Geotechnical Investigation Report

Project

Proposed Rural Ambulance Infrastructure Reconfiguration Program (RAIR)
7 Squires Way, Fairy Meadow NSW 2500

Prepared for

MACE Australia Pty Ltd

Date

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Report No

15348-GR-1-1

alliance
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Table of Contents

Appendices

1 INTRODUCTION

This report presents the findings of a geotechnical investigation carried out by Alliance Geotechnical Pty Ltd (Alliance) for MACE Australia Pty Ltd (the Client) for the Proposed Rural Ambulance Infrastructure Reconfiguration Program at 7 Squires Way, Fairy Meadow NSW 2500. The geotechnical investigation was undertaken in accordance with Alliance's fee proposal Estimate No. 6886, dated 08 June 2022.

The objective of this Geotechnical Investigation Report was to address the subsurface conditions encountered, field and laboratory testing results, and provide comments and recommendations regarding:

- The site subsurface soil and rock profile and groundwater conditions.
- Seismic sub-soil class.
- Reactivity of site soils in terms of shrink-swell potential.
- Temporary and permanent earth retaining structures
- Geotechnical design parameters required for shallow and deep foundations.
- Recommendations on footings and suitable foundation material.
- Earthworks including topsoil stripping and suitability of site won material for re-use.
- Geotechnical input parameters for Pavement Design.

2 PROPOSED DEVELOPMENT

To assist with the geotechnical investigation, Alliance was provided with the following documents:

- Detailed Site Investigation Report by JK Environments, Ref No. E34610PTrpt, dated 16/05/2022.
- Proposed Site Plan by DJRD Architects, Project No. 21410, Drawing No. R23-AR-0101, Rev B, dated 01/07/2022.
- Marked-up Borehole Location Plan from Bonacci Group (NSW) Pty Ltd, Project Ref. 12537, Drawing No. SK 220223-01, dated 23/02/2022.

Based on the provided documents and information received from the Client, it is understood that a geotechnical assessment is required to be carried out for an alternate location of the proposed ambulance station along Innovation Way, Fairy Meadow. It is understood that the proposed development at the site comprises the following:

- Construction of a two-storey building expecting relatively light structural loads.
- Conversion of the remaining part of the site into car parking areas.

Alliance understands that excavations or filling at the site for the proposed development are not expected to exceed 1.5m.

3 SITE DESCRIPTION AND REGIONAL GEOLOGY

The site comprises the north-western portion of Lot 1 in DP1172135 which covers a grass-covered area of approximately 4,700 sqm. located within the suburb of Fairy Meadow in the City of Wollongong. The site location relative to the surrounding features is shown in Figure 1 below. The site is bound by residential properties to the west and is accessible through Cowper Street via Elliotts Road, and through Innovation Way via Squires Way. There is a concrete walking pathway that runs diagonally across the site.

Based on available survey data from NSW Foundation Spatial Data Framework (FSDF), the site is situated on a relatively flat terrain with Relative Levels (RL) ranging approximately between 3.53m to 4.49m Australian Height Datum (AHD).

Figure 1 - The Site Location & Aerial Image (extracted from MinView)

The New South Wales Seamless Geology dataset, version 2.1 [Digital Dataset] published by the Geological Survey of New South Wales accessible through the MinView webservce indicates that the site is underlain by Pleistocene undifferentiated regolith which may contain *clay, silt, fluvial and marine sand.* It is then underlain by the Pheasants Nest Formation characterised by *shale, siltstone, sandstone with lenticular coal seams; sporadic thin cherty tuff and syenite intrusives (in the southwest).* The NSW Department of Mineral Resources 1:100,000 Geological Map of Wollongong – Port Hacking (Geological Series Sheet 9029) indicated the site is underlain by *quartz and lithic fluvial sand, silt and clay.*

Two perennial streams, Cabbage Tree Creek and Towradgi Arm, were identified to be within 500m from the site.

The site overlaying NSW Seamless Geology map with 10m contours are presented in Figure 2 below.

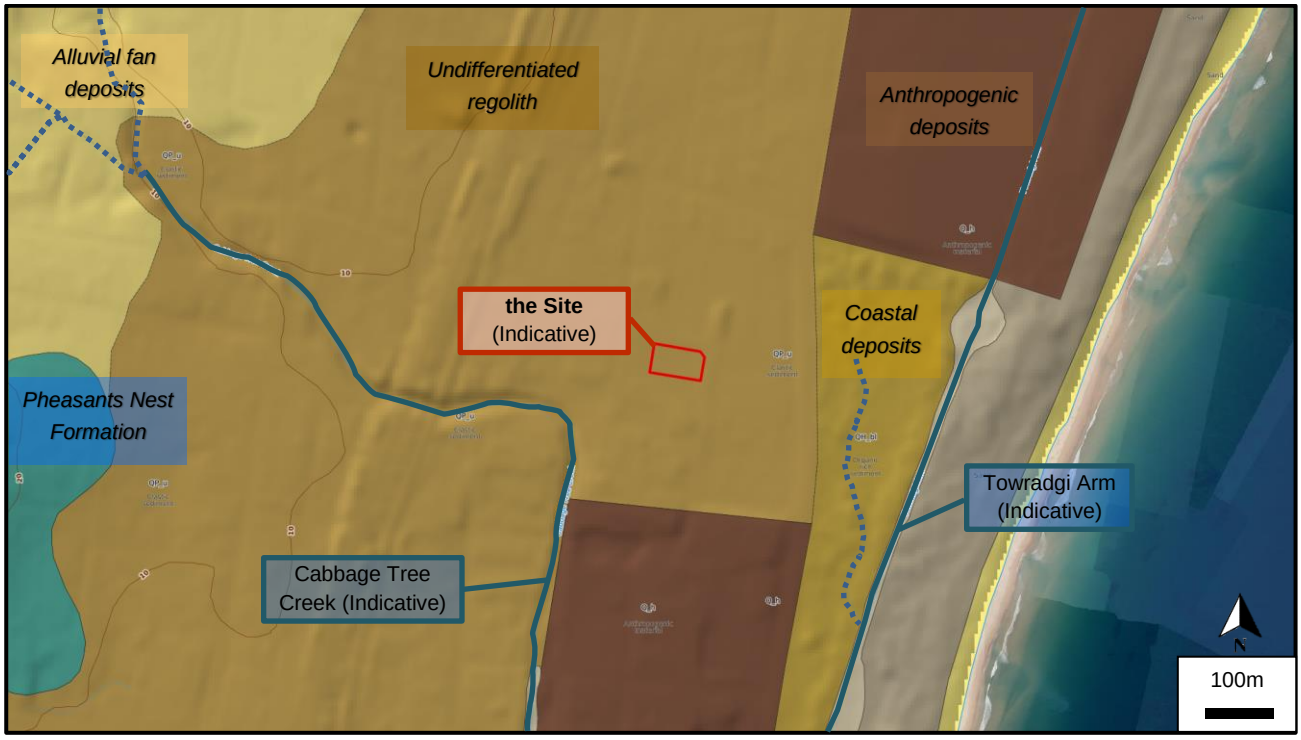

Figure 2 - The Site Location with NSW Seamless Geology and 10m Contours

4 FIELDWORK

The geotechnical investigation was undertaken as per the details provided by the client.

4.1 Methods

The geotechnical investigation was undertaken by Alliance on 14th July 2022. Alliance undertook the drilling of four boreholes and dynamic cone penetrometer testing aligned to the geotechnical scope. Borehole locations were cleared of underground services by a subcontracted service locator prior to drilling. Initial borehole locations were provided by the client, and final locations were confirmed on site before drilling/testing.

During the field investigation, four boreholes were drilled using a track-mounted drilling rig. The boreholes were advanced in the overburden soils using 110mm diameter solid flight augers fitted with a tungsten carbide (TC)-bit to the following target depths:

- Boreholes BH1 and BH4 to 4.0m bgl, and
- Boreholes BH2 and BH3 to 8.0m bgl

Standard Penetration Tests (SPT) were undertaken at 1.5m intervals starting at 1.5m bgl to assess the soil consistency at depth. Dynamic Cone Penetrometer Tests (DCP) were undertaken adjacent to the borehole locations to a target depth of 1.5m or prior refusal to determine the near-surface soil consistency.

The encountered soil profiles were documented by an experienced geotechnical engineer from Alliance generally in accordance with AS 1726 - 2017 Geotechnical Site Investigation. Recovered samples were transported to Alliance's NATA accredited materials testing laboratory for further testing and storage.

A summary of the geotechnical site investigation scope at each site and approximate borehole coordinates are presented in Table 1.

Table 1 - Summary of the Geotechnical Site Investigation Scope of Work

ID	Easting (m MGA20)	Northing (m MGA20)	Termination Depth (m bgl)
BH1	306832	6191741	4.0
BH2	306878	6191733	8.0
BH3	306823	6191710	8.0
BH4	306865	6191706	4.0

The approximate borehole locations are indicated on the Geotechnical Investigation Plan (Drawing 15348-GR-1-1-A) in Appendix B. The site coordinates were obtained using a handheld GPS. The coordinate values provided should be used for reference only and a registered surveyor must be engaged for design and/or construction purposes.

The borehole logs and DCP Test Report can be found in Appendix C.

These results should be read in conjunction with the attached Explanatory Note which explains the terms, abbreviations, and symbols used, together with the interpretation and limitation of the logging procedure.

On completion, the boreholes were backfilled with drilling spoils and made flush with the surrounding surface.

4.2 Results

4.2.1 Soils

A summary of the generalised subsurface conditions encountered in the boreholes has been provided in Table 2 below. Reference to the individual borehole log sheets attached in Appendix C should be made for a full description of the subsurface conditions encountered at each borehole location.

Table 2 - Summary of the Subsurface Profiles Encountered

Ground Profile	Consistency/ Density	Depth to top of unit (m)	Thickness (m)
Fill (uncontrolled) **Silty CLAY**	-	0.0	0.3 – 0.6
Alluvial **Silty CLAY**	Firm	0.3 – 0.6	0.15 – 0.6
Alluvial **Silty CLAY**	Stiff	0.75 – 0.9	4.1 – 4.4
Alluvial **Clayey SAND**	Medium Dense to Dense	5.0 – 5.3	Not penetrated

The site is underlain by uncontrolled fill (up to 0.6m thick), which is underlain by firm to stiff alluvial clay (up to 4.7m thick). Medium dense to dense clayey sands underlay the alluvial clays and were encountered at deeper depths (5.0 - 5.3mbgl)

4.2.2 Groundwater

Groundwater was encountered in boreholes BH2 and BH3 as seepage between depths 5.0m and 5.3m during the geotechnical investigation. It should be noted that groundwater seepage condition is subject to seasonal and climatic conditions and may vary across the site.

5 LABORATORY TESTING

Laboratory tests were carried out on selected soil samples collected from the boreholes during the site investigation. The following tests were carried out on selected soil samples in Alliance's NATA-accredited soil laboratory:

- Atterberg Limits
- Linear Shrinkage
- Moisture Content
- California Bearing Ratio
- Shrink-Swell Index
- Soil Aggressivity

The laboratory tests certificates are provided in Appendix D.

5.1 Moisture Content, Atterberg Limits, and Linear Shrinkage

Two Atterberg limit (four-point liquid limit), moisture content, and linear shrinkage tests were completed on selected samples in accordance with AS1289 2.1.1, 3.1.1, 3.2.1, and 3.3.1:2008 by Alliance NATA accredited laboratory. The results are summarised in Table 3 below:

Table 3 - Summary of Atterberg Limits and Linear Shrinkage

Sample Source	Soil Description	Moisture Content (%)	Atterberg Limits (%)			Linear Shrinkage (%)
			Liquid Limit	Plastic Limit	Plasticity Index	
BH1 1.5 – 2.0m	Silty CLAY	30.3	58	25	33	13.0
BH4 1.5 – 2.0m	Sandy CLAY	28.9	57	24	33	12.5

5.2 California Bearing Ratio

One bulk sample was collected from borehole BH4 for CBR testing. The CBR test specimen were compacted to approximately 100% of Standard Maximum Dry Density at Optimum Moisture Content (AS 1289 5.1.1 and 2.1.1), thereafter, the CBR test specimen were soaked for 4 days prior to testing.

The CBR values are shown in Table 4 below:

Table 4 - California Bearing Ratio Test Results

Borehole	Depth (m)	Material Description	FMC (%)	OMC (%)	MDD (t/m^3)	CBR (%)	Swell (%)
BH4	1.0 – 1.5	Silty CLAY	28.5	17.5	1.73	2.0	4.5

5.3 Shrink-Swell Index

Two undisturbed samples (U75) were collected at boreholes BH2 and BH3 for shrink-swell index testing. The shrink-swell index tests were completed by Alliance NATA accredited laboratory testing facility in accordance with AS1289.7.1.1:2003. The results are presented in Table 5 below with test certificates included in Appendix D.

Table 5 - Shrink Swell Index Results

Sampling Location	Depth	Material	Shrinkage	Swell	Shrink-Swell Index
	m	-	%	%	%
BH2	1.0 – 1.3	Silty CLAY	3.0	0.1	1.7
BH3	1.0 – 1.2	Silty CLAY	1.2	0.0	0.7

5.4 Soil Aggressivity

Two soil samples were collected from boreholes BH3 and BH4 for soil aggressivity testing. The tests were performed on the soil samples to aid with the durability design of concrete and steel. The results and exposure classifications are presented in Table 6.

Table 6 - Summary of Soil Aggressivity Tests

Test	Unit	BH3 1.3 – 1.4m	BH4 1.8 – 1.9m
Chloride	mg.kg^{-1}	< 10	140
Conductivity(1)	uS.cm^{-1}	75	120
pH(1)	pH Units	5.6	5.5
Resistivity	Ohm.cm	13000	8300
Sulfate (SO4)	mg.kg^{-1}	< 10	190
Moisture	%	18	21
Exposure Classification (2)	Concrete	Non-aggressive	Mild

	Steel	Non-aggressive	Non-aggressive
(1): Tests were carried out on a 1:5 aqueous extract at 25°C as recorded. **(2): Assessed in accordance with AS 2159 – 2009, Table 6.4.2 (C) and Table 6.5.2 (C)**			

6 COMMENTS AND RECOMMENDATIONS

6.1 Site Classification

The site is underlain by uncontrolled fill to a maximum depth of 0.6m bgl at Borehole BH02. Hence, the site is classified as Class P in accordance to AS2870 – 2011 Residential Slabs and Footings. Although the site isn't residential, in our experience the site classification based on AS2870 – 2011 is still useful to assess foundation conditions.

Furthermore, footings founded on the natural silty clay can be designed for a Class H1 classification, 'highly reactive clay or silt site'. Footings may experience high ground movement from moisture changes with an estimated surface movement, y_s, between 40mm and 60mm.'

6.2 Sub-Soil Classification for Earthquake Design

Determination of the Site Sub-Soil Classification has been carried out in accordance with AS1170.4-2007 Structural Design Actions Part 4: Earthquake Actions in Australia.

Based on the site investigations, the site is underlain by very stiff to hard cohesive soils, the site is classified as Class C_e – shallow soil site.

A Hazard Factor, z, of 0.09 for Wollongong region is recommended.

6.3 Temporary Retention and Batter Slopes

The minor site preparation excavation works for the proposed development is anticipated to encounter firm to stiff clay. The feasibility of using unsupported slope depends on the footing level of the adjoining structures which should be assessed by a structural designer. Given the proposed development set back from the site boundaries and adjacent structures, temporary batters are considered feasible for the proposed excavation. The recommended maximum temporary batter slopes are presented in Table 7.

Batter slopes should be extended below the 'zone of influence' of any adjacent structure, road, or services. i.e., a 45° line drawn downward from the foundation level of any adjacent structures.

Table 7 Temporary Dry Batter Slopes

Description	Temporary Batter Slopes H : V
Residual clay (firm to stiff)	2 : 1

6.4 Excavation Conditions

Excavations for the proposed development are not expected to exceed 1.5m. Excavation through uncontrolled fill and natural clays is expected to be readily achievable using conventional earthwork equipment such as a tracked excavator with tiger-tooth bucket. The construction related vibrations are expected to be negligible.

Generally, the peak particle velocity during any demolition, excavation, and construction should be limited to 5mm/s.

6.5 Footing System and design parameters

The existing uncontrolled fill material is not considered to be a suitable foundation strata and footings should be taken to found on the underlying natural clays. The proposed structure may be supported at the ground level by shallow pad or strip footings founded on stiff clay. Design parameters for shallow footing design in residual clay are presented in Table 8.

Table 8 Preliminary Geotechnical Design Parameters for Shallow Foundations

Description	Allowable Bearing Pressure (kPa)	Youngs Modulus (Mpa)	Poisson Ratio
Alluvial Clay: Stiff	120*#	15	0.3

***** Based on a 1.0m square pad footing, 1.0m deep.
# Separate settlement assessment should be undertaken to ensure that the footing settlements are within the tolerable range.

Should the magnitude of the building loads dictate that larger bearing capacities are required then it is recommended that bored piles founding be the method of foundation. The recommended design parameters for the bored pile foundations are presented in Table 9.

Table 9 - Preliminary Geotechnical Design Parameters for Deep Foundation

Description	End bearing Capacity		Ultimate Shaft adhesion	Elastic Modulus
	kPa		kPa	MPa
	Ultimate	Allowable assuming ϕ_g=0.33		
Alluvial Clay: Stiff	250	80	35	15

A preliminary value of 0.33 should be used for geotechnical reduction factor (Φg). In accordance with AS2159-2009 “Piling–Design and Installation”, for limit state design, the ultimate geotechnical pile capacity shall be multiplied by a geotechnical reduction factor (Φg). This factor is derived from an Average Risk Rating (ARR) which considers geotechnical uncertainties, redundancy of the foundation system, construction supervision, and the quantity and type of pile testing (if any). Where testing is undertaken, or more comprehensive ground investigation is carried out, it may be possible to adopt a larger Φg value that results in a more economical pile design. Further geotechnical advice will be required in consultation with the pile designer and piling contractor, to develop an appropriate Φg value.

Separate settlement assessment should be undertaken to ensure that the pile settlements are within the tolerable range. Serviceability limit state loads and Elasticity Modulus values should be used to carry out a separate settlement assessment to ensure that the pile settlements are within the tolerable range. Settlements should be checked using the ULS loads and the Ultimate Bearing Capacity from the table. In addition, the

SLS loads and the Serviceability Bearing Pressure in the table should be used to check that the pile base remains in the elastic range.

It is recommended that the footings are founded on the same strata to minimise the risk of differential settlement.

If bored piles are adopted for this project, groundwater inflow may occur during pile drilling. Therefore, pumps may be required to remove water from the bored pile holes prior to the placement of concrete if cast in-situ piles are selected. Alternatively, tremie concrete placement method could be adopted for the concrete placement if the pile foundation has been approved for concrete placement prior to the recent entry.

All footing excavations are required to be cleaned of any loose or disturbed material and any water immediately prior to placing the concrete.

An inspection by an experienced geotechnical engineer should be undertaken during pile boring or shallow footing excavation to confirm the founding strata and bearing pressures are consistent with the findings of this report.

6.6 Earthwork Construction Recommendations

The results of the fieldwork indicate that the although the existing fill is uncontrolled in nature, it could be reused on site provided any organic or deleterious materials are removed. The natural strata underlying the fill on site may also be used for filling. Any imported filling proposed for either building or pavement areas should consist of granular material such as crushed sandstone or similar. All filling material should be placed in layers not exceeding 250 mm maximum loose thickness and the material moisture conditioned to within 2% of standard optimum by the addition or removal of water, as appropriate. Each layer should be compacted by rolling to a density ratio not less than 95% standard maximum density, increasing to 98% standard maximum over the final two layers.

Over compaction should be avoided due to the potential for ground surface heave, which may cause ground slabs to crack and distortion in paving. It is recommended that a programme of density testing be implemented to ensure that the required level of compaction is being achieved in accordance with AS1289 to minimum Level 2 standard, but Level 1 is recommended.

It is recommended that for the development at this site, service trenches are backfilled with clay-based filling and, using hand equipment, compacted to 95% standard. Using clay-based filling instead of sand will reduce the risk of any water back flowing along the service trenches and penetrating below the ground slabs, causing the subgrade to heave and potentially damage ground slabs.

Methods of maintaining moisture content may include the use of plastic membranes or gravel layers over the surface of the exposed subgrade or lime blending within the upper subgrade layers. Maintaining correct moisture content within the subgrade will be assisted if there are minimal delays in construction of ground slabs and pavements after completion of earthworks. Interception and relief of subsoil seepage in all areas of significant cut is essential if subsequent softening of the subgrade below ground slabs and pavements is to be avoided.

Further advice should be sought where filling is required to support major structures.

The following recommendations are provided for subgrade preparation for earthworks and slab-on-ground construction:

- Stripping existing topsoil and fill. Removing unsuitable materials from the site (e.g., material containing deleterious matter). Stockpiling the remaining for re-use as fill or removing from site.
- Excavating natural clayey soils, stockpiling the soils for re-use as engineered fill or to be removed from site.
- Where soil is exposed at bulk excavation level, proof roll with a 12-tonne roller (witnessed by a geotechnical engineer) to identify any soft or spongy areas. Where these areas are identified, excavate the soft material, and replace with suitable fill and compact areas to a dry density ratio not less than 100% standard.

Subgrade preparation for the pavements is to comprise the following steps:

- After excavation to the design subgrade level, the exposed surface will require inspecting and proof rolling in the presence of a geotechnical engineer to identify and delineate any areas of loose, soft, or unsuitable subgrade material or where the design CBR value is considered to be not achievable. The test roll should be carried out using a minimum 5-tonne pad drum roller to pass over the entire subgrade area under low speed and in static mode.
- Following the inspection and proof roll, areas of loose, soft, or unsuitable subgrade where the design CBR is considered to be not achievable shall be excavated to expose a suitable foundation strata. The excavated areas should then be backfilled using controlled fill moisture conditioned to within ± 2% of standard optimum then placed and compacted to 100% SMDD in layers not exceeding 300mm loose thickness.

It is recommended that subgrade preparation works are to be undertaken in accordance with AS 37898 – 2007 Guidelines on earthworks for commercial and residential developments.

Any waste soils being removed from the site must be classified in accordance with current regulatory authority requirements to enable appropriate reuse or disposal to an appropriately licensed landfill facility.

6.7 Pavement Design Parameters

Based on the CBR test results, a CBR value of 2% may be adopted for the natural clay at the site. Based on the recommendations from AGPT02-17 the following preliminary parameters are suggested for pavement design.

- Design CBR Value: 2.0%
- Elasticity (Young's) Modulus: 20 MPa
- Subgrade Reaction (k): 18 kPa/mm
- Poisson's Ratio (n): 0.45

The suggested parameters for the pavement design rely on control of subgrade moisture content as detailed previously which will necessitate an appropriate drainage system be designed for the site.

It is likely that improvement of the subgrade will be required in the form of addition of lime (between 2% and 8%: lime demand testing will need to be undertaken to determine this more accurately) in order to provide a subgrade which can be built upon. A minimum subgrade CBR of 3% is required to enable compaction of the upper pavement layers. Mechanical stabilisation (addition of granular material) may work (not recommended by Austroads guide) but has more disadvantage than lime stabilisation. Although they both provide

strengthening of the subgrade material through different means, lime stabilisation has the added benefit of making the subgrade waterproof by having the lime reacts with the clay minerals or other pozzolanic components in the soil to form a tough, water-insoluble gel of calcium silicates and calcium aluminates whereas the remove and replace method will increase permeability. The increased permeability would in turn cause moisture induced stress to the pavement.

The subgrade should be proof rolled with a roller of at least 12-tonne deadweight capacity and the proof roll should be witnessed by a geotechnical engineer so that any soft or spongy areas can be identified and remediated. Remediation may involve replacement of the unsuitable material or cement stabilising the clays to increase their strength.

7 LIMITATIONS

Alliance Geotechnical Pty Ltd (Alliance) has prepared this report for the site located at 7 Squires Way, Fairy Meadow NSW 2500 in accordance with Alliance's fee proposal and Terms of Engagement. This geotechnical report has been prepared for MACE Australia Pty Ltd for this project and for the purposes outlined in this report. This report cannot be relied upon for other projects, other parties on this site or any other site. The comments and recommendations provided in this report are based on the assumption that the geotechnical recommendations contained in this report will be fully complied with during the design and construction of the proposed site development.

The borehole investigation and cone penetrometer test results provided in this report are indicative of the subsurface conditions at the site only at the specific sampling and testing locations, and to the depths drilled at the time of the investigation. Subsurface conditions can change significantly due to geological and human processes. Where variations in conditions are encountered further geotechnical advice should be sought from Alliance.

APPENDIX A – Site Photograph

Photo 1 – General view of the site, looking southwest

APPENDIX B – Geotechnical Investigation Plan (Drawing 15348-GR-1-1-A)

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Site Plan Scale 1:300 on A3

Client Name:	MACE Australia Pty Ltd	Figure Number:	15348-GR-1-1-A
Project Name:	Proposed Rural Ambulance Infrastructure Reconfiguration Program	Figure/Drawing Date:	02/08/2022
Project Location	7 Squires Way, Fairy Meadow NSW 2500	Report Number:	15348-GR-1-1

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Meters

APPENDIX C – Explanatory Notes, Borehole Logs, and DCP Test Report

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Explanatory Notes
Drill & Excavation Logs

General

Information obtained from site investigations is recorded on log sheets. Soils and very low strength rock are commonly drilled using a combination of solid-flight augers with a Tungsten-Carbide (TC) bit. Descriptions of these materials presented on the “Borehole Log” are based on a combination of regular sampling and in-situ testing. Rock coring techniques commences once material is encountered that cannot be penetrated using a combination of solid-flight augers and Tungsten-carbide bit. The "Cored Borehole Log" presents data from drilling where a core barrel has been used to recover material - commonly rock.

The "Excavation - Geological Log" presents data and drawings from exposures of soil and rock resulting from excavation of pits or trenches.

The heading of the log sheets contains information on Project Identification, Hole or Test Pit Identification, Location and Elevation. The main section of the logs contains information on methods and conditions, material description and structure presented as a series of columns in relation to depth below the ground surface which is plotted on the left side of the log sheet. The scale is presented in the depth column as metres below ground level.

As far as is practicable the data contained on the log sheets is factual. Some interpretation is included in the identification of material boundaries in areas of partial sampling, the location of areas of core loss, description and classification of material, estimation of strength and identification of drilling induced fractures, and geological unit. Material description and classifications are based on Australian Standard Geotechnical Site Investigations: AS 1726 - 2017 with some modifications as defined below.

These notes contain an explanation of the terms and abbreviations commonly used on the log sheets.

Drilling

Drilling, Casing and Excavating

Drilling methods deployed are abbreviated as follows

Abbreviation	Method
AS	Auger Screwing
ADV	Auger Drilling with V-Bit
ADT	Auger Drilling with TC Bit
BH	Backhoe
E	Excavator
HA	Hand Auger
HQ	HQ core barrel (~63.5 mm diameter core) *
HMLC	HMLC core barrel (~63.5 mm diameter core) *
NMLC	NMLC core barrel (~51.9 mm diameter core) *
NQ	NQ core barrel (~47.6 mm diameter core) *
RR	Rock Roller
WB	Wash-bore drilling

* Core diameters are approximate and vary due to the strength of material being drilled.

Drilling Fluid/Water

The drilling fluid used is identified and loss of return to the surface estimated as a percentage. It is introduced to assist with the drill process, in particular, when core drilling. The introduction of drill fluid/water does not allow for accurate identification of water seepages.

Drilling Penetration/Drill Depth

Core lifts are identified by a line and depth with core loss per run as a percentage. Ease of penetration in non-core drilling is abbreviated as follows:

Abbreviation	Description
VE	Very Easy
E	Easy
F	Firm
H	Hard
VH	Very Hard

Groundwater Levels

Date of measurement is shown.


Standing water level measured in completed borehole


Level taken during or immediately after drilling


Groundwater inflow water level

Samples/Tests

Samples collected and testing undertaken are abbreviated as follows

Abbreviation	Test
ES	Environmental Sample
DS	Disturbed Sample
BS	Bulk Sample
U50	Undisturbed (50 mm diameter)
C	Core Sample
SPT	Standard Penetration Test
N	Result of SPT (*sample taken)
VS	Vane Shear Test
IMP	Borehole Impression Device
PBT	Plate Bearing Test
PZ	Piezometer Installation
HP	Hand Penetrometer Test
HB	Hammer Bouncing

Excavation Logs

Explanatory notes are provided at the bottom of drill log sheets. Information about the origin, geology and pedology may be entered in the "Structure and other Observations" column. The depth of the base of excavation (for the logged section) at the appropriate depth in the "Material Description" column. Refusal of excavation plant is noted should it occur. A sketch of the exposure may be added. Photos are recommended.

Material Description – Soil

Material Description - In accordance with AS 1726-2017

Classification Symbol - In accordance with the Unified Classification System (AS 1726-2017).

Abbreviation	Typical Name
GW	Well-graded gravels, gravel-sand mixtures, little or no fines.
GP	Poorly graded gravels and gravel-sand mixtures, little or no fines, uniform gravels
GM	Silty gravels, gravel-sand-silt mixtures
GC	Clay ey gravels, gravel-sand-clay mixtures.
SW	Well graded sands, gravelly sands, little or no fines.
SP	Poorly graded sands and gravelly sands; little or no fines, uniform sands.
SM	Silty sand, sand-silt mixtures.
SC	Clayey sands, sand-clay mixtures.
ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity
CL, CI	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
OL	Organic silts and organic silty clays of low plasticity. *
MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, clastic silts.
CH	Inorganic clays of high plasticity, fat clays
OH	Organic clays of medium to high plasticity, organic silts. *
Pt	Peat and other highly organic soils. *

* Additional details may be provided in accordance with the Von Post classification system (1922).

Organic Soils - Identification using laboratory testing:

Material	Organic Content - % of dry mass
Inorganic	<2
Organic Soil	<2 ≤ 25
Peat	> 25

Organic Soils - Descriptive terms for the degree of decomposition of peat:

Term	Decomposition	Remains	Squeeze
Fibrous	Little or none	Clearly recognizable	Only water No solid
Pseudo-fibrous	Moderate	Mixture of fibrous and amorphous	Turbid water < 50% solids
Amorphous	Full	Not recognizable	Paste > 50% solids

Particle Characteristics– Definitions are as follows:

Fraction	Component (& subdivision)		Size (mm)
Oversize	Boulders		> 200
	Cobbles		> 63 ≤ 200
Coarse grained soils	Gravel	Coarse	> 19 ≤ 63
		Medium	> 6.7 ≤ 19
		Fine	> 2.36 ≤ 6.7
	Sand	Coarse	> 0.6 ≤ 2.36
		Medium	> 0.2 ≤ 0.6
		Fine	> 0.075 ≤ 0.21
Fine grained soils	Silt		0.002 ≤ 0.075
	Clay		< 0.002

Secondary and minor soil components

In coarse grained soils – The proportions of secondary and minor components are generally estimated from a visual and tactile assessment of the soils. Descriptions for secondary and minor soil components in coarse grained soils are as follows.

Designation of components	Percentage fines	Terminology (as applicable)	Percentage accessory coarse fraction	Terminology (as applicable)
Minor	≤ 5	Trace clay / silt	≤ 5	Trace sand / gravel
	> 5 ≤12	With clay / silt	> 5 ≤12	With sand / gravel
Secondary	> 12	Silty or clayey	> 30	Sandy or gravelly

Descriptions for secondary and minor soil components in fine grained soils are as follows.

Designation of components	Percentage coarse grained soils	Terminology (as applicable)
Minor	≤ 5	Trace sand / gravel / silt / clay
	> 5 ≤12	With sand / gravel / silt / clay
Secondary	> 30	Sandy / gravelly / silty / clayey

Plasticity Terms – Definitions for fine grained soils are as follows:

Descriptive Term	Range of Liquid Limit for silt	Range of Liquid Limit for clay
Low Plasticity	≤ 50	≤ 35
Medium Plasticity	N/A	> 35 ≤50
High Plasticity	> 50%	> 50

Particle Characteristics

Particle shape and angularity are estimated from a visual assessment of coarse-grained soil particle characteristics. Terminology used includes the following:

Particle shape – spherical, platy, elongated,

Particle angularity –angular, sub-angular, sub-rounded, rounded.

Moisture Condition – Abbreviations are as follows:

D	Dry, looks and feels dry
M	Moist, No free water on remoulding
W	Wet, free water on remoulding

Moisture content of fine-grained soils is based on judgement of the soils moisture content relative to the plastic and liquid limit as follows:

MC < PL	Moist, dry of plastic limit
MC ≈ PL	Moist, near plastic limit
MC > PL	Moist, wet of plastic limit
MC ≈ LL	Wet, near liquid limit
MC > LL	Wet of liquid limit

Consistency - of cohesive soils in accordance with AS 1726-2017, Table 11 are abbreviated as follows:

Consistency Term	Abbreviation	Indicative Undrained Shear Strength Range (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**	-

Density Index (%) of granular soils is estimated or is based on SPT results. Abbreviations are as follows:

Description	Abbreviation	Relative Density	SPT N
Very Loose	VL	< 15%	0 - 4
Loose	L	15 - 35%	4 - 10
Medium Dense	MD	35 - 65%	10 - 30
Dense	D	65 - 85%	30 - 50
Very Dense	VD	> 85%	> 50

Structures - Fissuring and other defects are described in accordance with AS 1726-2017 using the terminology for rock defects

Origin - Where practicable an assessment is provided of the probable origin of the soil, e.g. fill, topsoil, alluvium, colluvium, residual soil.

MATERIAL DESCRIPTION - ROCK

Material Description

Descriptions of rock for geotechnics and engineering geology in civil engineering

Identification of rock type, composition and texture based on visual features in accordance with AS 1726-2017.

Rock Naming – Where possible conventional geological names are used within the logs. Engineering properties cannot be inferred directly from the rock names in the table, but the use of a particular name provides an indicative range of characteristics to the reader. Lithological identification of rock is provided to appreciate the geology of an area, to correlate geological profiles seen in boreholes or to distinguish boulders from bedrock.

Grain Size – Grain size is done in accordance with AS1726-2017 as follows:

Coarse grained	Mainly 0.6 to 2 mm
Medium grained	0.2 to 0.6 mm
Fine grained	0.06 to 0.2 mm

Colour – Rock colour is described in the moist condition.

Texture and Fabric - Frequently used terms include:

Sedimentary Rock	Metamorphic Rock	Igneous
Bedded	Cleaved	Massive
Interbedded	Foliated	Flow banded
Laminated	Schistose	Folded
Folded	Banded	Lineated
Massive	Lineated	Porphyritic
Graded	Gneissose	Crystalline
Cross-bedded	Folded	Amorphous

Bedding and Laminated – AS 1726 – 2017 bedding and laminated rock descriptions are provided below with additional detail from BS EN ISO 14689-1 as guidance.

Description	Spacing (mm)
Very Thickly Bedded	> 2000
Thickly Bedded	> 600 ≤ 2000
Medium Bedded	> 200 ≤ 600
Thinly Bedded	> 60 ≤ 200
Very Thinly Bedded	> 20 ≤ 60
Thickly Laminated	> 6 ≤ 20
Thinly Laminated	< 6

Features, inclusions and minor components – Features, inclusions and minor components within the rock material shall be described where those features could be significant such as gas bubbles, mineral veins, carbonaceous material, salts, swelling minerals, mineral inclusions, ironstone or carbonate bands, cross-stratification or minerals the readily oxidise upon atmospheric exposure.

Moisture content – Where possible descriptions are made by the feel and appearance of the rock using one according to following terms:

Dry	Looks and feels dry.
Moist	Feels cool, darkened in colour, but no water is visible on the surface
Wet	Feels cool, darkened in colour, water film or droplets visible on the surface

The moisture content of rock cored with water may not be representative of its in-situ condition.

Durability – Descriptions of the materials durability such as tendency to develop cracks, break into smaller pieces or disintegrate upon exposure to air or in contact with water are provided where observed.

Rock Material Strength – The strength of the rock material is based on uniaxial compressive strength (UCS). The following terms are used:

Rock Strength Class	Abbreviation	UCS (MPa)	Point Load Strength Index, $I_{s\,(50)}$ (MPa)
Very Low	VL	> 0.6 ≤ 2	> 0.03 ≤ 0.1
Low	L	> 2 ≤ 6	> 0.1 ≤ 0.3
Medium	M	> 6 ≤ 20	> 0.3 ≤ 1
High	H	> 20 ≤ 60	> 1 ≤ 3
Very High	VH	> 60 ≤ 200	> 3 ≤ 10
Extremely High	EH	> 200	> 10

Strengths are estimated and where possible supported by Point Load Index Testing of representative samples. Test results are plotted on the graphical logs as follows:

D	Diametral Point Load Test
A	Axial Point Load Test

Where the estimated strength log covers more than one range it indicates the rock strength varies between the limits shown. Point Load Strength Index test results are presented as $I_{s\,(50)}$ values in MPa.

Weathering - Weathering classification assists in identification but does not imply engineering properties. Descriptions are as follows:

Term (Abbreviation)	Description
Fresh (FR)	No signs of mineral decomposition or colour change.
Slightly Weathered (SW)	partly stained or discoloured. Not or little change to strength from fresh rock.
Moderately Weathered (MW)	material is completely discoloured, little or no change of strength from fresh rock.
Highly Weathered (HW)	material is completely discoloured, significant decrease in strength from fresh rock.
Extremely Weathered (EW)	Material has soil properties. Mass structure, material texture and fabric of original rock are still visible.
Residual Soil (RS)	Material has soil properties. Mass structure and material texture and fabric of original rock not visible, but the soil has not been significantly transported.

Alteration – Physical and chemical changes of the rock material due to geological processes by fluids at depth at pressures and temperatures above atmospheric conditions. Unlike weathering, alteration shows no relationship to topography and may occur at any depth. When altered materials are recognized, the following terms are used:

Term		Abbreviation		Definition
Extremely Altered		XA		Material has soil properties. Structure, texture and fabric of original rock are still visible. The rock name is replaced with the name of the parent material, e.g. Extremely Altered basalt. Soil descriptive terms are used.
Highly Altered	Distinctly altered	HA	DA	The whole of the rock material is discoloured. Rock strength is changed by alteration. Some primary minerals are altered to clay minerals. Porosity may be higher or lower due to loss of minerals or precipitation of secondary minerals in pores.
Moderately Altered	Distinctly altered	MA	DA	The whole of the rock material is discoloured Little or no change of strength from fresh rock. The term 'Distinctly Altered' is used where it is not practicable to distinguish between 'Highly Altered' and 'Moderately Altered'. Distinctly Altered is defined as follows: The rock may be highly discoloured; Porosity may be higher due to mineral loss; or may be lower due to precipitation of secondary minerals in pores; and Some change of rock strength.
Slightly Altered		SA		Rock is slightly discoloured Little or no change of strength from fresh rock.

Alteration is only described in the context of the project where it has relevance to the civil and structural design.

Defect Descriptions

General and Detailed Descriptions – Defect descriptions are provided to suit project requirements. Generalized descriptions are used for some projects where it is unnecessary to describe each individual defect in a rock mass, or where multiple similar defects are present which are too numerous to log individually. The part of the rock mass to which this applies is delineated.

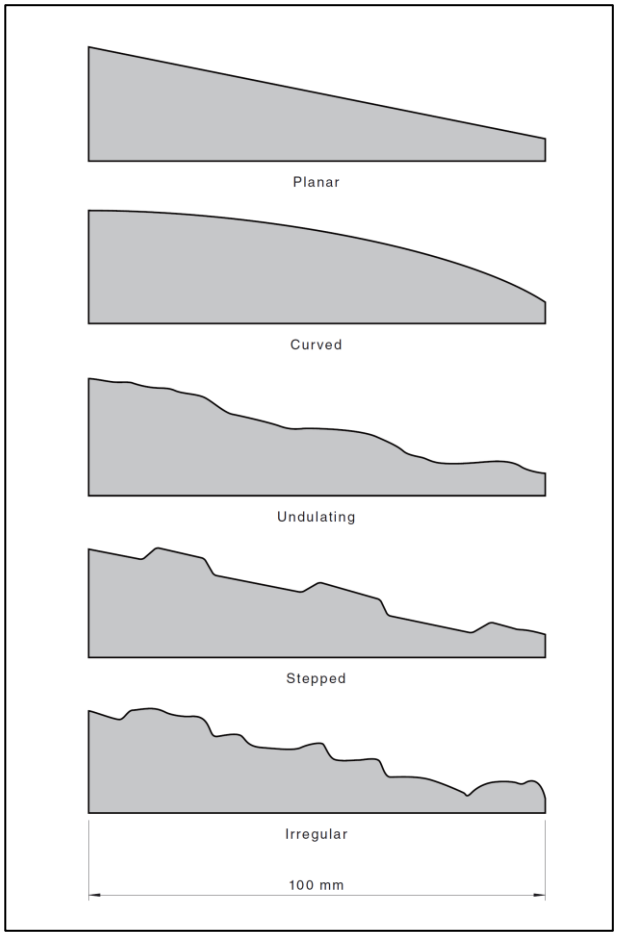
Detailed descriptions are given of defects judged to be particularly significant in the context of the project. For example, crushed seams in an apparently unstable slope. As a minimum, general descriptions outlining the number of defect sets within the rock mass and their broad characteristics are provided where it is possible to do so.

Defect Type – Defect abbreviations are as follows:

BP	Bedding Parting	**FL**	Foliation	**SP**	Shear Plane
CL	Cleavage	**FZ**	Fracture Zone	**SZ**	Shear Zone
CS	Crushed Seam	**HB**	Handling break	**VN**	Vein
DB	Drilling break	**JT**	Joint		
DL	Drill Lift	**SM**	Seam		

Defect Orientation – The dip and dip direction are recorded as a two-digit and three-digit number separated by a slash, e.g. 50/240 only when orientated core are collected and there is not core loss that could obscure core orientation. If alternative measurements are made, such as dip and strike or dip direction relative to magnetic north this shall be documented.

Surface Shape –At the medium scale of observation, description of the roughness of the surface shall be enhanced by description of the shape of the defect surface using the following terms, as illustrated below:



Defect Coatings and Seam Composition – Coatings are described using the following terms:

(a) *Clean* No visible coating.
(b) *Stained* No visible coating but surfaces are discoloured.
(c) *Veneer* A visible coating of soil or mineral, too thin to measure; may be patchy.
(d) *Coating* A visible coating up to 1 mm thick. Soil in-fill greater than 1 mm shall be described using defect terms (e.g. infilled seam). Defects greater than 1 mm aperture containing rock material great described as a vein.

Defect Spacing, Length, Openness and Thickness – described directly in millimetres and metres. In general descriptions, half order of magnitude categories are used, e.g. joint spacing typically 100 mm to 300 mm, sheared zones 1 m to 3 m thick.

Depending on project requirements and the scale of observation, spacing may be described as the mean spacing within a set of defects, or as the spacing between all defects within the rock mass. Where spacing is measured within a specific set of defects, measurements shall be made perpendicular to the defect set.

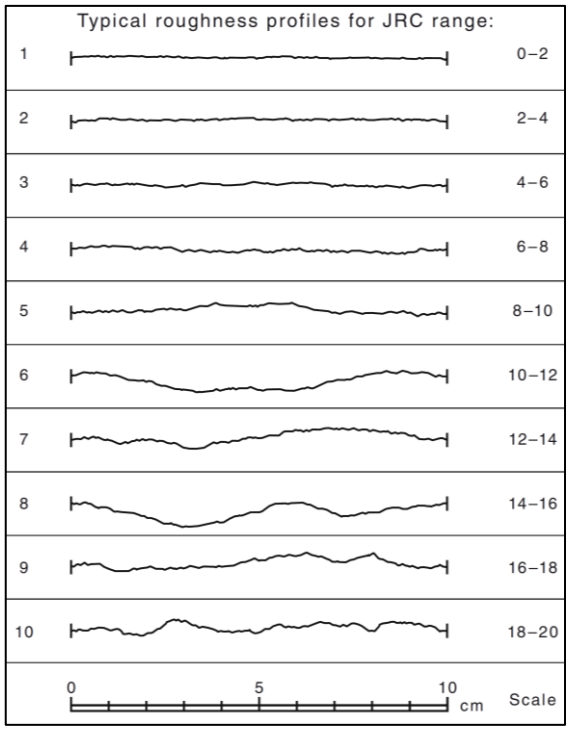
Defect spacing and length (sometimes called persistence), shall be described directly inmillimetres and metres.

Stratigraphic Unit - Geological maps related to the project are used for the designation of lithological formation name and, where possible geological unit name, e.g. Bringelly Shale, Potts Hill Sandstone Member.

Defect Roughness and Shape – Defect surface roughness is described as follows:

Very rough	Many large surface irregularities with amplitude generally more than 1 mm.
Rough	Many small surface irregularities with amplitude generally less than 1 mm.
Smooth	Smooth to touch. Few or no surface irregularities.
Polished	Shiny smooth surface
Slickensided	Grooved or striated surface, usually polished.

Where applicable Joint Roughness Range (JRC) is provided as follows:



Joint roughness profiles and corresponding JRC range based on Barton, N and Choubey, V. The Shear Strength of Rock Joints in Theory and Practice. *Rock Mechanics.* Vol. 10 (1977), pp. 1–54.

Where possible the mineralogy of the coating is identified.

Defect Infilling - abbreviated as follows:

CA	Calcite	**KT**	Chlorite
CN	Clean	**MS**	Secondary Mineral
Cy	Clay	**MU**	Unidentified Mineral
CS	Crushed Seam	**Qz**	Quartz
Fe	Iron Oxide	**X**	Carbonaceous

Parameters Related to Core Drilling

Total Core Recovery – T

Defect Spacing or Fracture Index – T

Rock Quality Designation – Y

Core Loss – Core loss occurs when material is lost during the drilling process It is shown at the bottom of the run unless otherwise indicated where core loss is known.

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BH No: BH1
Sheet: 1 of 1
Job No: 15348

Borehole Log

Client: Mace Australia Pty Ltd
Project: Geotechnical Investigation
Location: Innovation Way, Fairy Meadow, NSW

Started: 14/07/2022
Finished: 14/07/2022
Borehole Size: 100 mm

Rig Type: Hanjin
Hole Location 306832E, 6191741N
Driller: Andrew
Logged: EY

RL Surface: 4.12m
Contractor: BG Drilling
Bearing: ---
Checked: AS

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	DCP per 150mm (2 4 9 18)	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
ADT	Not Encountered		4.0			-	FILL: Silty CLAY, low to medium plasticity, dark brown and dark grey, well compacted	7 4	Ass 0.0	M <PL	-	FILL
			3.5	0.5		CI-CH	Silty CLAY, medium to high plasticity, brown and light grey, with orange mottling.	7 5	Ass 0.5	M ~PL	F	ALLUVIAL
			3.0	1.0				8 12 16	Ass 1.0		St	
			2.5	1.5			1.7m: with ironstone gravel, fine to medium grained, subrounded.	25 24 30	Ass 1.5 SPT 4, 4, 5 N=9 PSD 1.5-2.0			
			2.0	2.0					Ass 2			
			1.5	2.5					Ass 2.5			
			1.0	3.0			3.2m: becoming grey-light grey.		Ass 3.0 SPT 4, 6, 8 N=14			
			0.5	3.5					Ass 3.5			
				4.0					Ass 4.0			
			0.0				Borehole BH1 terminated at 4m					
			-0.5	4.5								
				5.0								

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BH No: BH2
Sheet: 1 of 2
Job No: 15348

Borehole Log

Client: Mace Australia Pty Ltd
Project: Geotechnical Investigation
Location: Innovation Way, Fairy Meadow, NSW

Started: 14/07/2022
Finished: 14/07/2022
Borehole Size: 100 mm

Rig Type: Hanjin
Hole Location 306878E, 6191733N
Driller: Andrew
Logged: EY
RL Surface: 3.71m
Contractor: BG Drilling
Bearing: ---
Checked: AS

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	DCP per 150mm (2 4 9 18)	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
ADT			3.5	0.5		-	FILL: Silty CLAY, low to medium plasticity, dark brown, with rootlets, trace fine to medium grained, subangular gravel, appears well compacted.	1 0 0 4	Ass 0.0	MC ~PL		FILL
									Ass 0.5			
			3.0	1.0		CI-CH	Silty CLAY, medium to high plasticity, yellow brown mottled grey	7 11 19 23		MC ~PL	F	ALLUVIAL
									Ass 1.0		St	
			2.5	1.5		CI-CH	Silty CLAY, medium to high plasticity, red brown and dark red, trace fine grained rounded ironstone gravel	28 33				
			2.0	2.0			1.8m: becoming grey and light grey mottled brown		Ass 1.5 SPT 3, 4, 5 N=9			
									Ass 2.0			
			1.5	2.5					Ass 2.5			
			1.0	3.0					Ass 2.5-2.6			
			0.5	3.5					Ass 3.0 SPT 2, 3, 4 N=7			
			0.0	4.0					Ass 3.5			
			-0.5	4.5					Ass 4.0			
			-1.0	5.0					SPT 5, 4, 6 N=10			

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BH No: BH2
Sheet: 2 of 2
Job No: 15348

Borehole Log

Client: Mace Australia Pty Ltd
Project: Geotechnical Investigation
Location: Innovation Way, Fairy Meadow, NSW

Started: 14/07/2022
Finished: 14/07/2022
Borehole Size: 100 mm

Rig Type: Hanjin
Hole Location 306878E, 6191733N
Driller: Andrew
Logged: EY
RL Surface: 3.71m
Contractor: BG Drilling
Bearing: ---
Checked: AS

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	DCP per 150mm (2 4 9 18)	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
ADT	Seepage @ 5.3m		-1.5	5.5		CI-CH	Silty CLAY, medium to high plasticity, red brown and dark red, trace fine grained rounded ironstone gravel *(continued)*			MC ~PL	St	
			-2.0			SC	Clayey SAND, fine to medium grained, dark grey and grey.			W	MD	
				6.0					SPT 5, 5, 7 N=12 Ass 6.3-6.4			
			-2.5	6.5								
			-3.0	7.0								
			-3.5	7.5							L	
			-4.0	8.0					SPT 4, 4, 4 N=8			
			-4.5				Borehole BH2 terminated at 8m					
				8.5								
			-5.0									
				9.0								
			-5.5									
				9.5								
			-6.0									
				10.0								

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BH No: BH3
Sheet: 1 of 2
Job No: 15348

Borehole Log

Client: Mace Australia Pty Ltd
Project: Geotechnical Investigation
Location: Innovation Way, Fairy Meadow, NSW

Started: 14/07/2022
Finished: 14/07/2022
Borehole Size: 100 mm

Rig Type: Hanjin
Hole Location 306823E, 6191710N
Driller: Andrew
Logged: EY

RL Surface: 4.47m
Contractor: BG Drilling
Bearing: ---
Checked: AS

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	DCP per 150mm (2 4 9 18)	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
ADT						-	FILL: Silty CLAY, low to medium plasticity, dark brown, trace fine to medoum grained gravel, trace fine grained sand and rootlets.	1, 6	Ass 0.0	MC ~PL	-	FILL
			4.0	0.5		CI-CH	Silty CLAY, medium to high plasticity, brown mottled yellow, trace fine to medium grained, subrounded gravel.	4, 6, 12, 17	Ass 0.5	MC ~PL	F	ALLUVIAL
			3.5	1.0				24, 29, 32	U75 1.0-1.2 Ass 1.0 Agg 1.3-1.4		St	
			3.0	1.5			1.2m: becoming grey and light grey mottled brown		Ass 1.5 SPT 3, 5, 6 N=11			
			2.5	2.0					Ass 2.0			
			2.0	2.5					Ass 2.5			
			1.5	3.0					Ass 3.0 SPT 4, 4, 5 N=9			
			1.0	3.5					Ass 3.5			
			0.5	4.0					Ass 4.0			
			0.0	4.5					Agg 4.5-4.6 SPT 5, 5, 8 N=13			
			-0.5	5.0								

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BH No: BH3
Sheet: 2 of 2
Job No: 15348

Borehole Log

Client: Mace Australia Pty Ltd
Project: Geotechnical Investigation
Location: Innovation Way, Fairy Meadow, NSW

Started: 14/07/2022
Finished: 14/07/2022
Borehole Size: 100 mm

Rig Type: Hanjin
Hole Location 306823E, 6191710N
Driller: Andrew
Logged: EY
RL Surface: 4.47m
Contractor: BG Drilling
Bearing: ---
Checked: AS

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	DCP per 150mm (2 4 9 18)	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
ADT	Seepage @ 5.0m		-1.0	5.5		SC	Clayey SAND, fine to medium grained, red brown and orange, with fine to medium grained, subrounded gravel.			W	MD - D	
			-1.5	6.0					SPT 11, 15, 15 N=30			
			-2.0	6.5								
			-2.5	7.0								
			-3.0	7.5					SPT 6, 7, 8 N=15			
			-3.5	8.0								
							Borehole BH3 terminated at 8m					
			-4.0	8.5								
			-4.5	9.0								
			-5.0	9.5								
			-5.5	10.0								

A. AUGERED BOREHOLE 15348.GPJ GINT STD AUSTRALIA.GDT 4/8/22

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BH No: BH4
Sheet: 1 of 1
Job No: 15348

Borehole Log

Client: Mace Australia Pty Ltd
Project: Geotechnical Investigation
Location: Innovation Way, Fairy Meadow, NSW

Started: 14/07/2022
Finished: 14/07/2022
Borehole Size: 100 mm

Rig Type: Hanjin
Hole Location 306865E, 6191706N
Driller: Andrew
Logged: EY
RL Surface: 4.09m
Contractor: BG Drilling
Bearing: ---
Checked: S

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	DCP per 150mm (2 4 9 18)	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
ADT	Not Encountered		4.0	0.0		-	FILL: Silty CLAY, low to medium plasticity, dark brown and dark grey, with rootlets, trace fine to medium grained, subangular gravel.	1 2 8 6	Ass 0.0	MC ~PL	-	FILL
			3.5	0.5					Ass 0.5			
						CI-CH	Sandy CLAY, medium to high plasticity, grey-brown mottled orange.	9 17 17 18 20 24 21 22 23 30	Agg 0.7-0.8	MC ~PL	F	ALLUVIAL
			3.0	1.0					Ass 1.0		St	
									CBR4 1.0-1.5			
			2.5	1.5					Ass 1.5 SPT 3, 4, 5 N=9			
									Agg 1.8-1.9			
			2.0	2.0					PSD 1.5-2.0			
									Ass 2.0			
			1.5	2.5					Ass 2.5			
			1.0	3.0			3.3m: dark grey-brown.		Ass 3.1 SPT 4, 7, 6 N=13			
			0.5	3.5					Agg 3.4-3.5			
									Ass 3.5			
				4.0					Ass 4.0			
			0.0				Borehole BH4 terminated at 4m					
			-0.5	4.5								
				5.0								

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Dynamic Cone Penetrometer (DCP) Test Report

Client	MACE Australia Pty Ltd	**Report Number**	15348-GR-1-1
Project Name	Proposed Rural Ambulance Infrastructure Reconfiguration Program (RAIR)	**Project Number**	15348
Project Location	7 Squires Way, Fairy Meadow NSW 2500	**Date Tested**	14/07/2022
Test Method	AS 1289.6.3.2		

Test Number	**DCP01 (BH1)**	**DCP02 (BH2)**	**DCP03 (BH3)**	**DCP04 (BH4)**
Test Locations	Refer to drawing 15348-GR-1-1-A			
Surface Material	FILL: Silty CLAY	FILL: Silty CLAY	FILL: Silty CLAY	FILL: Silty CLAY
Surface Conditions	Moist	Moist	Moist	Moist
Depth (m)				
0.00 – 0.15	7	1	1	1
0.15 – 0.30	4	0	1	2
0.30 – 0.45	7	0	6	8
0.45 – 0.60	5	4	4	6
0.60 – 0.75	8	7	6	9
0.75 – 0.90	12	11	12	17
0.90 – 1.05	16	19	17	17
1.05 – 1.20	25	23	24	18
1.20 – 1.35	24	28	29	20
1.35 – 1.50	30	33	32	24
1.50 – 1.65	Target Depth	Target Depth	Target Depth	21
1.65 – 1.80				22
1.80 – 1.95				23
1.95 – 2.10				30
2.10 – 2.25				Target Depth

Notes: This test report is intended to be read in conjunction with the geotechnical report by Alliance Geotechnical (ref: 15348-GR-1-1).

APPENDIX D – Laboratory Test Certificates

Material Test Report

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Accredited for compliance with ISO/IEC 17025 - Testing

NATA
WORLD RECOGNISED ACCREDITATION

Approved Signatory: Brett Bellingham
Conformance Testing Manager
NATA Accredited Laboratory Number: 15100

Report Number: **15348-1**
Issue Number: 1
Date Issued: 02/08/2022
Client: Alliance Geotechnical Pty Ltd
8-10 Welder Road, Seven Hills NSW 2147
Contact: Emerson You
Project Number: 15348
Project Name: Geotechnical Investigation - Fairy Meadow
Project Location: Part of 7 Squires Way, Fairy Meadow
Contractor: Mace Australia Pty Ltd
Work Request: 20073
Sample Number: 22-20073A
Date Sampled: 14/07/2022
Dates Tested: 15/07/2022 - 19/07/2022
Sampling Method: Sampled by Client
The results apply to the sample as received
Sample Location: **BH1, Depth: 1.5-2.0m**
Material: Silty CLAY, high plasticity, brown-light grey mottled orange

Atterberg Limit (AS1289 3.1.1 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Air Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	58		
Plastic Limit (%)	25		
Plasticity Index (%)	**33**		

Linear Shrinkage (AS1289 3.4.1)		Min	Max
Moisture Condition Determined By	AS 1289.3.1.1		
Linear Shrinkage (%)	13.0		
Cracking Crumbling Curling	Curling		

Material Test Report

alliance
geotechnical & environmental solutions
Alliance Geotechnical Pty Ltd
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PO Box 275, Seven Hills NSW 1730
Phone: 1800 288 188
Email: brett@allgeo.com.au

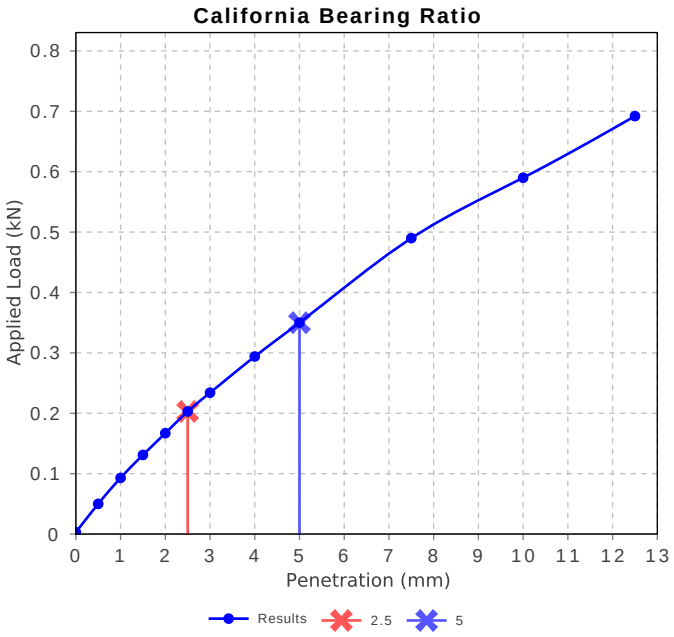
Accredited for compliance with ISO/IEC 17025 - Testing

NATA
WORLD RECOGNISED ACCREDITATION

Approved Signatory: Brett Bellingham
Conformance Testing Manager
NATA Accredited Laboratory Number: 15100

Report Number: **15348-1**
Issue Number: 1
Date Issued: 02/08/2022
Client: Alliance Geotechnical Pty Ltd
8-10 Welder Road, Seven Hills NSW 2147
Contact: Emerson You
Project Number: 15348
Project Name: Geotechnical Investigation - Fairy Meadow
Project Location: Part of 7 Squires Way, Fairy Meadow
Contractor: Mace Australia Pty Ltd
Work Request: 20073
Sample Number: 22-20073D
Date Sampled: 14/07/2022
Dates Tested: 15/07/2022 - 25/07/2022
Sampling Method: Sampled by Client
The results apply to the sample as received
Sample Location: **BH4, Depth: 1.0-1.5m**
Material: Silty CLAY, low to medium plasticity, brown-dark grey trace gravel

California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	5 mm		
CBR %	**2.0**		
Method of Compactive Effort	Standard		
Method used to Determine MDD	AS 1289 5.1.1 & 2.1.1		
Method used to Determine Plasticity	Tactile		
Maximum Dry Density (t/m^3)	1.73		
Optimum Moisture Content (%)	17.5		
Laboratory Density Ratio (%)	100.0		
Laboratory Moisture Ratio (%)	101.0		
Dry Density after Soaking (t/m^3)	1.66		
Field Moisture Content (%)	28.5		
Moisture Content at Placement (%)	17.5		
Moisture Content Top 30mm (%)	25.3		
Moisture Content Rest of Sample (%)	20.0		
Mass Surcharge (kg)	4.5		
Soaking Period (days)	4		
Curing Hours	51.2		
Swell (%)	4.5		
Oversize Material (mm)	19		
Oversize Material Included	N/A		
Oversize Material (%)	0.0		



Material Test Report

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Approved Signatory: Brett Bellingham
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NATA Accredited Laboratory Number: 15100

Report Number: **15348-1**
Issue Number: 1
Date Issued: 02/08/2022
Client: Alliance Geotechnical Pty Ltd
8-10 Welder Road, Seven Hills NSW 2147
Contact: Emerson You
Project Number: 15348
Project Name: Geotechnical Investigation - Fairy Meadow
Project Location: Part of 7 Squires Way, Fairy Meadow
Contractor: Mace Australia Pty Ltd
Work Request: 20073
Sample Number: 22-20073E
Date Sampled: 14/07/2022
Dates Tested: 15/07/2022 - 19/07/2022
Sampling Method: Sampled by Client
The results apply to the sample as received
Sample Location: **BH4, Depth: 1.5-2.0m**
Material: Sandy CLAY, high plasticity, grey-brown mottled orange

Atterberg Limit (AS1289 3.1.1 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Air Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	57		
Plastic Limit (%)	24		
Plasticity Index (%)	**33**		

Linear Shrinkage (AS1289 3.4.1)		Min	Max
Moisture Condition Determined By	AS 1289.3.1.1		
Linear Shrinkage (%)	12.5		
Cracking Crumbling Curling	Curling		

Material Test Report

Report Number: **15348-1**
Issue Number: 1
Date Issued: 02/08/2022
Client: Alliance Geotechnical Pty Ltd
8-10 Welder Road, Seven Hills NSW 2147
Contact: Emerson You
Project Number: 15348
Project Name: Geotechnical Investigation - Fairy Meadow
Project Location: Part of 7 Squires Way, Fairy Meadow
Contractor: Mace Australia Pty Ltd
Work Request: 20073
Date Sampled: 14/07/2022
Dates Tested: 15/07/2022 - 15/07/2022
Sampling Method: Sampled by Client
The results apply to the sample as received
Location: Part of 7 Squires Way, Fairy Meadow

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Moisture Content AS 1289 2.1.1			
Sample Number	Sample Location	Moisture Content (%)	Material
22-20073A	BH1, Depth: 1.5-2.0m	30.3 %	Silty CLAY, high plasticity, brown-light grey mottled orange
22-20073E	BH4, Depth: 1.5-2.0m	28.9 %	Sandy CLAY, high plasticity, grey-brown mottled orange

Material Test Report

Report Number: **15348-1**
Issue Number: 1
Date Issued: 02/08/2022
Client: Alliance Geotechnical Pty Ltd
8-10 Welder Road, Seven Hills NSW 2147
Contact: Emerson You
Project Number: 15348
Project Name: Geotechnical Investigation - Fairy Meadow
Project Location: Part of 7 Squires Way, Fairy Meadow
Contractor: Mace Australia Pty Ltd
Work Request: 20073
Date Sampled: 14/07/2022
Dates Tested: 15/07/2022 - 29/07/2022
Sampling Method: Sampled by Client
The results apply to the sample as received
Location: Part of 7 Squires Way, Fairy Meadow

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Shrink Swell Index AS 1289 7.1.1 & 2.1.1					
Sample Number	22-20073B	22-20073C			
Date Sampled	14/07/2022	14/07/2022			
Date Tested	29/07/2022	29/07/2022			
Material Source	Bore Hole	Bore Hole			
Sample Location	BH2 (1.0-1.3m)	BH3 (1.0-1.2m)			
Inert Material Estimate (%)	1	0			
Pocket Penetrometer before (kPa)	340	260			
Pocket Penetrometer after (kPa)	200	180			
Shrinkage Moisture Content (%)	24.0	20.9			
Shrinkage (%)	**3.0**	**1.2**			
Swell Moisture Content Before (%)	23.8	21.3			
Swell Moisture Content After (%)	26.1	22.5			
Swell (%)	**0.1**	**-0.0**			
Shrink Swell Index Iss (%)	**1.7**	**0.7**			
Visual Description	Silty CLAY	Silty CLAY			
Cracking	MC	MC			
Crumbling	No	No			
Remarks	Nil	Nil			

Shrink Swell Index (Iss) reported as the percentage vertical strain per pF change in suction.
Cracking Terminology: UC Uncracked, SC Slightly Cracked, MC Moderately Cracked, HC Highly Cracked, FR Fragmented.
NATA Accreditation does not cover the performance of pocket penetrometer readings.

eurofins | Environment Testing

Certificate of Analysis

Alliance Geotechnical
10 Welder Road
Seven Hills
NSW 2147

NATA Accredited
Accreditation Number 1261
Site Number 18217

Accredited for compliance with ISO/IEC 17025 – Testing
NATA is a signatory to the ILAC Mutual Recognition Arrangement for the mutual recognition of the equivalence of testing, medical testing, calibration, inspection, proficiency testing scheme providers and reference materials producers reports and certificates.

Attention: **Anurag Sobti**

Report **906373-S**
Project name FAIRY MEADOW
Project ID 15348
Received Date Jul 15, 2022

Client Sample ID			**BH3-1.3-1.4M**	**BH4-1.8-1.9M**
Sample Matrix			**Soil**	**Soil**
Eurofins Sample No.			**S22-JI0032583**	**S22-JI0032584**
Date Sampled			**Jul 14, 2022**	**Jul 14, 2022**
Test/Reference	LOR	Unit		
Chloride	10	mg/kg	< 10	140
Conductivity (1:5 aqueous extract at 25 °C as rec.)	10	uS/cm	75	120
pH (1:5 Aqueous extract at 25 °C as rec.)	0.1	pH Units	5.6	5.5
Resistivity*	0.5	ohm.m	130	83
Sulphate (as SO4)	10	mg/kg	< 10	190
% Moisture	1	%	18	21

Sample History

Where samples are submitted/analysed over several days, the last date of extraction is reported.

If the date and time of sampling are not provided, the Laboratory will not be responsible for compromised results should testing be performed outside the recommended holding time.

Description	Testing Site	Extracted	Holding Time
Chloride	Sydney	Jul 16, 2022	28 Days
- Method: LTM-INO-4270 Anions by Ion Chromatography			
Conductivity (1:5 aqueous extract at 25 °C as rec.)	Sydney	Jul 16, 2022	7 Days
- Method: LTM-INO-4030 Conductivity			
pH (1:5 Aqueous extract at 25 °C as rec.)	Sydney	Jul 16, 2022	7 Days
- Method: LTM-GEN-7090 pH by ISE			
Sulphate (as SO4)	Sydney	Jul 16, 2022	28 Days
- Method: In-house method LTM-INO-4270 Sulphate by Ion Chromatograph			
% Moisture	Sydney	Jul 15, 2022	14 Days
- Method: LTM-GEN-7080 Moisture			

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IANZ# 1290

Company Name: Alliance Geotechnical
Address: 10 Welder Road
Seven Hills
NSW 2147

Project Name: FAIRY MEADOW
Project ID: 15348

Order No.:
Report #: 906373
Phone: 1800 288 188
Fax: 02 9675 1888

Received: Jul 15, 2022 6:07 PM
Due: Jul 22, 2022
Priority: 5 Day
Contact Name: Anurag Sobti

Eurofins Analytical Services Manager : Andrew Black

Sample Detail						Aggressivity Soil Set	Moisture Set
Sydney Laboratory - NATA # 1261 Site # 18217						X	X
External Laboratory							
No	**Sample ID**	**Sample Date**	**Sampling Time**	**Matrix**	**LAB ID**		
1	BH3-1.3-1.4M	Jul 14, 2022		Soil	S22-Jl0032583	X	X
2	BH4-1.8-1.9M	Jul 14, 2022		Soil	S22-Jl0032584	X	X
Test Counts						2	2

Internal Quality Control Review and Glossary

General

1. Laboratory QC results for Method Blanks, Duplicates, Matrix Spikes, and Laboratory Control Samples follows guidelines delineated in the National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended May 2013 and are included in this QC report where applicable. Additional QC data may be available on request.
2. All soil/sediment/solid results are reported on a dry basis, unless otherwise stated.
3. All biota/food results are reported on a wet weight basis on the edible portion, unless otherwise stated.
4. Actual LORs are matrix dependant. Quoted LORs may be raised where sample extracts are diluted due to interferences.
5. Results are uncorrected for matrix spikes or surrogate recoveries except for PFAS compounds.
6. SVOC analysis on waters are performed on homogenised, unfiltered samples, unless noted otherwise.
7. Samples were analysed on an 'as received' basis.
8. Information identified on this report with blue colour, indicates data provided by customer that may have an impact on the results.
9. This report replaces any interim results previously issued.

Holding Times

Please refer to 'Sample Preservation and Container Guide' for holding times (QS3001).

For samples received on the last day of holding time, notification of testing requirements should have been received at least 6 hours prior to sample receipt deadlines as stated on the SRA.

If the Laboratory did not receive the information in the required timeframe, and regardless of any other integrity issues, suitably qualified results may still be reported.

Holding times apply from the date of sampling, therefore compliance to these may be outside the laboratory's control.

For VOCs containing vinyl chloride, styrene and 2-chloroethyl vinyl ether the holding time is 7 days however for all other VOCs such as BTEX or C6-10 TRH then the holding time is 14 days.

Units

mg/kg: milligrams per kilogram
mg/L: milligrams per litre
µg/L: micrograms per litre
ppm: parts per million
ppb: parts per billion
%: Percentage
org/100 mL: Organisms per 100 millilitres
NTU: Nephelometric Turbidity Units
MPN/100 mL: Most Probable Number of organisms per 100 millilitres

Terms

APHA	American Public Health Association
COC	Chain of Custody
CP	Client Parent - QC was performed on samples pertaining to this report
CRM	Certified Reference Material (ISO17034) - reported as percent recovery.
Dry	Where a moisture has been determined on a solid sample the result is expressed on a dry basis.
Duplicate	A second piece of analysis from the same sample and reported in the same units as the result to show comparison.
LOR	Limit of Reporting.
LCS	Laboratory Control Sample - reported as percent recovery.
Method Blank	In the case of solid samples these are performed on laboratory certified clean sands and in the case of water samples these are performed on de-ionised water.
NCP	Non-Client Parent - QC performed on samples not pertaining to this report, QC is representative of the sequence or batch that client samples were analysed within.
RPD	Relative Percent Difference between two Duplicate pieces of analysis.
SPIKE	Addition of the analyte to the sample and reported as percentage recovery.
SRA	Sample Receipt Advice
Surr - Surrogate	The addition of a like compound to the analyte target and reported as percentage recovery.
TBTO	Tributyltin oxide (*bis*-tributyltin oxide) - individual tributyltin compounds cannot be identified separately in the environment however free tributyltin was measured and its values were converted stoichiometrically into tributyltin oxide for comparison with regulatory limits.
TCLP	Toxicity Characteristic Leaching Procedure
TEQ	Toxic Equivalency Quotient or Total Equivalence
QSM	US Department of Defense Quality Systems Manual Version 5.4
US EPA	United States Environmental Protection Agency
WA DWER	Sum of PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFBS, PFHxS, PFOS, 6:2 FTSA, 8:2 FTSA

QC - Acceptance Criteria

The acceptance criteria should be used as a guide only and may be different when site specific Sampling Analysis and Quality Plan (SAQP) have been implemented

RPD Duplicates: Global RPD Duplicates Acceptance Criteria is 30% however the following acceptance guidelines are equally applicable:

Results <10 times the LOR: No Limit

Results between 10-20 times the LOR: RPD must lie between 0-50%

Results >20 times the LOR : RPD must lie between 0-30%

NOTE: pH duplicates are reported as a range not as RPD

Surrogate Recoveries: Recoveries must lie between 20-130% for Speciated Phenols & 50-150% for PFAS

PFAS field samples that contain surrogate recoveries in excess of the QC limit designated in QSM 5.4 where no positive PFAS results have been reported have been reviewed and no data was affected.

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QC Data General Comments

1. Where a result is reported as a less than (<), higher than the nominated LOR, this is due to either matrix interference, extract dilution required due to interferences or contaminant levels within the sample, high moisture content or insufficient sample provided.
2. Duplicate data shown within this report that states the word "BATCH" is a Batch Duplicate from outside of your sample batch, but within the laboratory sample batch at a 1:10 ratio. The Parent and Duplicate data shown is not data from your samples.
3. pH and Free Chlorine analysed in the laboratory - Analysis on this test must begin within 30 minutes of sampling. Therefore, laboratory analysis is unlikely to be completed within holding time.Analysis will begin as soon as possible after sample receipt.
4. Recovery Data (Spikes & Surrogates) - where chromatographic interference does not allow the determination of recovery the term "INT" appears against that analyte.
5. For Matrix Spikes and LCS results a dash "-" in the report means that the specific analyte was not added to the QC sample.
6. Duplicate RPDs are calculated from raw analytical data thus it is possible to have two sets of data.

Quality Control Results

Test	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Method Blank							
Chloride	mg/kg	< 10			10	Pass	
Conductivity (1:5 aqueous extract at 25 °C as rec.)	uS/cm	< 10			10	Pass	
Sulphate (as SO4)	mg/kg	< 10			10	Pass	
LCS - % Recovery							
Chloride	%	119			70-130	Pass	
Conductivity (1:5 aqueous extract at 25 °C as rec.)	%	95			70-130	Pass	
Resistivity*	%	95			70-130	Pass	
Sulphate (as SO4)	%	119			70-130	Pass	

Test	Lab Sample ID	QA Source	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Spike - % Recovery									
				Result 1					
Chloride	S22-Jl0021593	NCP	%	114			70-130	Pass	
Sulphate (as SO4)	S22-Jl0021593	NCP	%	120			70-130	Pass	

Test	Lab Sample ID	QA Source	Units	Result 1	Result 2	RPD	Acceptance Limits	Pass Limits	Qualifying Code
Duplicate									
				Result 1	Result 2	RPD			
Chloride	S22-Jl0032583	CP	mg/kg	< 10	< 10	<1	30%	Pass	
Conductivity (1:5 aqueous extract at 25 °C as rec.)	S22-Jl0034419	NCP	uS/cm	19	22	13	30%	Pass	
pH (1:5 Aqueous extract at 25 °C as rec.)	S22-Jl0034419	NCP	pH Units	6.3	6.3	<1	30%	Pass	
Resistivity*	S22-Jl0034419	NCP	ohm.m	530	470	13	30%	Pass	
Sulphate (as SO4)	S22-Jl0032583	CP	mg/kg	< 10	< 10	<1	30%	Pass	
% Moisture	S22-Jl0032341	NCP	%	17	16	3.4	30%	Pass	

Comments

Sample Integrity

Custody Seals Intact (if used)	N/A
Attempt to Chill was evident	Yes
Sample correctly preserved	Yes
Appropriate sample containers have been used	Yes
Sample containers for volatile analysis received with minimal headspace	Yes
Samples received within HoldingTime	Yes
Some samples have been subcontracted	No

Authorised by:

Quinn Raw	Analytical Services Manager
Ryan Phillips	Senior Analyst-Inorganic

Glenn Jackson
General Manager

Final Report – this report replaces any previously issued Report

- Indicates Not Requested

* Indicates NATA accreditation does not cover the performance of this service

Measurement uncertainty of test data is available on request or please click here.