**Coffs Harbour City Council**

# Proposed Cultural and Civic Space Project

## 23-31 Gordon Street Coffs Harbour NSW

## Geotechnical Report

Report No. RGS31785.1 – AC Rev. 1

18 June 2019

REGIONAL GEOTECHNICAL SOLUTIONS

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Manning-Great Lakes
Port Macquarie
Coffs Harbour

RGS31785.1 – AC Rev. 1

18 June 2019

Coffs Harbour City Council
2 Castle Street
COFFS HARBOUR NSW 2450

**Attention: Ken Welham**

Dear Ken

**RE: Proposed Cultural and Civic Space Project - 23-31 Gordon Street Coffs Harbour NSW**

**Geotechnical Report**

Regional Geotechnical Solutions Pty Ltd (RGS) has completed geotechnical investigations and assessment at the site of the proposed Cultural and Civic Space Project to be constructed at 23-31 Gordon Street Coffs Harbour NSW (Lot 20 DP758258, Lot B DP346105 and Lot 123 DP749233). The assessment was commissioned by Coffs Harbour City Council.

This report presents the results of the geotechnical investigations and assessment. A preliminary Phase 1 site contamination assessment (SCA) was undertaken in conjunction with the assessment, the results of which are presented in a separate report (RGS31785.1 – AB).

If you have any questions regarding this project, or require any further assistance, please do not hesitate to contact the undersigned.

For and on behalf of **Regional Geotechnical Solutions Pty Ltd**

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# 1 INTRODUCTION

Regional Geotechnical Solutions Pty Ltd (RGS) has completed geotechnical investigations and assessment at the site of the proposed Cultural and Civic Space Project to be constructed at 23-31 Gordon Street, Coffs Harbour (Lot 20 DP758258, Lot B DP346105 and Lot 123 DP749233).

This report presents the results of the geotechnical investigations. A preliminary Phase 1 site contamination assessment (SCA) was undertaken in conjunction with the assessment, the results of which are presented in a separate report (RGS31785.1 – AB).

The site is situated within the Coffs Harbour CBD within flat low-lying alluvial topography as illustrated in Diagram 1. The site encompasses an area of approximately 4,000m$^2$ and is currently occupied by single storey residential and commercial buildings with associated on grade car parking areas. Development to the north comprises single and double storey brick and timber residential buildings on the site boundary, while to the south is a single storey clad structure set back about 2.5m from the boundary. Gordon Street forms the eastern frontage with a lane and on grade carparking beyond to the west.

**Diagram 1: Site Location and Setting**


The purpose of the work was to obtain preliminary geotechnical information on site conditions as the basis for providing comments and recommendations on:

- General site conditions and geology including;
    - Soil profile;
    - Presence / extent of fill;

    - Depth to rock; and
    - Groundwater water levels.
- Site earthworks including:
    - General site preparation;
    - Stripping and foundation preparation;
    - Fill material requirements including suitability for reuse of site won material
    - Fill placement and compaction control;
    - Excavation conditions;
    - Retention and retaining wall design parameters; and
    - Potential impacts on nearby buildings.
- Site classification to AS2870-2011 'Residential Slabs and Footings';
- Alternative footing types and foundation design parameters including allowable/ultimate bearing pressures and data to calculate expected settlements;
- Assessment of durability requirements (aggressivity) for buried steel and concrete elements;
- Assessment of the presence of acid sulfate soils (ASS) and treatment requirements;
- Assessment of site subsoil classification for earthquake design in accordance with AS1170.4-2007;
- Pavements – Subgrade CBR values for pavement thickness design for proposed carparks; and
- Agronomy test results on a soil sample collected from around the existing Fig tree in the west of the site. Interpretation of the test results are to be undertaken by others.

The investigations were undertaken in general accordance with the scope of works as outlined in proposal No. RGS31785.1 – AA. Variation to the scope of works outlined in the proposal included the drilling of boreholes to greater depth than that nominated (12m) to satisfy the requirements of the geotechnical assessment.

## 2 PROPOSED DEVELOPMENT

The project is in the planning phases and specific details of the proposed structures have not yet been provided, however, the development is understood to include the construction of a new Cultural and Civic Space building. The building is anticipated to be multi-level (likely 2 to 3 floors) with a single level basement car parking area and an aero-bridge to the existing multi-level car park to the west of Riding Lane. The building will include:

- A regional gallery;
- Regional library;
- Regional museum;
- Multipurpose meeting rooms;
- Co-worker space;
- Shop and café;
- Function space;
- Customer service area; and

- Council staff office accommodation.

## 3 FIELD WORK

Fieldwork was undertaken in April 2019 and comprised a site walkover assessment and intrusive investigations. Intrusive investigations included:

- The drilling and logging of four (4) boreholes drilled to depths of up to 18.9m with a four-wheel drive truck mounted drill rig. Two of the boreholes (BH1 and BH2) were advanced using NMLC diamond core drilling methods once competent rock was encountered with up to 4.15m of rock core recovered;
- Standard penetration tests (SPTs) were carried out within the soil and weathered rock profile at approximately 1.5m intervals to assess the strength of the soils and weathered rock.
- Hand penetrometer (HP) tests were undertaken in samples recovered from the SPT to assess the strength of the clays and weathered rock.
- Installation of two temporary standpipe piezometers (BH1 and BH2);
- Collection of samples at various depths for laboratory testing as discussed in Section 4.

Groundwater level measurements were undertaken during the drilling programme. Ongoing monitoring of the standpipe piezometers were undertaken on completion of drilling, then again on an approximate weekly basis and shortly after a significant rainfall event.

The fieldwork was undertaken by a Senior Geotechnical Engineer or an Associate Geotechnical Engineer from RGS. Engineering logs are presented in Appendix A. The boreholes were drilled at location that were accessible by a truck mounted drill rig in consideration of providing good site coverage. The approximate locations of which are presented on Figure 1. Their approximate locations were obtained by measurements from existing site features.

## 4 LABORATORY TESTING

Samples collected during the fieldwork were sent to contract NATA accredited laboratories for analysis. The following testing was undertaken:

- Two (2) soil aggressivity test suite to assess durability requirements of steel and concrete in accordance with AS2259 – 2009 Piling – Design and Installation;
- Two (2) shrink-swell tests to assess the soil reactivity;
- Two Atterberg Limit tests to assess plasticity properties;
- Two (2) CBR tests to assess subgrade CBR values;
- Twelve (12) acid sulfate soil screening tests; and
- Four (4) acid sulfate soil CRS test suites.

The results of the testing are presented in Appendix B and discussed in the subsequent sections of this report.

# 5 SITE CONDITIONS

## 5.1 Surface Conditions

The site consists of three lots within Coffs Harbour CBD as illustrated in Diagram 1. The site is situated within flat low lying alluvial topography with surface grades less than 1°.

Approximately 50% is occupied by buildings while the remaining areas comprise grass, garden beds or sealed carparking areas. The buildings are generally single storey residential (Lot 6, DP758258) or commercial, generally comprising brick masonry and timber framed fibro clad construction. The buildings are run down, however, structurally they appear to be in fair condition. Extensive cracking was observed in the carpark in the centre lot.

Nearby structures include a two storey brick building adjoining the western portion of the northern boundary and a single storey residential building adjoining the eastern portion of the northern boundary which is set back about 1m from the boundary. There is an approximately 2m high brick boundary fence along the eastern portion of the northern boundary. A single storey timber framed, and clad commercial building is located about 2.5m from the western portion of the southern boundary. Riding Lane forms the western boundary beyond which is an at grade carparking area and entry road to a multi-level parking station located about 18m from the western boundary. Gordon Street forms the eastern frontage.

There is a large fig tree situated between Riding lane and the parking station, approximately 5m from the site boundary to the west of the proposed development.

Typical site photographs are presented below in Plate 1.

**Plate 1: Site Photographs Illustrating Site Conditions**

1. *Looking west across northern portion of site towards BH4.*


2. *Looking northwest across northern portion of site towards BH1.*

3. *Looking southwest at the carkpark and structures in the middle section of the site.*

4. *Building and garden beds at southern end of the site.*

5. *Looking west at the carkpark and structures in the middle section of the site.*

6. *Large fig tree located to the northwest of the site.*

7. *Looking west at the access driveway, carkpark and structures in the southern section of the site.*

8. *Looking north east at the rear of the structures in the southern portion of the site.*

## 5.2 Subsurface Conditions

The 1:100,000 Coffs Harbour Quaternary Geological Map indicates the site is underlain by a Pleistocene terrace comprising silt, clay, fluvial sand, and gravel. The 1:250,000 Dorrigo - Coffs Harbour Geology Map indicates that the alluvial materials are underlain by the Brooklana Formation which comprises siliceous argillite, slate and rare siliceous greywacke.

In summary, the investigations encountered a subsurface profile comprising:

**Pavements:** BH2 and BH3 were drilled through pavements comprising 2 coat spray seal (BH2) and 30mm AC (BH3).

**Fill:** sandy gravel fill (pavement materials) were encountered below the seal in BH2 and BH3 which extended to depths of 0.25m. Fill was also encountered in BH1 which comprised clayey silt.

**Topsoil:** A thin topsoil layer was encountered below the fill in BH2 and from the surface in BH4. The topsoil comprised sandy and clayey silt.

**Alluvial Soils:** Comprising clayey silt (low to medium plasticity) and silty clay (medium to high plasticity), typically very stiff to hard with some stiff zones.

**Residual Soils / Extremely Weathered Argillite:** Comprising clayey silt and silty clay, low to medium plasticity, stiff to hard. The residual soils graded into weathered argillite.

**Weathered Argillite:** Extremely weathered argillite (very stiff to hard silty clay) was encountered in all boreholes. The argillite generally improved with depth with slightly weathered low to medium strength.

A summary of the subsurface conditions including depth of units is provided in Table 1.

**Table 1: Summary of Subsurface Conditions**

| Unit | Material Description | Depth to Base of Material (m) | | | |
|---|---|---|---|---|---|
| | | BH1 | BH2 | BH3 | BH4 |
| 1a | Pavements | - - | 2 coat seal with 0.2m gravel | 30mm AC with 0.25m gravel | - - |
| 1b | Fill | 0.20 | 0.20 | 1.8 | - - |
| 1c | Topsoil | - - | - - | - - | 0.25 |
| 2 | Alluvial soils | 12.00 | 9.50 | 10.50 | 9.0 |
| 3 | Residual soils/ Extremely Weathered Argillite | 15.50 | 15.80 | 16.00 | 13.00 |
| 4a | HW – MW Argillite | 16.85 | - - | ≥17.4# | ≥17.40# |
| 4b | SW-Fr Argillite | ≥18.90 | ≥17.80 | - - | - - |

**NOTES:** - - *indicates material not encountered*
≥ *indicates base of material not encountered*
\# *indicates TC bit refusal (inferred to be on slightly weathered to fresh argillite).*

Groundwater seepage was encountered during drilling. Table 2 provides a summary of the groundwater observations.

**Table 2: Summary of Groundwater Observations**

| Borehole No. | Inflow Depth During Drilling (m) | Standing Water Level – Depth Below Ground Surface (m) |
|---|---|---|
| BH1 | 6.50 | 1.2 (30 April 2019) |
| BH2 | - - | 1.85 (30 April 2019) |
| BH3 | 10.00 | - - |
| BH4 | 7.00 | - - |

**NOTES:** - - *not observed*

Long term monitoring of groundwater is currently being undertaken and the results will be presented in a separate report. Groundwater levels may fluctuate seasonally and in response to rainfall.

### 5.3 Laboratory Test Results

The results of laboratory testing are summarized in Table 3 and Table 4. The results of the soil aggressivity testing and acid sulfate soil testing are presented and discussed in Sections 10 and 0 respectively. A copy of the laboratory test results sheets, including the soil agronomy testing are provided in Appendix B.

**Table 3: Results of Atterberg Limit and Shrink-Swell Testing**

| Sample Location | Sample Depth (m) | Liquide Limit (%) | Plastic Limit (%) | Plasticity Index PI (%) | Linear Shrinkage (%) | Shrink – Swell Index [(1)] (Iss) |
|---|---|---|---|---|---|---|
| BH1 | 7.30 to 7.60 | 46 | 21 | 25 | 10 | - - |
| BH4 | 7.50 to 7.95 | 55 | 19 | 36 | 13 | - - |
| CBR1 | 0.20 to 0.50 | - - | - - | - - | - - | * |
| CBR2 | 0.20 to 0.50 | | | | | 3.4 |

**NOTES:** 1 *Sample remoulded to 100% SMDD at OMC*
* *Sample Fragmented, therefore unable to be measured*

**Table 4: CBR Test Results**

| Sample Location | Sample Depth (m) | Material Description | Natural Moisture Content (%) | Optimum Moisture Content (%) | Maximum Dry Density (t/m$^3$) | Swell (%) | CBR (%) |
|---|---|---|---|---|---|---|---|
| CBR 1 | 0.2 to 0.5 | Clayey Silt | 18.5 | 18.0 | 1.77 | 0.0 | 4.5 |
| CBR 2 | 0.2 to 0.5 | Silty Clay | 18.4 | 19.0 | 1.76 | 0.0 | 4.5 |

## 6 PREVIOUS WORK UNDERTAKEN NEARBY

RGS have completed many similar investigations in the Coffs Harbour CBD including the recent Palms Centre re-development on the corner of Gordon and Vernon Streets (approximately 75m to the south), 28 Gordon Street (directly across the road), the current redevelopment of the Coffs C.EX club, and the new Forestry Building on the corner of Gordon Street and Park Avenue. An infilled creek was encountered during construction works for the Palm centre development, but was encountered during construction at 28 Gordon Street, indicating the old creek line runs to the south of the proposed development site in a general west to east direction. A summary of the conditions encountered at these sites is provided below to supplement the information obtained during this assessment as presented in this report.

Palm Centre Redevelopment

Geotechnical investigations and site contamination assessment for the recently completed extensions to The Palms Centre directly south of the subject site. Investigations included deep drilling for foundations for potential ten storey building and basement level excavations up to the existing building. During the investigations an old infilled creek was encountered that impacted the stability of excavations, particularly in the vicinity of the adjoining building. Significant levels of contaminated material were encountered in the creek along with a poorly remediated underground storage tank excavation in the south-east corner from a previous service station at the site. The subsurface profile encountered is summarised in Table 5.

**Table 5: Summary of Subsurface Conditions Encountered at CNR Gordon and Vernon Streets**

| Geotechnical Unit | Material Description | Depth to Base of Material from Ground Level (m) | |
|---|---|---|---|
| | | Northern End (BH1) | Southern End (BH2) |
| Fill | Concrete Slab and Sand: | 0.6 | 0.4 |
| Firm Clay Alluvium | Firm, grey, high plasticity clay (Su = 30 to 40kPa) | 1.3 | 1.5 |
| Very Stiff to Hard Clay Residual | Very Stiff to Hard clay, grey and orange brown mottle (Su = 100 to 300kPa) | 5.5 | 4.5 |
| Extremely Weathered to Highly Weathered Metasiltstone | Grey and brown, very low to low strength | 11.8 | 6.6 |
| Highly Weathered to Moderately Weathered Metasiltstone | Grey and pale brown, low to medium strength | 12.25 | 8.0 |
| Slightly Weathered Metasiltstone | Dark grey, high strength | 12.5 | 10.7 |
| Slightly Weathered to Fresh Metasiltstone | Dark grey and high to very high strength | >14.5 | >11.75 |

28 Gordon Street

Located directly across the street from the subject site. Geotechnical investigations were undertaken for the purpose of foundation design and excavation and retention of a two storey commercial development with basement. The assessment provided guidance on foundation design as well as excavation support requirements in consideration of adjoining multi-level commercial buildings being built up to the boundary.

Coffs C.EX

Located to the west of the subject site. Geotechnical investigations were undertaken for the purpose of foundation design of a multi-level extension to the existing building. The assessment provided guidance on foundation depths and foundation design parameters.

In summary the investigations encountered a variable subsurface profile that included:

**Pavement:** Concrete slab; over

**Fill:** Gravel/Sand depths of up to 0.4m; overlying.

**Alluvial soils:** Comprising silty Clay, medium to high plasticity stiff to very stiff to depths of up to at least the termination of the boreholes at 10.45m.

## 7 GENERAL SITE CONDITIONS AND GEOTECHNICAL CONSIDERATIONS

The investigations have encountered a subsurface profile comprising minor fill and topsoil overlying alluvial and residual clay soils that grade into highly weathered argillite at depths of about 15m with more competent slightly weathered rock from depths of about 17m. Based on the proposed development details and conditions encountered the key geotechnical considerations for this projected are:

- Excavation conditions, including support of excavations and material disposal;
- Acid sulfate Soils and treatment requirements; and
- Footings and foundation materials.

Further discussion on these and other relevant geotechnical aspects of the development are provided below and in the subsequent sections of this report.

Basement carparking is proposed below the building which will require excavations to about 4m depth across much of the site. The excavations will extend up to the property boundaries at some locations. Excavations along the southern and northern boundary could impact on the zone of influence of the footings of the adjoining buildings, where the buildings adjoin the boundary to the north. Therefore, it is recommended that a detailed property condition report be carried out on the neighbouring buildings to reduce exposure to possible damage claims as a result of the construction work.

Based on the depth of excavation and boundary setbacks temporary batters and/or benching will unlikely be feasible for much of the excavations. Therefore, a contiguous or soldier pile wall is recommended along those boundaries where benching and/or battering is not achievable.

An estimated 13,000m$^3$ of material will be excavated from the site assuming an average excavation depth of 4m over the proposed basement footprint (full site footprint). To comply with the Department of Environment and Climate Change NSW Waste Classification Guidelines any material to be disposed of off-site requires waste classification. It is noted that the acid sulfate soils

assessment (Refer to Section 11) indicates the material is acid sulfate soils due to potential sulfidic acidity. Therefore, the materials cannot be classified as virgin excavated natural material (VENM) or excavated natural material (ENM). This could have significant implication on the proposed development from a material disposal perspective. A site specific exemption for the material could be sort from the EPA to enable the material to be used elsewhere, otherwise the material may require disposal to landfill. It is noted that a more detailed assessment will be required once final details of the proposed works including material disposal requirements and volumes are known.

Given the significant increase of heavy vehicle traffic on the local roads, particularly during the bulk earthworks, consideration should be given to the condition of the roads. The developer/contractor could be liable for the repair of roads that are perceived to have been damaged during construction. It is therefore recommended that a pavement condition assessment be undertaken prior to the commencement of any work to document the existing condition of the pavements. This could assist in reducing the potential exposure to risk regarding the repair of damage not necessarily attributable to the development.

# 8 EARTHWORKS

## 8.1 Site Preparation

There are several buildings on the site. These buildings and associated footings buried services and associated infrastructure will need to be demolished and removed prior to construction commencing. Given the age of the buildings a hazardous material assessment is recommended prior to demolition to assess the presence of potential contamination such as asbestos. Reference should be made to the Phase 1 Site Contamination Assessment report that was completed in conjunction with this report (REF: RGS31785.1 – AB).

An earthworks management plan, that includes an acid sulfate soil (or acid soil) management plan as necessary (Refer to Section 0), and an erosion and sediment control plan should be developed. As a minimum silt fencing and runoff control and dissipation measures will need to be installed around the site boundaries to reduce the potential for silt entering waterways.

Site preparation will then involve the removal of vegetation and the stripping of the topsoil and fill materials. These materials are not suitable for reuse as engineered fill but could be reused for onsite landscaping. If they are to be disposed of offsite they will require waste classification assessment to determine disposal requirements.

Following this bulk earthwork can commence.

## 8.2 Excavation and Retention

Excavations of up to about 4m will be required across most of the site to achieve the proposed basement floor level with possibly some localised deeper excavations required for service trenches, elevator shafts etc.

Where bulk excavation is setback from the property boundary the excavation could be battered/benched at the angles presented in Section 8.5, or conventional reinforced blockwork walls or similar could be adopted to provide permanent support without the need for pre-support.

Based on the depth of excavation and anticipated boundary setbacks temporary batters and / or benching is not likely to be feasible for most of the excavations. Therefore, pre support measures

such as a soldier pile wall with infill panels or a contiguous pile wall will be required. It is anticipated that the piles could be drilled to sufficient depth to achieve the required lateral capacity to reduce deflections at the top of the piles without the need for ground anchors, however, further assessment will be required during design.

Further comments and recommendations and retaining wall design parameters are provided in Section 8.6

### 8.3 Excavation Conditions

Excavations to the expected maximum depths of about 3 to 4m will encounter the alluvial soil profile. Excavation of these materials could be achieved using conventional earth-moving equipment, such as medium to large sized excavators (20 to 30 tonne). Detailed excavations for service trenches etc could be undertaken with smaller plant.

During construction, the basement floor will become untrafficable when wet and cross-falls to drains should be maintained at all times. It may be necessary or desirable to construct a working platform of crushed concrete or similar durable granular material in the basement area.

### 8.4 Groundwater and Dewatering

Groundwater seepage was encountered at depths in excess of 6m with the standing water level measured at about 1.2m about four weeks after the completion of drilling. Approximately 200mm of rainfall has occurred in Coffs Harbour during April 2019 between the drilling of the boreholes and the initial round of groundwater measuring.

Seepage into the basement excavations during excavation is likely to be low given the low permeability of the clay soils encountered. Potential flow paths may be encountered within higher permeability seams within the soil mass such as gravel seams. Inflow rates are likely to increase during and following rainfall.

Based on the conditions encountered it is anticipated that groundwater seepage into the excavations will be controllable using conventional gravity drainage to a sump from where it can be pumped to the council stormwater system or other suitable measures employed as required by council. Permanent basement drainage could also be achieved using this method or the basement designed as fully tanked. Pump out tests could be undertaken to assess the soil permeability and pump out requirements.

It may be necessary to carry out groundwater testing in order to determine an appropriate method of disposal if groundwater pumping and disposal is required during construction and on completion of the structure.

### 8.5 Temporary & Permanent Batter Slopes

Temporary batters and / or benching may be feasible for the temporary support of the basement excavations in some areas provided there is sufficient setback from boundaries and nearby structures. Engineered retaining walls can then be constructed at the toe of the batters and backfilled on completion. Batters should be constructed as outlined in Table 6.

**Table 6: Temporary & Permanent Batter Geometry**

| Maximum Vertical Batter Height (m) | Material Type | Temporary Batters | Permanent Batters |
|---|---|---|---|
| 1.5 | Alluvial Soils / Controlled Fill (stiff or better) | 0.75H:1V | 1.5H:1V |
| 3 | | 1.5H:1V | 2.0H:1V(1) |

**NOTES:** *1 Incorporating a minimum 1m wide bench mid height*

Flatter batters may be required if seepage is encountered during excavation and during rainfall and should be assessed by a Geotechnical Engineer on completion of excavation to assess batter requirements.

Batters should be protected from erosion by constructing surface drains along the crest of the up-slope batters that divert water away from the slope face. The batter face should also be trimmed smooth. Vegetation or other means of protection should be rapidly established on permanent batters. Such measures could include proprietary products such as Grassroots or other similar products.

Excavation work should be undertaken in accordance with the Safe Work Australia '*Excavation Code of Practice (March 2015)*'

### 8.6 Retaining Walls

Temporary batters and / or benching is not likely to be feasible for most of the excavations. Therefore, pre-support measures such as a soldier pile wall with infill panels or a contiguous pile wall will be required. It is anticipated that the piles could be drilled to sufficient depth the achieve the required lateral capacity to reduce deflections at the top of the piles without the need for ground anchors.

Retaining walls can be designed based on a triangular lateral earth pressure distribution using the following characteristic earth pressure coefficients and subsoil parameters:

- Retaining walls should be uniformly founded within the underlying natural soils or weathered argillite. For retaining wall foundation recommendations refer to Section 9.
- For cantilever walls where movement is of little concern, an active earth pressure coefficient (ka) of 0.4 can be adopted for the soil profile, assuming a horizontal backfill surface.
- Where the top of the retaining wall is to be restrained, such as by the ground floor slab, or if the walls are retaining areas which are sensitive to movement, an 'at rest' earth pressure coefficient (ko) of 0.6 should be adopted.
- The following soil parameters should be adopted for the soil profile for the design of retaining walls at the site:
    - Angle of internal friction ($\phi$) = 24°
    - Cohesion (c') = 5kPa
- A bulk unit weight of 20kN/m3 should be adopted for the soils.
- To provide lateral restraint at the wall toe the toe of the walls must be embedded below the base of the excavations and below the zone of influence of any nearby service trenches etc. A passive earth pressure coefficient (kp) of 2.9 can be adopted for the soils at the toe of the wall. The excavation should be assessed during construction to determine appropriate passive resistance values.

- If the top of the walls are to be restrained by anchors that will extend beyond the site boundaries, then permission from the property owners should be obtained before installation. Anchors bonded at least 3m into the alluvial soils, with a free length of at least 4m, can be designed for an allowable bond stress within the bond zone of 30kPa. The bond length of the anchors should be entirely behind a line drawn upward at 45° from the toe of the excavation. All anchors should be proof tested to 1.5 times the working load under the supervision of an experienced engineer. If more than one row of anchors is to be used, an alternative pressure distribution would apply, and further advice should be sought.
- Any surcharge affecting the walls (e.g. building footings, traffic loading, adjacent retaining walls and their backfill, etc.) should be allowed for in the design. If inclined backfill surfaces are proposed, then the lateral earth pressure coefficient would have to be appropriately increased or the inclined surface treated as a surcharge.

The retaining walls should be designed as drained and measures taken to induce complete and permanent drainage of the ground behind the wall. The wall backfill should comprise free draining granular material such as a 20mm drainage gravel. Crusher dust should not be used as a drainage medium. Subsoil drains should comprise a geocomposite drain or geotextile (Bidim A34 or similar) wrapped gravel drain at the toe of the back of the wall. The drains should be connected to the basement drainage system and discharged to the stormwater system. Flushing points should be incorporated into the design. These measures should reduce the potential for pore water pressures to build up behind the walls, however the design of the walls should include an allowance of potential water pressure build-up equivalent to the full retained height.

For walls such as contiguous bored pile walls that do not allow placement of drainage behind, weep holes connected to the basement drainage system should be adopted.

Care must be taken when compacting at the back of retaining walls. Only small equipment should be used directly behind the wall and could include vibrating plate compactors and hand operated walk behind roller compactors.

### 8.7 Subgrade Preparation, Fill Placement and Compaction Control

Proposed fill depths are unknown but given the extent of basement excavations proposed filling is likely to be minor, localised and less than about 0.5m. The following general comments and recommendations are provided regarding subgrade preparation, fill placement and compaction control.

- All root affected material, uncontrolled fill and topsoil should be fully stripped and stockpiled for later reuse for landscaping purposes over the site. These materials are not considered suitable for reuse as engineered fill.
- Following stripping to an appropriate foundation level below fill areas, the exposed subgrade materials should be proof rolled to identify any wet, excessively deflecting or other deleterious material. Any such areas should be over-excavated down to a stiff base and backfilled with a clean select material. Any such areas are likely to be isolated.
- Controlled fill should be placed in layers not exceeding 300mm loose thickness. Fill below structures and pavement areas should be compacted to a minimum dry density ratio of not less than 98% Standard. The upper 300mm below pavements should be compacted to a minimum density ratio of 100% standard compaction
- Fill should be placed and maintained at ±2% of Standard OMC.
- Where footings are to be founded within fill it must be undertaken in accordance with Level 1 construction monitoring and testing as defined in AS3798 – 2007.

- Filling below pavements should be carried out in accordance with Level 2 construction monitoring and testing as defined in AS3798 – 2007.

### 8.8 Fill Materials and Offsite Disposal

Materials recommended for use as engineered fill include good quality well graded granular materials (such as crushed or ripped rock), free of deleterious materials and having a maximum particle size of 200mm. The natural alluvial soils won from site excavations can be reused on site for general filling following appropriate treatment as required (Refer to Section 11).

Where offsite disposal of material, or reuse of material at an alternative site is proposed it should be assessed in accordance with the requirements of the '*Department of Environment and Climate Change NSW Waste Classification* Guidelines *Part 1 Classifying Waste*' (July 2009) and / or the EPA Resource Recovery Order under Part 9, Clause 93 of the Protection of the Environment Operations (Waste) Regulation 2014. The investigations have generally encountered fill and natural clay and silt soils and weathered rock. Much of this material could be classified as Excavated Natural Material or Virgin Excavated Natural Material (VENM), however the results of the acid sulfate soil assessment indicate the soils are acid sulfate soils. Therefore, the soils cannot be classified as VENM or ENM. The material would therefore require disposal to landfill unless a site specific exemption can be obtained from the EPA.

## 9 FOUNDATIONS

The investigations have encountered a profile comprising isolated fill overlying generally stiff to hard alluvial soils, that intern overly residual soils that grade into weathered argillite. Highly to moderately weathered argillite was encountered from depths of between 13 to 16m while slightly weathered to fresh argillite was encountered from 15.4 to 17.4m. Therefore, depending on the structural loads and loading configuration shallow footings and / or piles founded within the weathered argillite could be feasible footing options.

All structural elements should be uniformly founded on similar materials to reduce the potential for differential settlements and subsequent damage to the structures. All footings must be founded outside the zone of influence of existing or proposed service trenches, footings etc.

All footings should be assessed by a geotechnical engineer prior to the placement of reinforcement and concrete to assess that the required founding materials and bearing capacity requirements have been achieved.

Discussion of the options and design parameters for the relevant materials is provided in the following sections.

### 9.1 Preliminary Site Classification

The proposed building is of a commercial nature with basement carparking, therefore AS2870-2011 "*Residential Slabs and Footings*" does not strictly apply. Where structures are similar in construction and loading to a typical domestic building, the guidance provided in AS2870 - 2011 could be used in assessing footing and slab requirements, provided the performance expectations presented in AS2870-2011 are acceptable.

The investigations have shown that areas of the site are underlain by fill to depths more than 0.4m. The fill is unlikely to have been placed as Controlled Fill under Level 1 supervision (ref AS3798-2007) and we are unaware of any documentation that outlines the manner of fill placement. Therefore, generally the site is classified as **Class 'P'** in accordance with AS2870 – 2011.

Provided all building footings are founded within natural soils or Level 1 controlled fill shallow footings could be adopted for the support of buildings and structures. The following preliminary estimates of potential shrink-swell related ground surface movement ($y_s$) are provided as a guide to the design of shallow footings.

1. Footing in natural alluvial soils at a depth greater than 2m below surrounding surface levels – estimated $y_s$ negligible as depth of design suction (Hs) is 1.5m.
2. Footing in natural alluvial soils at typical shallow footing depths of say 0.5m – estimated $y_s$ is 20 - 40mm.
3. Footing in Level 1 controlled fill comprising site won clay at typical shallow footing depths of say 0.5m – estimated Ys is 40-50mm.

The above estimates are provided as a preliminary guide only based on assumed soil profiles below the structures and the results of shrink-swell testing. Due to the variability of the soil profile and material characteristics, it is conceivable that different classifications could be achieved for certain areas of the site. However, to reclassify individual areas a more specific assessment targeting the individual building areas would be required once final designs, layouts and soil profile have been assessed.

Shrink - swell related movements can be affected by alterations to the soil profile by cutting and filling, and by the suction related effects of trees close to the building area. The effects of any such cutting, filling, tree planting or tree removal should be considered when selecting design values for differential movement across the building.

Site maintenance must comply with the recommendations and advice provided in CSIRO Sheet BTF18 "*Foundation Maintenance and Footing Performance: A Homeowners Guide*" a copy of which can be obtained from www.publish.csiro.au/pid/7076.htm.

### 9.2 Shallow Footings

Shallow footings comprising pad and / or strip footings supporting line or column loads or a stiffened raft slab could be feasible for the support of the building depending on loading configurations. Gravity retaining walls could also be supported on shallow footings.

Shallow footings can be designed based on the allowable bearing pressures provided in Table 7.

**Table 7: Summary of Shallow Footing Bearing Pressure Recommendations**

| Founding Material | Allowable Base Bearing Pressure (kPa) | |
|---|---|---|
| | Minimum Founding Depth[1] | |
| | 0.5m | 2.0m |
| Level 1 Controlled Fill | 150 | - - |
| Unit 2 – Alluvial Soils<br>(Very Stiff or better, Cu ≥ 100kPa) | 150 | 350 |

**NOTES:**

1. *Minimum depth from ground surface to underside of footing.*

### 9.3 Piles

If shallow footings cannot be proportioned to provide the required support piles can be adopted. Conventional open bored piles would be feasible over most of the site however cased bored piles may be required in areas where groundwater seepage is encountered to reduce the potential for pile wall collapse. The use of casing can significantly reduce the available shaft adhesion by smearing the pile wall and in the case of permanent casing reducing pile shaft capacity to zero. CFA piles would be a feasible pile alternative that would alleviate possible issues with pile wall collapse and would enable some shaft capacity. Steel screw piers are another alternative, however, they may not be able to achieve sufficient penetration into the weathered argillite and will therefore not be able to achieve the bearing capacity attainable with other pile types discussed above. Driven piles are not considered feasible within the CBD environment due to potential ground induced vibrations impacting nearby structures and noise during installation.

For pile design in accordance with AS2159-2009, 'Piling-Design and installation', the ultimate geotechnical strength ($Rd,_{ug}$) can be calculated using the shaft capacity and ultimate end bearing capacity values provided in Table 8. Calculation of the design geotechnical strength (Rd,g) requires an assessment of the geotechnical strength reduction factor ($\Phi_g$), which is based on a series of project specific variables. In assessing a suitable geotechnical strength reduction factor for this project, the following assumptions have been made:

- Design of piles and pile groups will be undertaken in accordance with the recommendations presented in this report;
- Limited geotechnical involvement will occur during pile installation;
- Some performance monitoring of the supported structure would be undertaken during or after construction;
- At least 10% of piles will be statically load tested;
- The foundations will be designed by a designer of at least moderate experience in similar geotechnical profiles and pile design;
- Established pile design methods will be used.

Based on the above assumptions and in accordance with AS2159-2009 a risk rating of 2.03 is estimated. Therefore, assuming the pile configuration will have low redundancy a Geotechnical Strength Reduction Factor of $\Phi_g$=0.66 would be appropriate. If no static load testing is undertaken the Geotechnical Strength Reduction Factor would be increased to 0.56.

If any of the assumptions outlined above are not correct, the Geotechnical Strength Reduction Factor may change, and further advice should be sought.

At least the initial stages of pile installation should be observed by a suitably experienced geotechnical engineer to assess that the recommended founding material has been reached and to check initial assumptions about foundation conditions and possible variations between borehole locations.

**Table 8: Summary of Pile Design Parameters**

| Founding Material | Ultimate End Bearing Capacity[1] (MPa) | Serviceability End Bearing Pressure [2] (MPa) | Ultimate Shaft Adhesion[3] (MPa) | Ultimate Lateral Capacity [4] (MPa) | Young' s Modulus, E (MPa) |
|---|---|---|---|---|---|
| Unit 2: Alluvial Soils | - - | - - | 0.05 | 0.4 | $E_v$ – 30<br>$E_h$ – 20 |
| Unit 3: Residual / Extremely Weathered Argillite | 2.5 | 1.0 | 0.1 | 0.75 | $E_v$ – 50<br>$E_h$ – 30 |
| Unit 4a: Highly Weathered Argillite | 5.0 | 2.0 | 0.5 | 1.2 | $E_v$ – 500<br>$E_h$ – 350 |
| Unit 4b: Slightly Weathered to Fresh Argillite | 12.0 | 4.8 | 1.0 | 6.0 | $E_v$ – 8,000<br>$E_h$ – 6,000 |

**NOTES:**

1. *Ultimate end bearing values occur at large displacements (approx. 5% of pile diameter).*
2. *Serviceability end bearing values are based on limiting settlements to 1% of footing diameter.*
3. *Assumes pile walls have adequate roughness (Roughness Class ≥ R2). This could be affected by using temporary liners and must be taken as zero over the cased length of pile where permanent casing is used.*
4. *Lateral capacity for pile lengths within 4.5 pile diameters of the surface must be taken to be zero. Assumes pile centre to centre spacing of at least 5 pile diameters.*

## 10 AGGRESSIVITY

The aggressivity test results presented in Table 9 below were compared to the exposure classifications provided in Australian Standard AS2159-2009, *Piling Design and Installation*.

**Table 9: Results of Soil Aggressivity Testing**

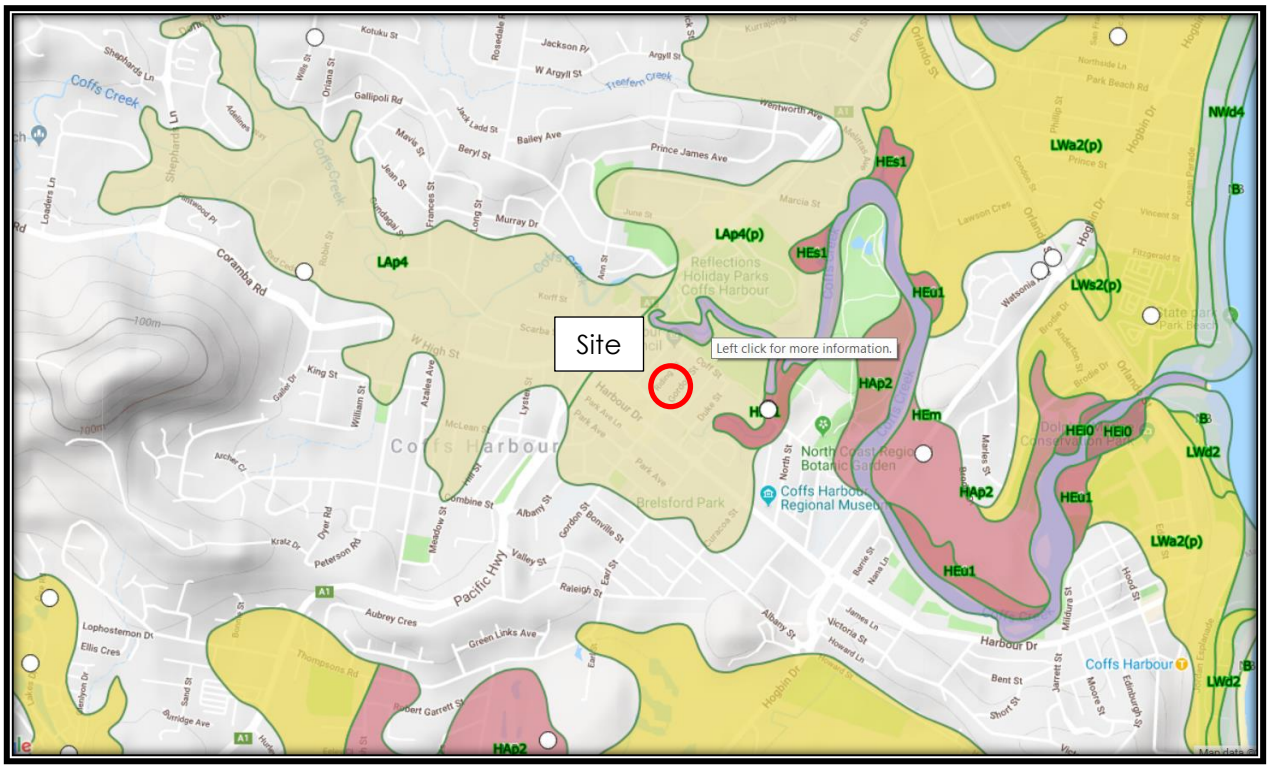
| Sample Location | Sample Depth (m) | Sample Type | pH | Soluble Sulfate (mg/kg) | Chloride (mg/kg) | Resistivity (ohm.cm) |
|---|---|---|---|---|---|---|
| BH1 | 4.30 to 4.75 | Soil | 4.68 | 88 | 6 | 35,511 |
| BH3 | 12.00 to 12.45 | Soil | 5.04 | 98 | 78 | 14,339 |

The laboratory results indicate the soil is mildly aggressive to concrete and non-aggressive to steel elements.

## 11 ACID SULFATE SOILS

An extract of the acid sulfate soils risk map for Coffs Harbour is presented below, the map indicates the site is within an area of low probability of acid sulfate soils.

**Diagram 3: Acid Sulfate Soil Risk Map for Site**




*Sourced from the NSW Government Environment and Heritage eSPADE website.*

### 11.1 Sampling and Analysis

Twelve samples were submitted to a contract laboratory for ASS screening. The results are summarised below:

- The samples revealed pHF values between 3.99 and 4.32 in distilled water. pHF less than 4 is an indicator of Actual ASS;
- The samples revealed pHFOX values between 3.36 and 4.19 in hydrogen peroxide. Values less than 3 can be an indicator of Potential ASS (PASS) but can also be the result of high organic content in the soil;
- A pH change of less than 1 unit was recorded between pHF and pHFOX. A pH change of more than 1 unit is an indicator of PASS.

To provide a more comprehensive assessment, four samples were submitted for Chromium Reducible Sulphur (CRS) analysis. A summary of the test results is presented in Table 9.

**Table 9: Summary of ASS CRS Test Results**

| Test location | Depth (m) | Texture | Action Criteria[1] (mol $H^+$ / t) | Actual Acidity – TAA (mol $H^+$ / t) | Potential Sulfidic Acidity – CRS (mol $H^+$ / t) | Net Acidity (mol $H^+$ / t) | Lime Calculation[2] |
|---|---|---|---|---|---|---|---|
| BH1 | 2.8 to 3.25 | Fine | 18 | **90** | 3 | **104** | 8 |
| BH2 | 1.0 to 1.45 | Fine | 18 | **83** | 5 | **92** | 7 |
| BH4 | 1.5 to 1.95 | Fine | 18 | **105** | **19** | **132** | 10 |
| BH4 | 3.0 to 3.45 | Fine | 18 | **92** | 0 | **101** | 8 |

**NOTE:**

1. *Action criteria is based on more than 1000 tonnes of soil being disturbed*
2. *Lime calculation includes a factor of safety of 1.5*
3. *Values in **Bold** exceed the action criteria.*

### 11.2 Results of Analysis

The results of the analysis were compared against the action criteria as presented in Table 5.4 of the Water Quality Australia *National Acid Sulfate Soils Guidance National acid sulfate soils sampling and identification methods manual June 2018.*

The laboratory test results presented in Table 5 indicate:

- The soils are naturally acidic with acidity levels (TAA) exceeding the action criteria for all of the samples tested;
- There is some potential sulfidic acidity (CRS), however the levels are below the assessment criteria in all but one sample (BH4, 1.5 to .195m);
- The net acidity concentrations exceed the action criteria in all of the samples tested;

### 11.3 ASS Management Plan

Net acidity exceeds the action criteria for all soils tested. Therefore, an Acid Sulfate Soils Management Plan (ASSMP) is required for the proposed works where these soils will be impacted.

The management plan should be prepared once details of the proposed development are known.

## 12 EARTHQUAKE DESIGN REQUIREMENTS

In accordance with AS1170.4-2007 based on the soil profile present the site would be considered a Class $C_e$ site (Shallow Rock). A site hazard factor (z) of 0.05 can be adopted for the purposes of earthquake design in Coffs Harbour.

## 13 PAVEMENTS

The basement floor slab will form a car parking pavement and should therefore be designed as such. Other on grade pavements may also be required as part of the development. Once details of the proposed pavements are known (such as design traffic and subgrade level) pavement thickness designs can be provided which may include flexible and rigid (concrete) pavement options as appropriate.

CBR testing on potential subgrade materials indicate a soaked CBR value of 4.5%. Therefore, where pavements are constructed over subgrades comprising similar materials to those tested a design CBR value of 4.5% should be adopted for pavement design purposes. A modulus of subgrade reaction of 35kPa/mm may be adopted based the CBR results.

### 13.1 Pavement Construction

#### 13.1.1 Construction Methodologies

The following sections provide advice on general construction procedures for pavements.

The subgrade below these pavements should be prepared as follows:

- All root affected material, uncontrolled fill and topsoil should be fully stripped and stockpiled for later reuse for landscaping purposes over the site. These materials are not suitable for reuse as engineered fill.
- Following excavation to an appropriate foundation level, the exposed subgrade materials should be proof rolled to assess any wet, excessively deflecting, heaving or other deleterious material. Any such areas should be over-excavated down to an appropriate base and backfilled with a clean select material.
- Construct pavement as per design requirements.
- Place AC or two coat seal or gravel wearing surface as per Council or design requirements;
- Pavement filling should be carried out in accordance with Level 2 construction monitoring and testing as defined in AS3798 – 2007.

### 13.2 Pavement Drainage

The provision of adequate surface and subsurface drainage is imperative to pavement performance and should be considered in the design and construction of all pavements. As a minimum suitable cross-falls should be maintained both during and following construction. The basement pavement should incorporate drainage measures, such as a drainage blanket between the subgrade and pavement to ensure drainage. The drainage blanket should drain to the basement drainage system. Subsoil drains should also be constructed around the perimeter of on-grade pavements. The invert level of the subsoil drains should be no deeper than the thickness of the pavement profile. Subsoil drains should discharge to an appropriate stormwater system away from pavements.

## 14 SOIL AGGRONOMY TESTING

A soil sample was collected from the upper soil profile near the fig tree located to the north west of the site on Riding Lane. The results of the soil analysis are presented in Appendix B. A appropriately qualified and trained Soil Agronomist should be consulted regarding the interpretation of the results.

## 15 LIMITATIONS

The findings presented in the report and used as the basis for recommendations presented herein were obtained using normal, industry accepted geotechnical practises and standards. To our knowledge, they represent a reasonable interpretation of the general condition of the site. Under no circumstances, however, can it be considered that these findings represent the actual state of the site at all points. If site conditions encountered during construction vary significantly from those discussed in this report, Regional Geotechnical Solutions Pty Ltd should be contacted for further advice.

This report alone should not be used by contractors as the basis for preparation of tender documents or project estimates. Contractors using this report as a basis for preparation of tender documents should avail themselves of all relevant background information regarding the site before deciding on selection of construction materials and equipment.

If you have any questions regarding this project, or require any additional consultations, please contact the undersigned.

For and on behalf of

**Regional Geotechnical Solutions Pty Ltd**

Prepared by

**Adam Holzhauser**

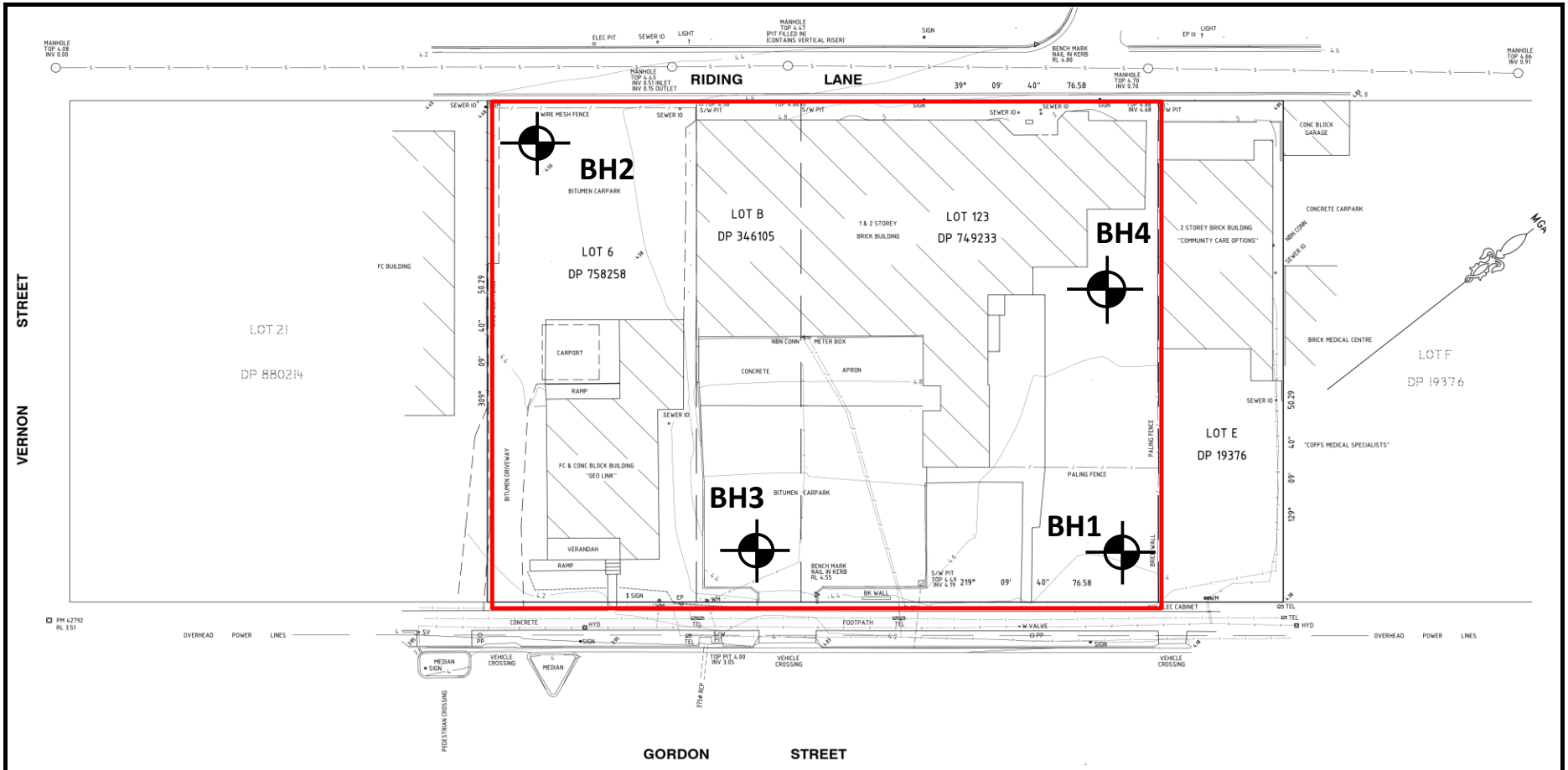
Associate Geotechnical Engineer

Reviewed by

**Simon Keen**

Senior Geotechnical Engineer

# Figures




Temporary Standpipe Piezometer Installed in BH1 and BH2

| | | | | |
|---|---|---|---|---|
| REGIONAL GEOTECHNICAL SOLUTIONS | **Client:** | Coffs Harbour City Council | Job No. | RGS31785.1 |
| | **Project:** | Proposed Cultural & Civic Space Project | Drawn By: | AH |
| | | | Scale: | NTS |
| | | 23-31 Gordon Street, Coffs Harbour | Date: | 1/05/2019 |
| | **Title:** | Borehole Location Plan | Drawing No. | **Figure 1** |

# Appendix A

## Results of Field Investigations

REGIONAL GEOTECHNICAL SOLUTIONS

# ENGINEERING LOG - BOREHOLE

**BOREHOLE NO:** BH1

**CLIENT:** Coffs Harbour City Council
**PAGE:** 1 of 3
**PROJECT NAME:** Proposed Cultural & Civic Space Project
**JOB NO:** RGS31785.1
**SITE LOCATION:** 22-31 Gordon Street, Coffs Harbour
**LOGGED BY:** AH
**TEST LOCATION:** Refer to Figure 1
**DATE:** 25/3/19

**DRILL TYPE:** Truck Mounted Drill Rig
**EASTING:**
**SURFACE RL:**
**BOREHOLE DIAMETER:** 100 mm
**INCLINATION:** 90°
**NORTHING:**
**DATUM:** AHD

| Drilling and Sampling | | | | | Material description and profile information | | | | | Field Test | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| METHOD | WATER | SAMPLES | RL (m) | DEPTH (m) | GRAPHIC LOG | CLASSIFICATION SYMBOL | MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components | MOISTURE CONDITION | CONSISTENCY DENSITY | Test Type | Result | Structure and additional observations |
| AD/TC | | 0.10m ES 0.50m | | | | | 0.20m **FILL:** Clayey SILT, low plasticity, dark brown with some fine to coarse grained Gravel and concrete fragments and rootlets | M ≈ $W_P$ | | | | GRASS |
| | | SPT 7,7,8 N=15 0.95m | | | | | 0.30m **Clayey SILT:** Low plasticity, grey, brown | M ≈ $W_P$ | St | | | ALLUVIAL |
| | | | | 1.0 | | | **Clayey SILT:** Low to medium plasticity, pale grey, mottled orange brown | | | | | |
| | | | | | | | 1.20m **Silty CLAY:** Medium to high plasticity, pale grey mottled red brown | M > $W_P$ | H | | | HP = >600kPa |
| | | | | | | | | | | | | HP = >600kPa |
| | | | | 2.0 | | | | | | | | |
| | | 2.80m SPT 10,23,22 N=45 3.25m | | | | | 2.80m **Silty CLAY:** Medium to high plasticity, pale grey | | | | | HP = >600kPa |
| | | | | 3.0 | | | | | | | | HP = >600kPa |
| | | | | 4.0 | | | | | | | | |
| | | 4.30m SPT 12,25,22 N=47 4.75m | | | | | | | | | | HP = >600kPa |
| | | | | 5.0 | | | Increase in moisture content | | VSt | | | HP = >600kPa |
| | | 6.00m SPT 5,11,17 N=28 6.45m | | 6.0 | | | | | | HP<br>HP<br>HP | 320<br>350<br>380 | |
| | | 7.00m SPT 20,30/150 N=R 7.30m | | 7.0 | | | 7.00m **Silty CLAY:** Medium plasticity, pale grey mottled red brown | | H | | | HP = >600kPa |
| | | | | 8.0 | | | 8.00m **Clayey SILT:** Low to medium plasticity, pale grey mottled red brown, with fine to medium grained ironstone Gravel bands | | VSt | | | HP = >600kPa |
| | | 8.60m SPT 9,16,18 N=34 9.05m | | 9.0 | | | | | | HP<br>HP | 350<br>320 | |
| | | | | | | | 9.50m **Clayey SILT:** Low plasticity, pale grey with pale blue/green mottle | | St | | | |

**LEGEND:**

**Water**
- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

**Strata Changes**
- Gradational or transitional strata
- Definitive or distict strata change

**Notes, Samples and Tests**

| | |
|---|---|
| $U_{50}$ | 50mm Diameter tube sample |
| CBR | Bulk sample for CBR testing |
| E | Environmental sample |
| ASS | Acid Sulfate Soil Sample |
| B | Bulk Sample |

**Field Tests**

| | |
|---|---|
| PID | Photoionisation detector reading (ppm) |
| DCP(x-y) | Dynamic penetrometer test (test depth interval shown) |
| HP | Hand Penetrometer test (UCS kPa) |

**Consistency**

| | | UCS (kPa) |
|---|---|---|
| VS | Very Soft | <25 |
| S | Soft | 25 - 50 |
| F | Firm | 50 - 100 |
| St | Stiff | 100 - 200 |
| VSt | Very Stiff | 200 - 400 |
| H | Hard | >400 |
| Fb | Friable | |

**Density**

| | | |
|---|---|---|
| V | Very Loose | Density Index <15% |
| L | Loose | Density Index 15 - 35% |
| MD | Medium Dense | Density Index 35 - 65% |
| D | Dense | Density Index 65 - 85% |
| VD | Very Dense | Density Index 85 - 100% |

**Moisture Condition**

| | |
|---|---|
| D | Dry |
| M | Moist |
| W | Wet |
| $W_p$ | Plastic Limit |
| $W_L$ | Liquid Limit |

REGIONAL GEOTECHNICAL SOLUTIONS

# ENGINEERING LOG - BOREHOLE

**BOREHOLE NO:** BH1

**CLIENT:** Coffs Harbour City Council
**PAGE:** 2 of 3
**PROJECT NAME:** Proposed Cultural & Civic Space Project
**JOB NO:** RGS31785.1
**SITE LOCATION:** 22-31 Gordon Street, Coffs Harbour
**LOGGED BY:** AH
**TEST LOCATION:** Refer to Figure 1
**DATE:** 25/3/19

**DRILL TYPE:** Truck Mounted Drill Rig
**EASTING:**
**SURFACE RL:**
**BOREHOLE DIAMETER:** 100 mm
**INCLINATION:** 90°
**NORTHING:**
**DATUM:** AHD

| Drilling and Sampling | | | | | Material description and profile information | | | | | Field Test | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| METHOD | WATER | SAMPLES | RL (m) | DEPTH (m) | GRAPHIC LOG | CLASSIFICATION SYMBOL | MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components | MOISTURE CONDITION | CONSISTENCY DENSITY | Test Type | Result | Structure and additional observations |
| AD/TC | | 10.30m<br>SPT 6,6,8 N=14<br>10.75m | | 11.0 | | | **Clayey SILT:** Low plasticity, pale grey with pale blue/green mottle *(continued)* | M > $w_P$ | St | HP<br>HP<br>HP | 150<br>110<br>110 | ALLUVIAL |
| | | 12.00m | | 12.0 | | | 12.00m | | | | | |
| | | SPT 7,14,25 N=39<br>12.45m | | 13.0 | | CL | **Clayey SILT:** Low plasticity, mottled grey, pale grey and orange brown | M < $w_P$ | H / Fb | HP | 420 | RESIDUAL SOIL/EXTREMELY WEATHERED ARGILLITE RELIC ROCK STRUCTURE |
| | | 13.50m<br>SPT 7,13,25 N=38<br>13.95m | | 14.0 | | | | | | | | |
| | | 14.60m<br>SPT 25/100 N=R | | 15.0 | | | 14.75m<br>Continued as Cored Drill Hole | | | | | |
| | | | | 16.0 | | | | | | | | |
| | | | | 17.0 | | | | | | | | |
| | | | | 18.0 | | | | | | | | |
| | | | | 19.0 | | | | | | | | |

**LEGEND:**

**Water**
- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

**Strata Changes**
- Gradational or transitional strata
- Definitive or distict strata change

**Notes, Samples and Tests**

| | |
|---|---|
| $U_{50}$ | 50mm Diameter tube sample |
| CBR | Bulk sample for CBR testing |
| E | Environmental sample |
| ASS | Acid Sulfate Soil Sample |
| B | Bulk Sample |

**Field Tests**

| | |
|---|---|
| PID | Photoionisation detector reading (ppm) |
| DCP(x-y) | Dynamic penetrometer test (test depth interval shown) |
| HP | Hand Penetrometer test (UCS kPa) |

**Consistency**

| | | UCS (kPa) |
|---|---|---|
| VS | Very Soft | <25 |
| S | Soft | 25 - 50 |
| F | Firm | 50 - 100 |
| St | Stiff | 100 - 200 |
| VSt | Very Stiff | 200 - 400 |
| H | Hard | >400 |
| Fb | Friable | |

**Density**

| | | |
|---|---|---|
| V | Very Loose | Density Index <15% |
| L | Loose | Density Index 15 - 35% |
| MD | Medium Dense | Density Index 35 - 65% |
| D | Dense | Density Index 65 - 85% |
| VD | Very Dense | Density Index 85 - 100% |

**Moisture Condition**

| | |
|---|---|
| D | Dry |
| M | Moist |
| W | Wet |
| $W_p$ | Plastic Limit |
| $W_L$ | Liquid Limit |

# ENGINEERING LOG - CORED BOREHOLE

REGIONAL GEOTECHNICAL SOLUTIONS

**BOREHOLE NO:** BH1
**PAGE:** Page 3 of 3
**CLIENT:** Coffs Harbour City Council
**PROJECT NAME:** Proposed Cultural & Civic Space Project
**JOB NO:** RGS31785.1
**SITE LOCATION:** 22-31 Gordon Street, Coffs Harbour
**LOGGED BY:** AH
**TEST LOCATION:** Refer to Figure 1
**DATE:** 25/3/19

**DRILL TYPE:** Truck Mounted Drill Rig
**EASTING:**
**SURFACE RL:**
**BOREHOLE DIAMETER:** 100 mm
**INCLINATION:** 90°
**NORTHING:**
**DATUM:** AHD

| Drilling and Sampling | | | | Material description and profile information | | | | Testing | Rock Mass Defects | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| METHOD | WATER | RL (m) | DEPTH (m) | GRAPHIC LOG | Material Description: Rock type, particle characteristics, colour, minor components, structure | WEATHERING | ESTIMATED STRENGTH | $I_{s(50)}$D/A | RQD % | Defect Spacing mm | Defect Description: Type, inclination, planarity, roughness, coating, thickness |
| | | | 11.0 | | | | | | | | |
| | | | 12.0 | | | | | | | | |
| | | | 13.0 | | | | | | | | |
| | | | 14.0 | | START CORING AT 14.75m | | | | | | |
| NMLC | 100% LOSS | | 15.0 | | **ARGILLITE:** Fine grained, grey, mottled red brown, highly fractured to fragmented | EW - HW | VL | | | | |
| | | | | | NO CORE 0.25m | | | | | | |
| | | | 16.0 | | **ARGILLITE:** Fine grained, grey, indistinctly bedded | HW - MW | L | D=0.21 | 0 | 50 | JT, 30°, IR, RO, IS<br>JT, 45°, IR, RO, IS<br>JT, 60°, IR, RO, IS<br>JT, 45°, IR, RO, IS<br>JT, 30°, IR, RO, IS<br>JT, 10°, IR, RO, IS<br>JT, 35°, IR, RO, IS<br>JT, 45°, IR, RO, IS<br>JT, 35°, IR, RO, IS<br>JT, 45°, IR, RO, IS<br>Highly fractured to fragmented<br>JT, 35°, 35°, IR, RO, IS<br>Fragmented<br>JT, 45°, IR, RO, IS |
| | | | | | NO CORE 0.44m | EW SW | VL H - VH | | | | |
| | | | 17.0 | | **ARGILLITE:** Fine grained, grey, indistinctly bedded | | | D=3.96 | 20 | 100 | JT, 60°, IR, RO, IS<br>JT, 45°, IR, RO, IS<br>JT, 35°, IR, RO, IS<br>JT, 45°, IR, RO<br>JT, 45°, IR, RO, IS<br>JT, 85-90°, IR, RO, IS<br>JT, 35°, IR, RO<br>JT, 35°, IR, RO, IS<br>JT, 25°, IR, RO, IS<br>JT, 35°, IR, RO, IS<br>JT, 45-60°, IR, RO, IS |
| | | | 18.0 | | | | | | | | |
| | | | 19.0 | | Hole Terminated at 18.90 m | | | | | | |

**LEGEND:**

**Method**

| | |
|---|---|
| WB | Wash Bore |
| RR | Rock Roller |
| CB | Claw or Blad Bit |
| NMLC | NMLC Core |
| NQ,HQ,PQ | Wireline Coring |

**Bedding**

| | |
|---|---|
| Laminated | <20mm |
| Thinnly Bedded | 20-200mm |
| Medium Bedded | 200-600mm |
| Thickly Bedded | 600-2000mm |
| Very Thickly Bedded | 2000mm |
| Massive | No Visible Bedding |

**Degree of Fracturing**

| | |
|---|---|
| Fragmented | <20mm |
| Highly Fractured | 20mm to 40mm |
| Fractured | 40mm to 200mm |
| Slightly Fractured | 200mm to 1000mm |

**Weathering**

| | |
|---|---|
| EW | Extremely Weathered |
| HW | Highly Weathered |
| MW | Moderately Weathered |
| SW | Slightly Weathered |
| FR | Fresh |

**Strength**

| | | $I_{s(50)}$ |
|---|---|---|
| VL | Very Low | <0.1 |
| L | Low | 0.1 - 0.3 |
| M | Medium | 0.3 - 1 |
| H | High | 1 - 3 |
| VH | Very High | 3 - 10 |
| EH | Extremely High | >10 |

**Defect Type**

| | |
|---|---|
| JT | Joint |
| PT | Parting |
| SM | Seam |
| SZ | Shear Zone |
| CS | Crushed Seam |

**Roughness**

| | |
|---|---|
| VR | Very Rough |
| RO | Rough |
| SO | Smooth |
| SL | Slickensided |

**Coating**

| | |
|---|---|
| CN | Clean |
| SN | Stained |
| VN | Veneer(<1mm) |
| CO | Coating(1-5mm) |

**Planarity**

| | |
|---|---|
| PL | Planar |
| CU | Curved |
| ST | Stepped |
| IR | Irregular |

# ENGINEERING LOG - BOREHOLE

REGIONAL GEOTECHNICAL SOLUTIONS

| | | | |
|---|---|---|---|
| **CLIENT:** | Coffs Harbour City Council | **BOREHOLE NO:** | **BH2** |
| **PROJECT NAME:** | Proposed Cultural & Civic Space Project | **PAGE:** | 1 of 3 |
| **SITE LOCATION:** | 22-31 Gordon Street, Coffs Harbour | **JOB NO:** | RGS31785.1 |
| **TEST LOCATION:** | Refer to Figure 1 | **LOGGED BY:** | SK |
| | | **DATE:** | 26/3/19 |

**DRILL TYPE:** Truck Mounted Drill Rig **EASTING:** **SURFACE RL:**

**BOREHOLE DIAMETER:** 100 mm **INCLINATION:** 90° **NORTHING:** **DATUM:** AHD

| Drilling and Sampling | | | | | Material description and profile information | | | | | Field Test | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| METHOD | WATER | SAMPLES | RL (m) | DEPTH (m) | GRAPHIC LOG | CLASSIFICATION SYMBOL | MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components | MOISTURE CONDITION | CONSISTENCY DENSITY | Test Type | Result | Structure and additional observations |
| AD/TC | | 0.05m<br>0.20m<br>E<br>0.40m<br>E<br>0.50m<br>1.00m<br>E | | | | GP<br>ML<br>CL | 0.20m **FILL:** Sandy GRAVEL, fine to medium grained, grey, fine to medium grained Sand<br>0.40m **TOPSOIL:** Clayey SILT, low plasticity, dark brown<br>**Silty CLAY:** Medium plasticity, pale brown, mottled orange | D<br>M ~ $w_P$ | VD<br>VSt | | | 2 COAT SEAL<br>PAVEMENT GRAVEL<br>TOPSOIL<br>ALLUVIAL SOIL |
| | | SPT<br>7,7,7<br>N=14<br>1.45m | | 1.0 | | CL | 1.00m **Silty CLAY:** Medium plasticity, pale grey, mottled pale brown and orange to brown | M < $w_P$ | VSt - H | | | |
| | | 2.50m<br>SPT<br>9,10,11<br>N=21<br>2.95m | | 2.0<br>3.0 | | CL | 1.50m **Silty CLAY:** Low to medium plasticity, pale grey with dark red and orange to brown staining along fissures | M < $w_P$ | VSt - H | | | |
| | | 4.00m<br>SPT<br>8,14,16<br>N=30<br>4.45m | | 4.0<br>5.0 | | | | | | | | SPT No sample recovery |
| | | 5.50m<br>SPT<br>10,14,16<br>N=30<br>5.95m | | 6.0 | | | | | | | | |
| | ▽ 26/03/2019 11:00:00 AM | 7.00m<br>SPT<br>13,14,25<br>N=39<br>7.45m | | 7.0<br>8.0 | | | Fine to medium grained quartz Gravel band between 6.8 and 6.9m<br>Zones of distinct dark rede and red to brown iron oxide staining along fissures and throughout the sill mass from about 7m | | | | | |
| | | 8.50m<br>SPT<br>8,11,13<br>N=24<br>8.95m | | 9.0 | | | 9.50m **Silty CLAY:** Low plasticity, grey and pale brown with orange to brown staining along defects, relic fabric | M < $w_P$ | H | | | EXTREMELY WEATHERED ARGILLITE |
| | | 10.00m | | | | | | | | | | |

**LEGEND:**

**Water**
- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

**Strata Changes**
- Gradational or transitional strata
- Definitive or distict strata change

**Notes, Samples and Tests**

| | |
|---|---|
| $U_{50}$ | 50mm Diameter tube sample |
| CBR | Bulk sample for CBR testing |
| E | Environmental sample |
| ASS | Acid Sulfate Soil Sample |
| B | Bulk Sample |

**Field Tests**

| | |
|---|---|
| PID | Photoionisation detector reading (ppm) |
| DCP(x-y) | Dynamic penetrometer test (test depth interval shown) |
| HP | Hand Penetrometer test (UCS kPa) |

**Consistency**

| | | UCS (kPa) |
|---|---|---|
| VS | Very Soft | <25 |
| S | Soft | 25 - 50 |
| F | Firm | 50 - 100 |
| St | Stiff | 100 - 200 |
| VSt | Very Stiff | 200 - 400 |
| H | Hard | >400 |
| Fb | Friable | |

**Moisture Condition**

| | |
|---|---|
| D | Dry |
| M | Moist |
| W | Wet |
| $W_p$ | Plastic Limit |
| $W_L$ | Liquid Limit |

**Density**

| | | |
|---|---|---|
| V | Very Loose | Density Index <15% |
| L | Loose | Density Index 15 - 35% |
| MD | Medium Dense | Density Index 35 - 65% |
| D | Dense | Density Index 65 - 85% |
| VD | Very Dense | Density Index 85 - 100% |

REGIONAL GEOTECHNICAL SOLUTIONS

# ENGINEERING LOG - BOREHOLE

**BOREHOLE NO:** BH2

**CLIENT:** Coffs Harbour City Council
**PAGE:** 2 of 3
**PROJECT NAME:** Proposed Cultural & Civic Space Project
**JOB NO:** RGS31785.1
**SITE LOCATION:** 22-31 Gordon Street, Coffs Harbour
**LOGGED BY:** SK
**TEST LOCATION:** Refer to Figure 1
**DATE:** 26/3/19

**DRILL TYPE:** Truck Mounted Drill Rig
**EASTING:**
**SURFACE RL:**
**BOREHOLE DIAMETER:** 100 mm
**INCLINATION:** 90°
**NORTHING:**
**DATUM:** AHD

| Drilling and Sampling | | | | | Material description and profile information | | | | | Field Test | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| METHOD | WATER | SAMPLES | RL (m) | DEPTH (m) | GRAPHIC LOG | CLASSIFICATION SYMBOL | MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components | MOISTURE CONDITION | CONSISTENCY DENSITY | Test Type | Result | Structure and additional observations |
| AD/TC | | SPT 3,9,13 N=22 10.45m | | 11.0 | | | **Silty CLAY:** Low plasticity, grey and pale brown with orange to brown staining along defects, relic fabric *(continued)* | M < $w_P$ | H | | | EXTREMELY WEATHERED ARGILLITE |
| | | 11.50m SPT 10,21,23 N=44 11.95m | | 12.0 | | | | | | | | |
| | | 13.00m SPT 7,15,25/140mm N=R 13.44m | | 13.0 | | | Traces of fine grained highly weathered argillite<br>Gravel from about 13m | | | | | |
| | | 14.60m SPT 25/135mm M=R 14.74m | | 14.0 | | | 14.90m | | | | | |
| | | | | 15.0 | | | Continued as Cored Drill Hole | | | | | |
| | | | | 16.0 | | | | | | | | |
| | | | | 17.0 | | | | | | | | |
| | | | | 18.0 | | | | | | | | |
| | | | | 19.0 | | | | | | | | |

**LEGEND:**

**Water**
- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

**Strata Changes**
- Gradational or transitional strata
- Definitive or distict strata change

**Notes, Samples and Tests**

| | |
|---|---|
| $U_{50}$ | 50mm Diameter tube sample |
| CBR | Bulk sample for CBR testing |
| E | Environmental sample |
| ASS | Acid Sulfate Soil Sample |
| B | Bulk Sample |

**Field Tests**

| | |
|---|---|
| PID | Photoionisation detector reading (ppm) |
| DCP(x-y) | Dynamic penetrometer test (test depth interval shown) |
| HP | Hand Penetrometer test (UCS kPa) |

**Consistency**

| | | UCS (kPa) |
|---|---|---|
| VS | Very Soft | <25 |
| S | Soft | 25 - 50 |
| F | Firm | 50 - 100 |
| St | Stiff | 100 - 200 |
| VSt | Very Stiff | 200 - 400 |
| H | Hard | >400 |
| Fb | Friable | |

**Density**

| | | |
|---|---|---|
| V | Very Loose | Density Index <15% |
| L | Loose | Density Index 15 - 35% |
| MD | Medium Dense | Density Index 35 - 65% |
| D | Dense | Density Index 65 - 85% |
| VD | Very Dense | Density Index 85 - 100% |

**Moisture Condition**

| | |
|---|---|
| D | Dry |
| M | Moist |
| W | Wet |
| $W_p$ | Plastic Limit |
| $W_L$ | Liquid Limit |

# ENGINEERING LOG - CORED BOREHOLE

REGIONAL GEOTECHNICAL SOLUTIONS

**BOREHOLE NO:** BH2
**PAGE:** Page 3 of 3
**CLIENT:** Coffs Harbour City Council
**JOB NO:** RGS31785.1
**PROJECT NAME:** Proposed Cultural & Civic Space Project
**LOGGED BY:** SK
**SITE LOCATION:** 22-31 Gordon Street, Coffs Harbour
**DATE:** 26/3/19
**TEST LOCATION:** Refer to Figure 1

**DRILL TYPE:** Truck Mounted Drill Rig
**EASTING:**
**SURFACE RL:**
**BOREHOLE DIAMETER:** 100 mm
**INCLINATION:** 90°
**NORTHING:**
**DATUM:** AHD

| Drilling and Sampling | | | | Material description and profile information | | | | Testing | Rock Mass Defects | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| METHOD | WATER | RL (m) | DEPTH (m) | GRAPHIC LOG | Material Description: Rock type, particle characteristics, colour, minor components, structure | WEATHERING | ESTIMATED STRENGTH | $I_{s(50)}$D/A | RQD % | Defect Spacing mm | Defect Description: Type, inclination, planarity, roughness, coating, thickness |
| | | | 11.0 | | | | | | | | |
| | | | 12.0 | | | | | | | | |
| | | | 13.0 | | | | | | | | |
| | | | 14.0 | | | | | | | | |
| | | | 15.0 | | START CORING AT 14.90m | | | | | | |
| NMLC | 0-5% LOSS | | | | NO CORE 800mm | | | | 0 | | |
| | | | 16.0 | | **ARGILLITE:** Dark grey, some calcite stained defects | SW - FR | H - VH | D=3.61 | 70 | 250 | JT, 45°, VR, CN<br>JT, 35°, VR, IR, SN, (Fe)<br>JT, 85°, VN, VR, SN, (Fe) |
| | | | 17.0 | | | | | D=3.17<br>D=4.69 | 100 | 450<br>650 | JT, 10°, PL, RO, SN, (Fe)<br>JT, 85°, PL, RO<br>JT, 80°, PL, RO, CN |
| | | | 18.0 | | Hole Terminated at 17.80 m | | | | | | |
| | | | 19.0 | | | | | | | | |

**LEGEND:**

**Method**

| | |
|---|---|
| WB | Wash Bore |
| RR | Rock Roller |
| CB | Claw or Blad Bit |
| NMLC | NMLC Core |
| NQ,HQ,PQ | Wireline Coring |

**Bedding**

| | |
|---|---|
| Laminated | <20mm |
| Thinnly Bedded | 20-200mm |
| Medium Bedded | 200-600mm |
| Thickly Bedded | 600-2000mm |
| Very Thickly Bedded | 2000mm |
| Massive | No Visible Bedding |

**Degree of Fracturing**

| | |
|---|---|
| Fragmented | <20mm |
| Highly Fractured | 20mm to 40mm |
| Fractured | 40mm to 200mm |
| Slightly Fractured | 200mm to 1000mm |

**Weathering**

| | |
|---|---|
| EW | Extremely Weathered |
| HW | Highly Weathered |
| MW | Moderately Weathered |
| SW | Slightly Weathered |
| FR | Fresh |

**Strength**

| | | $I_{s(50)}$ |
|---|---|---|
| VL | Very Low | <0.1 |
| L | Low | 0.1 - 0.3 |
| M | Medium | 0.3 - 1 |
| H | High | 1 - 3 |
| VH | Very High | 3 - 10 |
| EH | Extremely High | >10 |

**Defect Type**

| | |
|---|---|
| JT | Joint |
| PT | Parting |
| SM | Seam |
| SZ | Shear Zone |
| CS | Crushed Seam |

**Roughness**

| | |
|---|---|
| VR | Very Rough |
| RO | Rough |
| SO | Smooth |
| SL | Slickensided |

**Coating**

| | |
|---|---|
| CN | Clean |
| SN | Stained |
| VN | Veneer(<1mm) |
| CO | Coating(1-5mm) |

**Planarity**

| | |
|---|---|
| PL | Planar |
| CU | Curved |
| ST | Stepped |
| IR | Irregular |

REGIONAL GEOTECHNICAL SOLUTIONS

# ENGINEERING LOG - BOREHOLE

**BOREHOLE NO:** BH3

**CLIENT:** Coffs Harbour City Council
**PAGE:** 1 of 2
**PROJECT NAME:** Proposed Cultural & Civic Space Project
**JOB NO:** RGS31785.1
**SITE LOCATION:** 22-31 Gordon Street, Coffs Harbour
**LOGGED BY:** AH
**TEST LOCATION:** Refer to Figure 1
**DATE:** 27/3/19

**DRILL TYPE:** Truck Mounted Drill Rig
**EASTING:**
**SURFACE RL:**
**BOREHOLE DIAMETER:** 100 mm
**INCLINATION:** 90°
**NORTHING:**
**DATUM:** AHD

| Drilling and Sampling | | | | | Material description and profile information | | | | | | Field Test | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| METHOD | WATER | SAMPLES | RL (m) | DEPTH (m) | GRAPHIC LOG | CLASSIFICATION SYMBOL | MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components | MOISTURE CONDITION | CONSISTENCY DENSITY | | Test Type | Result | Structure and additional observations |
| AD/TC | | | | | | | 0.03m **ASPHALT:** 30mm thick | D | | | | | WEARING SURFACE |
| | | | | | | | 0.25m **FILL:** Sandy GRAVEL fine to coarse grained, grey | M > $w_P$ | | | | | PAVEMENT BASE |
| | | | | | | | **FILL:** Silty CLAY, medium plasticity, red brown with trace medium to coarse angular Gravel | | | | | | FILL SUBGRADE |
| | | 1.00m SPT 5,5,6 N=11 1.45m | | 1.0 | | | | | | | HP | 250 | |
| | | | | | | | | | | | HP | 280 | |
| | | | | | | | 1.60m | | | | HP | 350 | |
| | | | | 2.0 | | ML | **Clayey SILT:** Low to medium plasticity, orange, brown, mottled pale grey | M < $w_P$ | VSt | | | | ALLUVIAL |
| | | | | | | | 2.40m | | | | | | |
| | | | | | | CL | **Silty CLAY:** Medium plasticity, pale grey with trace orange brown mottle | | H | | | | |
| | | 3.00m SPT 9,16,18 N=34 3.45m | | 3.0 | | | | | | | | | HP = >600kPa |
| | | | | 4.0 | | | | | | | | | HP = >600kPa |
| | | 4.50m DS 5.00m | | 5.0 | | | 5.00m | | | | | | |
| | | | | | | CL | **Silty CLAY:** Medium plasticity, pale grey with trace red brown mottle and trace fine to medium ironstone Gravel | M < $w_P$ | | | | | |
| | | 6.00m SPT 10,15,16 N=31 6.45m | | 6.0 | | | | | | | HP | 420 | |
| | | | | | | | | | | | HP | 430 | |
| | | | | 7.0 | | | 7.50m | | | | | | |
| | | | | | | ML | **Clayey SILT:** Low plasticity, pale grey | | | | | | |
| | | | | 8.0 | | | | | VSt / H | | | | |
| | | 9.00m SPT 7,10,12 N=22 9.45m | | 9.0 | | | | | | | HP | 380 | |
| | | | | | | | | | | | HP | 420 | |

**LEGEND:**

**Water**
- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

**Strata Changes**
- Gradational or transitional strata
- Definitive or distict strata change

**Notes, Samples and Tests**

| | |
|---|---|
| $U_{50}$ | 50mm Diameter tube sample |
| CBR | Bulk sample for CBR testing |
| E | Environmental sample |
| ASS | Acid Sulfate Soil Sample |
| B | Bulk Sample |

**Field Tests**

| | |
|---|---|
| PID | Photoionisation detector reading (ppm) |
| DCP(x-y) | Dynamic penetrometer test (test depth interval shown) |
| HP | Hand Penetrometer test (UCS kPa) |

**Consistency**

| | | UCS (kPa) |
|---|---|---|
| VS | Very Soft | <25 |
| S | Soft | 25 - 50 |
| F | Firm | 50 - 100 |
| St | Stiff | 100 - 200 |
| VSt | Very Stiff | 200 - 400 |
| H | Hard | >400 |
| Fb | Friable | |

**Density**

| | | |
|---|---|---|
| V | Very Loose | Density Index <15% |
| L | Loose | Density Index 15 - 35% |
| MD | Medium Dense | Density Index 35 - 65% |
| D | Dense | Density Index 65 - 85% |
| VD | Very Dense | Density Index 85 - 100% |

**Moisture Condition**

| | |
|---|---|
| D | Dry |
| M | Moist |
| W | Wet |
| $W_p$ | Plastic Limit |
| $W_L$ | Liquid Limit |

REGIONAL GEOTECHNICAL SOLUTIONS

# ENGINEERING LOG - BOREHOLE

**BOREHOLE NO:** BH3

**CLIENT:** Coffs Harbour City Council
**PAGE:** 2 of 2
**PROJECT NAME:** Proposed Cultural & Civic Space Project
**JOB NO:** RGS31785.1
**SITE LOCATION:** 22-31 Gordon Street, Coffs Harbour
**LOGGED BY:** AH
**TEST LOCATION:** Refer to Figure 1
**DATE:** 27/3/19

**DRILL TYPE:** Truck Mounted Drill Rig
**EASTING:**
**SURFACE RL:**
**BOREHOLE DIAMETER:** 100 mm
**INCLINATION:** 90°
**NORTHING:**
**DATUM:** AHD

| Drilling and Sampling | | | | | Material description and profile information | | | | | Field Test | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| METHOD | WATER | SAMPLES | RL (m) | DEPTH (m) | GRAPHIC LOG | CLASSIFICATION SYMBOL | MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components | MOISTURE CONDITION | CONSISTENCY DENSITY | Test Type | Result | Structure and additional observations |
| AD/TC | | | | | | ML | **Clayey SILT:** Low plasticity, pale grey *(continued)* | M < $w_P$ | VSt / H | | | ALLUVIAL |
| | | | | | | | 10.50m | | | | | |
| | | | | | | CL | **Silty CLAY:** Medium plasticity, pale grey, mottled orange brown | M > $w_P$ | St | | | RESIDUAL SOIL |
| | | | | 11.0 | | | | | | | | |
| | | 12.00m SPT 5,9,14 N=23 12.45m | | 12.0 | | | | | | HP | 150 | |
| | | | | | | | | | | HP | 200 | |
| | | | | 13.0 | | | | | | | | |
| | | | | 14.0 | | | | | | | | |
| | | | | 15.0 | | | | | | | | |
| | | | | 16.0 | | | 16.00m | | | | | |
| | | | | | | | **ARGILLITE:** Fine grained, grey | | | | | EXTREMELY TO HIGHLY WEATHERED ARGILLITE VERY LOW STRENGTH |
| | | | | 17.0 | | | 17.40m | | | | | |
| | | | | | | | Hole Terminated at 17.40 m Auger Refusal | | | | | MODERATELY TO SLIGHTLY WEATHERED ARGILLITE MEDIUM STRENGTH |
| | | | | 18.0 | | | | | | | | |
| | | | | 19.0 | | | | | | | | |

**LEGEND:**

**Water**
- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

**Strata Changes**
- Gradational or transitional strata
- Definitive or distict strata change

**Notes, Samples and Tests**

| | |
|---|---|
| $U_{50}$ | 50mm Diameter tube sample |
| CBR | Bulk sample for CBR testing |
| E | Environmental sample |
| ASS | Acid Sulfate Soil Sample |
| B | Bulk Sample |

**Field Tests**

| | |
|---|---|
| PID | Photoionisation detector reading (ppm) |
| DCP(x-y) | Dynamic penetrometer test (test depth interval shown) |
| HP | Hand Penetrometer test (UCS kPa) |

**Consistency**

| | | UCS (kPa) |
|---|---|---|
| VS | Very Soft | <25 |
| S | Soft | 25 - 50 |
| F | Firm | 50 - 100 |
| St | Stiff | 100 - 200 |
| VSt | Very Stiff | 200 - 400 |
| H | Hard | >400 |
| Fb | Friable | |

**Density**

| | | |
|---|---|---|
| V | Very Loose | Density Index <15% |
| L | Loose | Density Index 15 - 35% |
| MD | Medium Dense | Density Index 35 - 65% |
| D | Dense | Density Index 65 - 85% |
| VD | Very Dense | Density Index 85 - 100% |

**Moisture Condition**

| | |
|---|---|
| D | Dry |
| M | Moist |
| W | Wet |
| $W_p$ | Plastic Limit |
| $W_L$ | Liquid Limit |

# ENGINEERING LOG - BOREHOLE

REGIONAL GEOTECHNICAL SOLUTIONS

**BOREHOLE NO:** BH4

**CLIENT:** Coffs Harbour City Council
**PAGE:** 1 of 2
**PROJECT NAME:** Proposed Cultural & Civic Space Project
**JOB NO:** RGS31785.1
**SITE LOCATION:** 22-31 Gordon Street, Coffs Harbour
**LOGGED BY:** AH
**TEST LOCATION:** Refer to Figure 1
**DATE:** 27/3/19

**DRILL TYPE:** Truck Mounted Drill Rig
**EASTING:**
**SURFACE RL:**
**BOREHOLE DIAMETER:** 100 mm
**INCLINATION:** 90°
**NORTHING:**
**DATUM:** AHD

| Drilling and Sampling | | | | | Material description and profile information | | | | | | Field Test | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| METHOD | WATER | SAMPLES | RL (m) | DEPTH (m) | GRAPHIC LOG | CLASSIFICATION SYMBOL | MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components | MOISTURE CONDITION | CONSISTENCY DENSITY | Test Type | Result | Structure and additional observations |
| AD/TC | | 0.10m<br>0.30m ES<br>0.40m ES | | | | | 0.25m **Sandy SILT:** Low plasticity, dark brown with rootlets | M | | | | TOPSOIL: GRASS |
| | | | | | | ML | **Clayey SILT:** Low plasticity, pale grey mottled orange brown | M > $w_P$ | VSt | | | ALLUVIAL |
| | | 1.00m<br>SPT 7,8,11 N=19<br>1.45m | | 1.0 | | | 1.00m | | | HP | 320 | |
| | | | | | | CH | **Silty CLAY:** Medium to high plasticity, grey mottled red brown and orange brown | | | HP | 330 | |
| | | | | 2.0 | | | | | | HP | 410 | |
| | | | | | | | | | H | | | |
| | | 3.00m<br>SPT 12,21,23 N=44<br>3.45m | | 3.0 | | | | | | | | |
| | 27/03/2019 3:36:00 PM | | | 4.0 | | | 4.00m | | | | | |
| | | 4.50m<br>SPT 10,11,5 N=16<br>4.95m | | | | CL | **Silty CLAY:** Medium plasticity, grey with some pale brown and red mottling | | | | | |
| | | | | 5.0 | | | | | | HP | 420 | |
| | | | | | | | | | | HP | 450 | |
| | | | | 6.0 | | | | | | | | |
| | | | | 7.0 | | | | | | | | |
| | | 7.50m<br>SPT 23,25,33/120 N=R<br>7.92m | | 8.0 | | | | | | | | |
| | | | | 9.0 | | | 9.00m | | | | | |
| | | | | | | ML | **Clayey SILT:** Low plasticity, mottled grey, pale brown, white | M < $w_P$ | VSt / Fb | | | RESIDUAL SOIL/EXTREMELY WEATHERED ARGILLITE RELIC ROCK STRUCTURE |

**LEGEND:**

**Water**
- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

**Strata Changes**
- Gradational or transitional strata
- Definitive or distict strata change

**Notes, Samples and Tests**

| | |
|---|---|
| $U_{50}$ | 50mm Diameter tube sample |
| CBR | Bulk sample for CBR testing |
| E | Environmental sample |
| ASS | Acid Sulfate Soil Sample |
| B | Bulk Sample |

**Field Tests**

| | |
|---|---|
| PID | Photoionisation detector reading (ppm) |
| DCP(x-y) | Dynamic penetrometer test (test depth interval shown) |
| HP | Hand Penetrometer test (UCS kPa) |

**Consistency**

| | | UCS (kPa) |
|---|---|---|
| VS | Very Soft | <25 |
| S | Soft | 25 - 50 |
| F | Firm | 50 - 100 |
| St | Stiff | 100 - 200 |
| VSt | Very Stiff | 200 - 400 |
| H | Hard | >400 |
| Fb | Friable | |

**Density**

| | | |
|---|---|---|
| V | Very Loose | Density Index <15% |
| L | Loose | Density Index 15 - 35% |
| MD | Medium Dense | Density Index 35 - 65% |
| D | Dense | Density Index 65 - 85% |
| VD | Very Dense | Density Index 85 - 100% |

**Moisture Condition**

| | |
|---|---|
| D | Dry |
| M | Moist |
| W | Wet |
| $W_p$ | Plastic Limit |
| $W_L$ | Liquid Limit |

REGIONAL GEOTECHNICAL SOLUTIONS

# ENGINEERING LOG - BOREHOLE

**BOREHOLE NO:** BH4

**CLIENT:** Coffs Harbour City Council
**PAGE:** 2 of 2
**PROJECT NAME:** Proposed Cultural & Civic Space Project
**JOB NO:** RGS31785.1
**SITE LOCATION:** 22-31 Gordon Street, Coffs Harbour
**LOGGED BY:** AH
**TEST LOCATION:** Refer to Figure 1
**DATE:** 27/3/19

**DRILL TYPE:** Truck Mounted Drill Rig
**EASTING:**
**SURFACE RL:**
**BOREHOLE DIAMETER:** 100 mm
**INCLINATION:** 90°
**NORTHING:**
**DATUM:** AHD

| Drilling and Sampling | | | | | Material description and profile information | | | | | Field Test | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| METHOD | WATER | SAMPLES | RL (m) | DEPTH (m) | GRAPHIC LOG | CLASSIFICATION SYMBOL | MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components | MOISTURE CONDITION | CONSISTENCY DENSITY | Test Type | Result | Structure and additional observations |
| AD/TC | | 10.50m<br>SPT 6,8,9 N=17<br>10.95m | | 11.0<br>12.0<br>13.0 | | ML | **Clayey SILT:** Low plasticity, mottled grey, pale brown, white *(continued)* | M < $w_P$ | VSt / Fb | | | RESIDUAL SOIL/EXTREMELY WEATHERED ARGILLITE RELIC ROCK STRUCTURE |
| | | 13.50m<br>SPT 22,30/120 N=R<br>13.77m | | 14.0<br>15.0<br>16.0<br>17.0 | | | 13.00m<br>**ARGILLITE:** Fine grained, pale brown with trace fine quartz Gravel<br>Becoming harder at 17.1m<br>17.40m | | | | | EXTREMELY TO HIGHLY WEATHERED ARGILLITE VERY LOW STRENGTH<br>HIGHLY WEATHERED ARGILLITE LOW STRENGTH |
| | | | | 18.0<br>19.0 | | | Hole Terminated at 17.40 m<br>Auger Refusal | | | | | |

**LEGEND:**

**Water**
- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

**Strata Changes**
- Gradational or transitional strata
- Definitive or distict strata change

**Notes, Samples and Tests**

| | |
|---|---|
| $U_{50}$ | 50mm Diameter tube sample |
| CBR | Bulk sample for CBR testing |
| E | Environmental sample |
| ASS | Acid Sulfate Soil Sample |
| B | Bulk Sample |

**Field Tests**

| | |
|---|---|
| PID | Photoionisation detector reading (ppm) |
| DCP(x-y) | Dynamic penetrometer test (test depth interval shown) |
| HP | Hand Penetrometer test (UCS kPa) |

**Consistency**

| | | UCS (kPa) |
|---|---|---|
| VS | Very Soft | <25 |
| S | Soft | 25 - 50 |
| F | Firm | 50 - 100 |
| St | Stiff | 100 - 200 |
| VSt | Very Stiff | 200 - 400 |
| H | Hard | >400 |
| Fb | Friable | |

**Density**

| | | |
|---|---|---|
| V | Very Loose | Density Index <15% |
| L | Loose | Density Index 15 - 35% |
| MD | Medium Dense | Density Index 35 - 65% |
| D | Dense | Density Index 65 - 85% |
| VD | Very Dense | Density Index 85 - 100% |

**Moisture Condition**

| | |
|---|---|
| D | Dry |
| M | Moist |
| W | Wet |
| $W_p$ | Plastic Limit |
| $W_L$ | Liquid Limit |

# Appendix B

## Laboratory Test results

**QUALTEST Laboratory (NSW) Pty Ltd (20708)**
**8 Ironbark Close Warabrook NSW 2304**
T: 02 4968 4468
F: 02 4960 9775
E: admin@qualtest.com.au
W: www.qualtest.com.au
ABN: 98 153 268 896

# California Bearing Ratio Test Report

**Report No: CBR:NEW19W-1220--S01**
**Issue No: 1**

**Client:** Regional Geotechnical Solutions Pty Ltd
44 Bent Street
Wingham NSW 2429

**Principal:**
**Project No.:** MNC16P-0001
**Project Name:** Various Testing

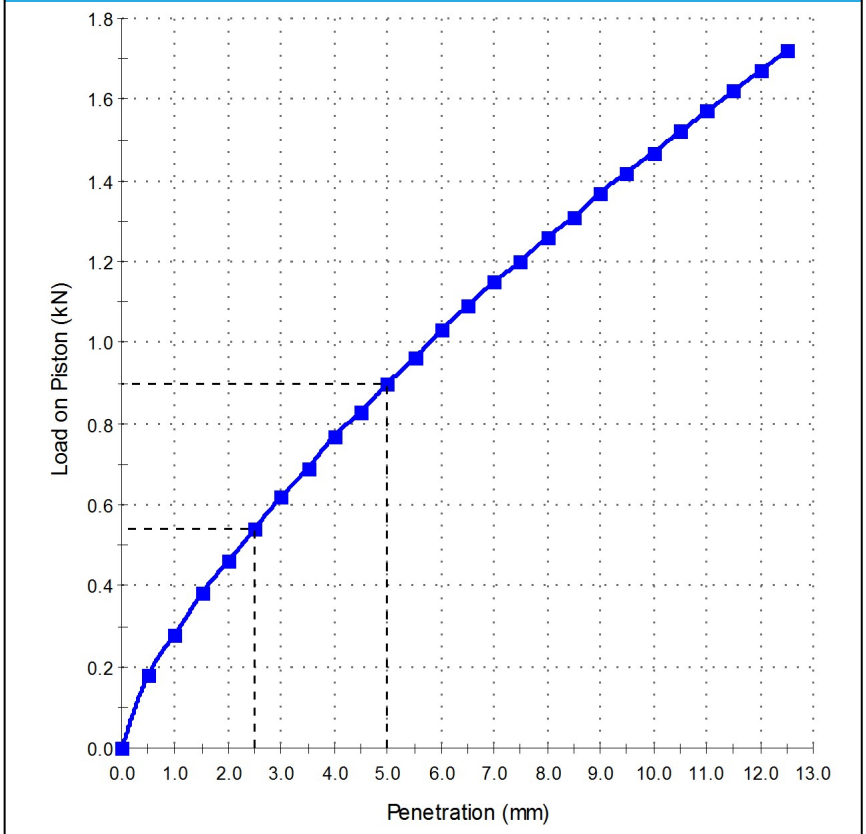


Approved Signatory: Brent Cullen
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 24/04/2019

## Sample Details

| | | | |
|---|---|---|---|
| **Sample ID:** | NEW19W-1220--S01 | **Lot No.:** | RGS19-924A |
| **Test Request No.:** | RGS31785.1 | **Date Sampled:** | 29/03/2019 |
| **Sampling Method:** | Sampled by Client | | |
| **Specification:** | No Specification | **Source:** | On Site |
| **Location:** | CBR1 - (0.2 - 0.5m) | **Material:** | Sandy Clay |
| **Project Location:** | Gordon Street, Coffs Harbour, NSW | | |

## Load vs Penetration




## Test Results

AS 1289.6.1.1 - 2014

| | |
|---|---|
| **CBR At 5.0mm (%):** | **4.5** |
| Maximum Dry Density (t/m³): | 1.77 |
| Optimum Moisture Content (%): | 18.0 |
| Dry Density before Soaking (t/m³): | 1.76 |
| Density Ratio before Soaking (%): | 99.0 |
| Moisture Content before Soaking (%): | 18.5 |
| Moisture Ratio before Soaking (%): | 103.0 |
| Dry Density after Soaking (t/m³): | 1.76 |
| Density Ratio after Soaking (%): | 99.0 |
| Swell (%): | 0.0 |
| Moisture Content of Top 30mm (%): | 18.5 |
| Moisture Content of Remaining Depth (%): | 18.3 |
| Compactive Effort: | Standard |
| | AS 1289.5.1.1 |
| Surcharge Mass (kg): | 4.50 |
| Period of Soaking (Days): | 4 |
| Oversize Material (%): | 0 |
| CBR Moisture Content Method: | AS 1289.2.1.1 |
| Curing Time (hrs) : | 48 |

## Comments

Method of establishing plasticity level: Visual Assessment
AS1289.5.1.1 Performed and supplied by Client

**QUALTEST Laboratory (NSW) Pty Ltd (20708)**
**8 Ironbark Close Warabrook NSW 2304**
T: 02 4968 4468
F: 02 4960 9775
E: admin@qualtest.com.au
W: www.qualtest.com.au
ABN: 98 153 268 896

# California Bearing Ratio Test Report

**Report No: CBR:NEW19W-1220--S02**
**Issue No: 1**

**Client:** Regional Geotechnical Solutions Pty Ltd
44 Bent Street
Wingham NSW 2429

**Principal:**
**Project No.:** MNC16P-0001
**Project Name:** Various Testing

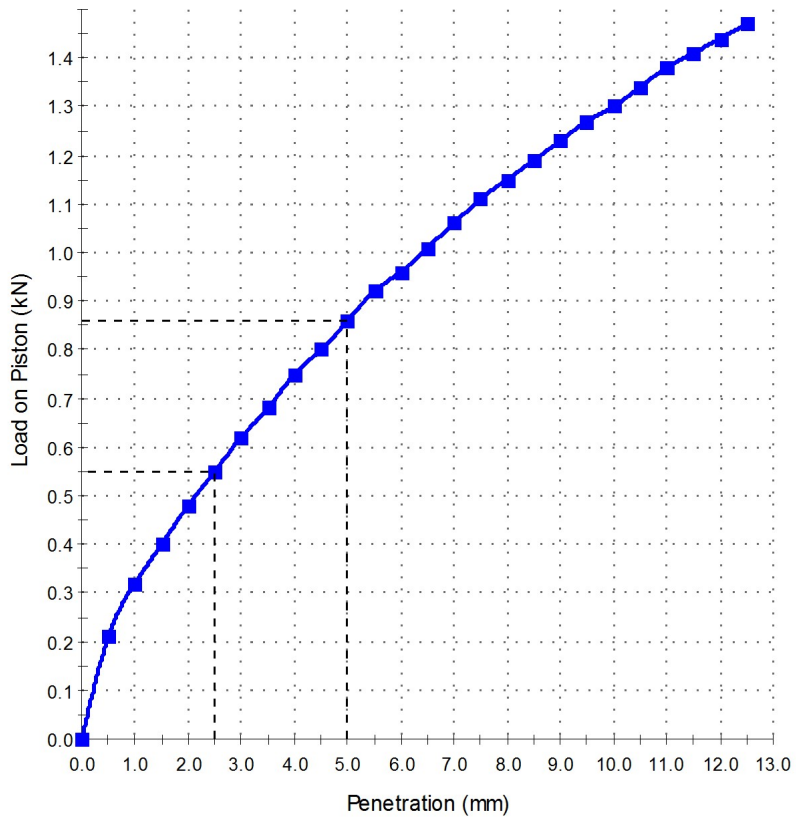
Accredited for compliance with ISO/IEC 17025-Testing.
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.
Results provided relate only to the items tested or sampled.
This report shall not be reproduced except in full.

Approved Signatory: Brent Cullen
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 24/04/2019

## Sample Details

| | | | |
|---|---|---|---|
| **Sample ID:** | NEW19W-1220--S02 | **Lot No.:** | RGS19-924B |
| **Test Request No.:** | RGS31785.1 | **Date Sampled:** | 29/03/2019 |
| **Sampling Method:** | Sampled by Client | | |
| **Specification:** | No Specification | **Source:** | On Site |
| **Location:** | CBR2 - (0.2 - 0.5m) | **Material:** | Sandy Clay |
| **Project Location:** | Gordon Street, Coffs Harbour, NSW | | |

## Load vs Penetration




## Test Results

AS 1289.6.1.1 - 2014

| | |
|---|---|
| **CBR At 5.0mm (%):** | **4.5** |
| Maximum Dry Density (t/m³): | 1.76 |
| Optimum Moisture Content (%): | 19.0 |
| Dry Density before Soaking (t/m³): | 1.77 |
| Density Ratio before Soaking (%): | 100.5 |
| Moisture Content before Soaking (%): | 18.4 |
| Moisture Ratio before Soaking (%): | 97.0 |
| Dry Density after Soaking (t/m³): | 1.77 |
| Density Ratio after Soaking (%): | 100.5 |
| Swell (%): | 0.0 |
| Moisture Content of Top 30mm (%): | 18.8 |
| Moisture Content of Remaining Depth (%): | 18.5 |
| Compactive Effort: | Standard |
| | AS 1289.5.1.1 |
| Surcharge Mass (kg): | 4.50 |
| Period of Soaking (Days): | 4 |
| Oversize Material (%): | 0 |
| CBR Moisture Content Method: | AS 1289.2.1.1 |
| Curing Time (hrs) : | 48 |

## Comments

Method of establishing plasticity level: Visual Assessment
AS1289.5.1.1 Performed and supplied by Client

# RESULTS OF ACID SULFATE SOIL ANALYSIS (Net Acidity results added)

12 samples supplied by Regional Geotechnical Solutions Pty Ltd on 2nd April, 2019. Lab Job No.I0266

Analysis requested by Adam Holzhauser. Your Job: RGS 31785.1

1/21 Cook Drive COFFS HARBOUR NSW 2450

| Sample Identification | EAL Lab Code | Texture | Moisture Content | | $pH_F$ and $pH_{FOX}$ | | | | KCl-extractable sulfur ($S_{KCl}$) | | Potential Sulfidic Acidity (Chromium Reducible Sulfur - CRS) | | $pH_{KCl}$ | Actual Acidity (Titratable Actual Acidity - TAA) | Retained Acidity ($\%S_{HCl} - \%S_{KCl}$) | | Non-treated soil: Acid Neutralising Capacity ($ANC_{BT}$) | | Non-treated soil: Net Acidity | Non-treated soil: Lime Calculation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (% moisture of total wet weight) | (g moisture / g of oven dry soil) | $pH_F$ | $pH_{FOX}$ | pH change | Reaction | (% $S_{KCl}$) | (equiv. mol $H^+$/t) | (% $S_{Cr}$) | (mol $H^+$/t) | | (mol $H^+$/t) | ($\%S_{NAS}$) | (mol $H^+$/t) | (% $CaCO_3$) | (mol $H^+$/t) | (mol $H^+$/t) | (kg $CaCO_3$/t DW) |
| *Method Info.* | | ** | * | | *(In-house method S21)* | | | | ** | | *(In-house method S20)* | | *(In-house method 16b)* | | ** | | *(In-house method S14)* | | ** | ** |
| **BH1 1.5-1.95** | *I0266/1* | Fine | 19.7 | 0.25 | 4.13 | 3.36 | -0.77 | Low | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| **BH1 2.8-3.25** | *I0266/2* | Fine | 14.5 | 0.17 | 3.99 | 3.47 | -0.52 | Low | 0.028 | 17 | 0.005 | 3 | 3.98 | 90 | 0.023 | 11 | .. | .. | 104 | 8 |
| **BH1 5.8-6.25** | *I0266/3* | Fine | 15.9 | 0.19 | 4.07 | 3.94 | -0.13 | Low | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| **BH2 1-1.45** | *I0266/4* | Fine | 16.7 | 0.20 | 4.18 | 3.56 | -0.62 | Low | 0.020 | 12 | 0.008 | 5 | 4.06 | 83 | 0.007 | 3 | .. | .. | 92 | 7 |
| **BH2 2.5-2.95** | *I0266/5* | Fine | 15.1 | 0.18 | 4.23 | 3.82 | -0.41 | Low | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| **BH2 5.5-5.95** | *I0266/6* | Fine | 13.5 | 0.16 | 4.09 | 3.97 | -0.12 | Low | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| **BH3 3-3.45** | *I0266/7* | Fine | 15.0 | 0.18 | 4.05 | 3.79 | -0.26 | Low | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| **BH3 4.5-5** | *I0266/8* | Fine | 15.8 | 0.19 | 4.45 | 4.19 | -0.26 | Low | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| **BH3 9-9.45** | *I0266/9* | Fine | 27.0 | 0.37 | 4.25 | 3.56 | -0.69 | Low | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| **BH4 1.5-1.95** | *I0266/10* | Fine | 18.6 | 0.23 | 4.05 | 3.40 | -0.65 | Low | 0.030 | 19 | 0.030 | 19 | 3.99 | 105 | 0.017 | 8 | .. | .. | 132 | 10 |
| **BH4 3-3.45** | *I0266/11* | Fine | 14.6 | 0.17 | 4.32 | 3.62 | -0.70 | Low | 0.020 | 13 | < 0.005 | 0 | 4.09 | 92 | 0.018 | 8 | .. | .. | 101 | 8 |
| **BH4 4.5-4.95** | *I0266/12* | Fine | 16.2 | 0.19 | 4.31 | 3.86 | -0.45 | Low | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |

**NOTES:**

1. All analysis is reported on a dry weight (DW) basis, unless wet weight (WW) is specified.
2. Samples are dried and ground immediately upon arrival (unless supplied dried and ground).
3. Analytical procedures are sourced from Sullivan L, Ward N, Toppler N and Lancaster G. 2018. National acid sulfate soils guidance: national acid sulfate soils identification and laboratory methods manual, Department of Agriculture and Water Resources, Canberra, ACT. CC BY 4.0.
4. The Acid Base Accounting Equation, where Acid Neutralising Capacity has not been corroborated by other data, is **Net Acidity = Potential Acidity + Actual Acidity + Retained Acidity** (Eq. 3.2; Sullivan et al. 2018 - full reference above).
5. The Acid Base Accounting Equation for post-limed soil materials is **Net Acidity = Potential Acidity + Actual Acidity + Retained Acidity - (post treatment Acid Neutralising Capacity - initial Acid Neutralising Capacity)** (Eq. 3.3; Sullivan et al. 2018 - full reference above).
   While the Acid Neutralising Capacity of a soil material may not be included in the Net Acidity calculation (Note 4), it must be measured to give an Initial Acid Neutralising Capacity if verification testing is planned post-liming.
   **The Inital Acid Neutralising Capacity must be provided by the client to enable EAL to produce Net Acidity and Liming calculations for post-limed soil materials.**
6. The Acid Base Accounting Equation, where Acid Neutralising Capacity has been corroborated by other data, is Net Acidity = Potential Acidity + Actual Acidity + Retained Acidity - Acid Neutralising Capacity (Eq. 3.1; Sullivan et al. 2018 - full reference above).
7. The lime calculation includes a Safety Factor of 1.5 as a safety margin for acid neutralisation (Sullivan et al. 2018). This is only applied to positive values. An increased Safety Factor may be required in some cases.
8. Retained Acidity is required when the $pH_{KCl}$ < 4.5 or where jarosite has been visually observed.
9. A negative Net Acidity result indicates an excess acid neutralising capacity.
10. If insufficient mixing occurs during intial sampling, or during post-liming, or both: the Potential Sulfidic Acidity may be greater in the post-limed sample than in the intial sample; the post-liming Acid Neutralising Capacity may be lower in the post-limed sample than in the intial sample.
11. **An acid sulfate soil management plan is triggered by Net Acidity results greater than the texture dependent criterion: coarse texture ≥ 0.03% S or 18 mol $H^+$/t; medium texture ≥ 0.06% S or 36 mol $H^+$/t; fine texture ≥ 0.1% S or 62 mol $H^+$/t)** (Table 1.1; Sullivan et al. 2018 - full reference above)
12. For projects that disturb > 1000 t of soil material, the coarse trigger of ≥ 0.03% S or ≥ 18 mol $H^+$/t must be applied in accordance with Sullivan et al. (2018) (full reference above).
13. Acid sulfate soil texture triggers can be related to NCST (2009) textures: coarse and peats = sands to loamy sands; medium = clayey sand to light clays; fine = light medium to heavy clays (Sullivan et al. 2018 - full reference above).
14. Bulk density is required to convert liming rates to soil volume based results. Field bulk density rings can be submitted to EAL for bulk density determination.
15. A negative Net Acidity result indicates an excess acid neutralising capacity.
16. '..' is reported where a test is either not requested or not required. Where $pH_{KCl}$ is < 4.5 or > 6.5, zero is reported for $S_{NAS}$ and ANC in Net Acidity calculations, respectively.
17. Results refer to samples as received at the laboratory. This report is not to be reproduced except in full.
18. ** NATA accreditation does not cover the performance of this service.
19. Analysis conducted between sample arrival date and reporting date.
20. All services undertaken by EAL are covered by the EAL Laboratory Services Terms and Conditions (refer scu.edu.au/eal or on request).
21. This report has been re-issued on the 2nd May, 2019 and replaces the report sent on the 4th April, 2019. Net Acidity results for selected samples have been added.

NATA ACCREDITATION
Accreditation No. 14960
Accredited for compliance with ISO/IEC 17025 - Testing



checked: .....
Graham Lancaster
Laboratory Manager

# RESULTS OF SOIL ANALYSIS (Page 1 of 1)

2 samples supplied by Regional Geotechnical Solutions Pty Ltd on 2/4/19 - Lab Job No. I0265
Analysis requested by Adam Holzhauser. - **Your Project: RGS31785.1 CHCC**
(1/21 Cook Drive COFFS HARBOUR NSW 2450)

| | Method | Sample 1<br>BH1 4.3 - 4.75 | Sample 2<br>BH3 12 - 12.45 |
|---|---|---|---|
| | *EAL job No.* | ***I0265/1*** | ***I0265/2*** |
| Moisture (%) | *inhouse* | 14 | 34 |
| Texture | *See note 2 below.* | fine | fine |
| pH | Rayment & Lyons 2011 - 4A1 (1:5 Water) | 4.68 | 5.04 |
| Conductivity (dS/m ) | Rayment & Lyons 2011 - 3A1 (1:5 Water) | 0.028 | 0.070 |
| Resistivity (ohm.mm) | ** Calculation | 355,114 | 143,390 |
| Chloride (mg/kg) | ** Water Extract- Rayment and Lyons 5A2a | 6 | 78 |
| Chloride **(as %)** | ** Calculation | 0.001 | 0.008 |
| Sulfate (mg/kg) | ** Water Extract-APHA 3120 ICPOES | 88 | 98 |
| Sulfate **(as % $SO_3$)** | ** Calculation | 0.007 | 0.008 |
| Chloride / Sulfate Ratio | ** Calculation | 0.1 | 0.8 |

Notes:

1. ppm = mg/kg dried soil
2. For Texture: coarse = sands to loamy sands; medium = sandy loams to light clays; fine = medium to heavy clays and silty clays
3. All results as dry weight DW - soils were dried at 60°C for 48hrs prior to crushing and analysis.
4. For conductivity 1 dS/m = 1 mS/cm = 1000 µS/cm
5. Methods from Rayment and Lyons, 2011. Soil Chemical Methods - Australasia.CSIRO Publishing: Collingwood.
6. Based on Australian Standard AS: 2159-2009
7. Methods from Ahern, CR, McElnea AE , Sullivan LA (2004). *Acid Sulfate Soils Laboratory Methods Guidelines* . QLD DNRME.
8. Analysis conducted between sample arrival date and reporting date.
9. ** NATA accreditation does not cover the performance of this service.
10. .. Denotes not requested.
11. This report is not to be reproduced except in full.
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Environmental Analysis Laboratory, Southern Cross University,
Tel. 02 6620 3678, website: scu.edu.au/eal

checked: .....
Graham Lancaster
Laboratory Manager

# POINT LOAD TEST REPORT

**CLIENT :** Coffs Harbour City Council
**PROJECT :** Cultural and Civic Space
**LOCATION :** 23-31 Gordon Street, Coffs Harbour
**TEST METHOD:** AS 4133.4.1

**DATE:** 12-Apr-19
**PROJECT NO :** RGS 31785.1
**TESTED BY :** RU

**BORE:** As Shown

**SHEET:** 1 OF 1

| DEPTH (m) | ROCK DESCRIPTION | TEST TYPE Axial (A), Diametral (D) Irregular (I) | DIMENSIONS Min. Width (*W*) (mm) | DIMENSIONS Depth (*d*) (mm) | FAILURE READING (KN) | POINT LOAD INDEX, $Is_{(50)}$ Axial (A) or Irregular (I) | POINT LOAD INDEX $I_{s(50)}$ Diametral (D) | INTERPRETED ROCK STRENGTH |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| 15.82 | BH1 (defect) | D | | 51 | 0.53 | - | 0.21 | LOW |
| 17.65 | BH1 | D | | 51 | 10.22 | - | 3.96 | V HIGH |
| 16.3 | BH2 (broke on defect) | D | | 51 | 9.30 | - | 3.61 | V HIGH |
| 17.18 | BH2 (broke on defect) | D | | 51 | 8.18 | - | 3.17 | V HIGH |
| 17.43 | BH2 | D | | 51 | 12.10 | - | 4.69 | V HIGH |
| | | | | | | | | |
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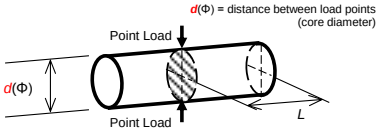
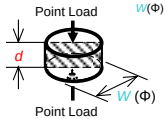
**Diametral Test:**
CHECK $L > 0.5 \cdot d$
$L$ = distance from load point to nearest free end
$d$ = distance between load points

Equivalent core diameter: $d_e = d$




**Axial Test:**
CHECK $0.3 \cdot W < d < W$

Equivalent core diameter: $d_e = \sqrt{4 \cdot \frac{d \cdot W}{\pi}}$




| CHECKED |
|---|
| Initials |
| Date |

Environmental Analysis Laboratory

**Southern Cross University**
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E: eal@scu.edu.au
www.scu.edu.au/eal

ABN: 41 995 651 524

# AGRICULTURAL SOIL ANALYSIS REPORT

1 sample supplied by Regional Geotechnical Solutions Pty Ltd on 2nd April, 2019. Lab Job No.I0267

Analysis requested by Adam Holzhauser. Your Job: RGS31785.1

1/21 Cook Dr COFFS HARBOUR NSW 2450

| | | | Sample 1 | *Heavy Soil* | *Medium Soil* | *Light Soil* | *Sandy Soil* |
|---|---|---|---|---|---|---|---|
| | | **Sample ID:** | **Agg 1** | | | | |
| | | **Crop:** | **N/G** | | | | |
| | | **Client:** | **RGS31785.1** | *Clay* | *Clay Loam* | *Loam* | *Loamy Sand* |
| | **Parameter** | **Method reference** | **I0267/1** | **Indicative guidelines - refer to Notes 6 and 8** | | | |
| | **Soluble Calcium (mg/kg)** | **Inhouse S10 - Morgan 1 | 668 | *1150* | *750* | *375* | *175* |
| | **Soluble Magnesium (mg/kg)** | | 196 | *160* | *105* | *60* | *25* |
| | **Soluble Potassium (mg/kg)** | | 82 | *113* | *75* | *60* | *50* |
| | **Soluble Phosphorus (mg/kg)** | | 4.8 | *15* | *12* | *10* | *5.0* |
| | **Phosphorus (mg/kg P)** | **Rayment & Lyons 2011 - 9E2 (Bray 1) | 19 | *45 note 8* | *30 note 8* | *24 note 8* | *20 note 8* |
| | | **Rayment & Lyons 2011 - 9B2 (Colwell) | 84 | *80* | *50* | *45* | *35* |
| | | **Inhouse S3A (Bray 2) | 41 | *90 note 8* | *60 note 8* | *48 note 8* | *40 note 8* |
| | **Nitrate Nitrogen (mg/kg N)** | **Inhouse S37 (KCl) | 2.2 | *15* | *13* | *10* | *10* |
| | **Ammonium Nitrogen (mg/kg N)** | | 5.1 | *20* | *18* | *15* | *12* |
| | **Sulfur (mg/kg S)** | | 7.2 | *10.0* | *8.0* | *8.0* | *7.0* |
| | **pH** | Rayment & Lyons 2011 - 4A1 (1:5 Water) | 5.74 | *6.5* | *6.5* | *6.3* | *6.3* |
| | **Electrical Conductivity (dS/m)** | Rayment & Lyons 2011 - 3A1 (1:5 Water) | 0.056 | *0.200* | *0.150* | *0.120* | *0.100* |
| | **Estimated Organic Matter (% OM)** | **Calculation: Total Carbon x 1.75 | 10.6 | *> 5.5* | *>4 .5* | *> 3.5* | *> 2.5* |
| | **Exchangeable Calcium** (cmol+/kg) | Rayment & Lyons 2011 - 15D3 (Ammonium Acetate) | 7.68 | *15.6* | *10.8* | *5.0* | *1.9* |
| | **Exchangeable Calcium** (kg/ha) | | 3446 | *7000* | *4816* | *2240* | *840* |
| | **Exchangeable Calcium** (mg/kg) | | 1538 | *3125* | *2150* | *1000* | *375* |
| | **Exchangeable Magnesium** (cmol+/kg) | | 2.57 | *2.4* | *1.7* | *1.2* | *0.60* |
| | **Exchangeable Magnesium** (kg/ha) | | 698 | *650* | *448* | *325* | *168* |
| | **Exchangeable Magnesium** (mg/kg) | | 312 | *290* | *200* | *145* | *75* |
| | **Exchangeable Potassium** (cmol+/kg) | | 0.33 | *0.60* | *0.50* | *0.40* | *0.30* |
| | **Exchangeable Potassium** (kg/ha) | | 288 | *526* | *426* | *336* | *224* |
| | **Exchangeable Potassium** (mg/kg) | | 129 | *235* | *190* | *150* | *100* |
| | **Exchangeable Sodium** (cmol+/kg) | | 0.31 | *0.3* | *0.26* | *0.22* | *0.11* |
| | **Exchangeable Sodium** (kg/ha) | | 159 | *155* | *134* | *113* | *57* |
| | **Exchangeable Sodium** (mg/kg) | | 71 | *69* | *60* | *51* | *25* |
| | **Exchangeable Aluminium** (cmol+/kg) | **Inhouse S37 (KCl) | 0.04 | *0.6* | *0.5* | *0.4* | *0.2* |
| | **Exchangeable Aluminium** (kg/ha) | | 8 | *121* | *101* | *73* | *30* |
| | **Exchangeable Aluminium** (mg/kg) | | 4 | *54* | *45* | *32* | *14* |
| | **Exchangeable Hydrogen** (cmol+/kg) | **Rayment & Lyons 2011 - 15G1 (Acidity Titration) | 0.12 | *0.6* | *0.5* | *0.4* | *0.2* |
| | **Exchangeable Hydrogen** (kg/ha) | | 3 | *13* | *11* | *8* | *3* |
| | **Exchangeable Hydrogen** (mg/kg) | | 1 | *6* | *5* | *4* | *2* |
| | **Effective Cation Exchange Capacity (ECEC) (cmol+/kg)** | **Calculation: Sum of Ca,Mg,K,Na,Al,H (cmol+/kg) | 11.04 | *20.1* | *14.3* | *7.8* | *3.3* |
| | **Calcium (%)** | **Base Saturation Calculations - Cation cmol+/kg / ECEC x 100 | 69.5 | *77.6* | *75.7* | *65.6* | *57.4* |
| | **Magnesium (%)** | | 23.2 | *11.9* | *11.9* | *15.7* | *18.1* |
| | **Potassium (%)** | | 3.0 | *3.0* | *3.5* | *5.2* | *9.1* |
| | **Sodium - ESP (%)** | | 2.8 | *1.5* | *1.8* | *2.9* | *3.3* |
| | **Aluminium (%)** | | 0.4 | *6.0* | *7.1* | *10.5* | *12.1* |
| | **Hydrogen** | | 1.1 | | | | |
| | **Calcium/Magnesium Ratio** | **Calculation: Calcium / Magnesium (cmol+/kg) | 3.0 | *6.5* | *6.4* | *4.2* | *3.2* |

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# AGRICULTURAL SOIL ANALYSIS REPORT

1 sample supplied by Regional Geotechnical Solutions Pty Ltd on 2nd April, 2019. Lab Job No.I0267

Analysis requested by Adam Holzhauser. Your Job: RGS31785.1

1/21 Cook Dr COFFS HARBOUR NSW 2450

| | | | Sample 1 | *Heavy Soil* | *Medium Soil* | *Light Soil* | *Sandy Soil* |
|---|---|---|---|---|---|---|---|
| | | **Sample ID:** | **Agg 1** | | | | |
| | | **Crop:** | **N/G** | | | | |
| | | **Client:** | **RGS31785.1** | *Clay* | *Clay Loam* | *Loam* | *Loamy Sand* |
| | **Parameter** | **Method reference** | **I0267/1** | **Indicative guidelines - refer to Notes 6 and 8** | | | |
| | **Zinc (mg/kg)** | Rayment & Lyons 2011 - 12A1 (DTPA) | 35 | *6.0* | *5.0* | *4.0* | *3.0* |
| | **Manganese (mg/kg)** | | 15 | *25* | *22* | *18* | *15* |
| | **Iron (mg/kg)** | | 326 | *25* | *22* | *18* | *15* |
| | **Copper (mg/kg)** | | 3.9 | *2.4* | *2.0* | *1.6* | *1.2* |
| | **Boron (mg/kg)** | **Rayment & Lyons 2011 - 12C2 (Hot $CaCl_2$) | 0.79 | *2.0* | *1.7* | *1.4* | *1.0* |
| | **Silicon (mg/kg Si)** | **Inhouse S11 (Hot CaCl2) | 32 | *50* | *45* | *40* | *35* |
| | **Total Carbon (%)** | Inhouse S4a (LECO Trumac Analyser) | 6.06 | *> 3.1* | *> 2.6* | *> 2.0* | *> 1.4* |
| | **Total Nitrogen (%)** | | 0.32 | *> 0.30* | *> 0.25* | *> 0.20* | *> 0.15* |
| | **Carbon/Nitrogen Ratio** | **Calculation: Total Carbon/Total Nitrogen | 19.1 | *10–12* | *10–12* | *10–12* | *10–12* |
| | **Basic Texture** | **Inhouse S65 | Loam | .. | .. | .. | .. |
| | **Basic Colour** | | Brownish | .. | .. | .. | .. |
| | **Chloride Estimate (equiv. mg/kg)** | **Calculation: Electrical Conductivity x 640 | 36 | .. | .. | .. | .. |

**Notes:**

**1**. All results presented as a 40°C oven dried weight. Soil sieved and lightly crushed to < 2 mm.
**2**. Methods from Rayment and Lyons, 2011. *Soil Chemical Methods - Australasia.* CSIRO Publishing: Collingwood.
**3**. Soluble Salts included in Exchangeable Cations - NO PRE-WASH (unless requested).
**4**. 'Morgan 1 Extract' adapted from 'Science in Agriculture', 'Non-Toxic Farming' and LaMotte Soil Handbook.
**5**. Guidelines for phosphorus have been reduced for Australian soils.
**6**. Indicative guidelines are based on 'Albrecht' and 'Reams' concepts.
**7**. Total Acid Extractable Nutrients indicate a store of nutrients.
**8**. National Environmental Protection (Assessment of Site Contamination) Measure 2013, Schedule B(1) - Guideline on Investigation Levels for Soil and Groundwater. Table 5-A Background Ranges.
**9**. Information relating to testing colour codes is available on sheet 2 - 'Understanding your agricultural soil results'.
**10.** Conversions for 1 $cmol_+$/kg = 230 mg/kg Sodium, 390 mg/kg Potassium, 122 mg/kg Magnesium, 200 mg/kg Calcium
**11.** Conversions to kg/ha = mg/kg x 2.24
**12.** The chloride calculation of Cl mg/L = EC x 640 is considered an estimate, and most likely an over-estimate
**13.** ** NATA accreditation does not cover the performance of this service.
**14.** Analysis conducted between sample arrival date and reporting date.
**15.** This report is not to be reproduced except in full. Results only relate to the item tested.
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*Agricultural Co-Ordinator* KS