Appendix C

Preliminary Geotechnical Investigation

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

PRELIMINARY GEOTECHNICAL INVESTIGATION AT DUDLEY STREET, MACKSVILLE

DRA ARCHITECTS

GEOTCOFH02223AA - AB
14 September 2007

Coffey Geotechnics Pty Ltd ABN 93 056 929 483
1/18 Hurley Drive Coffs Harbour NSW 2450 Australia

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

14 September 2007

DRA ARCHITECTS
44 Park Beach Road
Coffs Harbour NSW 2450

Attention: Adrian Borsato

Dear Adrian,

RE: PRELIMINARY GEOTECHNICAL INVESTIGATION AT DUDLEY STREET, MACKSVILLE

Coffey Geotechnics Pty Ltd is pleased to present our report on the preliminary geotechnical investigation for the above site.

We draw your attention to the attached sheet entitled "Important Information About Your Coffey Report" which should be read in conjunction with this report.

We trust that this report meets with your requirements. If you require further information please contact the undersigned in our Coffs Harbour office

For and on behalf of Coffey Geotechnics Pty Ltd

M. Rowbotham

Matthew Rowbotham

Engineering Geologist

Distribution:	Original held by:	Coffey Geotechnics Pty Ltd
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1 INTRODUCTION

Coffey Geotechnics Pty Ltd (Coffey) has conducted a preliminary geotechnical investigation for a proposed School on the southern side of Dudley Street, Macksville. The geotechnical investigation was carried out to provide preliminary information as to potential issues for the site. The aims of the study, which was commissioned by Mr Adrian Borsato of DRA Architects, were to provide a discussion and preliminary advice on:

- Potential for ground settlement under proposed site filling to raise the site above the 1 in 100 year flood level.
- Site Classification to AS2870-1996.
- Alternative footing types and founding levels, including recommendations as to allowable bearing pressure and data to assess expected settlements.
- Groundwater aggressivity to buried structural elements.
- Acid Sulphate Soils (ASS) assessment.
- Site preparation and earthworks.

Coffey conducted the work in general accordance with proposal no. GEOTCOFH02223AA-AA, dated 10 April 2007. A change to the scope of work was decided by Adrian Borsato of DRA Architects during the investigation. The change involved extending one of the boreholes deeper than the 10m allowed for in the proposal and removing the test pit investigation from the scope of work. This report presents the results of the investigation.

2 SITE DESCRIPTION & PROPOSED DEVELOPMENT

2.1 Site Description

Geographically the site is located in an area characterised by a relatively flat alluvial/ estuarine floodplain south of the Nambucca River and east/north east of residual hills. Locally the site occupies a flat parcel of rural land on the floodplain south of Dudley Street. At the time of field work the site was used for rural purposes with rural land to the north, east and south. Land to the west comprises sports fields and land to the north-west of the site was used for educational purposes with a two storey masonry building located at the site. The site occupies an area of approximately 30,000m^2.

Existing developments at the site of the investigation comprised general farm infrastructure such as farm fencing and watering troughs.

2.2 Proposed Development

Based on discussions with yourselves we understand that a school is proposed to be built on the site. At this stage no detailed plans have been developed for the school however based on the intended use of the land as educational purposes it is reasonable to assume that they are likely to comprise single or double storey buildings. It is also understood that that consideration has been given to raising the existing site levels by 1m to 2m for buildings to be above the 1 in 100 year flood level.

3 SCOPE OF WORK

3.1 Fieldwork

Fieldwork was carried out on the 23 August 2007 and comprised drilling of two boreholes to depths of 10.95m and 17.95m below existing ground level. The boreholes were advanced by auger drilling methods with an attached V- bit. Borehole BH1 was advanced past 15m by wash boring methods to a total depth of 17.95m. The boreholes were terminated at the above depths due to limit of reach of the drilling rig which was discussed with the client during the investigation. Standard penetration tests (SPT), and or U50 tubes were carried out at approximately 1.5m intervals in BH1, and in BH2 carried out at approximately 2.5m intervals to confirm a similar soil profile as BH1.

Fieldwork was conducted in the full time presence of an Engineering Geologist from Coffey who logged the materials observed, took samples and recorded results of in-situ testing. Figure 1 shows the investigation locations. Engineering Logs are presented in Appendices A and B, with explanation sheets defining the terms and symbols used in their preparation.

4 LABORATORY TEST RESULTS

Samples taken during fieldwork were returned to our NATA registered laboratory and/or sent to an external NATA registered laboratory for subsequent testing. The following testing was carried out:

- Two Atterbergs limits tests.
- Six CRS (chromium reducible sulphur) tests including total potential acidity (TPA), total sulfidic acidity (TSA) and total actual acidity (TAA) for assessment of acid sulphate soils (ASS).
- Two aggressivity tests for assessment of corrosivity to buried structural elements, (two soil).

The results of the Atterbergs limits testing are presented below.

Table 1: Summary of Atterberg Limits Testing

Sample	Sample Depth (m)	Sample Description	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Linear Shrinkage (%)
BH1	1.0	Silty Clay	35	20	15	7
BH1	5.9 to 6.35	Silty Clay	24	17	7	2

Testing was undertaken on the colluvial silty clay and the marine silty clay soil. The results of the Atterberg Limits tests carried out on samples indicated the colluvial soils being low to medium plasticity and the marine soils being low plasticity. As such the colluvial/alluvial material would be expected to have slight to moderate potential for shrink/swell movements with changes in moisture content.

The results of the aggressivity tests and CRS tests are presented in the relevant sections of the report. The laboratory results sheets are presented in Appendix B.

5 SUB-SURFACE CONDITIONS

5.1 Stratigraphy

The 1:250,000 Geological Series Sheet of Dorrigo-Coffs Harbour indicates the site to be underlain by Quaternary alluvium comprising sand, silt and clay, overlying unnamed phyllite (weakly metamorphosed shale).

The stratigraphy interpreted from the boreholes is summarised as follows:

- **Topsoil:** Generally comprising Silty Clay, low plasticity, extending to depths of 0.4m; overlying,
- **Alluvial/Colluvial Silty Clay/Clayey Silt:** Stiff to very stiff, low plasticity, pale orange, pale yellow, pale grey, extending to depths of about 2.2m in BH1 and 1.7m in BH2; overlying,
- **Marine Sandy Silty Clay and Silty Clay:** Very soft to soft to 10m becoming soft to firm to 15m, dark grey, low to medium plasticity; overlying,
- **Marine Silty Sand:** Medium dense, fine to medium grained, dark grey, extending to depths of about 15.5m in BH1; overlying,
- **Marine Silty Clay**: Firm, grey, low to medium plasticity, extending to depths of about 17.95m in BH1.

Further details of the materials intersected by the boreholes are given on the Engineering Logs presented in Appendix A, with explanation sheets defining the terms and symbols used in their preparation.

Groundwater

Groundwater was observed in both boreholes during drilling at a depth of between 1.7m (BH2) and 2.2m (BH1). It should be noted that no long term groundwater monitoring was carried out and groundwater levels may fluctuate after rain or as a consequence of other climatic effects.

6 CONSIDERATIONS FOR DESIGN & CONSTRUCTION

6.1 Geotechnical Issues

Given our understanding that the site is to be used for school buildings, structures would normally be anticipated to be one or two storey buildings founded on raft slabs, strip/pad footings or piles. Geotechnical issues that are likely to affect founding of such structures are:

- Settlement of the soft and firm clay layers under the loads imposed by the proposed fill and buildings.
- Possible shrink/swell movement from either the natural clay soils or the proposed controlled fill depending on the type of fill placed at the site.
- Bearing capacity of the founding materials.

6.2 Preliminary Geotechnical Model

To assess the issues outlined above many parameters are required for which no test data is currently available. Table 2 presents an outline Preliminary Geotechnical model of the site taking into account that the base of the soft to firm clay soils has not been encountered in the investigation. Where specific data for parameters is not available, values have been derived from experience with similar materials.

Table 2: Preliminary Geotechnical Model

Unit	1	2	3	4
Geological Origin	Colluvial/Alluvial Soil	Estuarine / Marine		
Material	Very Stiff Silty Clay	Soft Sandy Silty Clay	Silty Sand	Firm Silty Clay
*Depth to base (m)	2.0	15	15.5	≥ 17.95
**Shear Strength (s_u) kPa	50	20 to 25	NA	25
***Coefficient of Consolidation (c_v) m^2/year	NA	2	NA	2
***Compression Ratio $c_c/1+e_0$	NA	0.18 to 0.3	NA	0.18 to 0.3
***Recompression Ratio $c_r/1+e_0$	NA	0.018 to 0.03	NA	0.018 to 0.03
***Secondary Compression Index (Ca) %	NA	1 to 2	NA	1 to 2
***Preconsolidation Pressure p_c' kPa	NA	0 to 20	NA	0 to 20
***Elastic Modulus (E) MPa	25	NA	30	NA

*Based on data from BH1 and BH2 only – may vary on other parts of the site.

**Derived from pocket penetrometer values – approximate only.

***No data available. Based on experience with similar materials in northern NSW and South east Qld.

6.3 GEOTECHNICAL DESIGN ISSUES

6.3.1 Preliminary Estimates of Settlement for Controlled Fill and Shallow Footings

Given the depth of soft soils at the site and the depth of fill placed at the site, potential overall and differential settlements are likely to be a significant issue for the site from both the loads associated with the existing controlled fill and the structures. The natural soil units at the site are likely to be close to normally consolidated or slightly over consolidated and as such settlement will occur due to compression of each of the estuarine soil units, even under light loads. It is considered likely that the magnitude of settlement will be a constraint to the proposed school development, and as such a preliminary settlement assessment has been carried out.

The settlement assessment assumes the following:

- The profile and values for parameters shown in the geotechnical model (Table 2).
- A continuous layer of controlled fill placed to 1.0m or 2m depth (i.e. an effective stress of 20kPa or 40kPa respectively).
- Loads from a building creating an effective vertical stress of 15kPa giving a total effective stress increase of 35kPa and 55kPa for the various fill depths.
- The soft to firm clay will be normally consolidated to slightly over consolidated.
- *Settlement within the medium dense sand* will be elastic in nature occurring quickly, generally as construction proceeds.
- *Settlement within the Soft to Firm Estuarine Clays will occur generally in accordance with* one-dimensional consolidation theory.

Elastic settlement of the sand layer between 15.0m and 15.5m will be negligible (1mm to 2mm) compared to the estimated settlements in the soft and firm clays. Table 3 presents a summary of the preliminary calculations of primary settlement based on one dimensional consolidation.

Table 3: Summary of Primary Settlement Calculations

Major Consolidation Parameters	Settlement due to placement of 1m to 1.5m of fill and Building	Settlement due to placement of 2m to 2.5m of fill and Building
c_c=0.18 c_r=0.018	*200 to 500mm	*300 to 720mm
c_c=0.30 c_r=0.03	*400 to 850mm	*500 to1200mm

* All settlements indicated are preliminary based on adopted values and assuming the base of the soft to firm clay soils is about 18m.

As stated, the primary settlements given above are based on assumed consolidation parameters and do not include secondary (creep) settlement. Actual settlements could differ from these values significantly and secondary settlement would continue on a logtime basis. It should be noted that a range of settlement is provided due to the unknown level of overconsolidation of the various layers of soil. The surface soils will be overconsolidated due to various effects including drying and will only settle a small amount while the deeper soft clays will be normally consolidated or only lightly overconsolidated and additional load will result in large primary consolidation settlement.

The time scale for this settlement is highly dependent on soil properties especially the existence of thin layers of sand which can increase the rate of drainage of water from the soil and thereby increase the settlement rate. The time for primary settlement to be complete if there are few sand layers is guessed to be 4 to 12 years unless some artificial drainage medium is installed through the clay.

There are a number of options available to reduce the potential impacts of settlement on the development. Of these, the following have been used on similar sites.

1. ***Preloading:*** The site could be preloaded with a mound of soil fill to consolidate the soil units, thus reducing the settlement during the life of the structures and allowing a raft or similar footing to be constructed. This will be heavily dependent on the stress history of the soil, and would need to be further assessed by extensive field and laboratory testing resulting in more rigorous analysis of expected settlement and development of a preloading plan. Preloading is likely to take months to years to achieve depending on the whether artificial wickdrains are installed to speed up the drainage. Preloading will require monitoring to ensure that the predicted settlements have been achieved.
2. ***Piles:*** All structures could be piled. Piles would be designed to fully penetrate the soft to firm clay soils to be founded within a suitable underlying units beyond the depth of current investigation. The piles must be designed to accommodate the loads from the structures and negative skin friction from the surrounding soil as consolidation and creep occurs from the placement of controlled fill. Connections for services will also need to be carefully considered, as the ground surface will likely separate from the structures over time. This option would also need further investigations to determine suitable founding strata.

The above two options are likely to present the least risk of poor performance to the proposed structures. Option 3 below, presents a higher risk of potential poor performance to structures compared to the above two options.

3. ***Limited Filling of the Site and Building Flexible Light Weight Structures:*** To limit the potential of settlement at the site, consideration may need to be given to minimising filling of the site and building light weight flexible structures which can tolerate some differential settlements.

A brief observation of a nearby double storey masonry building was undertaken during the investigation. The building was located on the floodplain area adjacent to the Nambucca River. The building area appeared to have been raised by filling to a depth of about 0.5m above the surrounding flood plain surface level. Based on discussions with a local resident the building is about 20 years of age. It is unknown what the footings for the building comprise or what the subsurface conditions comprise below the structure, however at the time of the investigation no exterior structural damage was observed to the building. It is considered that should the existing building be founded on shallow foundations such as a stiffened raft slab or on strip and pad footings and be underlain by similar subsurface conditions to the proposed school area. Then it may be likely that similar performance could be expected at the proposed school site, (this assumes that fill placement will be kept to a minimum say less than 0.5m and light weight flexible structures are constructed above the fill).

6.3.2 Shrink/Swell Movements

Regardless of settlements discussed in Section 6.3.1 shrink/swell movements will still occur from the clay soils within the fill and will affect raft type footings. An approximation to the shrink/swell index can be achieved by dividing the linear shrinkage by 5. Using this method based on the linear shrinkage value of 7, a shrink/swell index of 1.4% is assessed. A value of 1.4% results in a characteristic soil movement due to seasonal moisture variation (y_s) of about 20mm, thereby resulting in a classification on the border between Class S and Class M in accordance with AS2870-1996. Based on the medium plasticity clay soils observed at the site and consideration of the test results and assessment, we recommend that the site be classified as Class M (Moderately Reactive), in accordance with the provisions of AS2870-1996. It should be noted that the predicted near surface movements do not take into account the effects of settlement as discussed in Section 6.3.1.

The above soil movement estimates (y_s) are preliminary only, we recommend that further laboratory testing of the clay fill should be undertaken to provide further assessment of the actual I_{ss} value of the clay fill to confirm the predicted near surface movements.

Should future moisture content changes in the soil exceed the design suction change provided by AS2870-1996, a larger (y_s) may occur. Such changes could occur adjacent to leaking services or where soils are desiccated by tree roots. Planting of trees (or removal of existing vegetation) on the site could cause changes outside those allowed for by AS2870-1996. In addition, appropriate site drainage must be maintained during and post construction.

The predicted (y_s) value (and thus the site classification) is based on the assumption that the site generally remains at the current surface level, and any engineering fill placed is non-reactive. Where final site levels vary by more than 300mm from the natural ground surface, (such as by the placement of controlled fill in accordance with AS3798-2007), then the classification may change and further advice should be sought.

6.4 Shallow Footings

If high level footings comprising strip or pad footings supporting column loads or a raft slab are adopted after preloading. These could be proportioned for an allowable bearing pressure of 100kPa.

Should pad footings not be feasible due to bearing capacity or serviceability concerns, a stiffened raft could be adopted. The raft should be designed to accommodate shear forces and bending moments from columns, walls and other applied loads. For the assessment of allowable bearing pressures for a stiffened raft slab an allowable bearing pressure of 40kPa is assessed. The assessment of serviceability beneath shallow footings founded as described above should take into account the preliminary assessment of settlements discussed in section 6.3.1.

Consideration should be given to the effects of uniform, point and line loads from the structure. Assessment of settlement for shallow footings should also consider the effects of one dimensional consolidation which may govern the types of footings suitable for the site. This is further discussed in Section 6.3.1.

High level footings are to be founded outside or below all zones of existing or future services trenches.

6.5 Piles

As noted previously piles may be adopted to support the proposed buildings. Piles could be designed as end bearing should a suitable founding material be encountered beyond the depths investigated. Further investigation work would be required to provide further discussion of founding depths, founding materials and recommended pile options.

6.6 Soil Aggressivity

The results of the laboratory testing of soil samples obtained from the site are presented in Table 4 below.

Table 4: Summary of Soil Aggressivity Results

Borehole	Sample Depth (m)	pH	Soil Resistivity (ohm.mm)	Sulphate (mg/kg)	Chloride (mg/kg)
BH1	1.0	6.81	21,413	339	1407
BH2	4.5 to 4.95	7.84	3,937	534	4121

The sample results are compared to exposure classifications given in Australian Standard AS2159-1995, *Piling Design and Installation* in Table 5 below.

Table 5: Aggressivity to Buried Structural Elements

Sample Location	Sample Type	Exposure Classification for Concrete Foundations	Exposure Classification for Steel Foundations
BH1 (1.0m)	Soil	Non Aggressive	Non Aggressive
BH2 (4.95-4.95m)	Soil	Non Aggressive	Non Aggressive

The laboratory results indicate that based on the soil testing, the site is non-aggressive for steel foundations. A uniform corrosion allowance of 0.01mm per year should be allowed for steel foundations.

For concrete elements the natural soils are classed as non aggressive. As such it is recommended that concrete elements be designed for a non aggressive exposure classification. A minimum concrete strength of 25MPa and a minimum cover to reinforcement of 20mm for precast and 40mm for cast in place footings should apply for footing design.

7 SITE PREPERATION AND EARTHWORKS

7.1 Temporary & Permanent Batter Slopes

Temporary batter slopes required through any proposed fill, may be cut at no steeper than about 1H:1V. During rainfall the slopes should be protected by covering with impermeable plastic sheeting or similar to reduce runoff.

Permanent batter slopes no steeper than 2H:1V may be adopted in the controlled fill to heights of 3m. As a minimum, surface drains should be installed at the top of the slope to divert water away from the face.

7.2 Site Preparation, Fill Placement and Compaction Control

The following general comments and recommendations are provided for site preparation beneath structures:

- Following excavation to design level, 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 and backfilled with a clean select material with similar engineering properties. All topsoil should be stripped and stockpiled for re-use as landscaping materials only.
- Compacted to a minimum dry density ratio of 100% Standard Compaction or 75% density index.
- Approved clay fill beneath structures should be placed in layers not exceeding 300mm loose thickness and be compacted to a minimum dry density ratio of 98% Standard Compaction. Approved granular materials beneath structures should be placed in layers not exceeding 300mm loose thickness and be compacted to a density index of 75%. Clay fill should be placed and maintained at ±2% of Standard OMC. All filling beneath structures should be carried out under Level 1 construction monitoring and testing as defined in AS3798-2007.

Earthworks should be carried out in accordance with the recommendations outlined in AS3798-2007, '*Guidelines for Earthworks for Commercial and Residential Developments*'.

8 ACID SULPHATE SOILS

8.1.1 Acid Sulphate Soils Risk Map

Based on the 1:25000 Acid Sulfate Soil Risk Map of Macksville the site is located in an area of high probabaility of acid sulphate soils within 1m to 3m of the ground surface.

8.1.2 Formation of Acid Sulphate Soils

Acid Sulphate Soils (ASS) are soils which contain significant concentrations of pyrite which, when exposed to oxygen, in the presence of sufficient moisture, oxidises, resulting in the generation of sulphuric acid. Unoxidised pyritic soils are referred to as potential ASS (PASS). When the soils are exposed, the oxidation of pyrite occurs and sulphuric acids are generated, the soils are said to be actual ASS (AASS).

Pyritic soils typically form in waterlogged, saline sediments rich in iron and sulphate. Typical environments for the formation of these soils include tidal flats, salt marshes and mangrove swamps below about RL 5m AHD. They can also form as bottom sediments in coastal rives and creeks.

Pyritic soils of concern on low lying NSW and coastal lands have mostly formed in the Holocene period, (i.e. 10,000 years ago to present day) predominantly in the 7,000 years since the last rise in sea level. It is generally considered that pyritic soils which formed prior to the Holocene period would already have oxidised and leached during periods of low sea level which occurred during ice ages, exposing pyritic coastal sediments to oxygen.

Disturbance or poorly managed development and use of acid sulphate soils can generate significant amounts of sulphuric acid, which can lower soil and water pH to extreme levels (generally <4) and produce acid and salts, resulting in high salinity.

The low pH, high salinity soils can reduce or altogether preclude vegetation growth and can produce aggressive soil conditions which may be detrimental to concrete and steel components of structures, foundations, pipelines and other engineering works.

Generation of the acid conditions often releases aluminium, iron and other naturally occurring elements from the otherwise stable soil matrices. High concentrations of such elements, coupled with low pH and alterations to salinity can be detrimental to aquatic life. In severe cases, affected waters flowing off-site can have detrimental effect on aquatic ecosystems.

8.1.3 Laboratory Testing

Samples collected during fieldwork were placed in tightly sealed plastic bags and stored in chilled insulated containers during transit to cold storage at Coffey's Coffs Harbour laboratory.

Samples obtained for the acid sulphate assessment were sent to an external NATA registered laboratory and CRS tested for ASS using laboratory methods 21Af and 21Bf of Ahern CR, Blunden B and Stone Y (eds) (1998), Acid Sulphate Soil Laboratory Methods Guidelines, ASSMAC. Results of the CRS testing are presented in the table below.

Table 6: Summary of CRS Testing

Borehole	Depth (m)	Texture	Reduced Inorganic Sulphur (%Scr)	Action Criteria For %Scr	Net Acidity Chromium Suite mole H^+/tonne (Based on % Scrs)	Liming Rate Kg $CaCO_3/m^3$
BH1	1.0m	Fine	0.005	0.1	6	1
BH1	3.9 to 4.35	Medium	**0.841**	0.06	406	34
BH1	4.4 to 4.85	Medium	**0.793**	0.06	405	32
BH2	2.0 to 2.45	Fine	**0.306**	0.1	195	21
BH2	7.5 to 7.95	Fine	**0.930**	0.06	378	34
BH2	8.9 to 9.35	Fine	**0.549**	0.06	149	16

1. Values in bold exceed action criteria;
2. Action criteria adopted are based on disturbance of between 1 and 1000 tonnes of acid sulphate soils.

Based on the above results the marine soils are classed as potential acid sulphate soils. It is recommended that all natural marine soil material excavated be treated the same.

8.1.4 Discussion and Preliminary Recommendations

Based on the results of the laboratory testing, the soil samples exceeded the action criteria for $\%S_{cr}$ in five of the six instances. In accordance with the ASSMAC (1998) Acid Sulphate Soil Manual, an acid sulphate soils management plan is required for the development where soils exceed the action criteria. Excavated soils will require treatment with lime to neutralise acidity produced by oxidation of the soils when excavated. Recommendations on required liming ratio for PASS excavated are provided below.

As no large excavations are expected to be required at the site, it is likely that only relatively small quantities of material will require treatment on the site. In calculating liming ratios test results have been assessed to provide a 95% confidence interval for neutralisation based on values calculated using a factor of safety of 1.5. This factor of safety above the theoretical requirement is adopted to take into account the rate of lime reactivity and the possibility of inhomogeneous mixing. A liming rate of $32kg/m^3$ should be adopted for all natural marine soils excavated (i.e. the soils underlying the stiff to very stiff Silty Clay/Clayey Silt).

Field testing of pH should be carried out to reduce the risk of the soil becoming too alkaline before disposal.

Good quality fine agricultural lime should be used to treat excavated PASS. It should be noted that liming is only one of a number of techniques to lower the risk posed by PASS. Other options include avoidance of disturbing PASS and placing the soil below the water table level immediately following excavation to prevent oxidation from occurring. The final option chosen could be a combination of techniques based on the likely construction scenario and the volumes of ASS requiring management.

To reduce the risks associated with acidification of run off, we recommend that the area set aside for all spoil is blanketed with agricultural lime prior to placing the spoil, and the surface of the spoil is dosed with lime to reduce the risk of acid runoff.

Excavated Pass should be contained within the limed area in layers of workable depth (typically not more than 300mm loose thickness) and be thoroughly mixed with lime through use of a rotary hoe or some similar mechanical process to achieve a thorough mix. The liming should be confined to areas of manageable size. Liming areas should be bunded to allow containment of all leachate and storm water runoff until test results indicate acceptable levels of neutralisation have been achieved.

The time required for applied lime to neutralise PASS is widely variable and depends on the specific properties of the neutralised soil, although the lime will begin to neutralise the soils from the time of application. Measurement of the neutralisation of the PASS being treated should be undertaken at a later date to provide an indication that the neutralisation process is working or has worked effectively.

Soil acidity in excavated materials should be monitored through visual observation and field laboratory testing of excavated material. Should field pH 'check tests' and laboratory tests show that the soil acidity has not fallen below action criteria, or that a greater amount of lime is required, then the material should be reworked and additional lime treatment carried out until it is verified that the soil meets the required specification.

9 SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

The site is underlain by deep soft soils that will undergo significant settlement under the load applied by additional site filling and construction of the structures. The settlement will take several years to occur and will continue as secondary settlement for even longer unless the site is preloaded with additional fill and the rate of settlement increased with the assistance of vertical wick drains installed through the soft clay. Following such site preparation the structures may be supported on surface footings or raft slabs.

Alternatively the structures could be supported on piles founded below the soft soils but designed for the negative skin friction from the settling soil produced by the placement of fill.

Based on the preliminary ASS assessment, should excavations be required for the installation of services or piles or the like, then excavated marine soils will require lime treatment.

The analyses carried out for this report are based on a limited amount of subsurface information, and no laboratory testing for the subject site. To allow further consideration of the site, it is recommended that the investigation include the following:

- Additional boreholes drilled to a suitable foundation material which will allow an assessment of the depth of soft to firm clay soils.

- Several piezocone tests including dissipation testing throughout the soil profile to at least a suitable founding depth (in excess of 18m).
- Several consolidation tests undertaken on samples of the estuarine soft to firm clay materials to assess consolidation parameters and enable a more detailed assessment of the magnitude and rate of consolidation
- Detailed analysis of alternative options and design of a preload plan.
- More detailed ASS testing should piled options be considered.

10 SITE LIMITATIONS

The assessment presented in this report is based on one borehole location and test results. Engineering judgement has been made to assess potential conditions between investigation locations, but significant variability could be expected in the nature and depth of the soil units within geological environments such as those evident at this site.

Please do not hesitate to contact the undersigned if you require further information with respect to this report.

Your attention is drawn to the document "Important Information About Your Coffey Report" which is attached.

M. Rowbotham

Matthew Rowbotham

Engineering Geologist

Important information about your **Coffey** Report

As a client of Coffey you should know that site subsurface conditions cause more construction problems than any other factor. These notes have been prepared by Coffey to help you interpret and understand the limitations of your report.

Your report is based on project specific criteria

Your report has been developed on the basis of your unique project specific requirements as understood by Coffey and applies only to the site investigated. Project criteria typically include the general nature of the project; its size and configuration; the location of any structures on the site; other site improvements; the presence of underground utilities; and the additional risk imposed by scope-of-service limitations imposed by the client. Your report should not be used if there are any changes to the project without first asking Coffey to assess how factors that changed subsequent to the date of the report affect the report's recommendations. Coffey cannot accept responsibility for problems that may occur due to changed factors if they are not consulted.

Subsurface conditions can change

Subsurface conditions are created by natural processes and the activity of man. For example, water levels can vary with time, fill may be placed on a site and pollutants may migrate with time. Because a report is based on conditions which existed at the time of subsurface exploration, decisions should not be based on a report whose adequacy may have been affected by time. Consult Coffey to be advised how time may have impacted on the project.

Interpretation of factual data

Site assessment identifies actual subsurface conditions only at those points where samples are taken and when they are taken. Data derived from literature and external data source review, sampling and subsequent laboratory testing are interpreted by geologists, engineers or scientists to provide an opinion about overall site conditions, their likely impact on the proposed development and recommended actions. Actual conditions may differ from those inferred to exist, because no professional, no matter how qualified, can reveal what is hidden by earth, rock and time. The actual interface between materials may be far more gradual or abrupt than assumed based on the facts obtained. Nothing can be done to change the actual site conditions which exist, but steps can be taken to reduce the impact of unexpected conditions. For this reason, owners should retain the services of Coffey through the development stage, to identify variances, conduct additional tests if required, and recommend solutions to problems encountered on site.

Your report will only give preliminary recommendations

Your report is based on the assumption that the site conditions as revealed through selective point sampling are indicative of actual conditions throughout an area. This assumption cannot be substantiated until project implementation has commenced and therefore your report recommendations can only be regarded as preliminary. Only Coffey, who prepared the report, is fully familiar with the background information needed to assess whether or not the report's recommendations are valid and whether or not changes should be considered as the project develops. If another party undertakes the implementation of the recommendations of this report there is a risk that the report will be misinterpreted and Coffey cannot be held responsible for such misinterpretation.

Your report is prepared for specific purposes and persons

To avoid misuse of the information contained in your report it is recommended that you confer with Coffey before passing your report on to another party who may not be familiar with the background and the purpose of the report. Your report should not be applied to any project other than that originally specified at the time the report was issued.

Important information about your **Coffey** Report

Interpretation by other design professionals

Costly problems can occur when other design professionals develop their plans based on misinterpretations of a report. To help avoid misinterpretations, retain Coffey to work with other project design professionals who are affected by the report. Have Coffey explain the report implications to design professionals affected by them and then review plans and specifications produced to see how they incorporate the report findings.

Data should not be separated from the report*

The report as a whole presents the findings of the site assessment and the report should not be copied in part or altered in any way.

Logs, figures, drawings, etc. are customarily included in our reports and are developed by scientists, engineers or geologists based on their interpretation of field logs (assembled by field personnel) and laboratory evaluation of field samples. These logs etc. should not under any circumstances be redrawn for inclusion in other documents or separated from the report in any way.

Geoenvironmental concerns are not at issue

Your report is not likely to relate any findings, conclusions, or recommendations about the potential for hazardous materials existing at the site unless specifically required to do so by the client. Specialist equipment, techniques, and personnel are used to perform a geoenvironmental assessment.
Contamination can create major health, safety and environmental risks. If you have no information about the potential for your site to be contaminated or create an environmental hazard, you are advised to contact Coffey for information relating to geoenvironmental issues.

Rely on Coffey for additional assistance

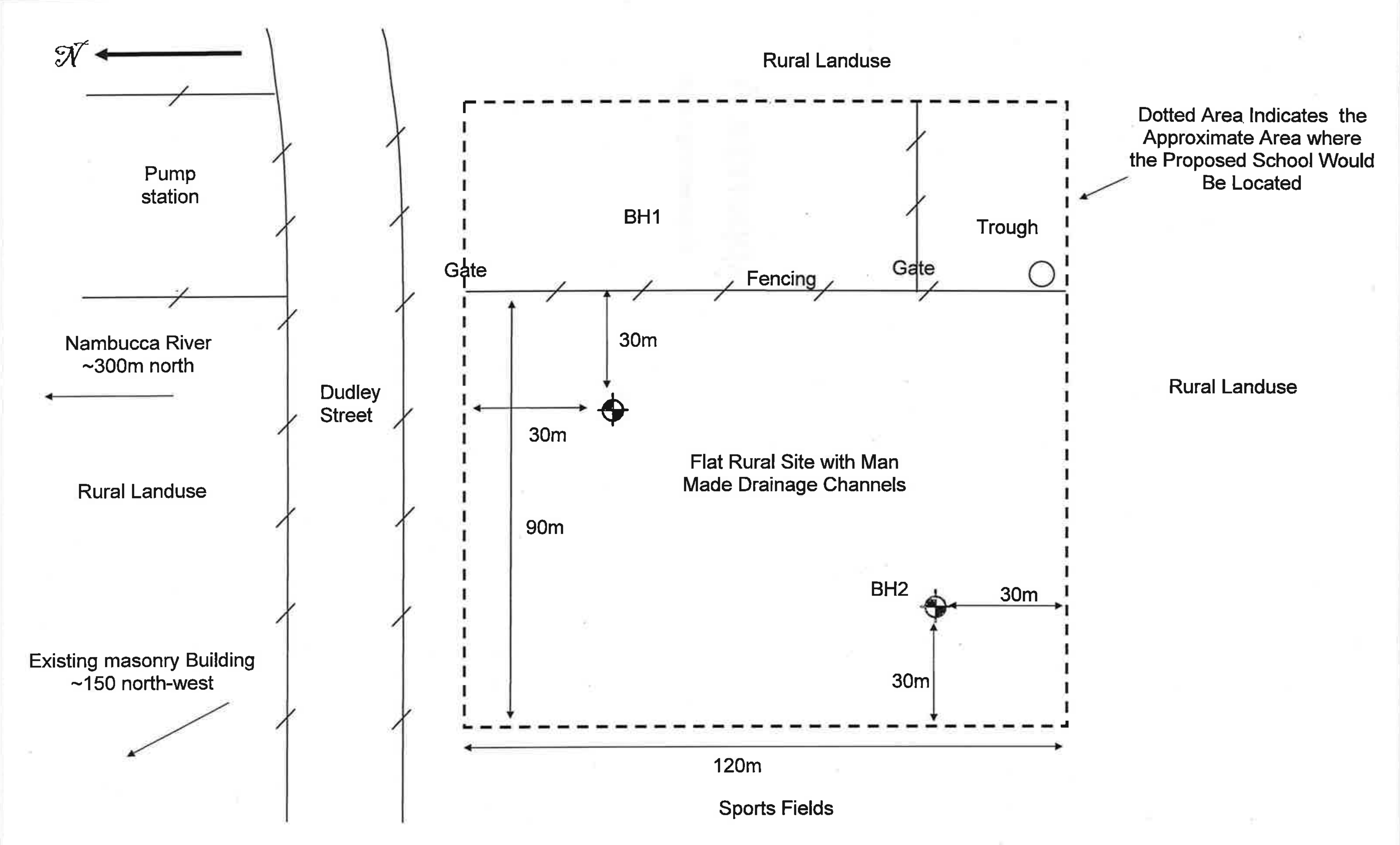
Coffey is familiar with a variety of techniques and approaches that can be used to help reduce risks for all parties to a project, from design to construction. It is common that not all approaches will be necessarily dealt with in your site assessment report due to concepts proposed at that time. As the project progresses through design towards construction, speak with Coffey to develop alternative approaches to problems that may be of genuine benefit both in time and cost.

Responsibility

Reporting relies on interpretation of factual information based on judgement and opinion and has a level of uncertainty attached to it, which is far less exact than the design disciplines. This has often resulted in claims being lodged against consultants, which are unfounded. To help prevent this problem, a number of clauses have been developed for use in contracts, reports and other documents. Responsibility clauses do not transfer appropriate liabilities from Coffey to other parties but are included to identify where Coffey's responsibilities begin and end. Their use is intended to help all parties involved to recognise their individual responsibilities. Read all documents from Coffey closely and do not hesitate to ask any questions you may have.

* For further information on this aspect reference should be made to "Guidelines for the Provision of Geotechnical information in Construction Contracts" published by the Institution of Engineers Australia, National headquarters, Canberra, 1987.

Figures



revision	description	drawn	approved	date

drawn	VS
approved	
date	23/8/07
scale	NTS
original size	A3

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

client: NAMBUCCA VALLEY CATHOLIC PARISH
project: PROPOSED SCHOOL
title: SITE PLAN
project no: GEOTCOFH2223AA
figure no: FIGURE 1

Appendix A

Engineering Logs

Soil Description Explanation Sheet (1 of 2)

DEFINITION:

In engineering terms soil includes every type of uncemented or partially cemented inorganic or organic material found in the ground. In practice, if the material can be remoulded or disintegrated by hand in its field condition or in water it is described as a soil. Other materials are described using rock description terms.

CLASSIFICATION SYMBOL & SOIL NAME

Soils are described in accordance with the Unified Soil Classification (UCS) as shown in the table on Sheet 2.

PARTICLE SIZE DESCRIPTIVE TERMS

NAME	SUBDIVISION	SIZE
Boulders		>200 mm
Cobbles		63 mm to 200 mm
Gravel	coarse	20 mm to 63 mm
	medium	6 mm to 20 mm
	fine	2.36 mm to 6 mm
Sand	coarse	600 µm to 2.36 mm
	medium	200 µm to 600 µm
	fine	75 µm to 200 µm

MOISTURE CONDITION

Dry	Looks and feels dry. Cohesive and cemented soils are hard, friable or powdery. Uncemented granular soils run freely through hands.
Moist	Soil feels cool and darkened in colour. Cohesive soils can be moulded. Granular soils tend to cohere.
Wet	As for moist but with free water forming on hands when handled.

CONSISTENCY OF COHESIVE SOILS

TERM	UNDRAINED STRENGTH s_u (kPa)	FIELD GUIDE
Very Soft	<12	A finger can be pushed well into the soil with little effort.
Soft	12 - 25	A finger can be pushed into the soil to about 25mm depth.
Firm	25 - 50	The soil can be indented about 5mm with the thumb, but not penetrated.
Stiff	50 - 100	The surface of the soil can be indented with the thumb, but not penetrated.
Very Stiff	100 - 200	The surface of the soil can be marked, but not indented with thumb pressure.
Hard	>200	The surface of the soil can be marked only with the thumbnail.
Friable	-	Crumbles or powders when scraped by thumbnail.

DENSITY OF GRANULAR SOILS

TERM	DENSITY INDEX (%)
Very loose	Less than 15
Loose	15 - 35
Medium Dense	35 - 65
Dense	65 - 85
Very Dense	Greater than 85

MINOR COMPONENTS

TERM	ASSESSMENT GUIDE	PROPORTION OF MINOR COMPONENT IN:
Trace of	Presence just detectable by feel or eye, but soil properties little or no different to general properties of primary component.	Coarse grained soils: <5% Fine grained soils: <15%
With some	Presence easily detected by feel or eye, soil properties little different to general properties of primary component.	Coarse grained soils: 5 - 12% Fine grained soils: 15 - 30%

SOIL STRUCTURE

ZONING		CEMENTING	
Layers	Continuous across exposure or sample.	Weakly cemented	Easily broken up by hand in air or water.
Lenses	Discontinuous layers of lenticular shape.	Moderately cemented	Effort is required to break up the soil by hand in air or water.
Pockets	Irregular inclusions of different material.		

GEOLOGICAL ORIGIN

WEATHERED IN PLACE SOILS

Extremely weathered material	Structure and fabric of parent rock visible.
Residual soil	Structure and fabric of parent rock not visible.

TRANSPORTED SOILS

Aeolian soil	Deposited by wind.
Alluvial soil	Deposited by streams and rivers.
Colluvial soil	Deposited on slopes (transported downslope by gravity).
Fill	Man made deposit. Fill may be significantly more variable between tested locations than naturally occurring soils.
Lacustrine soil	Deposited by lakes.
Marine soil	Deposited in ocean basins, bays, beaches and estuaries.

Soil Description Explanation Sheet (2 of 2)

SOIL CLASSIFICATION INCLUDING IDENTIFICATION AND DESCRIPTION

FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 60 mm and basing fractions on estimated mass)						USC	PRIMARY NAME
COARSE GRAINED SOILS More than 50% of materials less than 63 mm is larger than 0.075 mm	(A 0.075 mm particle is about the smallest particle visible to the naked eye)	GRAVELS More than half of coarse fraction is larger than 2.0 mm	CLEAN GRAVELS (Little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes.		GW	GRAVEL
				Predominantly one size or a range of sizes with more intermediate sizes missing.		GP	GRAVEL
			GRAVELS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below)		GM	SILTY GRAVEL
				Plastic fines (for identification procedures see CL below)		GC	CLAYEY GRAVEL
		SANDS More than half of coarse fraction is smaller than 2.0 mm	CLEAN SANDS (Little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate sizes missing		SW	SAND
				Predominantly one size or a range of sizes with some intermediate sizes missing.		SP	SAND
			SANDS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below).		SM	SILTY SAND
				Plastic fines (for identification procedures see CL below).		SC	CLAYEY SAND
FINE GRAINED SOILS More than 50% of material less than 63 mm is smaller than 0.075 mm			IDENTIFICATION PROCEDURES ON FRACTIONS <0.2 mm.				
			DRY STRENGTH	DILATANCY	TOUGHNESS		
		SILTS & CLAYS Liquid limit less than 50	None to Low	Quick to slow	None	ML	SILT
			Medium to High	None	Medium	CL	CLAY
			Low to medium	Slow to very slow	Low	OL	ORGANIC SILT
		SILTS & CLAYS Liquid limit greater than 50	Low to medium	Slow to very slow	Low to medium	MH	SILT
			High	None	High	CH	CLAY
			Medium to High	None	Low to medium	OH	ORGANIC CLAY
HIGHLY ORGANIC SOILS			Readily identified by colour, odour, spongy feel and frequently by fibrous texture.			Pt	PEAT

- Low plasticity – Liquid Limit W_L less than 35%.
- Modium plasticity – W_L between 35% and 50%.

COMMON DEFECTS IN SOIL

TERM	DEFINITION	DIAGRAM
PARTING	A surface or crack across which the soil has little or no tensile strength. Parallel or sub parallel to layering (eg bedding). May be open or closed.	
JOINT	A surface or crack across which the soil has little or no tensile strength but which is not parallel or sub parallel to layering. May be open or closed. The term 'fissure' may be used for irregular joints <0.2 m in length.	
SHEARED ZONE	Zone in clayey soil with roughly parallel near planar, curved or undulating boundaries containing closely spaced, smooth or slickensided, curved intersecting joints which divide the mass into lenticular or wedge shaped blocks.	
SHEARED SURFACE	A near planar curved or undulating, smooth, polished or slickensided surface in clayey soil. The polished or slickensided surface indicates that movement (in many cases very little) has occurred along the defect.	

TERM	DEFINITION	DIAGRAM
SOFTENED ZONE	A zone in clayey soil, usually adjacent to a defect in which the soil has a higher moisture content than elsewhere.	
TUBE	Tubular cavity. May occur singly or as one of a large number of separate or inter-connected tubes. Walls often coated with clay or strengthened by denser packing of grains. May contain organic matter	
TUBE CAST	Roughly cylindrical elongated body of soil different from the soil mass in which it occurs. In some cases the soil which makes up the tube cast is cemented.	
INFILLED SEAM	Sheet or wall like body of soil substance or mass with roughly planar to irregular near parallel boundaries which cuts through a soil mass. Formed by infilling of open joints.	

Rock Description Explanation Sheet (1 of 2)

The descriptive terms used by Coffey are given below. They are broadly consistent with Australian Standard AS1726-1993.

DEFINITIONS: Rock substance, defect and mass are defined as follows:

Rock Substance	In engineering terms roch substance is any naturally occurring aggregate of minerals and organic material which cannot be disintegrated or remoulded by hand in air or water. Other material is described using soil descriptive terms. Effectively homogenous material, may be isotropic or anisotropic.
Defect	Discontinuity or break in the continuity of a substance or substances.
Mass	Any body of material which is not effectively homogeneous. It can consist of two or more substances without defects, or one or more substances with one or more defects.

SUBSTANCE DESCRIPTIVE TERMS:

ROCK NAME	Simple rock names are used rather than precise geological classification.
PARTICLE SIZE	Grain size terms for sandstone are:
Coarse grained	Mainly 0.6mm to 2mm
Medium grained	Mainly 0.2mm to 0.6mm
Fine grained	Mainly 0.06mm (just visible) to 0.2mm
FABRIC	Terms for layering of penetrative fabric (eg. bedding, cleavage etc.) are:
Massive	No layering or penetrative fabric.
Indistinct	Layering or fabric just visible. Little effect on properties.
Distinct	Layering or fabric is easily visible. Rock breaks more easily parallel to layering of fabric.

CLASSIFICATION OF WEATHERING PRODUCTS

Term	Abbreviation	Definition
Residual Soil	**RS**	Soil derived from the weathering of rock; the mass structure and substance fabric are no longer evident; there is a large change in volume but the soil has not been significantly transported.
Extremely Weathered Material	**XW**	Material is weathered to such an extent that it has soil properties, ie, it either disintegrates or can be remoulded in water. Original rock fabric still visible.
Highly Weathered Rock	**HW**	Rock strength is changed by weathering. The whole of the rock substance is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable. Some minerals are decomposed to clay minerals. Porosity may be increased by leaching or may be decreased due to the deposition of minerals in pores.
Moderately Weathered Rock	**MW**	The whole of the rock substance is discoloured, usually by iron staining or bleaching , to the extent that the colour of the fresh rock is no longer recognisable.
Slightly Weathered Rock	**SW**	Rock substance affected by weathering to the extent that partial staining or partial discolouration of the rock substance (usually by limonite) has taken place. The colour and texture of the fresh rock is recognisable; strength properties are essentially those of the fresh rock substance.
Fresh Rock	**FR**	Rock substance unaffected by weathering.

Notes on Weathering:

1. AS1726 suggests the term 'Distinctly Weathered" (DW) to cover the range of substance weathering conditions between XW and SW. For projects where it is not practical to delineate between HW and MW or it is judged that there is no advantage in making such a distinction. DW may be used with the definition given in AS1726.
2. Where physical and chemical changes were caused by hot gasses and liquids associated with igneous rocks, the term "altered" may be substituted for "weathering' to give the abbreviations XA, HA, MA, SA and DA.

ROCK SUBSTANCE STRENGTH TERMS

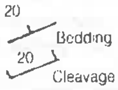
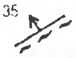
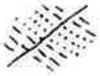
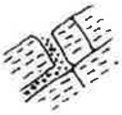
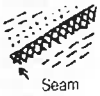
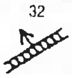
Term	Abbrev-iation	Point Load Index, I_s50 (MPa)	Field Guide
Very Low	**VL**	Less than 0.1	Material crumbles under firm blows with sharp end of pick; can be peeled with a knife; pieces up to 30mm thick can be broken by finger pressure.
Low	**L**	0.1 to 0.3	Easily scored with a knife; indentations 1mm to 3mm show with firm bows of a pick point; has a dull sound under hammer. Pieces of core 150mm long by 50mm diameter may be broken by hand. Sharp edges of core may be friable and break during handling.
Medium	**M**	0.3 to 1.0	Readily scored with a knife; a piece of core 150mm long by 50mm diameter can be broken by hand with difficulty.
High	**H**	1 to 3	A piece of core 150mm long by 50mm can not be broken by hand but can be broken by a pick with a single firm blow; rock rings under hammer.
Very High	**VH**	3 to 10	Hand specimen breaks after more than one blow of a pick; rock rings under hammer.
Extremely High	**EH**	More than 10	Specimen requires many blows with geological pick to break; rock rings under hammer.

Notes on Rock Substance Strength:

1. In anisotropic rocks the field guide to strength applies to the strength perpendicular to the anisotropy. High strength anisotropic rocks may break readily parallel to the planar anisotropy.
2. The term "extremely low' is not used as a rock substance strength term. While the term is used in AS1726-1993, the field guide therein makes it clear that materials in that strength range are soils in engineering terms.
3. The unconfined compressive strength for isotropic rocks (and anisotropic rocks which fall across the planar anisotropy) is typically 10 to 25 times the point load index (Is50). The ratio may vary for different rock types. Lower strength rocks often have lower ratios than higher strength rocks.

Rock Description Explanation Sheet (2 of 2)

COMMON DEFECTS IN ROCK MASSES

Term	Definition	Diagram	Map Symbol	Graphic Log (Note 1)
Parting	A surface or crack across which the rock has little or no tensile strength. Parallel or sub parallel to layering (eg bedding) or a planar anisotropy in the rock substance (eg, cleavage). May be open or closed.			
Joint	A surface or crack across which the rock has little or no tensile strength. but which is not parallel or sub parallel to layering or planar anisotropy in the rock substance. May be open or closed.			
Sheared Zone (Note 3)	Zone of rock substance with roughly parallel near planar, curved or undulating boundaries cut by closely spaced joints, sheared surfaces or other defects. Some of the defects are usually curved and intersect to divide the mass into lenticular or wedge shaped blocks.			
Sheared Surface (Note 3)	A near planar, curved or undulating surface which is usually smooth, polished or slickensided.			
Crushed Seam (Note 3)	Seam with roughly parallel almost planar boundaries, composed of disoriented, usually angular fragments of the host rock substance which may be more weathered than the host rock. The seam has soil properties.			
Infilled Seam	Seam of soil substance usually with distinct roughly parallel boundaries formed by the migration of soil into an open cavity or joint, infilled seams less than 1mm thick may be described as veneer or coating on joint surface.			
Extremely Weathered Seam	Seam of soil substance, often with gradational boundaries. Formad by weathering of the rock substance in place.			

DEFECT SHAPE TERMS

Planar	The defect does not vary in orientation
Curved	The defect has a gradual change in orientation
Undulating	The defect has a wavy surface
Stepped	The defect has one or more well defined steps
Irregular	The defect has many sharp changes of orientation

Note: The assessment of defect shape is partly influenced by the scale of the observation.

ROUGHNESS TERMS

Slickensided	Grooved or striated surface, usually polished
Polished	Shiny smooth surface
Smooth	Smooth to touch. Few or no surface irregularities
Rough	Many small surface irregularities (amplitude generally less than 1mm). Feels like fine to coarse sand paper.
Very Rough	Many large surface irregularities (amplitude generally more than 1mm). Feels like, or coarser than very coarse sand paper.

COATING TERMS

Clean	No visible coating
Stained	No visible coating but surfaces are discoloured
Veneer	A visible coating of soil or mineral, too thin to measure; may be patchy
Coating	A visible coating up to 1mm thick. Thicker soil material is usually described using appropriate defect terms (eg, infilled seam). Thicker rock strength material is usually described as a vein.

BLOCK SHAPE TERMS

Blocky	Approximately equidimensional
Tabular	Thickness much less than length or width
Columnar	Height much greate than cross section

Notes on Defects:

1. Usually borehole logs show the true dip of defects and face sketches and sections the apparent dip.
2. Partings and joints are not usually shown on the graphic log unless considered significant.
3. Sheared zones, sheared surfaces and crushed seams are faults in geological terms.

coffey geotechnics

Engineering Log - Borehole

Borehole No. **BH1**

Sheet 1 of 3

Project No: **GEOTCOFH02223AA**

Client: **DRA ARCHITECTS**

Principal:

Project: **PRELIMINARY INVESTIGATION, PROPOSED SCHOOL**

Borehole Location: **REFER TO FIGURE 1**

Date started: **23.8.2007**

Date completed: **23.8.2007**

Logged by: **MR**

Checked by:

drill model and mounting:	MD200 4WD	Easting:	slope: -90°	R.L. Surface:	
hole diameter:	100 mm	Northing	bearing:	datum:	

drilling information / **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
ADV		N						CL	**TOPSOIL:** Silty Clay, medium plasticity, brown	M	St		TOPSOIL
								CL	**Silty CLAY:** Low to medium plasticity, pale orange, pale yellow and pale grey				COLLUVIAL/ ALLUVIAL SOIL
						1							
								CL	**Sandy Silty CLAY/ Sandy Clayey SILT**Low plasticity, pale grey/ pale yellow, sand is fine to medium grained		VSt	X X	
				U_{50}									
						2							
			►										
								CL	**Silty Sandy CLAY:**Medium plasticity, dark grey, some clayey sandy silt lenses	W	VS		MARINE SOIL
				SPT 0,0,2 N*=2		3						X X	SPT sunk 300 mm under SPT hammer and rods weight
								SW	**Clayey Silty SAND:**Fine to medium grained, some shells		L		
								CL	**Silty CLAY:**Medium plasticity, dark grey, with some fine grained sand, occasional clayey sandy silt lenses		S		
						4							
												X X	
				SPT 0,0,0 N*=0		5							SPT sunk 450 mm under SPT hammer and rods weight
											S/F		
				U_{50}		6						X X	
						7							
				U_{50}								X X X X	
						8							

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit

*bit shown by suffix
e.g. ADT

support

M	mud	N	nil
C	casing		

penetration
1 2 3 4
no resistance ranging to refusal

water

▼ 10/1/98 water level on date shown

► water inflow

◄ water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressuremeter
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description
based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

coffey geotechnics

Engineering Log - Borehole

Borehole No. **BH1**
Sheet 2 of 3
Project No: **GEOTCOFH02223AA**

Client: **DRA ARCHITECTS**
Principal:
Project: **PRELIMINARY INVESTIGATION, PROPOSED SCHOOL**
Borehole Location: **REFER TO FIGURE 1**

Date started: **23.8.2007**
Date completed: **23.8.2007**
Logged by: **MR**
Checked by:

drill model and mounting:	MD200 4WD	Easting:	slope: -90°	R.L. Surface:	
hole diameter:	100 mm	Northing	bearing:	datum:	

drilling information / **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
ADV		N					CL	**Silty CLAY:** Medium plasticity, dark grey, with some fine grained sand, occasional clayey sandy silt lenses *(continued)*	W	S/F		
				SPT 0,0,0 N*=0		9					XXXX	SPT sunk 500 mm under SPT hammer and rods weight
						10				F		
				SPT 0,0,0 N*=0		11					XXXX	SPT sunk 500 mm under SPT hammer and rods weight
				SPT 0,0,0 N*=0		12					XX	SPT sunk 450 mm under SPT hammer and rods weight
						13	CL	**Sandy CLAY:** Medium plasticity, grey, sand is fine to medium grained		F		
				SPT 0,0,3 N*=3		14					XX	SPT sunk 300 mm under SPT hammer and rods weight
				SPT 0,4,6 N*=10		15	SW	**Silty SAND:** Fine to medium grained, dark grey, with some clay		MD		SPT sunk 150 mm under SPT hammer and rods weight
							CH	**Silty CLAY:** Medium to high plasticity, grey		F		
						16						

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit

*bit shown by suffix
e.g. ADT

support

M	mud	N	nil
C	casing		

penetration
1 2 3 4
no resistance ranging to refusal

water
▼ 10/1/98 water level on date shown
► water inflow
◄ water outflow

notes, samples, tests

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U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
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E	environmental sample
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classification symbols and soil description
based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

coffey geotechnics

Engineering Log - Borehole

Borehole No.	**BH1**
Sheet	3 of 3
Project No:	**GEOTCOFH02223AA**
Client:	**DRA ARCHITECTS**
Principal:	
Project:	**PRELIMINARY INVESTIGATION, PROPOSED SCHOOL**
Borehole Location:	**REFER TO FIGURE 1**
Date started:	**23.8.2007**
Date completed:	**23.8.2007**
Logged by:	**MR**
Checked by:	

drill model and mounting:	MD200 4WD	Easting:		slope:	-90°	R.L. Surface:	
hole diameter:	100 mm	Northing		bearing:		datum:	

drilling information							**material substance**						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
ADV		N		SPT 0,0,0 N*=0			▨	CH	**Silty CLAY:** Medium to high plasticity, grey *(continued)*	W	F	X X	SPT sunk 450 mm under SPT hammer and rods weight
						17	▨						
				SPT 3,1,2 N*=3			▨						
						18			End of hole at 17.95m due to limit of drilling capability Borehole BH1 terminated at 17.95m				
						19							
						20							
						21							
						22							
						23							
						24							

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit
*bit shown by suffix	
e.g.	ADT

support

M	mud	N	nil
C	casing		

penetration

1 2 3 4

no resistance ranging to refusal

water

▼	10/1/98 water level on date shown
►	water inflow
◄	water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressuremeter
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

coffey geotechnics

Engineering Log - Borehole

Borehole No. **BH2**

Sheet 1 of 2

Project No: **GEOTCOFH02223AA**

Client: ***DRA ARCHITECTS***

Principal:

Project: ***PRELIMINARY INVESTIGATION, PROPOSED SCHOOL***

Borehole Location: ***REFER TO FIGURE 1***

Date started: ***23.8.2007***

Date completed: ***23.8.2007***

Logged by: ***MR***

Checked by:

drill model and mounting:	MD200 4WD	Easting:	slope: -90°	R.L. Surface:	
hole diameter:	100 mm	Northing	bearing:	datum:	

drilling information							material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetrometer kPa 100 200 300 400	structure and additional observations
ADV		N						CL	**TOPSOIL:** Medium plasticity, brown	M			TOPSOIL
								CL	**Silty CLAY:** Low to medium plasticity, pale grey/ pale brown/ pale yellow/ pale brown mottle		St/VSt		COLLUVIAL/ ALLUVIAL SOIL
						1							
											F		
			▶					CL	**Silty CLAY:** Medium plasticity, dark grey, shells observed in drill cuttings, with occasional silty sand layers observed	W	VS/S		MARINE SOIL
				SPT 0,0,0 N=0		2							SPT sunk 800 mm under SPT hammer and rods weight
						3							
						4							
				SPT 0,0,0 N=0									SPT sunk 700 mm under SPT hammer and rods weight
						5					S		
						6							
						7							
				SPT 0,0,0 N*=0								× ×	SPT sunk 450 mm under SPT hammer and rods weight
						8							

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit
*bit shown by suffix	
e.g.	ADT

support

M	mud	N	nil
C	casing		

penetration

1 2 3 4 — no resistance ranging to refusal

water

- ▼ 10/1/98 water level on date shown
- ▶ water inflow
- ◀ water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressuremeter
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

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S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

coffey geotechnics

Engineering Log - Borehole

Borehole No.	*BH2*
Sheet	2 of 2
Project No:	*GEOTCOFH02223AA*

Client:	*DRA ARCHITECTS*
Principal:	
Project:	*PRELIMINARY INVESTIGATION, PROPOSED SCHOOL*
Borehole Location:	*REFER TO FIGURE 1*

Date started:	*23.8.2007*
Date completed:	*23.8.2007*
Logged by:	*MR*
Checked by:	

drill model and mounting:	MD200 4WD	Easting:	slope: -90°		R.L. Surface:
hole diameter:	100 mm	Northing	bearing:		datum:

drilling information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
ADV		N					▨	CL	**Silty CLAY:** Medium plasticity, dark grey, shells observed in drill cuttings, with occasional silty sand layers observed *(continued)*	W	S		
						9							
						10							
				SPT 0,0,0 N*=0								× ×	SPT sunk 500 mm under SPT hammer and rods weight
						11			End of hole due to limit of required investigation Borehole BH2 terminated at 10.95m		S/F		
						12							
						13							
						14							
						15							
						16							

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit
*bit shown by suffix	
e.g.	ADT

support

M	mud	N	nil
C	casing		

penetration

1 2 3 4

no resistance ranging to refusal

water

10/1/98 water level on date shown

water inflow

water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressuremeter
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

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S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Appendix B

Laboratory Test Results

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

Coffs Harbour Laboratory
Coffey Geotechnics Pty Ltd
ABN 93 056 929 483
1/18 Hurley Drive
Coffs Harbour NSW 2450

Telephone: +61 2 6651 3213
Facsimile: +61 2 6651 5194

Report No: MAT:COFH07S-02336
Issue No: 1
This report replaces all previous issues of report no 'MAT:COFH07S-02336'.

Aggregate/Soil Test Report

Client: Coffey Geotechnics Pty Ltd
1/18 Hurley Drive
Coffs Harbour NSW 2450
Principal:
Job No: LABTCOFH00054CC
Project: GEOTCOFH02223AA
Lot No: **TRN:**

NATA
WORLD RECOGNISED ACCREDITATION

This document is issued in accordance with NATAs accreditation requirements. Accredited for compliance with ISO/IEC 17025.

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Approved Signatory: Doug Dengate
(Laboratory Manager)
NATA Accredited Laboratory Number: 431
Date of Issue: 21/09/2007

Sample Details

Sample ID: COFH07S-02336
Field Sample: 0005
Date Sampled: 27/08/2007
Source:
Material: Clay
Specification:
Sampling Method: AS1289.1.2.1 Clause 6.5
Location: Proposed School,BH1,1.0M depth

Particle Size Distribution

Method:
Drying by:
Date Tested:

Sieve Size	% Passing	Limits

Other Test Results

Description	Method	Result	Limits
Sample History	AS 1289.1.1	Oven-dried	
Preparation	AS 1289.1.1	Dry Sieved	
Linear Shrinkage (%)	AS 1289.3.4.1	7.0	
Mould Length (mm)		254	
Crumbling		No	
Curling		No	
Liquid Limit (%)	AS 1289.3.1.1	35	
Method		Four Point	
Plastic Limit (%)	AS 1289.3.2.1	20	
Plasticity Index (%)	AS 1289.3.3.1	15	

Chart

Comments

N/A

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SPECIALISTS MANAGING THE EARTH

Coffs Harbour Laboratory

Coffey Geotechnics Pty Ltd
ABN 93 056 929 483
1/18 Hurley Drive
Coffs Harbour NSW 2450

Telephone: +61 2 6651 3213
Facsimile: +61 2 6651 5194

Aggregate/Soil Test Report

Report No: MAT:COFH07S-02334
Issue No: 1
This report replaces all previous issues of report no 'MAT:COFH07S-02334'.

Client: Coffey Geotechnics Pty Ltd
1/18 Hurley Drive
Coffs Harbour NSW 2450
Principal:
Job No: LABTCOFH00054CC
Project: GEOTCOFH02223AA
Lot No: **TRN:**

NATA
WORLD RECOGNISED ACCREDITATION

This document is issued in accordance with NATAs accreditation requirements. Accredited for compliance with ISO/IEC 17025.

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Approved Signatory: Doug Dengate
(Laboratory Manager)
NATA Accredited Laboratory Number: 431
Date of Issue: 21/09/2007

Sample Details

Sample ID: COFH07S-02334
Field Sample: 0003
Date Sampled:
Source:
Material: Clay
Specification:
Sampling Method: AS1289.1.2.1 Clause 6.5
Location: Proposed School,BH1,5.9-6.35M,BH1,5.9-6.35M

Particle Size Distribution

Method:
Drying by:
Date Tested:

Sieve Size	% Passing	Limits

Other Test Results

Description	Method	Result	Limits
Sample History	AS 1289.1.1	Oven-dried	
Preparation	AS 1289.1.1	Dry Sieved	
Linear Shrinkage (%)	AS 1289.3.4.1	2.0	
Mould Length (mm)		250	
Crumbling		No	
Curling		No	
Liquid Limit (%)	AS 1289.3.1.2	24	
Method		One Point	
Plastic Limit (%)	AS 1289.3.2.1	17	
Plasticity Index (%)	AS 1289.3.3.1	7	
Moisture Content (%)	AS 1289.2.1.1	33.6	

Chart

Comments

N/A

RESULTS OF SOIL ANALYSIS (Page 1 of 1)

2 samples requested by Coffey on the 29th August, 2007 - Lab Job No. E7878
Analysis requested by Matt. Project: COFH02223

	Method	Sample 1 BH1 1m	Sample 2 BH2 8.9-9.35m
	EAL job No.	*E7878/1*	*E7878/2*
Soil pH (1:5 water)	Rayment and Higgins 4A1	6.81	7.84
Soil Conductivity (1:5 water dS/m)	Rayment and Higgins 4B1	0.467	2.540
Soil Resistivity (ohm.mm)	Calculation	21,413	3,937
Chloride (mg/kg)	Water Extract- Rayment and Higgins	1407	4121
Chloride (as %)	Calculation	0.141	0.412
Sulfate (mg/kg)	Water Extract- Rayment and Higgins	339	534
Sulfate (as % SO_3)	Calculation	0.027	0.043

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 60oC for 48hrs prior to crushing and analysis.
4. For conductivity 1 dS/m = 1 mS/cm = 1000 µS/cm
5. Methods from Rayment and Higgins, 1992. Australian Laboratory Handbook of Soil and Water Chemical Methods.
6. **Based on Australian Standard AS: 159-1995**

checked:...............

RESULTS OF ACID SULFATE SOIL ANALYSIS (Page 1 of 1)

6 samples supplied by Coffey Geotechnics Coffs Harbour on 29th August, 2007 - Lab. Job No. E7877
Analysis requested by Matt Rowbotham. - **Your Project: Proposed School**

Sample Site	Depth (m)	EAL lab code	Texture (note 6)	Moisture Content (% moisture)	Lab. Bulk Density tonne DW/m³	TAA pH$_{KCl}$	Titratable Actual Acidity (TAA) mole H⁺/tonne (to pH 6.5)	Reduced Inorganic Sulfur (% chromium reducible S) (%Scr) (note 2)	Reduced Inorganic Sulfur (Scr) mole H⁺/tonne	% ANC$_{BT}$ %CaCO$_3$	s-ANC$_{E}$ mole H⁺/tonne	NET ACIDITY Chromium Suite mole H⁺/tonne (based on %Scrs)	LIME CALCULATION Chromium Suite kg CaCO$_3$/m³ (includes 1.5 safety Factor)
Method No.						*234*	*23F*	*22B*	*a-22B*	*19A2*	*a-19A2*	*note 5*	*note 5*
BH 1	3.9-4.35	*E7877/1*	Medium	25.7	1.1	8.34	0	0.841	525	0.89	178	406	34
BH 1	4.4-4.65	*E7877/2*	Medium	27.1	1.1	8.33	0	0.793	495	0.67	134	405	32
BH 1	1.0	*E7877/3*	Fine	19.0	1.4	6.23	3	0.005	3	0.00	0	6	1
BH 2	2.0-2.45	*E7877/4*	Fine	26.3	1.4	5.68	4	0.306	191	0.00	0	195	21
BH 2	8.9-9.35	*E7877/5*	Fine	27.8	1.5	7.31	0	0.549	342	1.45	290	149	16
BH 2	7.5-7.95	*E7877/6*	Fine	26.8	1.2	8.23	0	0.930	580	1.52	304	378	34

NOTE:
1 - All analysis is Dry Weight (DW) - samples dried and ground immediately upon arrival (unless supplied dried and ground)
2 - Samples analysed by SPOCAS method 23 (ie Suspension Peroxide Oxidation Combined Acidity & sulfate) and 'Chromium Reducible Sulfur' technique (Scr - Method 22B)
3 - Methods from Ahem, CR, McElnea AE , Sullivan LA (2004). ***Acid Sulfate Soils Laboratory Methods Guidelines.*** QLD DNRME.
4 - Bulk density was determined immediately on arrival to laboratory (insitu bulk density is preferred)
5 - ABA Equation: Net Acidity = Potential Sulfidic Acidity (ie. Scrs or Sox) + Actual Acidity + Retained Acidity - measured ANC/FF
6 - For Texture: coarse = sands to loamy sands; medium = sandy loams to light clays; fine = medium to heavy clays and silty clays
7 - .. Denotes not requested or required
8 - CRS, TAA and ANC are NATA certified but other SPOCAS segments are currently not NATA certification
9- Results at or below detection limits are replaced with '0' for calculation purposes.
10 - Projects that disturb >1000 tonnes of soil, the ≥0.03% S classification guideline would apply.

(Classification of potential acid sulfate material if: coarse Scr≥0.03%S or 19mole H+/t; medium Scr≥0.06%S or 37mole H+/t; fine Scr≥0.1%S or 62mole H+/t)

Lab. Accred. No.: 14960

checked: ....