REPORT TO

NSW HEALTH INFRASTRUCTRE

ON

GEOTECHNICAL INVESTIGATION

FOR

PROPOSED RURAL AMBULUANCE INFRASTRUCTURE (RAIR2)

AT

771 CUDGEN ROAD, KINGSCLIFF, NSW

Date: 7 March 2022
Ref: 34304URFrpt

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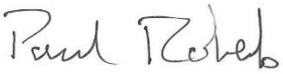

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Principal Associate | Engineering Geologist

For and on behalf of
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DOCUMENT REVISION RECORD

Report Reference	Report Status	Report Date
34304URFrpt	Final Report	7 March 2022

Table of Contents

ATTACHMENTS

1 INTRODUCTION

This report presents the results of a geotechnical investigation for the proposed rural ambulance infrastructure (RAIR2) at 771 Cudgen Road, Kingscliff. NSW. The location of the site is shown in Figure 1. The investigation was commissioned by Health Infrastructure and was carried out in accordance with our fee proposal, Ref: P55612URF, dated 7 December 2021.

We understand from correspondence with Mace Group that it is proposed to:

- Construct a one to two storey building at the eastern end of the site. We expect relatively light structural loads for a building of this type.
- Over the remainder of the site construct external on-grade pavements and car parking areas. Given the slope of the site, we expect that cut and fill earthworks will be required, although the extent of these are unknown at the time of writing this report.

The purpose of the investigation was to obtain geotechnical information on the subsurface conditions, and to use this as a basis for providing comments and recommendations on site classification, excavation conditions, footings, earthquake design classification, subgrade preparation and engineered fill.

2 INVESTIGATION PROCEDURE

The fieldwork for the investigation was carried out on 3 and 4 February 2022 by Pacific Geotech (PG) who were engaged by JK Geotechnics and comprised eleven boreholes drilled with a track mounted Hanjin drilling rig. The exception was BH4 which was drilled using handheld equipment due to access constraints for a drill rig due to existing trees. The boreholes were drilled to termination depths between 3.0m and 8.0m below existing surface levels using spiral auger techniques and a Tungsten Carbide ('TC') bit, except for BH4 which was drilled using a hand auger.

The borehole locations are shown on the attached Figure 2, and were set out by a registered surveyor at the locations nominated by the client. The surface reduced levels (RLs) shown on the attached logs were provided by the registered surveyor. The height datum used is the Australian Height Datum (AHD).

The strength of the residual clay soils were assessed from Standard Penetration Test (SPT) 'N' values augmented by hand penetrometer tests on the SPT split tube samples of clayey soils. Groundwater observations were made in the boreholes during and on completion of drilling. No further groundwater monitoring was carried out.

For more details of the investigation procedures and their limitations, reference should be made to the notes contained in the PG 'Notes Relating to this Report' presented in Appendix A.

The fieldwork was completed in the full-time presence of a PG geotechnical engineer who set out the borehole locations, nominated the testing and sampling, logged the encountered subsurface profile and

nominated in-situ testing and sampling. The borehole logs (which include field test results and groundwater observations) are attached in Appendix A, together with a glossary of logging terms and symbols used.

Selected samples were returned to the tested by PG laboratory for Standard compaction and four day soaked CBR, Atterberg limits, and linear shrinkage testing. The results are summarised in the attached PG test reports. Selected samples were also sent to an alternative NATA accredited analytical laboratory (Eurofins Environment Testing) for soil pH, sulphate, chloride and resistivity testing. The results are summarised in the attached Eurofins Certificate of Analysis No. 863199-S.

3 RESULTS OF INVESTIGATION

3.1 Site Description

The site is located in gently undulating topography with a general slope down towards the north and north-west. The site itself slopes down towards the north and north-west at up to 9°. The subject site forms the eastern portion of a larger site associated with the proposed Tweed Valley Hospital.

The site is roughly triangular in shape and has an eastern frontage onto Turnock Street. The site is also bounded by a service road to the south-east. Dense bushland was present to the north of the subject site.

At the time of the investigation, the site was generally vacant consisting of grassed areas with small to large trees. A large pile of rocks was present at the northern extent of the subject area. A temporary on-grade car park associated with construction of the Tweed Valley Hospital was present over a portion of the western side of the site. The asphaltic concrete paved car park generally appeared in good condition. A block retaining wall up to approximately 1.5m height formed the eastern site boundary supporting Turnock Street and appeared in moderate condition based upon a cursory inspection.

3.2 Subsurface Conditions

The 1:250,000 Geological Map of Tweed Heads indicates the site to be approximately at the boundary of Quaternary age alluvial soils and the Tertiary age Lamington Volcanics mainly comprising basalt with andesite, rhyolite, tuff, agglomerate and conglomerate. Based on our interpretation of the results of the investigation, we have assessed the encountered natural soils to comprise residual soils derived from the Lamington Volcanics.

The boreholes disclosed a subsurface profile generally comprising fill and topsoil overlying residual clays with occasional sand and gravel bands. No bedrock and groundwater was encountered over the depth of the investigation. Reference should be made to the attached borehole logs for detailed subsurface descriptions at specific locations. A summary of the subsoil conditions, as encountered, is presented below:

Pavement and Fill

An asphaltic concrete pavement was encountered in BH9 only and was approximately 20mm thick.

Fill was only encountered in BH10 and BH11 extending to approximately 0.5m and 1.4m depth below existing surface level, respectively. We consider the fill is likely associated with the construction of the service road and temporary car park for the adjoining works at the proposed Tweed Valley Hospital. The fill comprised gravelly clay assessed to be of medium plasticity.

Residual Clays

Residual clay was encountered below the pavement and fill in BH9 and BH10 and from the surface in the remaining boreholes. We consider the upper 0.4m to 0.5m depth is likely considered to be 'topsoil', although the extent of the root zone was difficult to quantify. The clays were assessed to be of medium to high plasticity and stiff to hard strength. The moisture content of the clays were generally greater than the plastic limit. The clays contained varying amounts of fine to medium grained sand. In BH1 an approximately 1m thick layer of sand and gravelly sand was encountered at 3.1m depth and was assessed to be of medium dense to dense relative density.

Groundwater

No groundwater was encountered during drilling or up to 18 hours after completion of drilling. No longer term groundwater monitoring has been undertaken.

3.3 Laboratory Test Results

Based on the Atterberg Limits and Linear Shrinkage determinations, the residual silty clays were confirmed to be of medium plasticity and have a moderate potential for shrink/swell movements with changes in moisture content.

The four day soaked CBR tests on samples of the medium plasticity clay from BH7, BH8 and BH10 returned values of 5%, 3.5% and 7%, respectively, when compacted to 100% of their Standard Maximum Dry Density (SMDD) and surcharged with 4.5kg. During soaking, the BH4 sample swelled by 0.5%, further confirming the high reactive potential, and potential for softening upon wetting.

The following table summarises the results from Eurofins Environment Testing. Reference should be made to the attached Certificate of Analysis No. 863199-S for further details.

Sample	Soil Type	pH	Chloride mg/kg	Sulphate mg/kg	Resistivity ohm.cm
BH1: 1.5-1.95m	Silty CLAY	6.0	14	<30	33,000
BH3: 0.5-1.0m	Silty CLAY	8.0	7.7	60	20,000
BH6: 3.0-3.45m	Silty CLAY	5.6	12	31	35,000

4 COMMENTS AND RECOMMENDATIONS

4.1 Site Preparation

Prior to any excavation commencing we recommend that reference be made to the NSW Government "Code of Practice Excavation Work" dated January 2020.

Site preparation is expected to comprise removal of trees and stripping of topsoil and/or root affected soils. We also expect at least partial removal of the existing temporary car park will be required for the proposed pavement.

Following the above site preparation, in areas where no excavation is required, any obvious deleterious or contaminated existing fill not disclosed by this investigation should be removed. These stripped materials should be taken offsite as they are not suitable for re-use as engineered fill. However, from a geotechnical perspective, existing gravelly car park pavement materials may be re-used as select fill provided it is separately stockpiled. The topsoil and/or root affected soils may also be separately stockpiled and used for subsequent landscaping purpose, or appropriately disposed of. If the depth of topsoil is critical, then we recommend test pits are excavated to confirm the topsoil thickness. We recommend test pits in lieu of boreholes as test pits allow a visual inspection of the soil compared to boreholes which is assessed from the drill spoil and SPT samples.

Tree root systems dry out the surrounding clayey soils and their removal will result in localised moisture recovery leading to swelling which may have a detrimental impact on the performance of proposed nearby buildings and paved surfaces founded/supported in the clayey soil profile within the site. Therefore, trees should only be removed where absolutely necessary and as soon as practicable, in order for the moisture content of the clayey subsoils to recover; ideally this would be years in advance of construction though we understand this is usually not practical.

Due to the existing site slope, we expect that cut and fill earthworks will be required to achieve design surface levels, although the extent is unknown at the time of writing this report. The soil materials should be readily excavated using the buckets of conventional earthmoving equipment, such as hydraulic excavators.

Temporary batter slopes of 1 Vertical (V) in 1 Horizontal (H) through the clay soils, and any limited thickness sandy materials are generally considered to be appropriate. Some instability of temporary sand batters may occur after rain periods and sand bagging may be required to stabilise the batter slopes at, and below, the level of any groundwater seepage.

The existing retaining wall along the eastern boundary appears in moderate condition. Notwithstanding, we recommend the structural engineer inspect the wall and advise on the need and extent of any required retaining wall remediation/reconstruction. Test pits may need to be excavated in an attempt to confirm the footing details and foundation materials. The test pits would need to be jointly inspected by the structural and geotechnical engineers.

4.2 Footing Design

Due to the presence of fill greater than 0.4m thickness in BH10 and BH11 and the possibility of abnormal moisture conditions due to existing pavements and trees, we consider that the site classifies as Class 'P' in accordance with AS2870-2011 'Residential Slabs and Footings'.

If the footings are designed to be founded on the natural clay soils, consideration must still be given to the potential for reactive movements of the residual clays with changes in moisture content. In our opinion, any new footings must be designed on the assumption that shrink-swell movements of the clays similar to Class 'H1' type movements will occur assuming that trees will be removed and filling will occur.

We note that in the strictest sense AS2870 does not apply to development such as this, however it provides a useful guide for footing design on reactive clay sites. Reference may also be made to AS2870 for design, construction, performance criteria and maintenance precautions on reactive clay sites. Once further details of the proposed development are known, including the extent of earthworks, then the reactivity of the clay soils must be checked to confirm Class 'H1' conditions are applicable, or revise as necessary.

Based on the results of the investigation, we expect natural clay of at least stiff strength or better to be present. As such, given the assumed relatively low loads, we consider that high level footings founded on the natural clay to be suitable. If filling occurs, then high level footings founded on engineered fill or piled footings founded on the clay below the fill may be adopted.

Stiffened rafts, strip or pad footings may be designed for an Allowable Bearing Pressure (ABP) of 150kPa when bearing on natural clays of at least stiff strength or 100kPa when bearing on engineered fill, provided it is placed under Level 1 supervision as defined in AS3798. Subgrade preparation and engineered fill recommendations below stiffened raft slabs are provided in Section 4.5 below.

The designer should also note that there are some trees within or in close proximity to the footprint of the proposed building and that these will affect the performance of footings on clay soils. We reiterate the warnings in Section 4.1 above regarding removal of trees and the potential impacts on soil moisture contents and reactive movements.

If higher bearing pressures are required, then consideration can be given to piles uniformly founded within the natural clay. For piles socketed a minimum five times the pile diameter into the natural clay of at least stiff strength may be designed based upon an allowable end bearing pressure of 300kPa. An allowable shaft adhesion of 15kPa may be adopted. Where piles are adopted, the effect of the shrink-swell potential of the soils must still be considered and we therefore recommend the use of void formers of at least 50mm thickness below the slab and beams to accommodate the potential shrink-swell reactivity of the clayey subgrade. Further advice in this regard can be provided once details of the footing system and site earthworks (cut and fill) are known.

In accordance with Table 6.4.2(C) of AS2159-2009 '*Piling – Design and Installation'*, the site is underlain by soils above groundwater and therefore 'Soil Conditions B' are warranted. Based on the aggressivity testing, the site has a 'Non-aggressive' exposure classification for concrete piles. For steel piles and in accordance with Table 6.5.2 (c), the exposure classification for the soils tested is 'Non-aggressive'.

At least the initial stages of footing excavation should be inspected by a geotechnical engineer to ascertain that the recommended founding material has been reached and to check initial assumptions about foundation conditions and possible variations that may occur between borehole locations. The need for further inspections can be assessed following the initial visit. Footings must be dry and free of any loose or water softened materials prior to pouring concrete. As the clayey soils are reactive and will deteriorate if exposed to moisture, if there is any delay in pouring footing then following geotechnical inspection, consideration should be given to protecting the base of the footing excavation with a blinding layer of concrete. If no blinding later is provided any water and/or water softened material must be removed prior to pouring the concrete.

4.3 Retaining Walls

For any cantilevered gravity type retaining walls supporting soil materials (if required and assuming they are set-back sufficient distance from the site boundaries), we recommend that walls can be designed on the basis of an 'active' earth pressure co-efficient (K_a) of 0.35 where some wall movements are tolerable and assuming a horizontal backfill surface. If retaining walls are temporarily propped, backfilled and permanently supported by the structure then an 'at rest' earth pressure co-efficient (K_o) of 0.55 should be adopted. A bulk unit weight of 20kN/m^3 should be adopted for the soil profile. Surcharge loads (e.g. nearby footings, compaction stresses, sloping retained surfaces, construction loads etc) should be allowed for in the design using the appropriate above earth pressure coefficient. The retaining walls should be designed as drained, otherwise hydrostatic pressures would be in addition to the above earth pressures.

Any backfill behind retaining walls should comprise engineered fill in order to reduce post construction settlements. We note that compaction of engineered fill behind retaining walls is very difficult and time consuming to carry out effectively, and it is inevitable that even with good quality control and compaction that some post construction settlements will occur. Post construction settlements can cause adverse impacts on paving, landscaped retaining walls or other structures and services founded on or within the backfill. If potential post construction settlements are deemed problematic by the designers, then we recommend that further geotechnical advice be obtained . However, due to the limited space that may be available behind the walls, our preference for backfill behind retaining walls is to backfill using a single sized durable gravel, such as 'blue metal' or crushed concrete gravel (free of fines). These granular materials do not require significant compactive effort and provide better long term performance in regard to settlement than soil materials. A non-woven geotextile filter fabric should be placed over the cut faces prior to backfilling and then over the top surface of the gravel in order to reduce subsoil erosion. A clay capping layer should be provided above the free draining backfill material to reduce the likelihood of surface water entering the backfill and surcharging the retaining walls.

4.4 Earthquake Design Classification

Based upon AS1170.4-2007 "Structural Design Actions, Part 4: Earthquake Actions in Australia", the following design parameters may be adopted:

- Hazard Factor (Z) = 0.08;
- Class C_e – Shallow soil site.

4.5 Subgrade Preparation and Engineered Fill

Earthworks recommendations provided in this report should be complemented by reference to AS3798.Subgrade Preparation

4.5.1 Subgrade Preparation

If the floor slabs are proposed to be fully suspended on the piled footings, then no particular subgrade preparation would be necessary other than stripping all root-affected or deleterious topsoil/fill. However, based on the reactivity of the clay soils, as discussed above, we recommend the use of void formers under the building floor slabs to separate the slab from the subgrade and suitable to accommodate at least 50mm of movement. Further advice in this regard can be provided once details of the footing system and site earthworks (cut and fill) are known.

Recommendations for subgrade preparation below stiffened raft slabs and slabs on ground are outlined below. Slab-on-ground (other than stiffened raft slabs) should also be constructed separate from the footings of the building (i.e. designed as 'floating').

1. All root affected or deleterious fill or topsoil must be removed; there may be an extensive zone of root affected soil where trees have been removed. These stripped materials should be taken off site as they are not suitable for reuse as engineered fill. Where depressions result from stripping, they may be infilled with inert well-graded granular fill such as crushed sandstone, placed and compacted in layers as engineered fill.
2. Where existing uncontrolled fill is present and the proposed building will be formed over areas of existing fill, then the existing fill must be excavated to the natural subgrade. We recommend the excavation of the fill extend at least 1m beyond the building footprint.
3. Following the above, the entire subgrade should be proof rolled with at least 6 passes of an at least 8 tonne roller tonne smooth drum roller used in static or non-vibratory mode of operation. The purpose of the proof rolling is to detect any soft or heaving areas.
4. The final pass of proof rolling should be undertaken in the presence of an experienced geotechnician or geotechnical engineer, to detect any unstable or soft subgrade areas, and to allow for some further improvement in strength/compaction. Care should be taken not to over-compact clayey subgrade areas.
5. If dry conditions prevail at the time of construction the clay subgrade may become desiccated or have shrinkage cracks prior to pouring any concrete slabs. If this occurs then the subgrade must be

watered and rolled until the cracks disappear. This should be completed immediately prior to pouring concrete.

6. Unstable subgrade detected during proof rolling should be locally excavated down to a stiff or sound base and replaced with engineered fill or further advice should be sought. Any fill placed to raise site levels should also be engineered fill. From the borehole results we expect few, if any, unstable subgrade areas to occur provided good site drainage is maintained and the earthworks are carried out during good weather.

4.5.2 Engineered Fill

Any fill used to backfill unstable subgrade areas, raise surface levels or backfill service trenches should be engineered fill. Materials preferred for use as engineered fill are well-graded granular materials, such as crushed sandstone, free of deleterious substances and having a maximum particle size not exceeding 75mm. Such fill should be compacted in horizontal layers not greater than 200mm loose thickness, to a minimum density of 98% of Standard Maximum Dry Density (SMDD). For backfilling confined excavations such as service trenches, a similar compaction to engineered fill should be adhered to, but if light compaction equipment is used then the layer thickness should be limited to 100mm loose thickness and with a reduced maximum particle size of 40mm for the engineered fill.

From a geotechnical perspective, the existing fill and residual clays at the site may be acceptable for re-use as engineered fill on condition that the soils used are clean (i.e. free of organics and inclusions greater than 75mm size (or 40mm size, as necessary), and free of contaminants. These clayey soils should be compacted in maximum 200mm loose layers to a density strictly between 98% and 102% of SMDD and at moisture content within 2% of their Standard Optimum Moisture Content (SOMC). All clay fill should preferably be used in the lower fill layers. Consideration must also be made by the building designer of the greater reactive potential of new fills comprising reactive clays as opposed to existing clayey soils, as discussed in Section 4.2 above Thus, the use of clay materials for engineered fill will entail more rigorous earthwork supervision and compaction control, time for possible moisture conditioning and hence, possibly a greater eventual cost for earthworks.

Density tests should be regularly carried out on engineered fill to confirm the above specifications are achieved. Density tests should be carried out at the frequencies outlined in AS3798 (Table 8.1) for the volume of fill involved. Within the proposed building footprint and particularly if the engineered fill will be supporting structural loads, then the fill must be placed under Level 1 supervision, as defined in AS3798-2007. Areas where engineered fill will not be supporting structural loads, then a reduced Level 2 control of fill compaction may be adopted. Any areas of insufficient compaction will require reworking and retesting to confirm the required specification has been achieved. Preferably, the geotechnical testing authority (GTA) should be engaged directly on behalf of the client and not by the earthworks subcontractor.

4.5.3 Drainage During Construction

The subgrade will comprise clay soils. The clays may be found to be unstable if proper site drainage is not implemented during construction. It is therefore important to provide good drainage in order to promote run-off and reduce ponding. Earthworks platforms should be graded to maintain cross-falls during construction. If the clays are exposed to periods of rainfall, softening may result and site trafficability will be poor. If softening occurs, the subgrade should be over-excavated to below the depth of moisture softening. The material removed should be replaced with engineered fill. Such work would likely cause delays to the earthworks program. Trafficability may be improved by the use of a sacrificial surface layer of crushed demolition rubble.

4.6 Pavement Design Parameters

The design of new pavements will depend on subgrade preparation, subgrade drainage, the nature and composition of fill excavated or imported to the site, as well as vehicle loadings and use. Various alternative types of construction could be used for the pavements. Concrete construction would undoubtedly be the best in areas where heavy vehicles maneuver. Flexible pavements may have a lower initial cost but maintenance will be higher. These factors should be considered when making the final choice. We recommend that reference also be made to AS2870 for drainage and vegetation precautions on reactive clay sites. We recommend the pavements are designed based on a CBR value of 3.5% or an estimated subgrade reaction modulus (for concrete slabs or pavements) of 25kPa/mm (750mm diameter plate).

Alternatively, if higher CBR values are required, then consideration could be given to providing an appropriate select fill layer as part of the overall pavement thickness. The select fill should be well graded crushed sandstone or good quality sandstone with a minimum soaked CBR value of 10%. The pavement sections where imported fill is used to raise site levels may be designed taking into account the thickness and soaked CBR value of the imported fill material.

Concrete pavements should have a sub-base layer of at least 100mm thickness of crushed rock to the latest revision of Transport for NSW QA specification 3051 (2010 unbound base material (or equivalent good quality and durable fine crushed rock) which is compacted using a heavy roller to at least 98% of Modified Maximum Dry Density (MMDD). Adequate moisture conditioning to within 2% of Modified Optimum Moisture Content (MOMC) should be provided during placement so as to reduce the potential for material breakdown during compaction. Concrete pavements should be designed with an effective shear transmission of all joints by way of either doweled or keyed joints. If flexible pavements are proposed then the base and sub-base materials must also comply with the above Transport for NSW QA specification 3051.

Careful attention to subsurface and surface drainage is required in view of the effect of moisture on the clay subgrade. The surface of the pavement and the subgrade should be sloped to shed water, and adequate subsurface drainage should be installed around the pavement to intercept and dispose of water flows. The drainage trenches should be excavated with a longitudinal fall to appropriate discharge points so as to reduce the risk of water ponding. The subsoil drainage should extend at least 0.3m below the subgrade levels.

The pavement sections where imported fill is used to raise site levels, by at least 0.5m may be designed on the basis of a four-day soaked CBR value of the imported fill material, as noted above.

4.7 Further Geotechnical Input

The following is a summary of the further geotechnical input which is required and which has been detailed in the preceding sections of this report:

- Confirmation of site classification once structural design and earthworks are known.
- Inspect test pits exposing footings of the eastern boundary retaining wall.
- Footing inspections.
- Proof rolling of subgrade
- Density tests of engineered fill and/or pavement construction materials.

5 GENERAL COMMENTS

The recommendations presented in this report include specific issues to be addressed during the construction phase of the project. In the event that any of the construction phase recommendations presented in this report are not implemented, the general recommendations may become inapplicable and JK Geotechnics accept no responsibility whatsoever for the performance of the structure where recommendations are not implemented in full and properly tested, inspected and documented.

The long term successful performance of floor slabs and pavements is dependent on the satisfactory completion of the earthworks. In order to achieve this, the quality assurance program should not be limited to routine compaction density testing only. Other critical factors associated with the earthworks may include subgrade preparation, selection of fill materials, control of moisture content and drainage, etc. The satisfactory control and assessment of these items may require judgment from an experienced engineer. Such judgment often cannot be made by a technician who may not have formal engineering qualifications and experience. In order to identify potential problems, we recommend that a pre-construction meeting be held so that all parties involved understand the earthworks requirements and potential difficulties. This meeting should clearly define the lines of communication and responsibility.

Occasionally, the subsurface conditions between and below the completed boreholes may be found to be different (or may be interpreted to be different) from those expected. Variation can also occur with groundwater conditions, especially after climatic changes. If such differences appear to exist, we recommend that you immediately contact this office.

This report provides advice on geotechnical aspects for the proposed civil and structural design. As part of the documentation stage of this project, Contract Documents and Specifications may be prepared based on our report. However, there may be design features we are not aware of or have not commented on for a variety of reasons. The designers should satisfy themselves that all the necessary advice has been obtained.

If required, we could be commissioned to review the geotechnical aspects of contract documents to confirm the intent of our recommendations has been correctly implemented.

A waste classification is required for any soil and/or bedrock excavated from the site prior to offsite disposal. Subject to the appropriate testing, material can be classified as Virgin Excavated Natural Material (VENM), Excavated Natural Material (ENM), General Solid, Restricted Solid or Hazardous Waste. Analysis can take up to seven to ten working days to complete, therefore, an adequate allowance should be included in the construction program unless testing is completed prior to construction. If contamination is encountered, then substantial further testing (and associated delays) could be expected. We strongly recommend that this requirement is addressed prior to the commencement of excavation on site.

This report has been prepared for the particular project described and no responsibility is accepted for the use of any part of this report in any other context or for any other purpose. If there is any change in the proposed development described in this report then all recommendations should be reviewed. Copyright in this report is the property of JK Geotechnics. We have used a degree of care, skill and diligence normally exercised by consulting engineers in similar circumstances and locality. No other warranty expressed or implied is made or intended. Subject to payment of all fees due for the investigation, the client alone shall have a licence to use this report. The report shall not be reproduced except in full.

Pacific Geotech
Consulting Geotechnical Engineers

ATTERBERG LIMITS INDEX REPORT

CLIENT:	JK Geotechnics	PROJECT NUMBER:	PG-7476
ADDRESS:	Tweed Valley Hospital, Cudgen	REPORT NUMBER:	PG-7476-ATT-01
PROJECT NAME:	Proposed Medical Facility	REPORT DATE:	17/02/2022
		TEST METHOD:	AS 1289.3.1.2

SAMPLE LOCATION:	**BH02, 1.5m**
SAMPLING METHOD:	DISTURBED
SAMPLED BY:	PACIFIC GEOTECH
DATE SAMPLED:	3/02/2022
DATE TESTED:	16/02/2022
PREPERATION METHOD:	DRY
MOISTURE METHOD:	AS 1289.2.1.1
MATERIAL TYPE:	Silty Clay (CI/CH)

MOULD LENGTH (mm):	140
LIQUID LIMIT (%):	**46.8**
PLASTIC LIMIT (%):	**24.4**
PLASTICITY INDEX (%):	**22.4**
LINEAR SHRINKAGE (%):	**9.5**
CRACKING:	yes
CURLING:	no

REMARKS:

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Consulting Geotechnical Engineers

ATTERBERG LIMITS INDEX REPORT

CLIENT:	JK Geotechnics	PROJECT NUMBER:	PG-7476
ADDRESS:	Tweed Valley Hospital, Cudgen	REPORT NUMBER:	PG-7476-ATT-02
PROJECT NAME:	Proposed Medical Facility	REPORT DATE:	25/02/2022
		TEST METHOD:	AS 1289.3.1.2

SAMPLE LOCATION:	**BH05 @ 1.5m**
SAMPLING METHOD:	DISTURBED
SAMPLED BY:	PACIFIC GEOTECH
DATE SAMPLED:	3/02/2022
DATE TESTED:	24/02/2022
PREPERATION METHOD:	DRY
MOISTURE METHOD:	AS 1289.2.1.1
MATERIAL TYPE:	Silty CLAY (CI)

MOULD LENGTH (mm):	140
LIQUID LIMIT (%):	**35.0**
PLASTIC LIMIT (%):	**25.5**
PLASTICITY INDEX (%):	**9.5**
LINEAR SHRINKAGE (%):	**2.9**
CRACKING:	yes
CURLING:	no

REMARKS:

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Pacific Geotech
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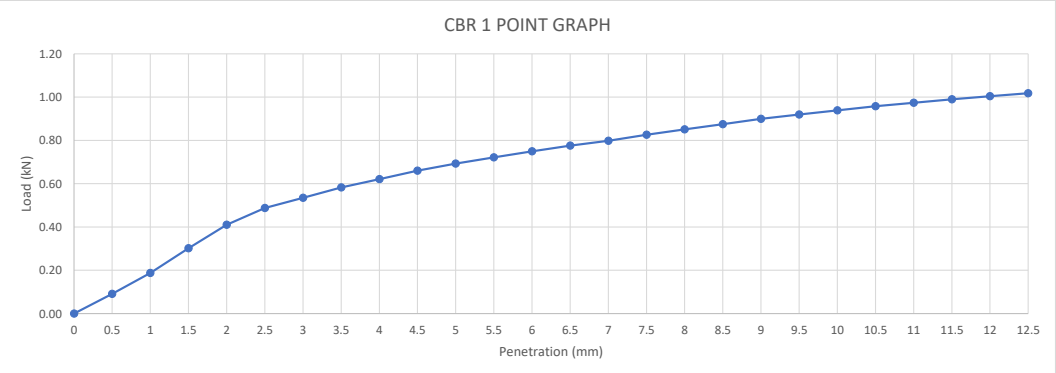
CALIFORNIA BEARING RATIO REPORT (1 POINT)			
CLIENT:	JK Geotechnics	PROJECT NUMBER:	PG-7476
ADDRESS:	Tweed Valley Hospital, 771 Cudgen Road, Cudgen	REPORT NUMBER:	PG-7476-CBR-01
PROJECT NAME:	Proposed Medical Facility	REPORT DATE:	17/02/2022
		TEST METHOD:	AS 1289.6.1.1

SAMPLE LOCATION:	BH08, 0.5m-1.5m
SAMPLING METHOD:	DISTURBED
SAMPLED BY:	PACIFIC GEOTECH
DATE SAMPLED:	3/02/2022
DATE TESTED:	14/02/2022
PREPERATION METHOD:	AS 1289.1.1
MOISTURE METHOD:	AS 1289.2.1.1
MATERIAL TYPE:	CLAY

MAXIMUM DRY DENSITY (t/m³):	1.49
OPTIMUM MOISTURE CONTENT (%):	19.83
COMPACTIVE EFFORT:	Standard
COMPACTIVE HAMMER:	AS 1289.5.1.1
LABORATORY DENSITY RATIO:	100
LABORATORY MOISTURE RATIO:	100
DRY DENSITY BEFORE SOAK (t/m³):	1.49
DRY DENSITY AFTER SOAK (t/m³):	1.43
MOISTURE CONTENT BEFORE SOAK (%):	19.8
MOISTURE CONTENT OF TOP 30mm AFTER PENETRATION (%):	27.5
MOISTURE CONTENT REST OF SAMPLE AFTER PENETRATION (%):	23.7
SWELL (%):	0
CBR SURCHARGE (kg):	4.5
SOAK PERIOD (days):	4
CURING HOURS:	24
OVERSIZE MATERIAL (%):	0
CBR 2.5mm (%):	3.5
CBR 5 mm (%):	3.5
CBR VALUE (%):	**3.5**



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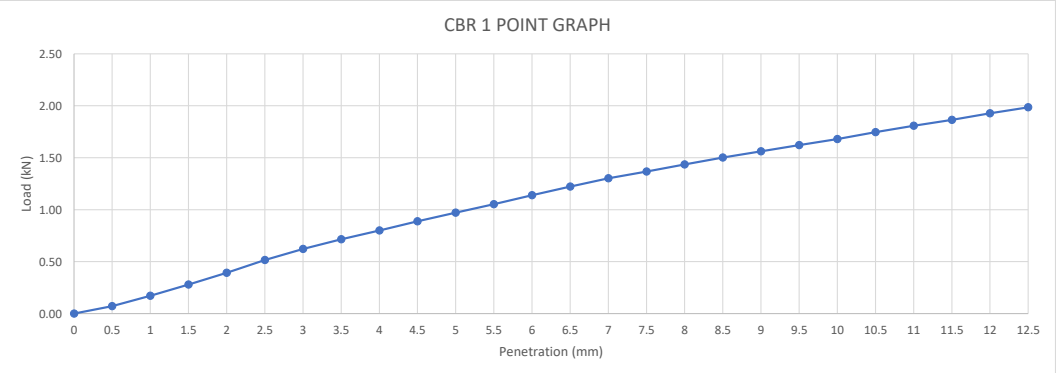
ABN: 62 615 248 952

Pacific Geotech
Consulting Geotechnical Engineers

CALIFORNIA BEARING RATIO REPORT (1 POINT)			
CLIENT:	JK Geotechnics	PROJECT NUMBER:	PG-7476
ADDRESS:	Tweed Valley Hospital, 771 Cudgen Road, Cudgen	REPORT NUMBER:	PG-7476-CBR-02
PROJECT NAME:	Proposed Medical Facility	REPORT DATE:	17/02/2022
		TEST METHOD:	AS 1289.6.1.1

SAMPLE LOCATION:	BH07, 0.5m-1.5m
SAMPLING METHOD:	DISTURBED
SAMPLED BY:	PACIFIC GEOTECH
DATE SAMPLED:	3/02/2022
DATE TESTED:	14/02/2022
PREPERATION METHOD:	AS 1289.1.1
MOISTURE METHOD:	AS 1289.2.1.1
MATERIAL TYPE:	Sandy CLAY

MAXIMUM DRY DENSITY (t/m³):	1.48
OPTIMUM MOISTURE CONTENT (%):	19.93
COMPACTIVE EFFORT:	Standard
COMPACTIVE HAMMER:	AS 1289.5.1.1
LABORATORY DENSITY RATIO:	100
LABORATORY MOISTURE RATIO:	100
DRY DENSITY BEFORE SOAK (t/m³):	1.48
DRY DENSITY AFTER SOAK (t/m³):	1.46
MOISTURE CONTENT BEFORE SOAK (%):	19.9
MOISTURE CONTENT OF TOP 30mm AFTER PENETRATION (%):	23.6
MOISTURE CONTENT REST OF SAMPLE AFTER PENETRATION (%):	23.9
SWELL (%):	0
CBR SURCHARGE (kg):	4.5
SOAK PERIOD (days):	4
CURING HOURS:	24
OVERSIZE MATERIAL (%):	0
CBR 2.5mm (%):	4.0
CBR 5 mm (%):	5.0
CBR VALUE (%):	**5.0**



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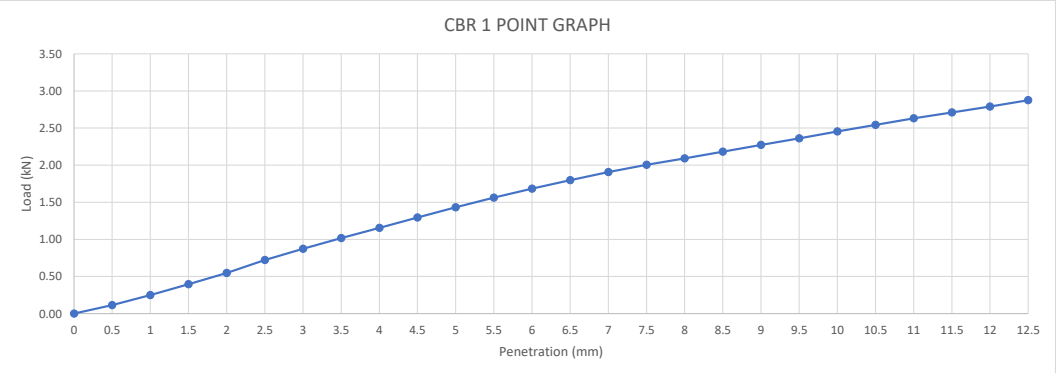
Pacific Geotech
Consulting Geotechnical Engineers

CALIFORNIA BEARING RATIO REPORT (1 POINT)			
CLIENT:	JK Geotechnics	PROJECT NUMBER:	PG-7476
ADDRESS:	Tweed Valley Hospital, 771 Cudgen Road, Cudgen	REPORT NUMBER:	PG-7476-CBR-03
PROJECT NAME:	Proposed Medical Facility	REPORT DATE:	17/02/2022
		TEST METHOD:	AS 1289.6.1.1

SAMPLE LOCATION:	BH10, 0.5m-1.0m
SAMPLING METHOD:	DISTURBED
SAMPLED BY:	PACIFIC GEOTECH
DATE SAMPLED:	3/02/2022
DATE TESTED:	14/02/2022
PREPERATION METHOD:	AS 1289.1.1
MOISTURE METHOD:	AS 1289.2.1.1
MATERIAL TYPE:	Sandy CLAY

MAXIMUM DRY DENSITY (t/m³):	1.52
OPTIMUM MOISTURE CONTENT (%):	19.45
COMPACTIVE EFFORT:	Standard
COMPACTIVE HAMMER:	AS 1289.5.1.1
LABORATORY DENSITY RATIO:	100
LABORATORY MOISTURE RATIO:	100
DRY DENSITY BEFORE SOAK (t/m³):	1.52
DRY DENSITY AFTER SOAK (t/m³):	1.49
MOISTURE CONTENT BEFORE SOAK (%):	19.4
MOISTURE CONTENT OF TOP 30mm AFTER PENETRATION (%):	22.9
MOISTURE CONTENT REST OF SAMPLE AFTER PENETRATION (%):	19.6
SWELL (%):	0.5
CBR SURCHARGE (kg):	4.5
SOAK PERIOD (days):	4
CURING HOURS:	24
OVERSIZE MATERIAL (%):	0
CBR 2.5mm (%):	5.0
CBR 5 mm (%):	7.0
CBR VALUE (%):	**7.0**



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Pacific Geotech Pty Ltd
47 Brisbane Road
Biggera Waters
QLD 4216

NATA Accredited
Accreditation Number 1261
Site Number 1254

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: **Ben Elsmore**

Report **863199-S**
Project name PROPOSED MEDICAL FACILITY
Project ID PG-7476
Received Date Feb 11, 2022

Client Sample ID			**BH01 - 1.5M**	**BH03 - 0.5-1.5M**	**BH06 - 3.0M**
Sample Matrix			**Soil**	**Soil**	**Soil**
Eurofins Sample No.			**B22-Fe25779**	**B22-Fe25780**	**B22-Fe25781**
Date Sampled			**Feb 09, 2022**	**Feb 09, 2022**	**Feb 09, 2022**
Test/Reference	LOR	Unit			
Chloride	5	mg/kg	14	7.7	12
Conductivity (1:5 aqueous extract at 25°C as rec.)	10	uS/cm	30	49	29
pH (1:5 Aqueous extract at 25°C as rec.)	0.1	pH Units	6.0	8.0	5.6
Resistivity*	0.5	ohm.m	330	200	350
Sulphate (as SO4)	30	mg/kg	< 30	60	31
% Moisture	1	%	28	27	28

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	Melbourne	Feb 17, 2022	28 Days
- Method: LTM-INO-4090 Chloride by Discrete Analyser			
Conductivity (1:5 aqueous extract at 25°C as rec.)	Melbourne	Feb 17, 2022	7 Days
- Method: LTM-INO-4030 Conductivity			
pH (1:5 Aqueous extract at 25°C as rec.)	Melbourne	Feb 17, 2022	7 Days
- Method: LTM-GEN-7090 pH in soil by ISE			
Sulphate (as SO4)	Melbourne	Feb 17, 2022	28 Days
- Method: LTM-INO-4110 Sulfate by Discrete Analyser			
% Moisture	Melbourne	Feb 15, 2022	14 Days
- Method: LTM-GEN-7080 Moisture			

eurofins | Environment Testing

web: www.eurofins.com.au
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Eurofins Environment Testing Australia Pty Ltd
ABN: 50 005 085 521

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6 Monterey Road
Dandenong South VIC 3175
Phone : +61 3 8564 5000
NATA # 1261 Site # 1254

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Unit F3, Building F
16 Mars Road
Lane Cove West NSW 2066
Phone : +61 2 9900 8400
NATA # 1261 Site # 18217

Brisbane
1/21 Smallwood Place
Murarrie QLD 4172
Phone : +61 7 3902 4600
NATA # 1261 Site # 20794

Newcastle
4/52 Industrial Drive
Mayfield East NSW 2304
PO Box 60 Wickham 2293
Phone : +61 2 4968 8448
NATA # 1261 Site # 25079

Eurofins ARL Pty Ltd
ABN: 91 05 0159 898

Perth
46-48 Banksia Road
Welshpool WA 6106
Phone : +61 8 6253 4444
NATA # 2377 Site # 2370

Eurofins Environment Testing NZ Limited
NZBN: 9429046024954

Auckland
35 O'Rorke Road
Penrose, Auckland 1061
Phone : +64 9 526 45 51
IANZ # 1327

Christchurch
43 Detroit Drive
Rolleston, Christchurch 7675
Phone : 0800 856 450
IANZ # 1290

Company Name: Pacific Geotech Pty Ltd
Address: 47 Brisbane Road
Biggera Waters
QLD 4216

Project Name: PROPOSED MEDICAL FACILITY
Project ID: PG-7476

Order No.: PG-7476
Report #: 863199
Phone: 07 5636 4680
Fax: 07 5636 0286

Received: Feb 11, 2022 3:40 PM
Due: Feb 18, 2022
Priority: 5 Day
Contact Name: Ben Elsmore

Eurofins Analytical Services Manager : Alana Wadsworth

Sample Detail						Chloride	Conductivity (1:5 aqueous extract at 25°C as rec.)	pH (1:5 Aqueous extract at 25°C as rec.)	Resistivity*	Sulphate (as SO4)	Moisture Set
Melbourne Laboratory - NATA # 1261 Site # 1254						X	X	X	X	X	X
Sydney Laboratory - NATA # 1261 Site # 18217											
Brisbane Laboratory - NATA # 1261 Site # 20794											
Mayfield Laboratory - NATA # 1261 Site # 25079											
Perth Laboratory - NATA # 2377 Site # 2370											
External Laboratory											
No	**Sample ID**	**Sample Date**	**Sampling Time**	**Matrix**	**LAB ID**						
1	BH01 - 1.5M	Feb 09, 2022		Soil	B22-Fe25779	X	X	X	X	X	X
2	BH03 - 0.5-1.5M	Feb 09, 2022		Soil	B22-Fe25780	X	X	X	X	X	X
3	BH06 - 3.0M	Feb 09, 2022		Soil	B22-Fe25781	X	X	X	X	X	X
Test Counts						3	3	3	3	3	3

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.

.

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	< 5			5	Pass	
Conductivity (1:5 aqueous extract at 25°C as rec.)	uS/cm	< 10			10	Pass	
Sulphate (as SO4)	mg/kg	< 30			30	Pass	
LCS - % Recovery							
Chloride	%	109			70-130	Pass	
Sulphate (as SO4)	%	113			70-130	Pass	

Test	Lab Sample ID	QA Source	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Duplicate									
				Result 1	Result 2	RPD			
Chloride	B22-Fe27180	NCP	mg/kg	5.7	< 5	40	30%	Fail	Q15
Conductivity (1:5 aqueous extract at 25°C as rec.)	B22-Fe26715	NCP	uS/cm	200	210	4.6	30%	Pass	
pH (1:5 Aqueous extract at 25°C as rec.)	B22-Fe26715	NCP	pH Units	11	11	pass	30%	Pass	
Resistivity*	B22-Fe26715	NCP	ohm.m	51	49	4.6	30%	Pass	
Sulphate (as SO4)	B22-Fe27180	NCP	mg/kg	< 30	< 30	<1	30%	Pass	
% Moisture	B22-Fe25779	CP	%	28	29	4.0	30%	Pass	

Comments

Sample Integrity

Custody Seals Intact (if used)	N/A
Attempt to Chill was evident	No
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

Qualifier Codes/Comments

Code	Description
Q15	The RPD reported passes Eurofins Environment Testing's QC - Acceptance Criteria as defined in the Internal Quality Control Review and Glossary page of this report.

Authorised by:

Alana Wadsworth	Analytical Services Manager
Scott Beddoes	Senior Analyst-Inorganic (VIC)

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.

AERIAL IMAGE SOURCE: MAPS.AU.NEARMAP.COM

This plan should be read in conjunction with the JK Geotechnics report.

Title: **SITE LOCATION PLAN**

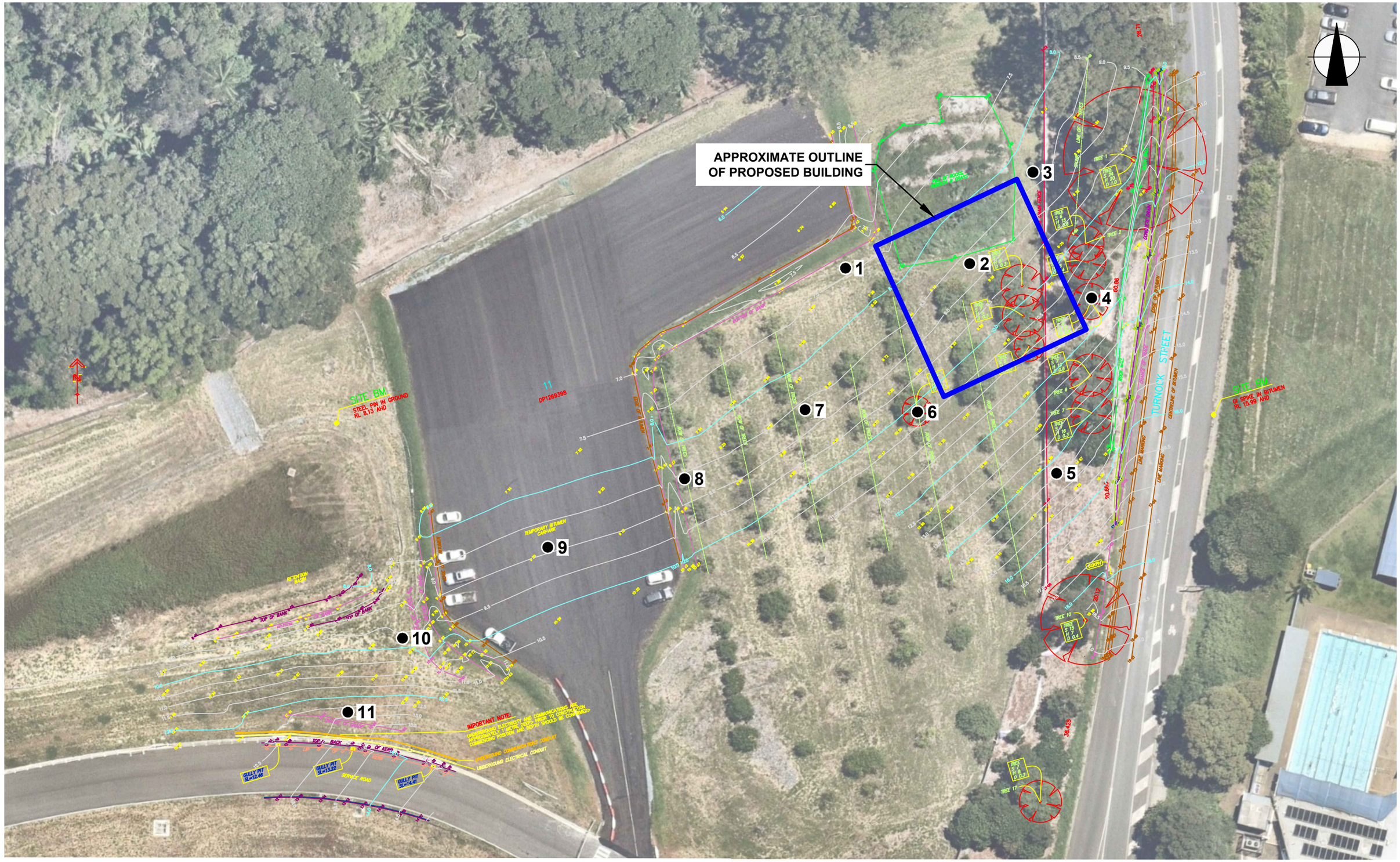
Location: CNR TURNOCK STREET & CUDGEN ROAD, KINGSCLIFF, NSW

Report No: 34304URF

Figure No: 1

JKGeotechnics

PLOT DATE: 8/03/2022 10:02:00 AM DWG FILE: S:\6 GEOTECHNICAL\6F GEOTECHNICAL JOBS\34000'S\34304URF KINGSCLIFF\CAD\NEW FOLDER\34304URF.DWG



AERIAL IMAGE SOURCE: MAPS.AU.NEARMAP.COM

0 6 12 18 24 30

SCALE 1:600 @A3 METRES

This plan should be read in conjunction with the JK Geotechnics report.

Title: **BOREHOLE LOCATION PLAN**

Location: CNR TURNOCK STREET & CUDGEN ROAD, KINGSCLIFF, NSW

Report No: 34304URF

Figure No: 2

JKGeotechnics

PLOT DATE: 8/03/2022 4:39:32 PM DWG FILE: S:\6 GEOTECHNICAL\6F GEOTECHNICAL JOBS\34000'S\34304URF KINGSCLIFF\CAD\34304URF QV\34304URF.DWG

APPENDIX A

Pacific Geotech
Consulting Geotechnical Engineers

Borehole No.
BH01
Page 1 of 1

Project No.: PG-7476

Client:	JK Geotechnics	Commenced:	03/02/2022
Project Name:	Proposed Drilling Works	Logged By:	TE
Hole Location:	Tweed Valley Hospital, Cudgen	Checked By:	
Hole Position:	555911.6 m E 6873662.0 m N MGA94 Zone 56		
Drill Model and Mounting:	Orange Hanjin	RL Surface:	7.52 m
Hole Diameter:		Datum:	AHD Operator: TE

Drilling Information								Soil Description		
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional
AD/T					7.52	0.00		CH	NATURAL Silty CLAY (CH) Stiff, medium plasticity, brown, with fine to medium grained sand, w>pl.
						0.50		CH	Silty CLAY (CH) Very stiff, medium plasticity, brown, with fine to medium grained sand, w>pl.
			SPT 1.50-1.95 m 4,7,10 N=17		6.5	1			
					5.5	2			
			SPT 3.00-3.45 m 5,9,11 N=20		4.5	3			
						3.10		SP	SAND (SP) Medium dense, fine to medium grained, pale brown, moist.
						3.60		SP	Gravelly SAND (SP) Very dense, fine to medium grained, pale grey, fine to medium sized gravel, moist.
					3.5	4			
						4.10		CH	Silty CLAY (CH) Hard, high plasticity, brown, w>pl.
			SPT 4.50-4.95 m 4,9,11 N=20						
			D 5.00-5.50 m		2.5	5			
			SPT 6.00-6.45 m 4,7,7 N=14		1.5	6			
					0.5	7			
						7.00		CI	Silty Sandy CLAY (CI) Very stiff, medium plasticity, brown, fine to medium grained sand, with fine to medium sized gravel, w>pl (water seepage).
			SPT 7.50-7.95 m 5,7,5 N=12			8.00			Hole Terminated at 8.00 m

Method
AS - Auger
RR - Rock Roller
WB - Washbore

Support
C - Casing

Water
Level (Date)
Inflow

Samples and Tests
U - Undisturbed Sample
D - Disturbed Sample
SPT - Standard Penetration Test
B - Bulk Sample

Classification Symbols and Soil Descriptions
Based on Unified Soil Classification System

Remarks
1. Groundwater not encountered.

Pacific Geotech
Consulting Geotechnical Engineers

Borehole No.
BH02
Page 1 of 1

Project No.: PG-7476

Client:	JK Geotechnics	Commenced:	03/02/2022
Project Name:	Proposed Drilling Works	Logged By:	TE
Hole Location:	Tweed Valley Hospital, Cudgen	Checked By:	
Hole Position:	555936.0 m E 6873668.2 m N MGA94 Zone 56		
Drill Model and Mounting:	Orange Hanjin	RL Surface:	8.29 m
Hole Diameter:		Datum:	AHD Operator: TE

Drilling Information							Soil Description		
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional
AD/T					8.29	0.00		CH	NATURAL Silty CLAY (CH) Stiff, medium plasticity, brown, with fine to medium sized gravel, with fine to medium grainedsand, w>pl.
						0.40		CH	Silty CLAY (CH) Very stiff, medium plasticity, brown, with fine to medium grained sand, w>pl.
			SPT 1.50-1.95 m 4,9,14 N=23		7.3	1			
					6.3	2			
			SPT 3.00-3.45 m 4,9,12 N=21		5.3	3			
					4.3	4			
			SPT 4.50-4.95 m 7,8,11 N=19		3.3	5			
			SPT 6.00-6.45 m 4,4,7 N=11		2.3	6			
					1.3	7			
			SPT 7.50-7.95 m 4,4,5 N=9			7.20		CH	Silty CLAY (CH) Stiff to very stiff, high plasticity, brown mottled pale grey, trace of fine sized gravel, with fine to medium grained sand, w>pl.
						8.00			Hole Terminated at 8.00 m

Method
AS - Auger
RR - Rock Roller
WB - Washbore

Water
Level (Date)
Inflow

Samples and Tests
U - Undisturbed Sample
D - Disturbed Sample
SPT - Standard Penetration Test
B - Bulk Sample

Remarks
1. Groundwater not encountered.

Support
C - Casing

Classification Symbols and Soil Descriptions
Based on Unified Soil Classification System

Pacific Geotech
Consulting Geotechnical Engineers

Borehole No.
BH03
Page 1 of 1

Project No.: PG-7476

Client:	JK Geotechnics	Commenced:	04/02/2022
Project Name:	Proposed Drilling Works	Logged By:	TE
Hole Location:	Tweed Valley Hospital, Cudgen	Checked By:	
Hole Position:	555943.2 m E 6873693.4 m N MGA94 Zone 56		
Drill Model and Mounting:	Orange Hanjin	RL Surface:	8.40 m
Hole Diameter:		Datum:	AHD Operator: TE

Drilling Information							Soil Description		
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional
AD/T			D 0.50-1.00 m		7.4	0.50		CH	NATURAL Silty CLAY (CH) Stiff, medium plasticity, brown, with fine to medium grained sand, w>pl.
			SPT 1.50-1.95 m 5,9,12 N=21		6.4	1		CH	Silty CLAY (CI/CH) Very stiff to hard, medium to high plasticity, brown, with fine to medium grained sand, w>pl.
			SPT 3.00-3.45 m 6,12,16 N=28		5.4	2			
			SPT 4.50-4.95 m 8,11,10 N=21		4.4	3			
					3.4	4			
						4.70		CI	Silty CLAY (CI) Hard, medium plasticity, brown mottled pale grey, with fine to medium grained sand, w>pl.
			SPT 6.00-6.45 m 6,11,21 N=32		2.4	5		CH	Silty CLAY (CH) Very stiff, high plasticity, brown, with fine grained sand, w>pl.
					1.4	6			
			SPT 7.50-7.95 m 4,4,2 N=6			7			
						7.40		CH	Silty CLAY (CH) Firm to stiff, high plasticity, pale grey blue, with fine to medium grained sand, w=ll.
						8.00			Hole Terminated at 8.00 m

Method
AS - Auger
RR - Rock Roller
WB - Washbore

Water
Level (Date)
Inflow

Samples and Tests
U - Undisturbed Sample
D - Disturbed Sample
SPT - Standard Penetration Test
B - Bulk Sample

Support
C - Casing

Classification Symbols and Soil Descriptions
Based on Unified Soil Classification System

Remarks
1. Groundwater not encountered.

Pacific Geotech
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Borehole No.
BH04
Page 1 of 1

Project No.: PG-7476

Client:	JK Geotechnics	Commenced:	03/02/2022
Project Name:	Proposed Drilling Works	Logged By:	TE
Hole Location:	Tweed Valley Hospital, Cudgen	Checked By:	
Hole Position:	555956.7 m E 6873664.7m N MGA94 Zone 56		
Drill Model and Mounting:	Hand Auger	RL Surface:	11.16 m
Hole Diameter:		Datum:	AHD Operator: TE

Drilling Information								***Soil Description***	
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional
AD/T			D 0.50-1.50 m	10.2		0.40		CH	NATURAL Silty CLAY (CH) Stiff, medium plasticity, brown, with fine to medium grained sand, w>pl.
			D 2.00-2.50 m	9.2		1		CH	Silty CLAY (CH) Very stiff, medium plasticity, brown, with fine to medium grained sand, w>pl.
					8.2	2			
						3.00			Hole Terminated at 3.00 m
						3			
						4			
						5			
						6			
						7			

Method
AS - Auger
RR - Rock Roller
WB - Washbore

Water
Level (Date)
Inflow

Samples and Tests
U - Undisturbed Sample
D - Disturbed Sample
SPT - Standard Penetration Test
B - Bulk Sample

Remarks
1. Groundwater not encountered.

Support
C - Casing

Classification Symbols and Soil Descriptions
Based on Unified Soil Classification System

Pacific Geotech
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Borehole No.
BH05
Page 1 of 1

Project No.: PG-7476

Client:	JK Geotechnics	Commenced:	04/02/2022
Project Name:	Proposed Drilling Works	Logged By:	TE
Hole Location:	Tweed Valley Hospital, Cudgen	Checked By:	
Hole Position:	555946.7 m E 6873633.7 m N MGA94 Zone 56		
Drill Model and Mounting:	Orange Hanjin	RL Surface:	14.46 m
Hole Diameter:		Datum:	AHD Operator: TE

Drilling Information							Soil Description		
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional
AD/T			SPT 1.50-1.95 m 7,8,15 N=23		13.5	0.50		CH	NATURAL Silty CLAY (CH) Stiff, high plasticity, brown, with medium to coarse sized gravel, with fine to medium grained sand, w>pl.
					12.5	1		CH	Silty CLAY (CI) Very stiff, medium plasticity, brown, with fine to medium grained sand, w>pl.
			SPT 3.00-3.45 m 4,5,8 N=13		11.5	2			
					10.5	3			
			SPT 4.50-4.95 m 5,8,12 N=20		9.5	3.00		CH	Silty CLAY (CH) Very stiff to hard, high plasticity, mottled brown grey, with fine to medium grained sand, w>pl.
					8.5	3.80		CH	Silty CLAY (CH) Very stiff to hard, high plasticity, grey, with fine to medium grained sand, w>pl.
			SPT 6.00-6.45 m 4,4,7 N=11		7.5	4			
						5			
						5.10		CH	Silty CLAY (CH) Very stiff to hard, high plasticity, brown, with fine to medium grained sand, w>pl.
			SPT 7.50-7.95 m 4,4,5 N=9			6			
						7			
						8.00			Hole Terminated at 8.00 m

Method
AS - Auger
RR - Rock Roller
WB - Washbore

Water
Level (Date)
Inflow

Samples and Tests
U - Undisturbed Sample
D - Disturbed Sample
SPT - Standard Penetration Test
B - Bulk Sample

Remarks
1. Groundwater not encountered.

Support
C - Casing

Classification Symbols and Soil Descriptions
Based on Unified Soil Classification System

Pacific Geotech
Consulting Geotechnical Engineers

Borehole No.
BH06
Page 1 of 1

Project No.: PG-7476

Client:	JK Geotechnics	Commenced:	04/02/2022
Project Name:	Proposed Drilling Works	Logged By:	TE
Hole Location:	Tweed Valley Hospital, Cudgen	Checked By:	
Hole Position:	555903.0 m E 6873642.0 m N MGA94 Zone 56		
Drill Model and Mounting:	Orange Hanjin	RL Surface:	10.35 m
Hole Diameter:		Datum:	AHD Operator: TE

Drilling Information								Soil Description		
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional
TC						0.50		CH	NATURAL Silty CLAY (CH) Stiff, medium plasticity, brown, with fine to medium sized gravel, with fine to medium grained sand, w>pl.
					9.4	1		CH	Silty CLAY (CH) Very stiff, medium plasticity, brown, with fine to medium grained sand, w>pl.
			SPT 1.50-1.95 m 6,11,14 N=25			1.80		CH	Silty CLAY (CH) Hard, high plasticity, grey brown, with fine to medium grained sand, w>pl.
					8.4	2			
			D 2.50-3.00 m			2.20		CH	Silty CLAY (CH) Very stiff, high plasticity, brown, with fine to medium grained sand, w>pl.
			SPT 3.00-3.45 m 4,5,7 N=12		7.4	3			
						3.50		CH	Silty CLAY (CH) Stiff, high plasticity, brown, trace of fine sized gravel, with fine to medium grained sand, w>pl.
					6.4	4			
			SPT 4.50-4.95 m 4,2,2 N=4		5.4	5			
						5.40		CH	Silty CLAY (CH) Stiff, high plasticity, brown, with medium to coarse sized gravel, with fine to medium grained sand, w>pl.
			SPT 6.00-6.45 m 3,4,5 N=9		4.4	6			
			D 6.50-7.50 m			6.10		CI	Sandy CLAY (CI) Stiff, medium plasticity, mottled brown grey, fine to medium grained sand, trace of fine sized gravel, w>pl.
					3.4	7			
			SPT 7.50-7.95 m 18,11,11 N=22			7.00		CI	Sandy CLAY (CI) Very stiff to hard, medium plasticity, mottled brown grey, fine to medium grained sand, trace of fine sized gravel, w>pl.
						8.00			Hole Terminated at 8.00 m

Method
AS - Auger
RR - Rock Roller
WB - Washbore

Water
Level (Date)
Inflow

Samples and Tests
U - Undisturbed Sample
D - Disturbed Sample
SPT - Standard Penetration Test
B - Bulk Sample

Support
C - Casing

Classification Symbols and Soil Descriptions
Based on Unified Soil Classification System

Remarks
1. Groundwater not encountered.

Pacific Geotech
Consulting Geotechnical Engineers

Borehole No.
BH07
Page 1 of 1

Project No.: PG-7476

Client:	JK Geotechnics	Commenced:	03/02/2022
Project Name:	Proposed Drilling Works	Logged By:	TE
Hole Location:	Tweed Valley Hospital, Cudgen	Checked By:	
Hole Position:	555910.1 m E 6873647.8 m N MGA94 Zone 56		
Drill Model and Mounting:	Orange Hanjin	RL Surface:	8.57 m
Hole Diameter:		Datum:	AHD Operator: TE

Drilling Information									***Soil Description***
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional
AD/T					8.57	0		CH	NATURAL Silty CLAY (CH) Stiff, medium plasticity, brown, with fine to medium grained sand, w>pl.
						0.40			
			B 0.50-1.50 m		7.6	1		CH	Silty CLAY (CH) Very stiff, medium plasticity, brown, with fine to medium grained sand, w>pl.
			D 2.00-2.50 m		6.6	2			
					5.6	3			Hole Terminated at 3.00 m
					4.6	4			
					3.6	5			
					2.6	6			
					1.6	7			

Method
AS - Auger
RR - Rock Roller
WB - Washbore

Water
Level (Date)
Inflow

Samples and Tests
U - Undisturbed Sample
D - Disturbed Sample
SPT - Standard Penetration Test
B - Bulk Sample

Remarks
1. Groundwater not encountered.

Support
C - Casing

Classification Symbols and Soil Descriptions
Based on Unified Soil Classification System

Pacific Geotech
Consulting Geotechnical Engineers

Borehole No.
BH08
Page 1 of 1

Project No.: PG-7476

Client:	JK Geotechnics	Commenced:	03/02/2022
Project Name:	Proposed Drilling Works	Logged By:	TE
Hole Location:	Tweed Valley Hospital, Cudgen	Checked By:	
Hole Position:	555889.2 m E 6873635.8 m N MGA94 Zone 56		
Drill Model and Mounting:	Orange Hanjin	RL Surface:	8.52 m
Hole Diameter:		Datum:	AHD Operator: TE

Drilling Information									***Soil Description***
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional
AD/T					8.02	0.50		CH	NATURAL Silty CLAY (CH) Stiff, medium to high plasticity, brown, with fine to medium grained sand, w>pl.
			B 0.50-1.50 m		7.5	1		CH	Silty CLAY (CH) Very stiff, medium plasticity, brown, with fine to medium grained sand, w>pl.
					6.5	2			
			D 2.50-3.00 m		5.5	3			
					5.02	3.00			Hole Terminated at 3.00 m
					4.5	4			
					3.5	5			
					2.5	6			
					1.5	7			

Method
AS - Auger
RR - Rock Roller
WB - Washbore

Water
Level (Date)
Inflow

Samples and Tests
U - Undisturbed Sample
D - Disturbed Sample
SPT - Standard Penetration Test
B - Bulk Sample

Remarks
1. Groundwater not encountered.

Support
C - Casing

Classification Symbols and Soil Descriptions
Based on Unified Soil Classification System

Pacific Geotech
Consulting Geotechnical Engineers

Borehole No.
BH09
Page 1 of 1

Project No.: PG-7476

Client:	JK Geotechnics	Commenced:	04/02/2022
Project Name:	Proposed Drilling Works	Logged By:	TE
Hole Location:	Tweed Valley Hospital, Cudgen	Checked By:	
Hole Position:	555865.5 m E 6873620.6 m N MGA94 Zone 56		
Drill Model and Mounting:	Orange Hanjin	RL Surface:	8.88 m
Hole Diameter:		Datum:	AHD Operator: TE

Drilling Information									***Soil Description***
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional
AD/T			D 0.50-1.50 m		8.9	0.20		ASP	ASPHALT (ASP).
					7.9	1		CH	NATURAL Silty CLAY (CH) Very stiff, medium to high plasticity, brown, with fine to medium grained sand, w>pl.
					6.9	2			
					5.9	3			3.00 Hole Terminated at 3.00 m
					4.9	4			
					3.9	5			
					2.9	6			
					1.9	7			

Method
AS - Auger
RR - Rock Roller
WB - Washbore

Water
Level (Date)
Inflow

Samples and Tests
U - Undisturbed Sample
D - Disturbed Sample
SPT - Standard Penetration Test
B - Bulk Sample

Remarks
1. Groundwater not encountered.

Support
C - Casing

Classification Symbols and Soil Descriptions
Based on Unified Soil Classification System

Pacific Geotech
Consulting Geotechnical Engineers

Borehole No.
BH10
Page 1 of 1

Project No.: PG-7476

Client:	JK Geotechnics	Commenced:	04/02/2022
Project Name:	Proposed Drilling Works	Logged By:	TE
Hole Location:	Tweed Valley Hospital, Cudgen	Checked By:	
Hole Position:	555835.9 m E 6873613.8 m N MGA94 Zone 56		
Drill Model and Mounting:	Orange Hanjin	RL Surface:	9.82 m
Hole Diameter:		Datum:	AHD Operator: TE

Drilling Information | ***Soil Description***

Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional
AD/T			B 0.50-1.00 m		8.8	0.50		CI	FILL Gravelly CLAY (CI) Very stiff, medium plasticity, brown, medium to coarse sized gravel, with fine to medium grained sand, w>pl.
						1		CH	NATURAL Silty CLAY (CH) Very stiff, medium to high plasticity, brown, with fine to medium grained sand, w>pl.
					7.8	1.10		CH	Silty CLAY (CH) Very stiff, medium to high plasticity, grey, with fine to medium grained sand, w>pl.
						2			
					6.8	1.80		CH	Silty CLAY (CH) Very stiff, high plasticity, brown, with fine to medium grained sand, w>pl.
						3			
					5.8	3.00			Hole Terminated at 3.00 m
						4			
					4.8	5			
					3.8	6			
					2.8	7			

Method
AS - Auger
RR - Rock Roller
WB - Washbore

Water
Level (Date)
Inflow

Samples and Tests
U - Undisturbed Sample
D - Disturbed Sample
SPT - Standard Penetration Test
B - Bulk Sample

Remarks
1. Groundwater not encountered.

Support
C - Casing

Classification Symbols and Soil Descriptions
Based on Unified Soil Classification System

Pacific Geotech
Consulting Geotechnical Engineers

Borehole No.
BH11
Page 1 of 1

Project No.: PG-7476

Client:	JK Geotechnics	Commenced:	04/02/2022
Project Name:	Proposed Drilling Works	Logged By:	TE
Hole Location:	Tweed Valley Hospital, Cudgen	Checked By:	
Hole Position:	555831.9 m E 6873599.7 m N MGA94 Zone 56		
Drill Model and Mounting:	Orange Hanjin	RL Surface:	12.83 m
Hole Diameter:		Datum:	AHD Operator: TE

Drilling Information							Soil Description		
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional
AD/T			D 0.50-1.00 m		11.8	1		CI	FILL Gravelly CLAY (CI) Very stiff, medium plasticity, brown, medium to coarse sized gravel, with fine to medium grained sand, w>pl.
						1.40			
					10.8	2		CH	NATURAL Silty CLAY (CH) Very stiff, medium to high plasticity, brown, with fine to medium grained sand, w>pl.
					9.8	3.00 3			Hole Terminated at 3.00 m
					8.8	4			
					7.8	5			
					6.8	6			
					5.8	7			

Method
AS - Auger
RR - Rock Roller
WB - Washbore

Water
Level (Date)
Inflow

Samples and Tests
U - Undisturbed Sample
D - Disturbed Sample
SPT - Standard Penetration Test
B - Bulk Sample

Remarks
1. Groundwater not encountered.

Support
C - Casing

Classification Symbols and Soil Descriptions
Based on Unified Soil Classification System

Notes Relating to this Report

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.

Every care has been taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical conditions and contains recommendations or suggestions for design and construction. However, unexpected variations in ground conditions will occur. The potential for this will depend partly on testing, spacing and sampling frequency.

If variations are identified, Pacific Geotech would be pleased to assist with additional investigations or advice to resolve the matter.

Copyright

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.

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.

Description and Classification Methods

The description and classification of soils and rocks used in this report are based on AS 1726.

Soil types are described according to the predominating particle size and behaviour as set out in the attached Unified Soil Classification Table qualified by the percent of other particles present (e.g. sandy clay) as set out below:

Soil Classification	Particle Size
Clay	less than 0.002mm
Silty	0.002 to 0.06mm
Sand	0.06 to 2mm
Gravel	2 to 60mm

Non-cohesive soils are classified on the basis of relative density which can be correlated from the results of Standard Penetration Test (SPT) as below:

Relative Density	SPT 'N' Value (blows/300mm)
Very Loose	less than 4
Loose	4 – 10
Medium Dense	10 – 30
Dense	30 – 50
Very Dense	greater than 50

Cohesive soils are classified on the basis of strength (consistency) and can be quantified by the Pocket Penetrometer test, Vane Shear test, laboratory testing or engineering examination. The strength terms are defined as follows:

Classification	Unconfined Compressive Strength kPa
Very Soft	less than 25
Soft	25 - 50
Firm	50 – 100
Stiff	100 – 200
Very Stiff	200 - 400
Hard	greater than 400
Friable	strength not attainable – soil crumbles

Rock types are classified by their geological names, together with descriptive terms regarding weathering, strength, defects, etc.

Planarity	
CU	Curved
DIS	Discontinuous
IR	Irregular
PR	Planar
ST	Stepped
UN	Undulose

Roughness	
POL	Polished
RJ	Rough
S	Smooth
SL	Slickened
VR	Very Rough

Defects	Type
BP	Bedding Parting
CL	Cleavage
CO	Contact
CS	Crushed Seam
CZ	Crushed Zone
DB	Drilling Break
DK	Dyke
DL	Drill Lift
DZ	Decomposed Zone
FC	Fracture
FL	Foliation
FZ	Fracture Zone
HB	Handling Break
IS	Infilled Seam
JT	Joint
H	Schistosity
SI	Sill
SM	Seam
SS	Shear Seam
SZ	Shear Zone
VN	Vein
VO	Void

Sampling

Sampling is undertaken during the fieldwork to allow examination of the soil or rock and to allow laboratory testing to be undertaken.

Disturbed samples taken during drilling provide information on plasticity, grain size, colour, moisture content and minor constituents. Bulk samples are similar but of greater volume required for some test procedures such as CBR testing.

Undisturbed samples are taken by pushing a thin-walled sample tube, usually 50mm diameter (known as a U50), into the soil and collecting a sample of the soil contained 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.

Details of the type and method of sampling used are given on the attached logs.

Investigation Methods

Test Pits: These are typically undertaken with a backhoe or a tracked excavator, allowing examination of the insitu soils. Limitations of test pits are the problems associated with collapse of the pits, disturbance and difficulty of reinstatement and the consequent effects on close-by structures. Care must be taken if construction is to be carried out near test pit locations to either properly recompact the backfill during construction or to design and construct the structure so as not to be adversely affected by poorly compacted backfill at the test pit location.

Hand Auger Drilling: A borehole of typical diameter of between 50mm to 75mm advance manually operated equipment. Premature refusal of the hand augers can occur on a variety of materials such as fill, gravel, hard clays and collapse of the borehole (typically in non-cohesive soil).

Continuous Spiral flight Augers: The borehole is advanced using 65mm to 100mm diameter continuous spiral flight augers, which are withdrawn at intervals to allow sampling and insitu testing. Augers of up to 300mm in diameter are used to recover larger volumes of sample. Samples are returned to the surface by the flights or may be collected after withdrawal of the auger flights. Samples can be disturbed and layers may become mixed. Augering below the groundwater table can be less reliable than augering above the water table.

A Tungsten Carbide (TC) bit for auger drilling into rock can be used to indicate rock strength and continuity by variation in drilling resistance and from examination of recovered rock fragments but provides only an indication of the likely rock strength. Where rock strengths may have a significant impact on construction feasibility or costs, then further investigation by means of cored boreholes may be warranted.

Wash Boring: The borehole is advanced by a bit attached to the end of a hollow rod string, with water being pumped down the drill rods and returned up the annulus of the borehole, carrying the drill cuttings. Changes in stratification can be determined from the return, together with information from "feel" and rate of penetration.

The borehole can be stabilised through the use of drilling mud as a circulating fluid. The term 'mud' encompasses a range of products ranging from bentonite to polymers such as Revert or Biogel.

Continuous Core Drilling: A continuous core sample is obtained using a diamond tipped core barrel. This technique provides a reliable (but relatively expensive) method of investigation. In rocks, an NMLC triple tube core barrel is used, which gives a core of about 50mm diameter. The length of core recovered is compared to the length drilled and any length not recovered is shown as CORE LOSS.

Standard Penetration Tests: Standard Penetration Tests (SPT) are used mainly in non-cohesive soils, but can also be used in cohesive soils as a means of indicating density or strength and also of obtaining a disturbed sample. The test procedure is described in Australian Standard 1289, "Methods of Testing Soils for Engineering Purposed", Test 6.3.1.

The test is carried out in a borehole by driving a 50mm diameter split sample tube with a tapered shoe, under the impact of a 63kg hammer, with a free fall of 760mm. The sample is driven in three successive 150mm increments and the 'N' value is taken as the number of blows for the last 300mm. In dense soils, hard clays or weak rock, the full 450mm 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 150mm of , say, 4, 6 and 7 blows, as
  N = 13
  4, 6, 7
- In a case where the test is discontinued short of full penetration, say after 15 blows for the first 150mm and 30 blows for the next 40mm, as
  N > 30
  15, 30/40mm

Cone Penetrometer Testing (CPT): Cone Penetrometer Testing with or without pore pressure measurement (CPTu) is carried out using a Cone Penetrometer in general accordance with AS 1289 6.5.1, 1999.

In the tests, a 36mm diameter rod with a conical tip is pushed continuously into the soil, the reaction being provided by a hydraulic ram system. Measurements are made of the end bearing resistance on the cone and the fractional resistance on a separate 135mm long sleeve, immediately behind the cone. Pore Pressure is recovered through a pore ring located either within, or more usually immediately behind the cone/tip.

As penetration occurs (at a rate of approximately 20mm per second) and data is recorded every 20mm of penetration, the results are presented graphically.

The information provided on the plot comprises:

- Cone resistance – expressed in mPa
- Sleeve friction – expressed in kPa
- Friction ratio – the ratio of sleeve friction to cone resistance expressed as a percentage.
- Pore pressure in kPa
- Tilt of probe (in degrees).

The ratios of the sleeve resistance to cone resistance will vary with the type of soil encountered, with higher relative friction in clays than in sands. Friction ratios of 1% to 2% are commonly encountered in sands and rising to 2% to as high as 8%, and higher in organic soils. Soil descriptions based on cone resistance and friction ratios are only inferred and must not be considered as exact.

Stratification can be inferred from the cone and friction traces and from experience and information from nearby boreholes, etc. Where shown, this information is presented for general guidance, but must be regarded as interpretive.

Dynamic Cone Penetrometers:

Dynamic Cone Penetrometer (DCP) tests are carried out by driving a 16mm diameter rod into the ground with a 9kg sliding hammer dropping 510mm and counting the blows for successive 100mm increments of penetration.

Logs

The borehole or test pit logs are an interpretation of the subsurface conditions, and their reliability will depend to some extent on the frequency of sampling and the method of drilling or excavation.

Interpretation of the information shown on the logs, and its application to design and construction, should therefore take into account the spacing of the boreholes or test pits, the method of drilling or excavation, the frequency of sampling and testing and the possibility of other than "straight line" variations between the boreholes or test pits. Subsurface conditions between boreholes or test pits may vary significantly from conditions encountered at the borehole or test pit locations.

Groundwater

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

- Although groundwater may be present, in low permeability soils it may enter the hole slowly or perhaps not at all during the time it 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 and may not be the same at the time of construction.
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be flushed from the hole and drilling mud must be washed out of the hole or 'reverted' chemically if water observations are to be made.

More reliable measurements can be made by installing standpipes from which ongoing monitoring can be undertaken.

Fill

The present of fill materials can often be determined only by the inclusion of foreign objects (e.g. bricks, steel ,etc.) or by distinctly unusual colour, texture or fabric. Identification of the extent of fill materials will also depend on investigation methods and frequency. Where natural soils similar to those at the site are used for fill, it may be difficult to reliably determine the extent of the fill.

Laboratory Testing

Laboratory testing is carried out in general accordance with Australian Standard 1289 'Methods of Testing Soil for Engineering Purposes'.

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, the company requests that it immediately be notified. Most problems are much more readily resolved when conditions are exposed than at some later stage.

Review of Design

Where major civil or structural developments are proposed or where only a limited investigation has been completed or where the geotechnical conditions/constraints are quite complex, it is prudent to have a design review.

Site Inspection

Pacific Geotech would be pleased to provide engineering inspection services for geotechnical aspects of work to which this report is related:

Requirements could range from:

i. a site visit to confirm that conditions exposed are no worse than those interpreted, to
ii. a visit to assist the contractor or other site personnel in identifying various soil/rock types such as appropriate footing or pier founding depths, or
iii. full time engineering present on site.