	>85

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;
- Extremely weathered material – formed from in-situ weathering of geological formations. Has soil strength but retains the structure or fabric of the parent rock;
- Alluvial soil – deposited by streams and rivers;
- Estuarine soil – deposited in coastal estuaries;
- Marine soil – deposited in a marine environment;
- Lacustrine soil – deposited in freshwater lakes;
- Aeolian soil – carried and deposited by wind;
- Colluvial soil – soil and rock debris transported down slopes by gravity;
- Topsoil – mantle of surface soil, often with high levels of organic material.
- Fill – any material which has been moved by man.

Moisture Condition – Coarse Grained Soils

For coarse grained soils the moisture condition should be described by appearance and feel using the following terms:

• Dry (D)	Non-cohesive and free-running.
• Moist (M)	Soil feels cool, darkened in colour. Soil tends to stick together. Sand forms weak ball but breaks easily.
• Wet (W)	Soil feels cool, darkened in colour. Soil tends to stick together, free water forms when handling.

Moisture Condition – Fine Grained Soils

For fine grained soils the assessment of moisture content is relative to their plastic limit or liquid limit, as follows:

- ‘Moist, dry of plastic limit’ or ‘w <PL’ (i.e. hard and friable or powdery).
- ‘Moist, near plastic limit’ or ‘w ≈ PL (i.e. soil can be moulded at moisture content approximately equal to the plastic limit).
- ‘Moist, wet of plastic limit’ or ‘w >PL’ (i.e. soils usually weakened and free water forms on the hands when handling).
- ‘Wet’ or ‘w ≈LL’ (i.e. near the liquid limit).
- ‘Wet’ or ‘w >LL’ (i.e. wet of the liquid limit).

Symbols & Abbreviations

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

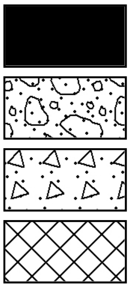
Other

fg	fragmented
bnd	band
qtz	quartz

Symbols & Abbreviations

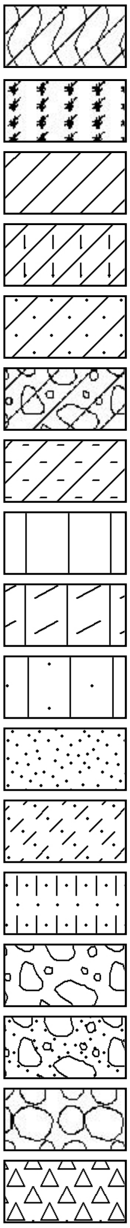
Graphic Symbols for Soil and Rock

General



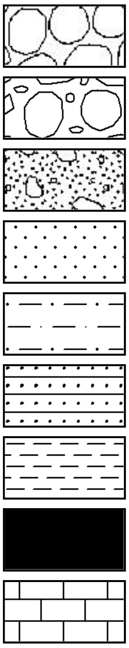
- Asphalt
- Road base
- Concrete
- Filling

Soils



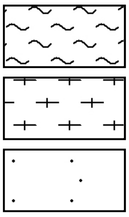
- Topsoil
- Peat
- Clay
- Silty clay
- Sandy clay
- Gravelly clay
- Shaly clay
- Silt
- Clayey silt
- Sandy silt
- Sand
- Clayey sand
- Silty sand
- Gravel
- Sandy gravel
- Cobbles, boulders
- Talus

Sedimentary Rocks



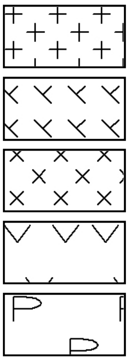
- Boulder conglomerate
- Conglomerate
- Conglomeratic sandstone
- Sandstone
- Siltstone
- Laminite
- Mudstone, claystone, shale
- Coal
- Limestone

Metamorphic Rocks



- Slate, phyllite, schist
- Gneiss
- Quartzite

Igneous Rocks



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

Appendix B

Borehole Logs (Bores 1 to 6)

BOREHOLE LOG

CLIENT: Charles David Pty Limited
PROJECT: Intrusive Salinity Investigation
LOCATION: Gundy Road, Scone

SURFACE LEVEL: 208 AHD
EASTING: 299647
NORTHING: 6450967
DIP/AZIMUTH: 90°/--

BORE No: 1
PROJECT No: 86959.01
DATE: 7/5/2020
SHEET 1 OF 2

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing				Water	Well Construction Details
				Type	Depth	Sample	Results & Comments		
208		TOPSOIL - Brown, silty clay, high plasticity, abundant rootlets, M<Wp		D	0.05				
	0.1	CLAY - Very stiff to hard, brown, high plasticity, M<Wp							
				D	0.5				
207	1			S	1.0 1.15		pp >400 3,-,-		1
206	2			D	2.0		pp >400		2
205	3			D	3.0		pp >400		3
204	4			D	4.0		pp >400		4
				D	5.0		pp >400		

RIG: DT100 **DRILLER:** Hickman **LOGGED:** Cowan **CASING:** Nil
TYPE OF BORING: Solid flight auger to 6.0m
WATER OBSERVATIONS: No free groundwater observed
REMARKS:

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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BOREHOLE LOG

CLIENT:	Charles David Pty Limited	**SURFACE LEVEL:**	208 AHD	**BORE No:**	1
PROJECT:	Intrusive Salinity Investigation	**EASTING:**	299647	**PROJECT No:**	86959.01
LOCATION:	Gundy Road, Scone	**NORTHING:**	6450967	**DATE:**	7/5/2020
		DIP/AZIMUTH:	90°/--	**SHEET**	2 OF 2

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing				Water	Well Construction Details
				Type	Depth	Sample	Results & Comments		
203		CLAY - Very stiff to hard, brown, high plasticity, M<Wp *(continued)*	▨						
202	6 6.0	Bore discontinued at 6.0m, limit of investigation		D	6.0		pp >400		6
201	7								7
200	8								8
199	9								9

RIG: DT100 **DRILLER:** Hickman **LOGGED:** Cowan **CASING:** Nil

TYPE OF BORING: Solid flight auger to 6.0m

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

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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BOREHOLE LOG

CLIENT: Charles David Pty Limited
PROJECT: Intrusive Salinity Investigation
LOCATION: Gundy Road, Scone

SURFACE LEVEL: 212 AHD
EASTING: 299763
NORTHING: 6450813
DIP/AZIMUTH: 90°/--

BORE No: 2
PROJECT No: 86959.01
DATE: 7/5/2020
SHEET 1 OF 2

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing				Water	Well Construction Details
				Type	Depth	Sample	Results & Comments		
212	0.1	TOPSOIL - Brown, silty clay, high plasticity, abundant rootlets, M~Wp		D	0.05				
		CLAY - Very stiff to hard, brown, high plasticity, M~Wp		D	0.5		pp >400		
	0.7	SANDY CLAY - Very stiff to hard, grey white, medium plasticity, fine to coarse grained sand, M<Wp							
211	1			S	1.0 1.45		pp >400 7,10,14 N = 24		1
210	2			D	2.0				2
	2.5	SILTY CLAY - Very stiff to hard, red brown, medium to high plasticity, trace fine to medium grained sand, M<Wp		S	2.5 2.95		pp >400 6,15,17 N = 32		
209	3								3
				D	3.5				
208	4	From 4.0m, grey brown		S	4.0 4.45		pp >400 11,18,18 N = 36		4

RIG: DT100 **DRILLER:** Hickman **LOGGED:** Cowan **CASING:** Nil

TYPE OF BORING: Solid flight auger to 5.95m

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

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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BOREHOLE LOG

CLIENT: Charles David Pty Limited
PROJECT: Intrusive Salinity Investigation
LOCATION: Gundy Road, Scone

SURFACE LEVEL: 212 AHD
EASTING: 299763
NORTHING: 6450813
DIP/AZIMUTH: 90°/--

BORE No: 2
PROJECT No: 86959.01
DATE: 7/5/2020
SHEET 2 OF 2

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing				Water	Well Construction Details
				Type	Depth	Sample	Results & Comments		
207		SILTY CLAY - Very stiff to hard, red brown, medium to high plasticity, trace fine to medium grained sand, M<Wp *(continued)*		S	5.5 5.95		pp = 300-350 6,14,14 N = 28		
206	5.95 6	Bore discontinued at 5.95m, limit of investigation							6
205	7								7
204	8								8
203	9								9

RIG: DT100 **DRILLER:** Hickman **LOGGED:** Cowan **CASING:** Nil
TYPE OF BORING: Solid flight auger to 5.95m
WATER OBSERVATIONS: No free groundwater observed
REMARKS:

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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BOREHOLE LOG

CLIENT: Charles David Pty Limited
PROJECT: Intrusive Salinity Investigation
LOCATION: Gundy Road, Scone

SURFACE LEVEL: 213 AHD
EASTING: 299948
NORTHING: 6450882
DIP/AZIMUTH: 90°/--

BORE No: 3
PROJECT No: 86959.01
DATE: 7/5/2020
SHEET 1 OF 2

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing				Water	Well Construction Details
				Type	Depth	Sample	Results & Comments		
213		TOPSOIL - Brown, clayey sand, with fine sized gravel, dry		D	0.01				
	0.2	SANDY CLAY - Very stiff, brown, medium to high plasticity, M<Wp							
				D	0.5		pp = 300-350		
212	1			D	1.0		pp >400		1
211	2			D	2.0		pp >400		2
210	3			D	3.0		pp >400		3
209	4			D	4.0		pp >400		4
				D	5.0		pp >400		

RIG: DT100 **DRILLER:** Hickman **LOGGED:** Cowan **CASING:** Nil

TYPE OF BORING: Solid flight auger to 6.0m

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

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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BOREHOLE LOG

CLIENT: Charles David Pty Limited
PROJECT: Intrusive Salinity Investigation
LOCATION: Gundy Road, Scone

SURFACE LEVEL: 213 AHD
EASTING: 299948
NORTHING: 6450882
DIP/AZIMUTH: 90°/--

BORE No: 3
PROJECT No: 86959.01
DATE: 7/5/2020
SHEET 2 OF 2

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing				Water	Well Construction Details
				Type	Depth	Sample	Results & Comments		
208		SANDY CLAY - Very stiff, brown, medium to high plasticity, M<Wp *(continued)*	▨						
207	6 6.0	Bore discontinued at 6.0m, limit of investigation		D	6.0		pp >400		6
206	7								7
205	8								8
204	9								9

RIG: DT100 **DRILLER:** Hickman **LOGGED:** Cowan **CASING:** Nil
TYPE OF BORING: Solid flight auger to 6.0m
WATER OBSERVATIONS: No free groundwater observed
REMARKS:

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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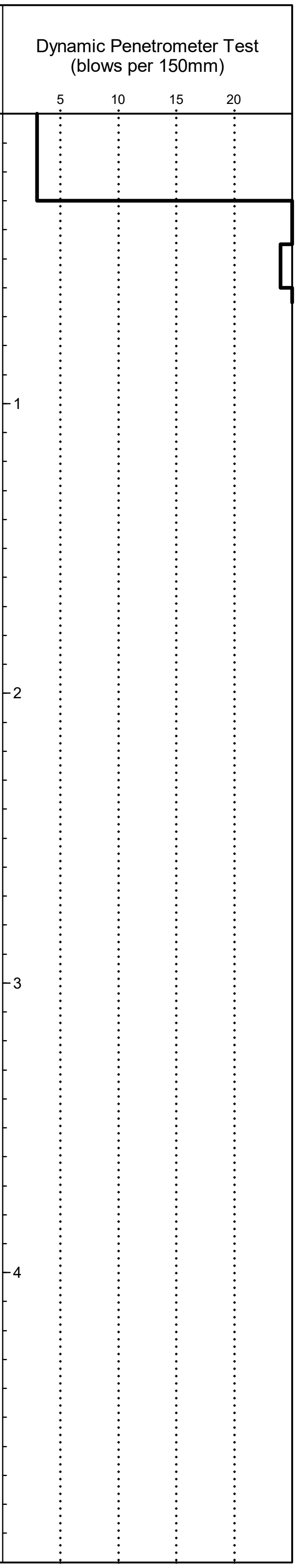
BOREHOLE LOG

CLIENT: Charles David Pty Limited
PROJECT: Intrusive Salinity Investigation
LOCATION: Gundy Road, Scone

SURFACE LEVEL: 219 AHD
EASTING: 300306
NORTHING: 6450809
DIP/AZIMUTH: 90°/--

BORE No: 4
PROJECT No: 86959.01
DATE: 7/5/2020
SHEET 1 OF 2

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
219		TOPSOIL - Grey brown, silty clay, trace fine to medium grained sand, gravel, abundant rootlets (gravel predominantly subangular, up to 20mm in size), M<Wp to M~Wp		D	0.05		pp = 250	
	0.25	CLAY - Hard, grey brown, with silt, trace fine to medium grained sand, medium to high plasticity, M<Wp		D	0.5		pp >400	
218	1	From 1.0m, grey		S	1.0 1.28		pp >400 13,25/130,- refusal	
217	2			D	2.0			
		From 2.5m, trace gravel, carbonaceous material (gravel predominantly subangular, up to 30mm in size)		S	2.5 2.79		pp >400 21,25/140,- refusal	
216	3			D	3.0			
215	4 4.0	GRAVELLY CLAY - Hard, grey mottled brown, with fine to medium grained sand, trace silt, medium plasticity (gravel predominantly subangular, up to 40mm in size), M<Wp		S	4.0 4.45		pp >400 23,20,23 N = 43	
				D	5.0			



RIG: DT100 **DRILLER:** Hickman **LOGGED:** Cudmore **CASING:** Nil
TYPE OF BORING: Solid flight auger to 6.0m
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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BOREHOLE LOG

CLIENT: Charles David Pty Limited
PROJECT: Intrusive Salinity Investigation
LOCATION: Gundy Road, Scone

SURFACE LEVEL: 219 AHD
EASTING: 300306
NORTHING: 6450809
DIP/AZIMUTH: 90°/--

BORE No: 4
PROJECT No: 86959.01
DATE: 7/5/2020
SHEET 2 OF 2

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing Type	Sampling & In Situ Testing Depth	Sampling & In Situ Testing Sample	Sampling & In Situ Testing Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm) 5 10 15 20
214		GRAVELLY CLAY - Hard, grey mottled brown, with fine to medium grained sand, trace silt, medium plasticity (gravel predominantly subangular, up to 40mm in size), M<Wp *(continued)*							
					5.55				
				S			pp >400 12,22,19 N = 41		
213	6 6.0	Bore discontinued at 6.0m, limit of investigation			6.0				6
212	7								7
211	8								8
210	9								9

RIG: DT100 **DRILLER:** Hickman **LOGGED:** Cudmore **CASING:** Nil

TYPE OF BORING: Solid flight auger to 6.0m

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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BOREHOLE LOG

CLIENT: Charles David Pty Limited
PROJECT: Intrusive Salinity Investigation
LOCATION: Gundy Road, Scone

SURFACE LEVEL: 223 AHD
EASTING: 299966
NORTHING: 6450633
DIP/AZIMUTH: 90°/--

BORE No: 5
PROJECT No: 86959.01
DATE: 7/5/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing				Water	Well Construction Details
				Type	Depth	Sample	Results & Comments		
223		TOPSOIL - Brown, clayey silt, abundant rootles, M<Wp		D	0.05				
	0.1	CLAY - Very stiff to hard, brown, medium to high plasticity, M<Wp		D	0.5		pp >400		
	0.7	CLAYEY SAND - Dense to very dense, grey brown, fine to medium grained sand (weathered bedrock), dry							
222	1			S	1.0 1.45		pp >400 13,19,21 N = 40		1
221	2			S	2.1 2.37		17,25/120,- refusal		2
	2.37	Bore discontinued at 2.37m, refusal							
220	3								3
219	4								4

RIG: DT100 **DRILLER:** Hickman **LOGGED:** Cowan **CASING:** Nil
TYPE OF BORING: Solid flight auger to 2.37m
WATER OBSERVATIONS: No free groundwater observed
REMARKS:

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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BOREHOLE LOG

CLIENT: Charles David Pty Limited
PROJECT: Intrusive Salinity Investigation
LOCATION: Gundy Road, Scone

SURFACE LEVEL: 233 AHD
EASTING: 300178
NORTHING: 6450502
DIP/AZIMUTH: 90°/--

BORE No: 6
PROJECT No: 86959.01
DATE: 7/5/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
233		TOPSOIL - Brown, clayey silt, abundant rootles, M<Wp		D	0.05				
	0.1	CLAY - Very stiff to hard, brown, high plasticity, M<Wp		D	0.5		pp >400		
	0.8	SANDY CLAY - Hard, grey brown, fine to medium grained sand, medium plasticity (weathered bedrock), M<Wp							
232	1			S	1.0		pp >400 13,13,24 N = 37		1
					1.45				
	1.85	Bore discontinued at 1.85m, refusal							
231	2								2
230	3								3
229	4								4

RIG: DT100 **DRILLER:** Hickman **LOGGED:** Cowan **CASING:** Nil
TYPE OF BORING: Solid flight auger to 1.85m
WATER OBSERVATIONS: No free groundwater observed
REMARKS:

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
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Appendix C

Laboratory Testing Results

Material Test Report

Douglas Partners
Geotechnics / Environment / Groundwater
Douglas Partners Pty Ltd
Port Macquarie Laboratory
Unit 2, 32 Geebung Drive Port Macquarie NSW 2444
Phone: (02) 6581 5992
Email: brandan.argent@douglaspartners.com.au

Report Number: **86959.01-1**
Issue Number: 1
Date Issued: 21/05/2020
Client: Charles David Pty Limited
PO Box 3050, Singleton NSW 2330
Contact: Beverley Martin
Project Number: 86959.01
Project Name: Intrusive Salinity Investigation
Project Location: Gundy Road, Scone
Work Request: 9925
Dates Tested: 18/05/2020 - 21/05/2020
Remarks: Bore Hole 3, Depth 6.0 was Missing.

NATA
WORLD RECOGNISED ACCREDITATION

Accredited for compliance with ISO/IEC 17025 - Testing

BA

Approved Signatory: Brandan Argent
Senior Technician
NATA Accredited Laboratory Number: 828

pH Value of Soil AS 1289 4.3.1

Sample Number	Borehole No	Depth (m)	pH	Electrical Conductivity (µS/cm)	Remarks
PM-9925A	Bore 1	0.5	8.3	175.2	**
PM-9925B	Bore 1	1.0-1.15	8.0	1954	**
PM-9925C	Bore 1	2.0	7.9	1592	**
PM-9925D	Bore 1	3.0	8.3	529	**
PM-9925E	Bore 1	4.0	8.3	493	**
PM-9925F	Bore 1	5.0	8.7	450	**
PM-9925G	Bore 2	0.05	7.4	171.2	**
PM-9925H	Bore 2	0.5	8.0	319	**
PM-9925I	Bore 2	1.0-1.45	8.0	1956	**
PM-9925J	Bore 2	2.0	8.1	1763	**
PM-9925K	Bore 2	2.5-2.95	7.7	1806	**
PM-9925L	Bore 2	3.5	8.1	1348	**
PM-9925M	Bore 2	5.5-5.95	8.1	736	**
PM-9925N	Bore 3	0.5	8.0	127	**
PM-9925O	Bore 3	1.0	8.4	109	**
PM-9925P	Bore 3	2.0	8.2	319	**
PM-9925Q	Bore 3	4.0	8.2	660	**
PM-9925R	Bore 3	5.0	8.5	520	**
PM-9925S	Bore 3	6.0	**	**	**
PM-9925T	Bore 4	0.05	6.5	95.6	**
PM-9925U	Bore 4	0.5	6.7	404	**
PM-9925V	Bore 4	2.0	8.6	717	**
PM-9925W	Bore 4	2.5-2.79	7.8	434	**
PM-9925X	Bore 4	4.0-4.45	7.3	644	**
PM-9925Y	Bore 4	5.0	8.4	554	**
PM-9925Z	Bore 4	5.55-6.0	6.8	964	**
PM-9925AA	Bore 5	0.05	5.7	194	**
PM-9925AB	Bore 5	0.5	7.2	77.0	**
PM-9925AC	Bore 5	1.0-1.45	8.6	228.3	**
PM-9925AD	Bore 6	0.05	6.2	218.2	**
PM-9925AE	Bore 6	1.0-1.45	8.6	345	**

Notes:
For Conductivity - 1 dS/m = 1 mS/cm = 1000 µS/cm
EC Not Covered Under our Terms of Accreditation.

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CERTIFICATE OF ANALYSIS 243186

Client Details

Client	Douglas Partners Pty Ltd (Port Macquarie)
Attention	Joel Cowan
Address	PO Box 5463, Port Macquarie, NSW, 2444

Sample Details

Your Reference	**86959.01, Intrusive Salinity Investigation Scone**
Number of Samples	6 soil
Date samples received	19/05/2020
Date completed instructions received	19/05/2020

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	26/05/2020
Date of Issue	26/05/2020

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

Results Approved By
Hannah Nguyen, Senior Chemist
Priya Samarawickrama, Senior Chemist

Authorised By

Nancy Zhang, Laboratory Manager

ESP/CEC						
Our Reference		243186-1	243186-2	243186-3	243186-4	243186-5
Your Reference	UNITS	Bore 1	Bore 2	Bore 3	Bore 4	Bore 5
Depth		6.0	4.0-4.45	3.0	1.0-1.28	2.1-2.37
Date Sampled		08/05/2020	08/05/2020	08/05/2020	08/05/2020	08/05/2020
Type of sample		soil	soil	soil	soil	soil
Date prepared	-	22/05/2020	22/05/2020	22/05/2020	22/05/2020	22/05/2020
Date analysed	-	22/05/2020	22/05/2020	22/05/2020	22/05/2020	22/05/2020
Exchangeable Ca	meq/100g	22	41	27	7.6	28
Exchangeable K	meq/100g	0.2	0.2	0.5	0.3	0.2
Exchangeable Mg	meq/100g	14	48	10	6.2	10
Exchangeable Na	meq/100g	1.5	4.5	0.52	2.6	0.59
Cation Exchange Capacity	meq/100g	37	93	38	17	39
ESP	%	4	5	1	16	2

ESP/CEC		
Our Reference		243186-6
Your Reference	UNITS	Bore 6
Depth		0.5
Date Sampled		08/05/2020
Type of sample		soil
Date prepared	-	22/05/2020
Date analysed	-	22/05/2020
Exchangeable Ca	meq/100g	31
Exchangeable K	meq/100g	1.5
Exchangeable Mg	meq/100g	13
Exchangeable Na	meq/100g	0.76
Cation Exchange Capacity	meq/100g	47
ESP	%	2

Texture and Salinity*						
Our Reference		243186-1	243186-2	243186-3	243186-4	243186-5
Your Reference	UNITS	Bore 1	Bore 2	Bore 3	Bore 4	Bore 5
Depth		6.0	4.0-4.45	3.0	1.0-1.28	2.1-2.37
Date Sampled		08/05/2020	08/05/2020	08/05/2020	08/05/2020	08/05/2020
Type of sample		soil	soil	soil	soil	soil
Date prepared	-	22/05/2020	22/05/2020	22/05/2020	22/05/2020	22/05/2020
Date analysed	-	22/05/2020	22/05/2020	22/05/2020	22/05/2020	22/05/2020
Electrical Conductivity 1:5 soil:water	μS/cm	470	670	250	510	130
Texture Value	-	8.5	7.0	8.0	7.0	7.0
Texture		LIGHT CLAY	MEDIUM CLAY	LIGHT MEDIUM CLAY	MEDIUM CLAY	MEDIUM CLAY
ECe	dS/m	4.0	4.7	2.0	3.5	<2
Class		MODERATELY SALINE	MODERATELY SALINE	SLIGHTLY SALINE	SLIGHTLY SALINE	NON SALINE

Texture and Salinity*		
Our Reference		243186-6
Your Reference	UNITS	Bore 6
Depth		0.5
Date Sampled		08/05/2020
Type of sample		soil
Date prepared	-	22/05/2020
Date analysed	-	22/05/2020
Electrical Conductivity 1:5 soil:water	μS/cm	260
Texture Value	-	7.0
Texture		MEDIUM CLAY
ECe	dS/m	<2
Class		NON SALINE

Method ID	Methodology Summary
Inorg-002	Conductivity and Salinity - measured using a conductivity cell at 25°C in accordance with APHA latest edition 2510 and Rayment & Lyons.
INORG-123	Determined using a "Texture by Feel" method.
Metals-020	Determination of exchangeable cations and cation exchange capacity in soils using 1M Ammonium Chloride exchange and ICP-AES analytical finish.

QUALITY CONTROL: ESP/CEC					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date prepared	-			22/05/2020	1	22/05/2020	22/05/2020		22/05/2020	[NT]
Date analysed	-			22/05/2020	1	22/05/2020	22/05/2020		22/05/2020	[NT]
Exchangeable Ca	meq/100g	0.1	Metals-020	<0.1	1	22	24	9	103	[NT]
Exchangeable K	meq/100g	0.1	Metals-020	<0.1	1	0.2	0.3	40	109	[NT]
Exchangeable Mg	meq/100g	0.1	Metals-020	<0.1	1	14	15	7	100	[NT]
Exchangeable Na	meq/100g	0.1	Metals-020	<0.1	1	1.5	1.7	12	105	[NT]
ESP	%	1	Metals-020	[NT]	1	4	4	0	[NT]	[NT]

QUALITY CONTROL: Texture and Salinity*					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date prepared	-			22/05/2020	[NT]	[NT]	[NT]	[NT]	22/05/2020	[NT]
Date analysed	-			22/05/2020	[NT]	[NT]	[NT]	[NT]	22/05/2020	[NT]
Electrical Conductivity 1:5 soil:water	µS/cm	1	Inorg-002	<1	[NT]	[NT]	[NT]	[NT]	97	[NT]

Result Definitions

NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

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.

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.

The recommended maximums for analytes in urine are taken from “2018 TLVs and BEIs”, as published by ACGIH (where available). Limit provided for Nickel is a precautionary guideline as per Position Paper prepared by AIOH Exposure Standards Committee, 2016.

Guideline limits for Rinse Water Quality reported as per analytical requirements and specifications of AS 4187, Amdt 2 2019, Table 7.2

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: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% – see ELN-P05 QA/QC tables for details; <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals (not SPOCAS); 60-140% for organics/SPOCAS (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics 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.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Measurement Uncertainty estimates are available for most tests upon request.

Analysis of aqueous samples typically involves the extraction/digestion and/or analysis of the liquid phase only (i.e. NOT any settled sediment phase but inclusive of suspended particles if present), unless stipulated on the Envirolab COC and/or by correspondence. Notable exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, total recoverable metals and PFAS where solids are included by default.

Samples for Microbiological analysis (not Amoeba forms) received outside of the 2-8°C temperature range do not meet the ideal cooling conditions as stated in AS2031-2012.

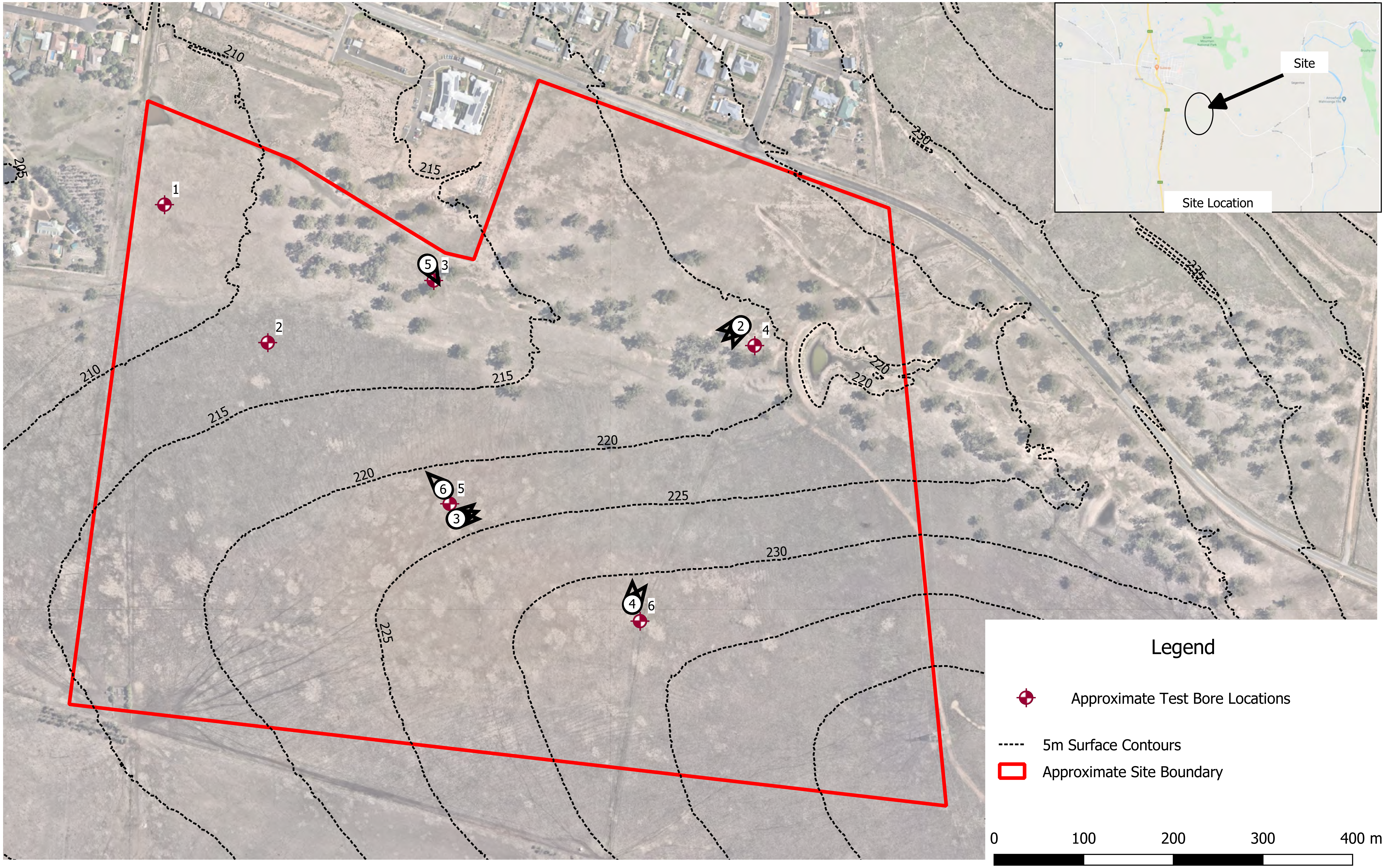
Report Comments

pH

Samples were out of the recommended holding time for this analysis.

Appendix D

Drawing 1 – Test Location Plan



Douglas Partners
Geotechnics | Environment | Groundwater

CLIENT: Charles David Pty Ltd
OFFICE: Port Macquarie
DRAWN BY: JRC
SCALE: 1:4,000@ A3
DATE: 28 May 2020

TITLE: **Test Location Plan**
Intrusive Salinity Investigation
150 Gundy Road, Scone

N

PROJECT: 86959.01
DRAWING No: 1
REVISION: 0

GHD

Level 3 GHD Tower 24 Honeysuckle Drive Newcastle NSW 2300
PO BOX 5403 Hunter Region Mail Centre NSW 2310
T: 61 2 4979 9999   F: 61 2 4979 9988   E: ntlmail@ghd.com

2219760-44837/https://projects.ghd.com/oc/Newcastle2/salinityreportscone/Delivery/Documents/2219760-REP_Lot2 Gundy Rd Scone Salinity Report.docx

Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	D Sparkes	B Batchelder		D Sparkes		31/05/2019
1	D Sparkes	B Batchelder		D Sparkes		25/06/2019
2	D Sparkes	B Batchelder		D Sparkes		25/10/2019
3	D Sparkes	S Gray		D Sparkes		26/06/2020

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