

PROPOSED SUBDIVISION AT KINGS AVE TERRIGAL

Prepared For

Crighton Properties Pty Ltd

GEOTKARI02083AA-AC 13 February 2008

URBAN CAPABILITY ASSESSMENT WITH RESPECT TO SLOPE RISK

13 February 2008

Crighton Properties Pty Ltd PO Box 3369 TUGGERAH NSW 2259

Attention: Peter Childs

Dear Peter

RE: PROPOSED SUBDIVISION AT KINGS AVENUE, TERRIGAL URBAN CAPABILITY ASSESSMENT WITH RESPECT TO SLOPE RISK

Coffey Geotechnics Pty Ltd is pleased to present our urban capability assessment report for a proposed subdivision off Kings Avenue at Terrigal.

Should you have any questions regarding this report, please contact Ben Seaford on 4340 1811.

For and on behalf of Coffey Geotechnics Pty Ltd

Report prepared by:

In love.

Ben Seaford Engineering Geologist

Authorised Signatory:

Strider Duerinckx Senior Engineering Geologist

Distribution List for Final Report:

Original copy Coffey Geotechnics Pty Ltd 1 copy Coffey Geotechnics Pty Ltd 4 copies Crighton Properties Pty Ltd (3 hardcopies, 1 electronic)

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Important Information about your Coffey Report

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1 INTRODUCTION

This report presents the results of a geotechnical assessment carried out by Coffey Geotechnics Pty Ltd (Coffey) for Crighton Properties Pty Ltd (Crighton) at the site of a proposed subdivision off Kings Avenue at Terrigal. The investigation was carried out in response to Gosford City Council (GCC) letter reference 3744897, forwarded to Coffey by Crighton.

The purpose of the work was to assess the suitability of the site for proposed residential subdivision with respect to risk of slope instability. This report provides an assessment of the risk of slope instability at the site in its existing condition and the risks associated with subdivision development. Recommendations for individual lot development are beyond the scope of this assessment.

The brief required specifications needed for the local environmental study for the rezoning application. The specifications pertaining to geotechnical issues were contained in Paragraph 3(a) and requested that the report contains assessment of:

- Description and analysis of the slopes, soils and topographical features of the site and its immediate surrounds with particular reference to GCC DCP 163 'Geotechnical Requirements for Development Applications';
- Identification of slopes, soils and topographical features which might impose constraints to future development or require specialised engineering approaches to address site constraints; and
- Location of land displaying slopes in excess of 20%.

Other geotechnical considerations, such as footing requirements, settlement, pavement design, bearing capacity, soil chemistry, soil and groundwater contamination, and the effects of mine subsidence, are beyond the scope of this assessment. These matters will be addressed at a future design stage.

2 PREVIOUS INVESTIGATIONS

In 1992 and 1993 Coffey conducted slope instability risk assessments on different parts of the site (Ref: GO540/1-AB and GO652/1-AB). A total of twenty five test pits were excavated to depths up to 3.3m. Subsurface conditions on slopes generally comprised shallow topsoil and slopewash overlying residual clays and weathered rock. Valley floors were generally underlain by relatively deep alluvium.

Slopes observed were generally between 5° to 18° with locally steeper slopes (up to 35°) in gully flanks. Minor slumping and erosion was observed on some of the gully flanks. Each respective area was assessed as having a "moderate" risk of overall slope instability based on the classification system that Coffey Geoscieces adopted at the time (based on system published in Australian Geomechanics News, Number 10, 1985).

Copies of the previous reports by Coffey have been included in Appendix C.

3 PROPOSED DEVELOPMENT

The entire site is about 50ha. It is understood that the proposed subdivision involves the construction of 146 residential lots with some allotments set aside for community space and future development. Plans of the proposed development by Geolyse (Ref: 403089 Sheets D01 to D13) were provided.

4 SCOPE OF ASSESSMENT REQUIRED BY GCC

Gosford City Council (GCC) Development Control Plan No.163 (DCP163) 'Geotechnical Requirements for Development Applications' nominates four categories of properties and the associated minimum geotechnical assessments required to support Development Applications.

The categories are defined in Tables M1 and M2 of DCP163 and are based primarily on site geology and general slope conditions. For the geology and slope conditions assessed (outlined below), the site in its current condition is considered to be a Category 2 (medium hazard) site.

A Category 2 site requires a Class 2 geotechnical report (as defined by GCC) to support future DA for the site. Coffey has prepared a report that conforms to the Class 2 guidelines.

5 METHODOLOGY

The slope risk assessment was based on the following:

- A review of relevant geology maps and previous reports referenced in Section 2 of this report;
- Observations of surface features on the property and the surrounding area by a Principal Geotechnical Engineer on 28 November 2007;
- Twenty test pits excavated across the site to depths up to 2.5m. Test pits were generally excavated in only areas where development is proposed.

The engineering logs of the test pits are presented in Appendix A, together with explanation sheets defining the terms and symbols used. Reduced levels shown on the engineering logs were inferred from contour levels on the plan prepared by Geolyse. Test pits were located using tape measurements from site features shown on the plan by Geolyse.

The risk of slope instability has been assessed from the observed site conditions using methods consistent with those presented in the Australian Geomechanics Society publication Landslide Risk Management Concepts and Guidelines, in Australian Geomechanics News, March 2000. Based on those methods, the risks to property associated with slope instability on the subject site have been assessed using the terms presented in Coffey Attachment 1, 'Classification of Risk of Slope Instability', which has been adapted from the classification system formulated by the Australian Geomechanics Society and published in Australian Geomechanics News, Number 10, 1985.

6 SITE CONDITIONS

6.1 Local Geology

The Gosford 1:25000 Geological Map (unpublished) indicates that the locality is underlain by rocks belonging to the Terrigal Formation of the Narrabeen Group, consisting of interbedded lithic sandstone and siltstone.

6.2 Surface Features

The site is situated on the north eastern flank of a moderately to steeply undulating ridge. This site features three roughly northeast/southwest trending spurs which forms the northeastern extent of the Kincumba Mountain Reserve. The site is located on the southern side of Kings Avenue. Existing residential development is located to the east and west, and to the north of Kings Avenue.

The three spurs are located in the western, central and eastern portions of the site. The eastern and western spurs extend only partway across the site with the central spur intersecting the entire length of site. The crest of the central spur has been cleared for power lines. Two broad valleys occupy the areas between the spurs.

The vegetation comprises paddocks cleared of trees, light woodland areas cleared of undergrowth with grass cover and localised scrub areas. Woodland areas comprise mature native trees with the area further to the south, beyond the property boundary, being moderately vegetated by mature native species. Tree trunks are generally vertical. Some lantana and blackberry scrub occur at scattered locations around the site. Site drainage (runoff and infiltration) was judged to be good. No evidence of seepage (spring activity) was observed, except locally near the eastern boundary, however this appears to be related to runoff from adjacent development.

6.3 Terrain Elements

Based on the site surface features and inferred subsurface profiles from the test pits, the site has been split up into three Land Areas. The inferred Land Areas are shown on Figure 2.

6.3.1 Land Area 1 (LA1)

LA1 comprises the valley floors and flatter footslopes located in the central eastern and central western portions of the site. The valleys are grassed paddocks. Two dams are located in the centre of the eastern valley. The valley floors are generally flat but minor slopes of about 10° were recorded where the flanks of the surrounding spurs intersect with valley floor.

Table 1 presents the inferred geotechnical model for LA1, based on test pits TP13 and TP15 and test pits from the previous investigations referenced in Section 2.

Unit	Typical Properties
Alluvium/Colluvium	Silty SAND and Clayey SAND, fine to medium grained, low plasticity. Ranging from 1.5m thick to greater than 3.5m thick.
Residual Soil	Sandy CLAY, low to medium plasticity, stiff to very stiff consistency. Fine to medium grained sand.

In summary, test pits excavated in LA1 generally encountered deep soils comprising silty sand colluvial soil overlying low to medium plasticity sandy clays. It is likely that the soil depth in LA1 in the western portion of the site will encounter similar soil depths.

Groundwater inflows were not encountered in test pits excavated in LA1, in this episode of fieldwork but minor flows were encountered in the western valley in 1992.

6.3.2 Land Area 2 (LA2)

LA2 encompasses the flanks of each spur and the steeper terrain to the south. Field slope measurements ranged from about 12° to 28°. Steeper slopes were observed further to the south of the proposed development.

Table 2 presents the inferred geotechnical model for LA2, based on test pits TP1 to TP3, TP5, TP6, TP8 to TP11, TP14 and TP16 to TP20.

Unit	Typical Properties
Colluvium	Silty SAND/SAND/Silty clayey SAND, fine to medium grained, low plastic clay fines. Thickness range between 0.2m to 1m.
Residual Soil and Extremely Weathered Rock	Sandy CLAY/CLAY/Silty CLAY, medium to high plasticity, grey-orange-red, generally very stiff to hard consistency, some fine to medium gravel. Grades into extremely weathered sandstone. Thicknesses range between 0.2m and 1.3m.
Distinctly Weathered Rock	SANDSTONE, inferred below the depth of excavator refusal. Estimated to be very low to medium strength, highly to moderately weathered. Excavator refusal was generally between 0.7 to 2m below the existing surface level.

TABLE 2 – INFERRED GEOTECHNICAL UNITS FOR LA2

6.3.3 Land Area 3 (LA3)

LA3 comprises the crest of the central spur extending through the centre of the site. The crest is relatively flat with slopes extending gently in all directions at a maximum of about 8°. A stand of dense native trees was observed on the central eastern portion of the spur.

Table 3 presents the inferred geotechnical model for LA3, based on test pits TP4, TP7, TP12, TP16 and TP17.

Some scattered sandstone outcrops were observed at the crest of the ridge, and rock was generally encountered at shallower depths in LA3 compared to LA1 and LA2.

Unit	Typical Properties
Colluvium	Silty SAND/Clayey SAND, fine to medium grained, low plastic clay fines. Gravelly CLAY of low to medium plasticity in TP12 and TP16. Thickness range between 0.2m to 0.8m.
Residual Soil and Extremely Weathered Rock	SAND, Clayey SAND, CLAY/Silty CLAY, medium to high plasticity, grey- orange-red, generally very stiff to hard consistency, fine to medium grained sand, some fine to medium gravel. Grades into extremely weathered sandstone. Thicknesses range between 0.5m and 1.1m.
Distinctly Weathered Rock	SANDSTONE, inferred below the depth of excavator refusal. Estimated to be very low to medium strength, highly to moderately weathered. Excavator refusal was between 0.9 to 1.6m depth.

TABLE 3 - INFERRED GEOTECHNICAL UNITS FOR LA3

6.4 Slopes Greater than 20%

GCC DCP 163 'Geotechnical Requirements for Development Applications' requires identification of land with slopes in excess of 20%. Geolyse Plan 403089 Sheet D03 shows slopes on site that exceed 20%. This plan is included as Figure 3. The land is part of LA2.

7 LABORATORY TESTING

Three undisturbed (U50 tube) samples of clay were assessed for shrink / swell potential (AS1289 7.1.1). The results of shrink / swell index (I_{ss}) testing are included in Appendix B and summarised in Table 4.

Location	Depth (m)	I _{ss} (%)
TP4	0.8 – 1.1	1.3
TP8	0.9 – 1.2	2.0
TP12	0.7 – 1.0	2.0

TABLE 4 - SUMMARY OF SHRINK / SWELL INDEX (Iss) TEST RESULTS

8 SLOPE RISK ASSESSMENT

8.1 Definitions

A qualitative risk assessment involves identification of the hazard event, and a qualitative estimation of the consequences and frequency of occurrence of the event.

The terms used in the risk assessment process are defined below:

Hazard: A condition with the potential for causing an undesirable consequence.

Consequence: Outcome arising from a hazard, expressed as loss or damage.

Risk: A term combining the probability and severity or consequence of any event causing adverse effects to property or the environment.

8.2 Property Elements at Risk

The principal elements at risk for the identified hazard would be the proposed roads and houses. The following consequence assessment addresses the risks associated with potential damage to these structures.

The consequences associated with loss of life of occupants of the dwelling are a separate issue and are not addressed by this urban capability assessment.

8.3 Hazard Identification

Deep seated, large scale slope instability is not expected to occur naturally due to the shallow depth to weathered bedrock and the generally good drainage. The principal hazards that could potentially impact on a proposed development would include shallow slumping of colluvium in existing steeper slopes, or deeper slumping that could be mobilised by excessively deep or steep cuttings and deep filling associated with the subdivision development.

8.4 Risk Evaluation for Existing Site Conditions

In assessing risk, the descriptors used are from Australian Geomechanics Society publication Landslide Risk Management Concepts and Guidelines, Australian Geomechanics News, March 2000.

Consequence	Medium
Likelihood/Frequency	Possible in LA2 Unlikely in LA1 and LA3
Risk	Medium in LA2 Low in LA1 and LA3

In accordance with GCC requirements the geotechnical assessment is summarised in Table 5.

Site Data	Site Data LA1		LA3
Location	Valley floors	Spur flanks	Spur crest
Likely Site Classification (AS 2870)	Class P Potential soft soils	Class P Potential slope risk	Class S or M Depending on soil depth
Land Slope	Flat to ~ 15°	12° to 28°	Up to 8°
Underlying Bedrock	Rnt (Terrigal Formation)		
Soils Deep Silty SAND colluvial and residual CLAY soils		Shallow Silty SAND colluvial and residual CLAY soils	
Type of Stability Risk Deposition from slumps in LA2		Slumping of colluvium Slips from excessive cutting and filling	Slips from excessive cutting and filling
Risk Assessment (Note 1)	Low	Medium	Low
Drainage Judged to be good, occurring by runoff and infiltration		Judged to be good, occurring by predominately by runoff with some infiltration	Judged to be good, occurring by some runoff and infiltration
Risk from Adjacent Land	Medium	Low	Low
Geotechnical Inspections Required During Construction	Yes		

TABLE 5 – SUMMARY OF GEOTECHNICAL ASSESSMENT

Note 1: Using the terminology defined in Attachment 1 'Classification of Risk of Slope Instability'

8.5 Geotechnical Risk Management for Subdivision Development

The proposed subdivision is considered feasible from a slope risk viewpoint. However, subdivision development on the site may increase the risk of instability. Nevertheless, Coffey consider that after subdivision development the risk of slope instability should not exceed the risks assessed in Table 5 above provided that development is carried out in accordance with good hillside practice (as set out in Attachments 2 and 3) and the geotechnical recommendations below.

The following recommendations are specific to the proposed subdivision development shown on the drawing by Geolyse Ref: 403089 Sht D01-D13 supplied. Theses plans show the proposed road alignments and lot layout. Long sections and selected cross sections are provided, but road chainages are not indicated on the plans provided so it is difficult to determine the proposed location of the specific cuts or fills.

8.5.1 Road Excavations

For general consistency with the reports referenced in Section 2, Coffey recommends that excavation should generally be limited to less than 1.5m vertical depth with excavation batters not steeper than 2H:1V.

In the plans provided, the long sections show excavation in excess of 1.5m depth at the centreline for:

- Road 01 Ch 70m to 110m (depth locally up to about 2.2m)
- Road 04 Ch 0m to 20m (depth locally up to about 2.5m)
- Road 04 Ch 400m to 540m (depth locally up to about 4m)
- Road 06 Ch 0m to 10m (depth locally up to about 3m)

Where these cuts occur across the slope, deeper cuts than indicated above may occur on the upslope side of the road. Other cuttings in excess of the general maximums indicated above may also occur locally on the upslope side of the roads, and should also be investigated.

Deep cuttings are likely to intersect weathered rock. Steeper batters than 2H:1V may be feasible, but retaining walls may be preferable depending on specific assessment.

Where cuts exceed 1.5m depth, further investigation will be required to assess the risk associated with deeper excavation, the need for engineer designed retaining walls and suitable types of wall construction for the slope and subsurface conditions.

For excavations to 2.5m depth investigation by backhoe may suffice, but for excavations greater than 2.5m, cored boreholes are likely to be necessary. The scope of investigation needed at each location will depend on the local slope and ground conditions.

8.5.2 Fill Embankments

Fill embankments for road construction should not exceed 1.5m vertical height with batters not steeper than 1V:2H and protected against erosion, or supported by engineer designed retaining walls.

Where filling is required to exceed 1.5m depth, specific investigation is recommended to assess the impact on slope stability. The cross sections provided show deeper filling is required at:

- Road 01 in the vicinity of Ch 310m (about 3m fill)
- Road 01 in the vicinity of Ch 530m (about 2.5m fill)
- Road 03 in the vicinity of Ch 75m (about 3.5m fill with batters at 1H:1V)
- Road 04 in the vicinity of Ch 290m (about 1.7m fill)
- Road 08 in the vicinity of Ch 320m (about 3.2m fill)

There is also a risk of embankment instability where roads cross potential soft soils in LA1 if significant embankments are constructed. Presently the embankments do not appear to exceed 1m at the centrelines.

Fill areas should be prepared by removing topsoil, and benching into the slope to create a level platform on which to place fill. Fill should be compacted in accordance with GCC specifications under Level 1

monitoring as described in AS 3798. Fill batters should be constructed by overfilling and then cutting back to the required slope.

8.5.3 Building platforms

Cutting and filling for building platforms for houses should be limited to a maximum depth of 1m unless site specific investigation and geotechnical assessment is conducted. The cut and fill batters should be battered at 1V:2H or flatter and protected against erosion, or supported by properly designed and constructed retaining walls as described below.

8.5.4 Retaining Walls

Retaining walls in excess of 1m height should be designed by a structural engineer familiar with the site conditions and should be designed for surcharge loading from slopes and structures and other existing or future improvements in the vicinity of the wall.

Excavations for the construction of retaining walls up to 1.5m high may adopt a temporary excavation batter of 1V:1H provided that appropriate construction planning, control of drainage and staged excavation minimises the extent of unsupported excavation. Excavations in excess of 1.5m high will require specific assessment as outlined in Section 8.5.1.

Adequate subsurface and surface drainage should be provided behind all retaining walls unless they are designed to resist hydrostatic pressures. Any subsoil drainage used on site behind retaining walls should at a minimum consist of filter sock-wrapped slotted pipe surrounded in free-draining, coarse granular backfill and should be provided around the perimeter of all excavations. Subsoil drains should be fitted with flushing and clean out points. Gradient along all drains should be sufficient to promote self-cleaning.

8.5.5 Drainage and Sewage Disposal:

Guidelines for surface and subsurface drainage are provided in the attachments to this report.

There should be no disposal of stormwater or liquid wastes on site, without further specific geotechnical assessment.

9 OTHER GEOTECHNICAL CONSIDERATIONS

9.1 Reactive Soils

The results of the shrink/swell testing indicate that the clay material encountered onsite is generally of low to moderately reactivity. It is considered that clay from cuts on site can be used as general fill. It is recommended that any material won from cuts on the site be inspected by a geotechnical authority prior to placement.

9.2 Acid Sulfate Soils

Acid Sulfate Soils (ASS) are soils containing significant concentrations of pyrite, which when it oxidises, generates sulfuric acid. Unoxidised pyritic soils are referred to as <u>potential</u> ASS (PASS). When the soils are exposed, the oxidation of pyrite occurs and sulfuric acids are generated, and the soils are said to be <u>actual</u> ASS (AASS).

Pyritic soils typically form in waterlogged, saline sediments deposited during the Holocene period (10,000 years ago to present day). Typical these soils occur in environments below about RL 5m AHD such as tidal flats, salt marshes, mangrove swamps and bottom sediments in coastal rivers and creeks.

Disturbance of acid sulfate soils can generate significant amounts of sulfuric acid, which can lower soil and water pH and produce acid salts, which affects vegetation and aquatic life and can produce aggressive soils that may be detrimental to concrete and steel in buildings and services.

The Gosford 1:25000 Scale Acid Sulfate Soil Risk Map (Reference 1) indicates that the site is not in an area known to have occurrence of Acid Sulfate Soils.

Based on the site geology, site elevation (above RL11m) and ASS risk map review, actual or potential ASS are not likely to be encountered within the areas of the site proposed for development. Based on this observation and the proposed development details, it is considered that no ASS Management Plan is required.

10 CONCLUSION

The scope of work for this assessment was to identify soil and landscape limitations for urban development to address slope issues raised by GCC. No significant areas of instability were noted over the area. Based on the results of this assessment, it is considered that the land is generally suitable for the type of urban use proposed subject to the geotechnical constraints on development detailed in section 8.5.

11 LIMITATIONS

The onus is on the owner, potential owner or interested parties to decide whether the assessed level of risk of slope instability is acceptable taking into account likely economic consequences of the risk and the recommended geotechnical constraints.

The findings contained in this report result from methodologies used in accordance with normal practices 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, Coffey should be advised.

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.

Guidance on the uses and limitations of this assessment is presented in the attached document 'Important information about your Coffey Report, in accordance with which this report should be read.

REFERENCES

- 1 Department of Land and Water Conservation (1997), Gosford 1:25000 Acid Sulfate Soil Risk Map, Edition 2
- 2 Ahern C R, Stone Y and Blunden B (1998) Acid Sulfate Soil Manual, Acid Sulfate Soils Management Advisory Committee, Wollongbar, NSW, August.



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.

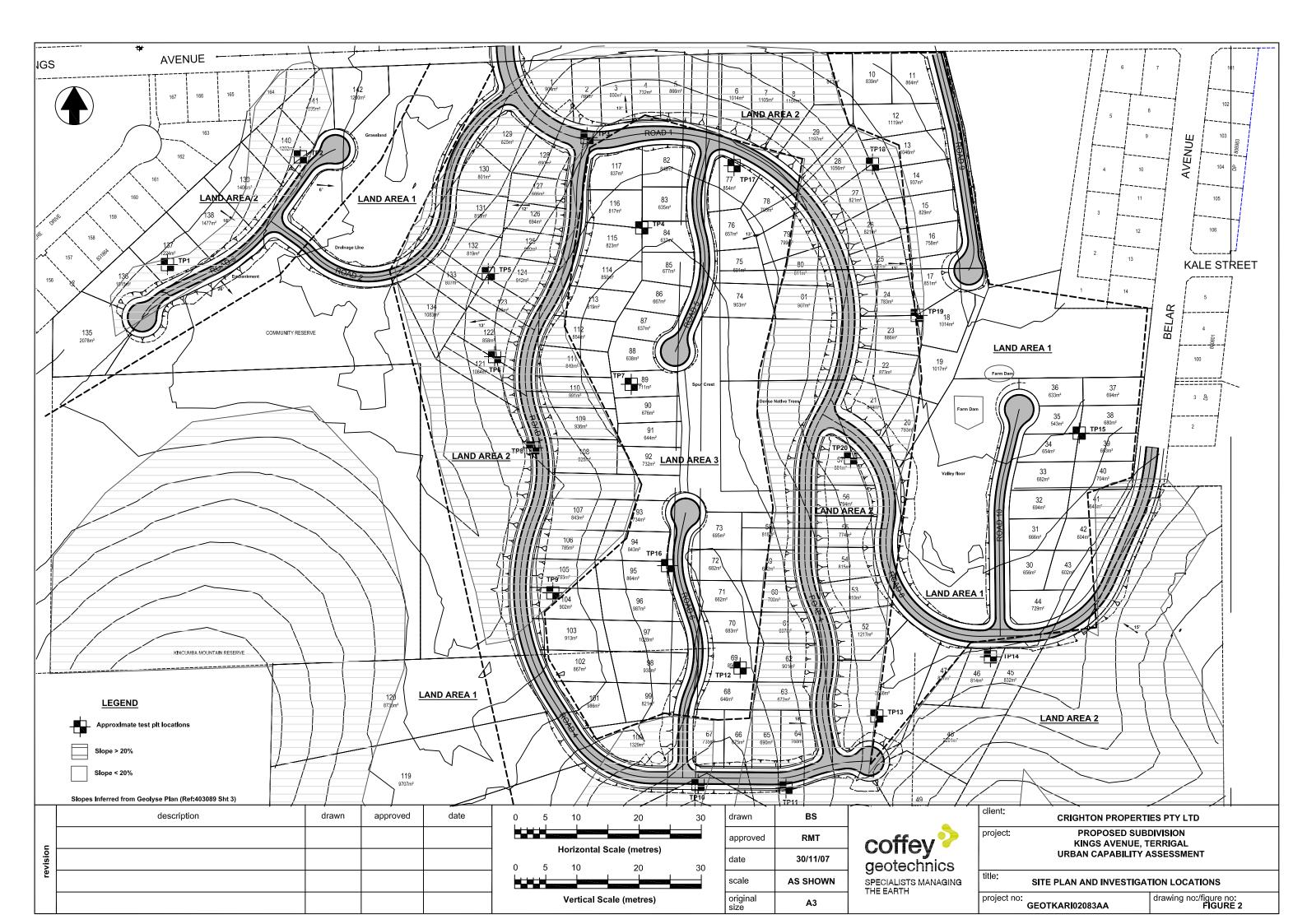
Responsibility

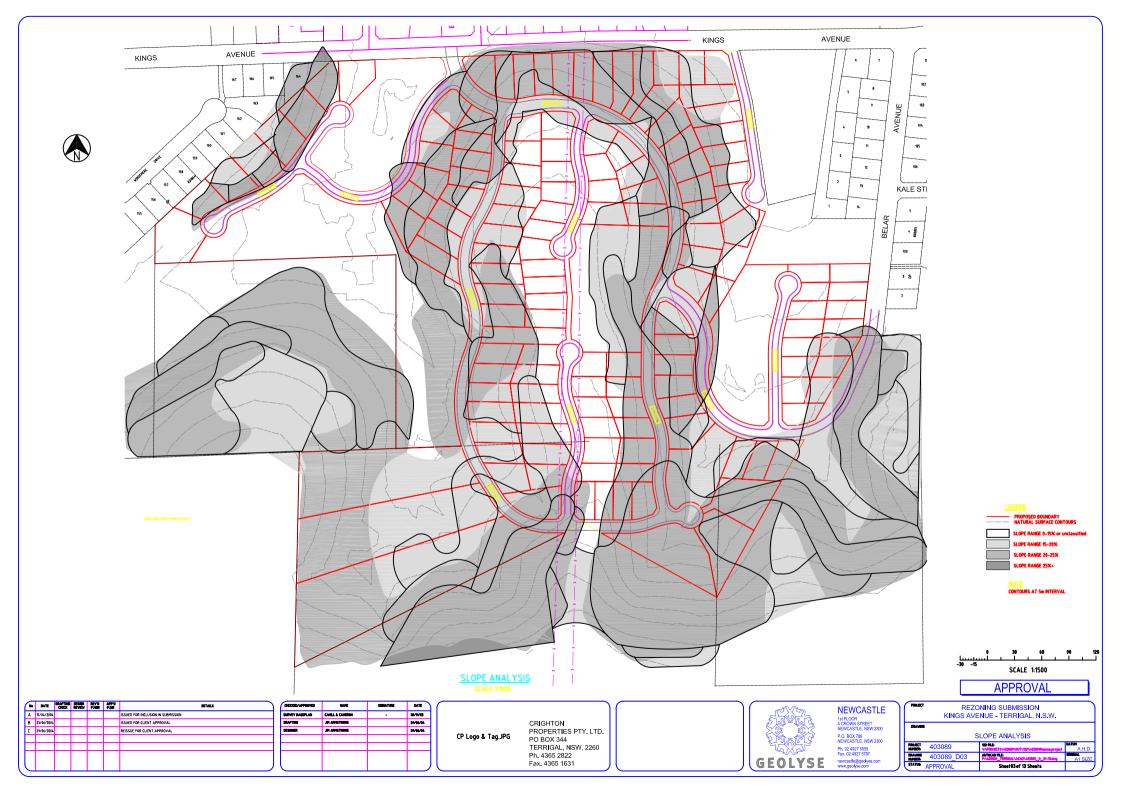
Reporting relies on interpretation of factual information based on judgement and opinion and has a level of uncertainty attached to it, which is far less exact than the design disciplines. This has often resulted in claims being lodged against consultants, which are unfounded. To help prevent this problem, 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







Appendix A

Engineering Logs and Explanation Sheets



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

GEOLOGICAI WEATHERED Extremely weathered material	- ORIGIN IN PLACE SOILS Structure and fabric of parent rock visible.
Residual soil	Structure and fabric of parent rock not visible.
TRANSPORTE	
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.

coffey **>**

Soil Description Explanation Sheet (2 of 2)

(Exclu	ding				ON PROCEDURE and basing fractions		USC	PRIMARY NAME		
0		arse 2.0 mm	CLEAN GRAVELS (Little or no fines)	Wide amou	range in grain size a ints of all intermediat	nd substantial e particle sizes.	GW	GRAVEL		
3 mm is		/ELS alf of co r than 2	CLE GRA (Lit fine	Predo with r	ominantly one size or more intermediate siz	a range of sizes es missing.	GP	GRAVEL		
SOILS than 6(m	eye)	GRAVELS More than half of coarse ction is larger than 2.0 m	/ELS FINES ciable unt nes)		plastic fines (for idented and a see ML below)		GM	SILTY GRAVEL		
AlINED ials less 0.075 m	e naked	GRAVELS More than half of coarse fraction is larger than 2.0 mm	GRAVELS WITH FINES (Appreciable amount of fines)		c fines (for identificat L below)	ion procedures	GC	CLAYEY GRAVEL		
COARSE GRAIINED SOILS 0% of materials less than 6 larger than 0.075 mm	ble to th	trse 2.0 mm	AN IDS ss) of ss)		range in grain sizes a ints of all intermediat		SW	SAND		
tin 50% larç	icle visi	DS If of coa ir than 2	CLEAN SANDS (Little or no fines)	Predo with s	ominantly one size or some intermediate siz	a range of sizes zes missing.	SP	SAND		
More the	00% of material less than More than 50% of materials less than 63 mm is smaller than 0.075 mm 00% of material less than 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) More than 10,075 mm YS SILTS & CLAYS More than half of cost to the naked eye)		SANDS WITH FINES (Appreciable amount of fines)	Non- proce	plastic fines (for iden dures see ML below	tification).	SM	SILTY SAND		
	the sma	SANDS More than half of coarse fraction is smaller than 2.0 mm	SAI WITH (Appre amo		c fines (for identificat L below).	tion procedures	SC	CLAYEY SAND		
	ont		IDENTIFICAT	ION PI	ROCEDURES ON FR	ACTIONS <0.2 mm.				
uan Lan	s ab	(0)	DRY STREN		DILATANCY	TOUGHNESS				
ILS less th 75 mr	rticle i	SILTS & CLAYS Liquid limit less than 50	None to Low	1	Quick to slow	None	ML	SILT		
FINE GRAINED SOILS in 50% of material less is smaller than 0.075 r	nm pa	TS & (-iquid ess the	Medium to H	ligh	None	Medium	CL	CLAY		
SRAIN of m aller th	.075 r	SIIS 1	Low to medi	um	Slow to very slow	Low	OL	ORGANIC SILT		
FINE (in 50% is sm	(A 0	LAYS mit an 50	Low to medi	um	Slow to very slow	Low to medium	MH	SILT		
FINE GRAINED SOILS More than 50% of material less than 63 mm is smaller than 0.075 mm		SILTS & CLAYS Liquid limit greater than 50	High		None	High	CH	CLAY		
Image: Second										
HIGHLY SOILS	(OF	GANIC	Readily ident frequently by		y colour, odour, spon s texture.	gy feel and	Pt	PEAT		
• Low pl	astic	city – Liqu	uid Limit W _L les	s than	35%. • Modium plast	icity – W _L between 35%	6 and 50%.	·		
	_									

SOIL CLASSIFICATION INCLUDING IDENTIFICATION AND DESCRIPTION

COMMON DEFECTS IN SOIL

TERM	DEFINITION	DIAGRAM	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.		SOFTENED ZONE	A zone in clayey soil, usually adjacent to a defect in which the soil has a higher moisture content than elsewhere.	ALCONTRACTOR OF
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.		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	
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.		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.	And
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.		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.	

coffey	🛹 geote	echnics			Excava	ation N	lo.	TP001
Engineering					Sheet Project	No:	1	of 1 GEOTKARI02083AA
Client: Crig Principal:	hton Properties I bosed Subdivisio	Pty Ltd			Date st Date co	arted:		28.11.2007 28.11.2007 BS
· · ·	er to Figure				Checke	-		RMT
	Kubota 4t		,		Surface: Not Measured			
excavation dimensions: 2 excavation information	2m long 0.6m wide	substance	Northing: r	n		с	datum	n: AHD
pour training internation inte	debth BLT metres symbol	materia soil type: plasticity or partic colour, secondary and mi	cle characteristics,	moisture condition	consistency/ density index	100 pocket 200 penetro-	ι	structure and additional observations
A None Observed	0.5 0.5 1.0 1.5 2.0 2.5	Silty SAND: Fine to medium g Grading to CLAY: High plasticity, orange mottling. Red colour increasing at 1.5m Test pit TP001 terminated at 1.	with some red — — –	D	o VSt/H		× R H × Sn × R	COLLUVIUM
Sketch method N natural exposure X existing excavation BH backhoe bucket B bulldozer blade R ripper E excavator	support S shoring N nil penetration 1 2 3 4 ranging to refusal water water level on date shown water inflow water outflow	notes, samples, tests U ₅₀ undisturbed sample 50r U ₆₃ undisturbed sample 63r D disturbed sample V vane shear (kPa) Bs bulk sample E environmental sample R refusal	nm diameter nm diameter mm diameter moistr D M W Wp	on unifie	d classifica			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

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Engineering						Excava Sheet	tion No	n. TP002 1 of 1
						Project	No:	GEOTKARI02083AA
Client: Crig	hton Prop	erties P	ty Ltd			Date st	arted:	28.11.2007
Principal:						Date co	mplete	d: 28.11.2007
Project: Proj	bosed Sub	division	1			Logged	by:	BS
Test pit location: Refe	er to Figure	е				Checke	d by:	RMT
equipment type and model:	Kubota 4t		Pit Orientation:	Easting:	m		R.	L. Surface: Not Measured
	2m long 0.6m		.h	Northing:	m		da	tum: AHD
excavation information	n	naterial su	Ibstance			_ ×		
bout the second	depth RL metres	graphic log classification symbol	materi soil type: plasticity or par colour, secondary and r	ticle characteristics,	moisture condition	consistency/ density index	¹⁰⁰ A pocket ²⁰⁰ d penetro- ³⁰⁰ b meter	
A None Observed		СН	Silty SAND: Fine to medium Fine to medium grained angu gravel. Sandy CLAY: Medium to hig and red, fine grained sand. Extremely weathered sandsto test pit. Test pit TP002 terminated at	lar sandstone and iron h plasticity, orange	- <wp< th=""><th>VSt/H</th><th>× × × × × ×</th><th>RESIDUAL -</th></wp<>	VSt/H	× × × × × ×	RESIDUAL -
Sketch method N natural exposure X existing excavation BH backhoe bucket B bulldozer blade R ripper E excavator	support S shoring penetration 1 2 3 4 rangi water water level on date sh water inflor water outfl	el nown ow	notes, samples, tests U ₆₀ undisturbed sample 5 U ₆₃ undisturbed sample 6 D disturbed sample V vane shear (kPa) Bs bulk sample E environmental sample R refusal	Omm diameter soil d 3mm diameter based syster moist	escriptio I on unifie m	d classifica		consistency/density indexVSvery softSsoftFfirmStstiffVStvery stiffHhardFbfriableVLvery looseLlooseMDmedium denseDdenseVDvery dense

Form GEO 5.2 Issue 3 Rev.2

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-						E	Excava	tion N	0.	TP003			
Engineering	j Loç	g - Ex	cavation				Sheet Project	No	1	of 1 GEOTKARIO	120 <u>834</u> 4		
		operties F					Date st			28.11.2007	2000/1/1		
Principal:		-	-			C	Date co	omplet	ed:	28.11.2007			
Project: Prop	osed Si	ubdivisio	n			L	ogged	l by:		BS			
•	r to Figu						Checke	-	d by: RMT				
equipment type and model: K	Kubota 4t		Pit Orientation:	Easting:	m			F	.L. S	urface: Not Meas	sured		
	2m long 0.0	6m wide		Northing:	: m		datu			: AHD			
excavation information		material s	ubstance				<u> </u>	÷ è					
notes samples, tests, etc		c log ication	m	aterial		on	tency, / inde	pocket penetro-	neter	structure a			
	depth RL metres	graphic log classification symbol	soil type: plasticity o	r particle characteristic and minor components	cs,	moisture condition	consistency/ density index	kPa		additional obser	rvations		
с 123 % > ш (N	KL metres	5, 8 %	Silty SAND: Fine to me	•		M	00	100 200 300		OLLUVIUM			
									М	loderate root system	to 0.3m –		
None		SP	SAND: Fine to medium	grained, pale grey and	l pale						-		
	0. <u>5</u>		orange, some low plastic								-		
		СН	Sandy CLAY: Medium t fine grained sand.	o high plasticity, orang	je,	<wp< td=""><td>VSt/H</td><td></td><td>* R</td><td>ESIDUAL — — — —</td><td>_</td></wp<>	VSt/H		* R	ESIDUAL — — — —	_		
			Test pit TP003 terminate	d at 0.7m						efusal on interpreted			
	1.0								W	eathered sandstone	at 0.7m –		
	1.0												
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	1. <u>5</u>												
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											-		
	2.0										-		
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Sketch	2.5												
OREIGH													
method	support		notes, samples, tests		classifica		mbols a	nd	1	consistency/density			
N natural exposure X existing excavation	S shoring	N nil	U ₆₃ undisturbed sam	ple 63mm diameter	soil desc based on		classifica	ation		VS very so S soft	oft		
BH backhoe bucket B bulldozer blade R ripper	penetratio	no resistance	D disturbed sample V vane shear (kPa Bs bulk sample)	system moisture				_	F firm St stiff VSt very st	iff		
R ripper E excavator	r r	ranging to refusal	E environmental sa R refusal	ample	D dry M moi					H hard Fb friable			
	water l	level e shown			W wet					VL very lo L loose	ose		
	► water i → water o	inflow outflow			W _L liqu	iid limit				MD mediur D dense VD very de	n dense ense		

TESTPIT GEOTKARI02083AA.GPJ COFFEY.GDT 13.2.08

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Test pi		ation:	-	-	o Figu							Checke			RM			
equipme	ent tyr	ce and		Kubot				Pit Orientation:	Easti	ing: m			-		Surface:		Measured	
excavat				2m loi	ng 0.	.6m wid		• • • • •	North	hing: m	<u> </u>			datu	um:	AHD	<u>)</u>	
	_		ormation			mat		substance						<u>.</u>	<u> </u>			
method 5 5 7 7 7 7 7 7 7	3	water	notes samples, tests, etc		depth metres		classification symbol	soil type: plasticity	material y or particle character ry and minor compon		moisture condition	consistency/ density index	kF	300 e penetro- 400 meter	add		ure and observation	าร
Ш 12	N	1			-		SM	Silty SAND: Fine grain			M			0.4	COLLUV Thick roo		ו to 0.7m	
		None Observed			0. <u>5</u>		SC	Silty Clayey SAND: Fi	low plasticity clay fine	es.								-
		NC		-			CL-CH	Silty CLAY: Medium p orange.	plasticity, grey with so	ome pale	< <wp< td=""><td>VSt/H</td><td></td><td>× × ×</td><td>RESIDU4</td><td>۸L</td><td></td><td>-</td></wp<>	VSt/H		× × ×	RESIDU4	۸L		-
			U ₅₀		1. <u>0</u>			Sandstone gravel conte	tent increasing with c	depth.				×				
					- - 1.5 - - 2.0 - - - - - - - - - - - - - - - - - - -			Test pit TP004 termina		<u>.</u>				+*	Refusal a interprete sandston	ed as ext	on clayey gra tremely wea	avel .thered - - - - - - - - - - - - - - - - - - -
Sket	i natu		¢posure		upport shoring		V nil		ample 50mm diameter	soil des	ication sy				VS	v	ensity index very soft	
х BH B R E	exis bac bull ripp	sting ex khoe b Idozer I	bxcavation bucket blade		enetratio 2 3 4 r r vater vater	no resista ranging to refusal level te showr inflow	ance to n		ample 63mm diameter nple Pa)	based o system D d M m W w Wp p	on unified	l classifica	ution		S F St VSt H Fb VL L MD D VD	s fi v fr fr la fr d	soft irm stiff riable very loose oose medium dense dense very dense	Э

C	of	ff,		9	C	ae	ote	echnics			_								
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Test pi	t loca	ation:	Refe	er to	o Figu	ure					(Checke	d by	/:		RMT			
equipme	ent typ	e and	d model:	Kubot	ta 4t			Pit Orientation:	Easting:	m				R.I	L. S	Surface:	Not M	leasured	
excavat			ions: ormation	2m loi	ng 0.	6m wid		substance	Northing:	m				da	atum	1:	AHD		
		T					-					ex	t at	þ.					
e	o penetration support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or partic colour, secondary and mir	le characteristics	š,	moisture condition	consistency/ density index	100 A pocket	Pa			structur ional ob	e and oservation	is
<u>-</u> 12 Ш	2 3 <i>°</i>				-		SM	Silty SAND: Fine grained, dark	•		M		5 4	84	С	COLLUVIU		o 0.2m	
		None						Becoming pale grey with depth.											_
					0. <u>5</u> –		СН	CLAY; High plasticity, dark ora medium grained angular sandsi	nge, some fine to	<u> </u>	< <wp< td=""><td>VSt/H</td><td></td><td> *</td><td></td><td>RESIDUAL</td><td></td><td></td><td> </td></wp<>	VSt/H		 *		RESIDUAL			
		+		+	+		 	Test pit TP005 terminated at 0.4	Ū				\mathbb{H}	+	R	Refusal on	d as beii	ng highly	
					1. <u>0</u>										[W	veathered	sandstu	ne	
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method N X	natu		posure		upport shoring	N	l nil	Notes, samples, tests U ₅₀ undisturbed sample 50m	nm diameter so	oil desc	ription					consiste VS S		sity index Ty soft	
A BH B	bac	khoe b dozer l		р е	enetratio		ſ	U ₆₃ undisturbed sample 63m D disturbed sample V vane shear (kPa)		ystem	unillea	classifica	uon			S F St	firm	n	
R	ripp					no resista ranging to refusal	ance o	Bs bulk sample E environmental sample	m D	noisture dry						VSt H		ry stiff	
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					 on date water i 	te showr inflow	1		w w		stic limit uid limit					L MD D		dium dense	•
					water of		ļ									D VD	der ver	nse ry dense	

TESTPIT GEOTKARI02083AA.GPJ COFFEY.GDT 13.2.08

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			-									Excava	ition	No.	11 0	206	
Eng	gir)e	erin	g I	_ 0ć	J -	Ex	cavation				Sheet Project	t No:	:	1 of 1 GEC	OTKARI0208	3AA
Client:			Criç	jhto	on Pre	oper	ties F	Pty Ltd				Date st	tarte	d:	28.1	1.2007	
Princip	al:										1	Date co	omp	leter	d: 28.1	1.2007	
Project	t:		Pro	pos	ed Su	ubdi [,]	visio	n			1	Loggec	d by:	:	BS		
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equipme	ent typ	e anc	d model:	Kubot	ta 4t			Pit Orientation:	Eastin	ıg: m		R.L.			Surface:	Not Measured	
excavat				2m lo	ing 0.0	.6m wid		substance	Northir	ng: m				datu	um:	AHD	
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thod	ut lana.	:	notes samples,		ļ	ic log	classification symbol	ma	aterial		tion	consistency/ density index	pocke	penetro- meter	ibbe	structure and tional observation	~~
8	3	water	tests, etc	:	depth metres	graphic log	classif	soil type: plasticity or colour, secondary a	r particle characteria	stics,	moisture condition	consis densit	kF	Pa Se esta		CIONAL ODSELVATION	S
드 12 프	23 00 N						SM	Silty SAND: Fine grained	•	11.5.	M		2(4 3	COLLUVIU	UM	
					-										Thick root	system to 0.4m	-
		e			_'												_
		None			0.5			Some fine to medium gra	ined angular grave	I from							-
								Silty CLAY: Medium plas	cticity orange and	- <u> </u>	< <wp< td=""><td>_</td><td></td><td></td><td>RESIDUAI</td><td></td><td></td></wp<>	_			RESIDUAI		
								mottling.	Slibity, trange and i	Eu	<~~~r				NEOLOG	L	_
								Sandstone gravel at 0.8m			<u> </u>	<u> </u>		$\downarrow\downarrow$	<u> </u>		
					1. <u>0</u>	'		Test pit TP006 terminated	d at 0.9m						intereprete	n gravel at 0.9m ed as being highly	
						1 '									weathered	d sandstone	-
					_'												_
					1. <u>5</u>	{ '											-
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Sket	ch						<u> </u>								<u></u>		
0.10	5																
				<u> </u>				÷							·		
method N	natu		posure		upport shoring	N	l nil		ple 50mm diameter	soil des	scription				VS	ency/density index very soft	
X BH	back	khoe b	xcavation bucket	pr	enetratio	on	ļ	D disturbed sample		based o system	n unified	l classifica	ation		S F	soft firm	
B R	rippe				Stand I r	no resista ranging to	ance o	V vane shear (kPa) Bs bulk sample		moistur					St VSt	stiff very stiff	
E	exca	avator		w	ater	refusal	ļ	E environmental sa R refusal	mple	M m	ry noist				H Fb	hard friable	
				-	water l on date	level te showr	n			Wp pl	vet Iastic limi quid limit				VL L MD	very loose loose medium dense	_
					 water i water i 	inflow outflow				۷۷ _L	Juiu mini				D VD	dense very dense	

TESTPIT GEOTKARI02083AA.GPJ COFFEY.GDT 13.2.08

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COILE	;y 🍷 🥲	yeole	CHINCS		Excava	tion No.	TP007			
Enginee					Sheet Project	No:	1 of 1 GEOTKARI02083AA			
Client:	Crighton Pr	roperties F	Pty Ltd		Date sta		28.11.2007			
Principal:	-	-	-		Date co	mpleted	: 28.11.2007			
Project:	Proposed S	Subdivisio	n		l ogged	ged by: BS				
Test pit location:	Refer to Fig				Checke		RMT			
equipment type and m	-		Pit Orientation: Eastin	ng: m	Onconc	,	. Surface: Not Measured			
excavation dimensions		0.6m wide	Northi	ing: m		datu	ım: AHD			
excavation inform	nation	material s	ubstance							
si od	notes amples, ests, etc depti RL metre		material soil type: plasticity or particle characteri colour, secondary and minor compone	istics, ents.	moisture condition consistency/ density index	100 × pocket 200 v penetro- 400 meter	structure and additional observations			
ш N		SC	Silty Clayey SAND: Fine to medium graine brown, low plasticity clay fines.	d, pale	М		COLLUVIUM -			
None	0.5	SC	Clayey SAND: Fine to coarse grained, pale and pale orange.	brown	M		RESIDUAL			
		=	SAND: Fine to coarse grained, orange and		VD		EXTREMELY WEATHERED			
	1.0		Fine to coarse sandstone gravel throughout Test pit TP007 terminated at 0.9m							
	1.9	-					-			
		-					-			
	1. <u>5</u>	;					-			
		_					-			
		_					-			
	2. <u>0</u>	<u>)</u>					_			
		-					-			
	2.5						-			
Sketch	2.0									
maked	Lauran			oloogifianti	ion ourshold o	nd	consistency/density index			
N natural expos X existing excav BH backhoe buck B bulldozer blac R ripper E excavator	vation ket de 1 2 3 4 1 2 3 4 water water ↓ wate ↓ wate	ig N nil	Notes, samples, tests U _{s0} undisturbed sample 50mm diameter U _{e3} undisturbed sample 63mm diameter D disturbed sample V vane shear (kPa) Bs bulk sample E environmental sample R refusal	soil descri based on u system moisture D dry M mois W wet Wp plast	nified classifica		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			

C	2	f	f		9	C	ae	ote	echnics			_								
		/		J			,					E	Excava	tion	No.	. 7	TP008	3	_	
Ε	ng	in	16(erin	gΙ	ΓΟĆ] -	Ex	cavation				Sheet Project	No.		1 of		(ARI0208	83 0 0	
Clie									Pty Ltd				Date sta				28.11.2		10/ 1/ 1	
Prir	ncipal:								-			[Date co	ompl	ete	d: 2	28.11.2	007		
Pro	ject:			Pro	pos	ed Su	ubdi [,]	visio	n			L	_ogged	l by:		E	BS			
Tes	t pit lo	ocat	ion:	Refe	er to	o Figu	ure					(Checke	d by	y:	RMT				
					Kubot				Pit Orientation:	Easting:	m				R.L	Surfa		lot Measured		
	avation cavat i			ons:	2m loi	ng 0.6	.6m wid		substance	Northing:	m				dat	tum:	A	HD		
	ation ation			notes			Ð	ion	materi				cy/ dex	ket otro	er er					
method	benetration	support	water	samples, tests, etc		depth metres		classification symbol	soil type: plasticity or par colour, secondary and r	ticle characteristics		moisture condition	consistency/ density index	100 200 30 200 10 200				cture and al observatio	ns	
ш	123	N	<u>_</u>	[+			SM	Silty SAND: Fine to medium some fine to coarse grained a	grained, dark brow		D		⊼¥	<u></u> 8 4	COLL				
									gravel.	Ingular sanusione							e sandstor lers in top	ne cobbles an 0.4m	ıd –	
			م م			0. <u>5</u>													_	
			None Observed					СН	Silty CLAY: High plasticity, o	prange and grey.		< <wp< td=""><td>VSt/H</td><td></td><td>×</td><td>RESI</td><td>DUAL</td><td></td><td></td></wp<>	VSt/H		×	RESI	DUAL			
			Nor												×				-	
						1.0									×					
															×				_	
						_ 			Sandstone gravel content inc	· ·					×				-	
					\square				Test pit TP008 terminated at	1.5m				\square	T	Refus	al on gra	vel at 1.5m		
																			_	
						2.0													-	
						<u></u>														
																			_	
																			_	
s	ketch				<u> </u>	2.5		<u> </u>	1				I							
me	thod					upport			notes, samples, tests	cl	lassific	ation sv	mbols a	nd		1 co	nsistency	density index		
N X	r			posure cavation		shoring	N	N nil	U ₅₀ undisturbed sample 50 U ₆₃ undisturbed sample 63	0mm diameter so	oil desc	ription	classifica			VS S		very soft soft		
BH B R	t		ozer b	bucket blade	ре 1		no resista		D disturbed sample V vane shear (kPa) Bs bulk sample		ystem					F St VS		firm stiff very stiff		
E		excav			w	ater	ranging to refusal	3	E environmental sample R refusal		dry	/				H Fb		hard friable		
						water l	level te showr	n		W W	V wet Vp pla:	t Istic limit	t			VL L		very loose loose		
						 water i water of 	inflow outflow			W	L liqu	uid limit				MD D VD		medium dens dense very dense	e	

TESTPIT GEOTKARI02083AA.GPJ COFFEY.GDT 13.2.08

1		ſ	f		9	C	neo	ote	chnics											
•				Ξy		3	,					E	Excava	tion	No.	TP009				
E	ing	jir	ne	erin	g l	<u>_0č</u>	J -	Ex	cavation				Sheet Project	No:		1 of 1 GEOTKA	ARI02083	AA		
Cli	ent:			Crig	hto	n Pro	oper	ties F	Pty Ltd			[Date sta	arte	d:	28.11.20	07			
Pr	incipa	l:										[Date co	mpl	eteo	ed: 28.11.2007				
Pr	oject:			Pro	pos	ed Si	ubdi	visio	1				_ogged	by:		BS				
Те	st pit	oca	tion:	Refe	er to	o Figu	ure						Checke	ed by	<i>y</i> :	RMT				
eq	uipmen	t typ	e and	d model:	Kubot	a 4t	Pit Orientation: Easting: m								R.L	. Surface: Not	Measured			
excavation dimensions: 2m long (excavation information							.6m wide Northing: m material substance								dat	um: AHI)			
					mai							, X t o								
method	penetration	notes samples tests, et 1 2 3		notes samples, tests, etc	samples,			classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.			moisture condition	consistency/ density index	200 A pocket	Ра	structure and additional observations				
— Ш	123	8 07 N	-					SM	Silty SAND: Fine grained,	•		M		2 Q	84	COLLUVIUM				
																Thin root system		_		
						-		SC	Clayey SAND: Fine to mee plasticity clay fines.	lium grained, grey, lo	w	М						-		
						0. <u>5</u>		CL-CH	Gravelly CLAY: Medium p some orange and red, fine angular sandstone gravel.			>Wp				COLLUVIUM/RE	SIDUAL			
			ed															_		
			bserv															_		
			None Observed			1.0		СН	Silty CLAY: Medium to hig	h plasticity, pale grey	,	<wp< td=""><td></td><td></td><td>×</td><td>RESIDUAL</td><td></td><td></td></wp<>			×	RESIDUAL				
			Ż						and pale orange.						×			_		
																		_		
						1. <u>5</u>			Some fine to medium grain	ed angular sandstone	e and				×					
						_									×			_		
															×			-		
															$ \hat{ }$	Very slow progre gravel	ss in clay and	_		
						2.0	(/X//	1	Test pit TP009 terminated a	at 2m					+*					
																		_		
						-												-		
						2.5												_		
	Sketch	ı																		
method N natural exposure X existing excavation BH backhoe bucket B bulldozer blade R ripper E excavator						ील्ला ।	on no resista ranging ti refusal	I nil ance o	U ₆₃ undisturbed sample D disturbed sample V vane shear (kPa) Bs bulk sample	 undisturbed sample 50mm diameter undisturbed sample 63mm diameter disturbed sample based on system bulk sample bulk sample moisture environmental sample D dry refusal 						S s F f St s VSt v H h Fb f	nsity index ery soft oft rm ery stiff iard riable ery loose			
						 on dat water i 	e showi	n		W wet Wp plast W _L liquic			t			L k MD r D c	oose nedium dense lense ery dense			

TESTPIT Form GEO 5.2 Issue 3 Rev.2

coffe	y 💙 🤅	geote	chnics			Ē	xcava	tion N	0.	TP010		
Enginee						S	heet roject			of 1 GEOTKARI02083AA		
Client: Principal: Project:		operties F	perties Pty Ltd bdivision						ed:	28.11.2007 28.11.2007 BS		
Test pit location:	Refer to Fig		Ire							RMT		
equipment type and mo	-				R	.L. S	urface: Not Measured					
excavation dimensions:		.6m wide	Northing: m					da	atum	um: AHD		
excavation inform	ation	material s	ubstance					Å				
po ta to sa	notes mples, sts, etc depth RL metres	graphic log classification symbol	mat soil type: plasticity or p colour, secondary an			moisture condition	consistency/ density index	100 A pocket 200 A penetro- 300 b motor		structure and additional observations		
Wone Observed		SM	Silty SAND: Fine to mediu Some fine to medium grain from 0.4m. CLAY: Medium to high pla and orange mottling. Some fine to medium grain 1m. Test pit TP010 terminated	ned angular sandsto asticity, pale grey wit ned sandstone grave	ne 	D >Wp			X R X R X R	OLLUVIUM		
Sketch method N natural exposu X existing excava BH backhoe bucke B bulldozer blade R ripper E excavator	ation et penetration 1 2 3 4 water water water	on no resistance ranging to refusal level te shown inflow	notes, samples, tests U ₅₀ undisturbed sample U ₆₃ undisturbed sample D disturbed sample V vane shear (kPa) Bs bulk sample E environmental sam R refusal	le 50mm diameter le 63mm diameter nple		ription unified c				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		

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	7		Cy		2)-		•			Ē	Excava	tion N	lo.	TP011				
Eng	gir	1 e						cavation				Sheet Project	No:	1	of 1 GEOTKARIO	02083AA			
Client:			Crig	ihto	n Pro	operi	ties F	Pty Ltd			[Date st	arted:		28.11.2007				
Princip	al:										[Date co	mplet	ted:	28.11.2007				
Project	:		Pro	pose	ed Sı	ubdi	visio	n			l	ogged	by:		BS				
Test pi	t loca	tion:	Refe	ər to	o Figu	ure					(Checke	d by:	_	RMT				
equipme	nt typ	e and	I model:	Kubota	a 4t			Pit Orientation:	Easting	g: m			F	R.L. 8	Surface: Not Meas	sured			
excavati			ons: ormation	2m lor	ng 0.	6m wide Northing: m material substance							d	latum	n: AHD				
												_ ×;	t ę						
od enetrati			notes samples,	mples,		graphic log	classification symbol	mater	ial		ure	consistency/ density index	pocket penetro-	meter	structure a additional obser				
method 15	13	water	tests, etc	RL	depth metres	graph	classi symb	soil type: plasticity or pa colour, secondary and	minor componer		moisture condition	consi densi	kPa ۵ ۵ ۵ ۵	400		Vullet			
E	N				-		SM	Silty SAND: Fine grained, d	ark brown.		D				COLLUVIUM	_			
		þ												Г	Thick root system top (0.2m –			
		serve			0.5											_			
		None Observed			0. <u>5</u>														
		Ž			-		SP	SAND: Fine to medium grai	ned, orange.		D	VD		F					
									-							-			
					1. <u>0</u>			Fine to coarse grained sand Pale grey and red colour at		n 1m.									
					-	<u>····</u>		Test pit TP011 terminated at							Refusal on gravel at 1. Interepreted as being h				
					-										veathered sandstone				
					1. <u>5</u>											-			
					-											-			
																-			
					2.0											-			
					2.0														
					-											-			
																-			
					2.5														
Skete	ch																		
method				i eu	ipport			notes, samples, tests	i	classific	ation sy	mbols a	nd		consistency/density	index			
N X	natu		posure cavation		shoring	N	l nil	U_{50} undisturbed sample s U_{63} undisturbed sample s		soil des based or	cription				VS very so S soft				
BH B	back	khoe b dozer b	ucket	ре 1	enetratio			D disturbed sample V vane shear (kPa)	_	system					F firm St stiff				
R E	rippe exca	er avator				no resista ranging to refusal	ance	Bs bulk sample E environmental sample	e	moistur D dr	ý				VSt very sti H hard	ff			
				wa ▼	ater water l			R refusal		W we					Fb friable VL very loo	ose			
					 on date water i 	ie showr	l				astic limi uid limit	t				n dense			
						outflow									D dense VD very de	ense			

C	` C	f	f	ev	7	C	je	ote	echnics			-							
				-								E	Excava	tion	No.	T	P012		
Ε	ng	in	ie	erin	g l	Lος] -	Ex	cavation				Sheet Project	No:		1 of ² G		ARI02083	24
Clie									Pty Ltd				Date sta				9.11.20		<u>A</u> .
Prir	ncipal:	:					-		-			ſ	Date co	ompl	letec	d: 2 {	9.11.20	07	
Pro	ject:			Pro	pos	ed Su	ubdi	visio	n			I	Logged	ł by:		B	S		
	st pit lo	ocat	ion:	Ref	er te	o Figu	ure								y:	R	MT		
equ	ipment	type	e and	d model:	Kubo	ta 4t		Pit Orientation: Easting: m							R.L	Surface	e: Not	Measured	
excavation dimensions: 2m long 0 excavation information							.6m wide Northing: m material substance								datu	um:	AHD)	
ex				Imation									~ ×	± {	<u>.</u>				—
g	penetration		notes samples,	,	I	ic log	classification symbol	material		ion Lre	consistency/ density index	pocket	meter		structure and additional observations				
method		support	water	tests, etc	, etc depth RL metres			classif symbr	soil type: plasticity or particle characteristics, colour, secondary and minor components.			moisture condition	consis densit	6 00 50 00 50 00	Pa	a	Jultional	DServations	
ш	123	N	آم		+			SM	Silty SAND: Fine grained, bro	own, some fine to		D		2,10	1 × 3	COLLU	JVIUM		
									medium grained angular grav	'el.									1
								CL	Gravelly CLAY: Low to media fine grained angular gravel.	ium plasticity, dark	c red,	<wp< td=""><td></td><td></td><td></td><td>COLLI</td><td>JVIUM/RES</td><td>SIDUAL</td><td></td></wp<>				COLLI	JVIUM/RES	SIDUAL	
						0. <u>5</u>		СН	CLAY: Medium to high plasti		<u></u>	1-\\/n	VSt/H		×	RESDI			
			None Observed						orange and red mottling, some		נ	<=vvp	V5Vn			KESDI	UAL		_
			e Obs				<i>V///</i>								×				
			Non			1.0									×				_
						-						14/10			×				
								СН	Silty CLAY: High plasticity, p and orange mottling.	ale grey with som	le rea	< <vvb< td=""><td>VSt/H</td><td></td><td></td><td></td><td></td><td></td><td>-</td></vvb<>	VSt/H						-
						1. <u>5</u>													
					+				Test pit TP012 terminated at	1.6m				ht			al on sands TP at 1.6m	stone in northe	ərn
																enu oi	IF at 1.00	1	-
						2.0													_
							-												4
						2.5													-
s	sketch	_ <u></u>		<u> </u>		2.0	<u> </u>	<u>.</u>	<u> </u>		I		<u> </u>			<u>.</u>			
-																			
	thod	—	—			upport			notes, samples, tests				ymbols a	nd			-	ensity index	
N X	(existi	ing ex	posure xcavation		shoring		N nil	U ₅₀ undisturbed sample 50 U ₆₃ undisturbed sample 63	3mm diameter			classifica	ation	ļ	VS S	S	very soft soft	
BH B R	ł		ozer b	oucket blade		2 3 4	no resista	ance	D disturbed sample V vane shear (kPa) Bs bulk sample		system					F St VSt	S	irm stiff /ery stiff	
E		rippei exca\				/ater	ranging to refusal	D	E environmental sample R refusal	e l	D dry				ļ	H Fb	h	very stiff hard riable	
						water	level te showi	'n	K	N N	W we		ıt		ļ	VL L	V	very loose oose	
						- water	inflow outflow			, in the second s	W _L liqu	juid limit			ļ	MD D VD	d	nedium dense dense very dense	

CC	Ŋ	fe	V C	2	ç	jeo	ote	chnics			_				
			-									Excava	tion N	۱o.	TP013
Eng	gin	e	ering	g l	_00	J -	Ex	cavation				Sheet Project	No:		1 of 1 GEOTKARI02083AA
Client:			Crig	hto	n Pro	pert	ies F	Pty Ltd				Date st			29.11.2007
Principa	l:											Date co	omple	ted:	29.11.2007
Project:			Pro	pos	ed Sı	ıbdi	/isio	n				Logged	l by:		BS
Test pit	locat	ion:	Ref	er to	o Figu	ıre						Checke	ed by:		RMT
equipmer	nt type	and	model:	Kubot	a 4t			Pit Orientation:	Eastir	ng: m			F	R.L. \$	Surface: Not Measured
excavatio				2m loi	ng 0.0	6m wid		ubstance	North	ing: m			c	datur	m: AHD
excavation informatio								ubstance				Xe	ro t		
method 5 penetration	support	water	notes samples, tests, etc	RI	depth metres	graphic log	classification symbol	soil type: plasticity o	material ity or particle characteristics, ary and minor components.		moisture condition	consistency/ density index	100 A pocket 200 A penetro- 300 benetro-	a	structure and additional observations
с 123 Ш	3 %	_				.	SM	Silty SAND: Fine graine	•	51113.	D		3 2 9		COLLUVIUM
		None Observed			0. <u>5</u> 		SM	Silty SAND: Fine grained	edium grained, pa sticity clay fines.	– – – –	M	-			Thin root system throughout
Method N X BH R E	natur existi backi	ng ex noe bi ozer b r	osure cavation ucket Ilade	S pe 1 ₩ ₩ ₩	ater water l	n no resista anging to efusal evel e showr nflow	•			W w Wp pl	n unified	classifica		_	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

TESTPIT GEOTKARI02083AA.GPJ COFFEY.GDT 13.2.08

coffey > geo	technics
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Engineering Log - Excavation

Crighton Properties Pty Ltd

Client:

Principal:

Proposed Subdivision

29.11.2007 Date completed: logged by: RS

Excavation No.

Sheet

Project No:

Date started:

TP014

29.11.2007

GEOTKARI02083AA

1 of 1

Project:		Prop	oos	ed Sı	ıbdi	visio	n			L	oggec	l by:		BS	
Test pit loca	ation:	Refe	er to	o Figu	ıre					(Checke	ed by	:	RMT	
equipment typ	pe anc	l model:	Kubot	a 4t			Pit Orientation:	Easting:	m				R.L	. Surface:	Not Measured
excavation di			2m lo	ng 0.6	6m wid			Northing:	m				datu	um:	AHD
excavatio	n info	ormation			mat		ubstance								
method 5 5 penetration	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	materia soil type: plasticity or parti colour, secondary and m	cle characteristics, inor components.		moisture condition	consistency/ density index	100 A pocket	a	additi	structure and onal observations
	None Observed			0.5 		СН	Some fine to coarse grained, dar Some fine to coarse grained u sandstone from 0.5 - 0.8m. CLAY: Medium to high plastic mottling, some fine to medium ironstone gravel. Silty CLAY: High plasticity, pa red-orange mottling. Test pit TP014 terminated at 1	to cobble size ity, orange and red grained angular		D <wp< td=""><td>VSt/H</td><td></td><td>* * *</td><td>Fine to coa from 1.7m</td><td>/stem throughout</td></wp<>	VSt/H		* * *	Fine to coa from 1.7m	/stem throughout
Sketch				2.5											

- [method		support	notes,	samples, tests	clas	sification symbols and	consister	ncy/density index
- 1	N	natural exposure	S shoring N nil	U ₅₀	undisturbed sample 50mm diameter	soil	description	VS	very soft
- 1	Х	existing excavation		U ₆₃	undisturbed sample 63mm diameter	base	ed on unified classification	S	soft
2	BH	backhoe bucket	penetration	D	disturbed sample	syst	em	F	firm
3 Rev	В	bulldozer blade	1234	V	vane shear (kPa)			St	stiff
Э	R	ripper	no resistance ranging to	Bs	bulk sample	moi	sture	VSt	very stiff
ne	E	excavator	refusal	E	environmental sample	D	dry	н	hard
5.2 Issue			water	R	refusal	М	moist	Fb	friable
5.2			 water level 			W	wet	VL	very loose
Ö			on date shown			Wp	plastic limit	L	loose
GEO						WL	liquid limit	MD	medium dense
			water inflow					D	dense
Form			- water outflow					VD	very dense

С	C)f	f	ev	9	ç	geo	ote	chnics			F	Excava	ition N		TP015	
				-					cavation				Sheet			of 1	
	<u> </u>	,,,,			_	-						F	Project	No:		GEOTKARI02083	BAA
Clie	nt:			Crig	ghto	n Pro	operi	ties F	Pty Ltd			[Date st	arted	:	29.11.2007	
Prin	cipa	l:										[Date co	omple	ted:	29.11.2007	
Proj	ect:			Pro	pos	ed Si	ubdi	visio	n			L	oggeo	l by:		BS	
Tes	t pit l	oca	tion:	Ref	er to	o Figi	ure					(Checke	ed by:		RMT	
equi	omen	t typ	e and	d model:	Kubot	ta 4t			Pit Orientation:	Easting:	m			ŀ	R.L. S	Surface: Not Measured	
	vatio				2m lo	ng 0.	6m wid			Northing:	m			(datum	n: AHD	
exc		tion	info	ormation			mat		ubstance					4			
method	penetration	support	water	notes samples, tests, etc		depth		classification symbol	material soil type: plasticity or particl			moisture condition	consistency/ density index	A penetro-	a	structure and additional observations	5
Е Ш	123	אן א	Š		RL	metres	ъ.	ප් ගි SM	colour, secondary and mir Silty SAND: Fine to grained, da	•		E 8 D	88	30 50 <u>1</u> 0 30 50 10		COLLUVIUM	
						-		Sivi	Sity SAND. Fille to grained, da	in biown.		D					-
						- - 0. <u>5</u> -		SM	Silty SAND: Fine to medium grasome low plasticity clay fines.	ained, pale brow		Μ					
						-		SC	Clayey SAND: Fine to medium	grained, orange	,	М			C		
			p			1.0	/		low to medium plastic fines.								_
			None Observed			-											_
			e Ob			-											-
			Non														_
						1. <u>5</u>			Red colour rising from about 1.5 Grading into	im							
								CL	Sandy CLAY: Low to medium p	lasticity, orange		>Wp	St/Vst		R		
									and red, fine to medium grained	sand.				×			_
																	-
						2.0											
														× ×			_
						-											-
						2.5											_
SI	ketch	<u>ו</u>							Test pit TP015 terminated at 2.5	im							
met N X BH	hod	exist	ing ex	posure ccavation bucket	s	shoring		nil	notes, samples, tests U ₅₀ undisturbed sample 50m U ₆₃ undisturbed sample 63m D disturbed sample	m diameter sim diameter bi	oil desc	ription	mbols a			consistency/density index VS very soft S soft F firm	
вп В R			ozer	blade			no resista		V vane shear (kPa) Bs bulk sample		noisture				\dashv	F IIIII St stiff VSt very stiff	
E			vator			ater	ranging to refusal	0	E environmental sample R refusal	D	dry					H hard Fb friable	
						water	level te showr	h	iorudai	V	V we		ł			VL very loose L loose	
						 on dat water 		1		N N		uid limit	L			L IOOSE MD medium dense D dense	
							outflow									VD very dense	

TESTPIT GEOTKARI02083AA.GPJ COFFEY.GDT 13.2.08

(: C	f	f	ev	9	ę	je	ote	echnics			-			<u> </u>			
				-									Excavat	tion	No		TP016	
E	ng	in	10	ering	g I	- 0ć	J -	Ex	cavation				Sheet Project	No:		1 (of 1 GEOTK	ARI02083AA
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TESTPIT GEOTKARI02083AA.GPJ COFFEY.GDT 13.2.08

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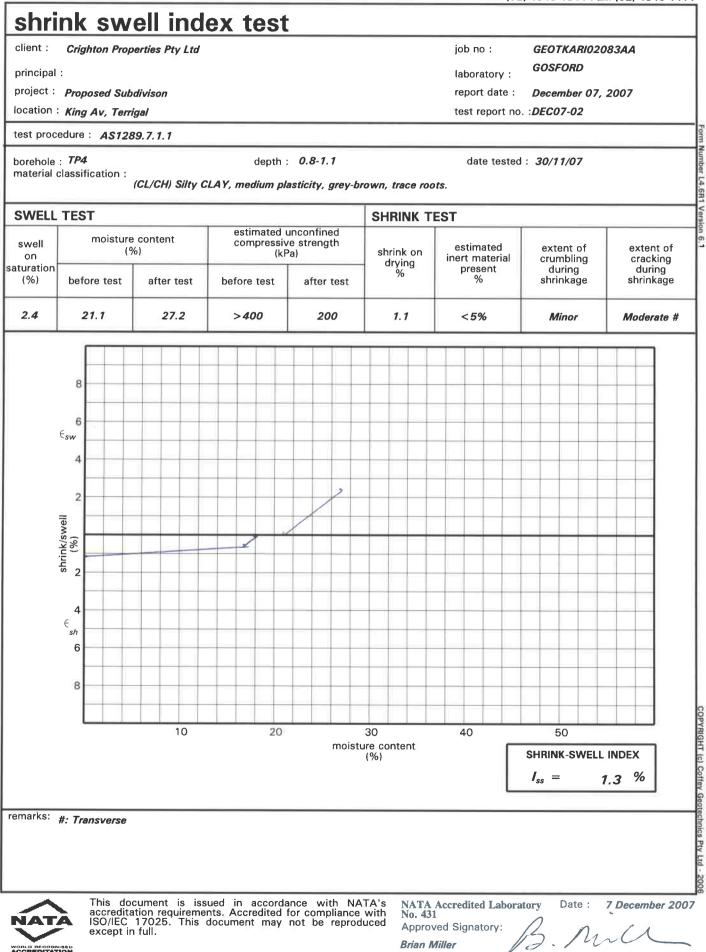
Appendix B

Laboratory Results



DEC07-2

Unit 17 Mt Penang Parklands, Kariong NSW 2250 Ph: (02) 4340 1811 Fax: (02) 4340 1411

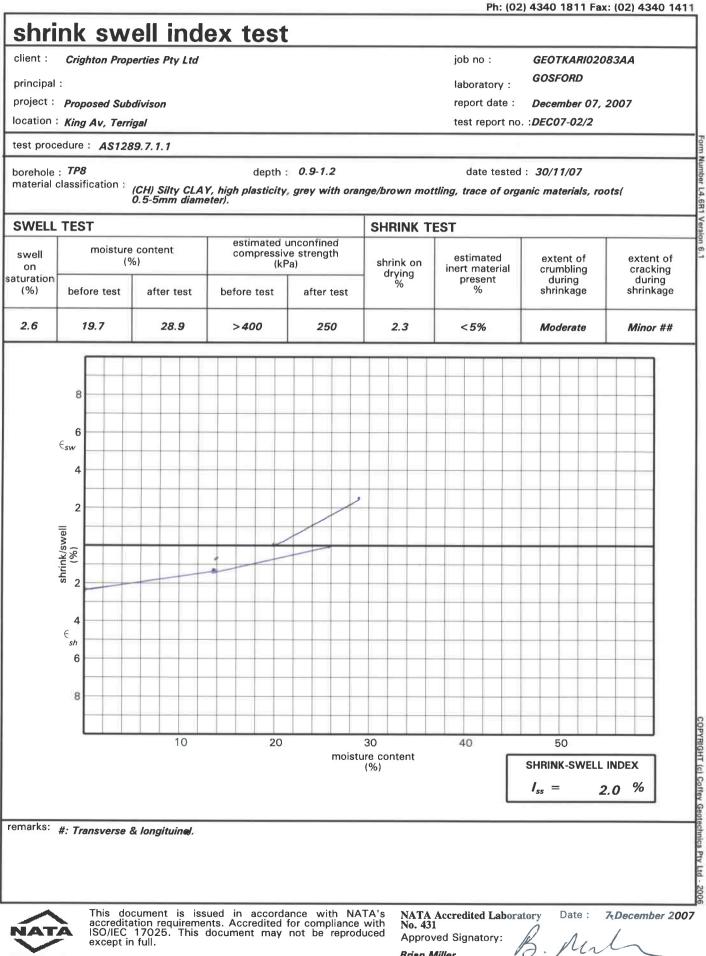


ECOQNISED

Brian Miller



Unit 17 Mt Penang Parklands, Kariong NSW 2250



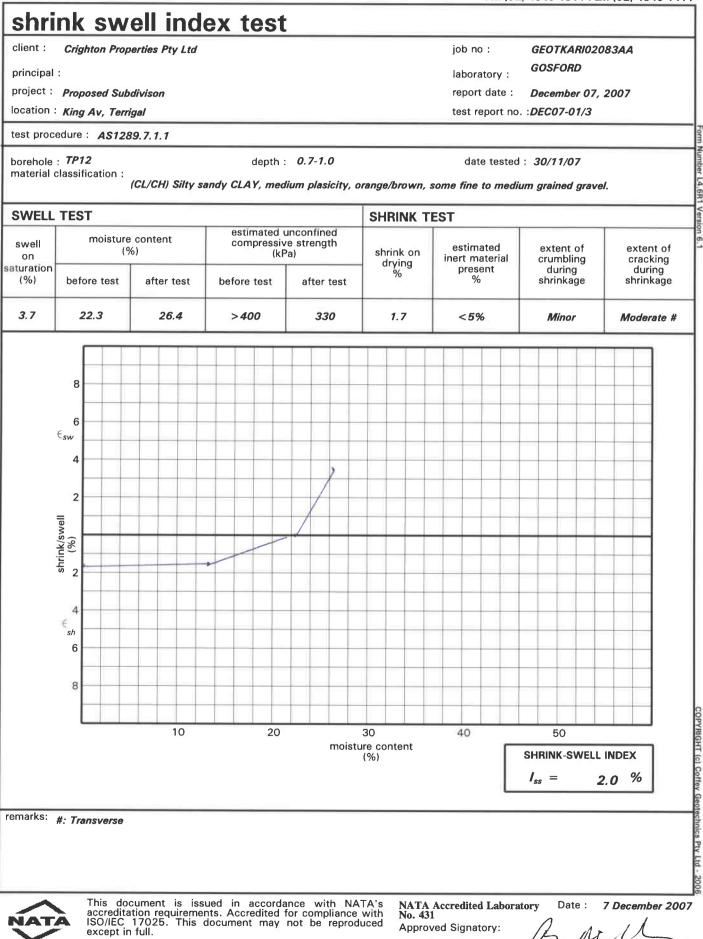
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Brian Miller



DEC07-01

Unit 17 Mt Penang Parklands, Kariong NSW 2250 Ph: (02) 4340 1811 Fax: (02) 4340 1411



ACCREDITATION

Brian Miller

B. pull

Appendix C

Copy of reports GO540/1-AB and GO652/1-AB

CRIGHTON PROPERTIES PTY LTD

PROPOSED SUBDIVISION LOT 22 KARALTA ROAD, PART PORTION 104 TERRIGAL GEOTECHNICAL ASSESSMENT

REPORT NO.GO540/1-AB MARCH, 1992

and the constraints

COFFEY

Coffey Partners International Pty Ltd

Consulting Engineers in the Geotechnical Sciences

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Consulting Engineers in the geotechnical sciences

> 42 Hills Street Gosford New South Wales Australia 2250

Fax (043) 23 6477 Telephone (043) 23 3585

Your Reference

Our Reference GO540/1-AB MGD:SG Date 13th March, 1992

> The Manager Crighton Properties Pty Ltd 28 Dalgetty Crescent GREEN POINT NSW 2251

ATTENTION: MR GEOFFERY COX

Dear Sir

RE: Proposed Subdivision, Lot 22 Karalta Road, Terrigal

We are pleased to submit our report on geotechnical studies carried out for the above proposed subdivision.

The site is assessed to have a Moderate Risk of overall slope instability and is unlikely to be affected by landslip provided development is carried out in accordance with the recommendations of this report. Geotechnical constraints on residential development have been outlined in Section 4.2 and are not considered to be of an unusual nature.

Please do not hesitate to contact the undersigned if you have any queries regarding this report.

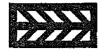
For and on behalf of COFFEY PARTNERS INTERNATIONAL PTY LTD

R J KING

Soil and rock engineering Environmental technology Engineering geology Groundwater hydrology Foundation engineering Mining geotechnics Dam engineering Computer applications



Offices and NATA Registered Laboratories Adelaide Albury-Wodonga Alstanvillo Brisbane Carberra Darwin Gosford Logan City Melboure Newcasile Pentith Perih Sydney Townsville Wollongong Burma, Thailand, Malaysia



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2.

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2.0	FIELDWORK	3
3.0	SITE DESCRIPTION	3
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Important Information About Your Geotechnical Engineering Report TABLE 1 - Classification of Risk of Slope Instability TABLE 2 - Some Guidelines for Hillside Development APPENDIX A Results of Field Investigations DRAWING NO. G0540/1-1 Site Plan G0540/1-AB 13th March, 1992



1.0 INTRODUCTION

This report presents an assessment of slope stability carried out for Crighton Properties Pty Ltd on Lot 22 (Part Portion 104) Karalta Road, Terrigal. The work was commissioned by Mr Geoffery Cox of Crighton Properties Pty Ltd. A 1:900 scale contour plan of the lot was provided by Cahill & Cameron Pty Ltd.

3.

It is understood that development plans have not been finalised for the site. However, it is understood to be likely that development will include residential allotments on moderately steep portions of the site, several large lakes with adjacent residential construction in low lying generally flat portions of the site and possibly terraced/split level units on the steeper portions of the site. It is also understood that roads are to be aligned generally across hillslopes on the steeper areas of the site.

This report assesses the suitability of the lot for development from a geotechnical viewpoint, provides a risk assessment in relation to slope stability and provides geotechnical constraints for development.

2.0 FIELDWORK

Field work initially involved a walk-over survey/site appraisal by a Senior Engineering Geologist on the 26th February, 1992, in which surface features were mapped. Utilising this information a program of test pitting was carried out on the 3rd March, 1992 by a Geotechnical Engineer to assess subsurface profiles.

Eleven test pits (TP1 to TP11) were excavated to depths ranging from 1.5m to 3.4m by a rubber tyred backhoe. The approximate location of the test pits is shown on Drawing No.GO540/1-1, together with the results of surface mapping. Test pit levels have been interpolated from the contour plan (A.H.D.).

Engineering Logs of the test pits are presented in Appendix A, together with explanation sheets defining the terms and symbols used.

Groundwater conditions were noted at the time of field work in test pits which were open only for a short time. Variations may occur due to fluctuations in rainfall, temperature and other factors.

3.0 SITE DESCRIPTION

3.1 Topography, Drainage & Vegetation

Topographically, the lot is situated in an area of moderate to steeply undulating terrain on the north-eastern end of a prominent south-west trending ridgeline. A secondary rounded spur/ridgeline forms the eastern site boundary. GO540/1-AB 13th March, 1992

Valley formation along two incised gullies has resulted in the existing site landform. Two prominent gullies originate at the upper slopes of the above ridgeline and fall to the north/north-east to join in the central part of the site. The combined watercourse discharges to the north of the site, into a broad flat watercourse that drains to the east towards Duffy's Road.

4.

Valley side slopes across the site are convex in profile with surface slopes generally 10° over the upper slopes increasing up to 15° over the lower slopes. Surface slopes of 5° to 9° occur along the crest and upper slopes of the ridgeline that trends along the eastern lot boundary. The base of the above valley side slopes are characterised by;

- * Flat alluvial areas of surface slope less than 3° adjacent to the watercourses across the central to northern part of the site. The transition from the valley side slopes to the flat alluvial areas is marked by a sharp concave slope break, or
- Steep gully side slopes ranging from 25° to 35°. The gullies are V-shaped in profile and are incised up to an estimated 5m to 6m in depth.

The site has been undersrcubbed with vegetation currently comprising mainly grasses with a sparse to moderate cover of mature eucalypts. The gullies and gully sides are generally covered with thick vegetation which includes palms and lantana.

Existing development on the site comprises a transmission easement along the eastern boundary and two small "farm" dams at the confluence of the two watercourses. The dams have been breached during recent heavy rain, most likely the result of piping at the contact between earth embankment and 600mm diameter concrete overflow pipes. A unformed section of Karalta Road runs along the northern site boundary.

3.2 Geology & Subsurface Conditions

Geologically, the site is situated in the Triassic Age Gosford Formation which is characterised by sandstone (often lithic) and siltstone rock types.

On the basis of surface features and subsurface conditions encountered in the test pits, the site can be divided into two units, namely

- * UNIT A comprising predominately residual soils overlying sandstone/siltstone rock at about 1m to 1.5m depth,
- * UNIT B comprising deep alluvial soils up to or greater than 3.5m in depth.

GO540/1-AB 13th March, 1992





The approximate extent of the above units is shown on Drawing No.GO540/1-1.

The subsurface profile encountered within Unit A (Test Pits 1, 2, 3, 5, 6, 7 and 11) can be summarised as follows;

- * TOPSOIL: Comprising Silty SAND to depths ranging from 0.25m to 0.5m; fine to coarse grained, with some gravel, moist, overlying
- * SLOPEWASH: Where encountered, comprising Gravelly Sandy CLAY of low plasticity and Gravelly Clayey SAND to depths generally of 0.5m and locally up to 0.9m, moist, overlying
- * RESIDUAL: Comprising CLAY, Sandy CLAY and Gravelly Sandy CLAY to depths ranging from 1.1m to 2.0m, medium to high plasticity, with some sandstone rock fragments, estimated very stiff to hard consistency, overlying
- * ROCK: Comprising SANDSTONE and SILTSTONE, extremely to highly weathered. Backhoe refusal on sandstone was encountered in Test Pits 1,5,6,7 and 11 at depths ranging from 1.5m to 2.8m.

The subsurface profile encountered within Unit B (Test Pits 4,8,9 and 10) can be summarised as follows;

* ALLUVIUM: Comprising interbedded Silty Clayey SAND, Clayey SAND and Sandy CLAY to depths up to or greater than 3.4m; sand mostly fine grained, clays are of low to medium plasticity, moist; overlying topsoil appears to be up to 0.5m thick.

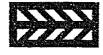
Fill, probably from underscrubbing operations and comprising Gravelly Silty SAND mixed with timber and charcoal, was encountered at the crest of steep gully banks in Test Pits 4 and 9 to depths of 0.6m and 0.4m respectively.

Minor groundwater seepage/inflows was only encountered in Test Pit 10 at about 1.0m depth.

4.0 SLOPE STABILITY ASSESSMENT

4.1 Risk Assessment

No evidence of overall slope instability was observed during the walk-over survey and backhoe test pitting. Minor localised instability was noted along some very steep gully banks where small scale slumping and erosion has occurred. GO540/1-AB 13th March, 1992



On the basis of the features of geology, topography and drainage presented in Section 3.0, the site is assessed as having a Moderate Risk of overall slope instability as defined in the attached Table 1. The risk of localised instability associated with future cuts and fills is assessed as moderate and can be limited by adopting the recommendations of this report.

6.

4.2 Geotechnical Constraints on Development

4.2.1 Area for Development

From a slope stability viewpoint, the entire site is considered suitable for development undertaken in accordance with good hillside construction practices and sound engineering principles as outlined in the attached Table 2.

There should be specific geotechnical investigation to assess local stability and foundation parameters for any proposed development along or adjacent to the steep to very steep gully banks. It is recommended that this constraint apply to the area situated within a line that projects upwards at 2H:1V (26.5°) from the toe of gully banks.

4.2.2 Type of Structure

Flexible structures of timber, brick veneer or similar construction would be preferred on the Unit A hillslopes. Development should be designed to accommodate.natural slope profiles with split level or suspended designs so as to limit the need for slope modification.

There are no particular geotechnical constraints on the type of structures within the flat Unit B alluvial areas or for structures founded on rock on the Unit A hillslopes provided they are supported on footings designed and constructed in accordance with AS2870 "Residential Slabs and Footings".

4.2.3 Foundation Types

Foundations should be designed and constructed in accordance with the recommendations and advice of AS2870 "Residential Slabs and Footings".

Pad/strip or pier and beam footing systems are considered appropriate for split level structures on Unit A moderate to steep hillslopes. Stiffened raft or piered slab footing systems may also be adopted provided the resulting slope modifications comply with the geotechnical constraints set out below. It is recommended that foundations for structures on slopes in excess of 4H;¹V (14°) be taken to rock.



Strip/pad, stiffened raft or piered footing systems would be appropriate for residential structures located within the flat Unit B alluvial areas. Further geotechnical work will be required to assess foundation parameters within Unit B areas for structures other than conventional one or two storey residences and for structures located adjacent to steep gully banks (Refer to 4.2.1).

7.

4.2.4 Excavation

Within Unit B areas and Unit A areas with hillslopes less than 4H:1V (14°) excavations should preferably not exceed 1.5m depth and should be either supported by a properly designed and constructed retaining wall or battered no steeper than 2H:1V and protected from erosion. Within Unit A areas with hillslopes greater than 4H:1V (14°) excavations should preferably not exceed 1m depth.

Excavations exceeding the above recommended depths should be supported by engineer designed retaining walls or battered as directed after assessment by a qualified geotechnical engineer.

4.2.5 Filling

The maximum depth of fill on residential lots should preferably be limited to 1.5m and should be either supported by a properly designed and constructed retaining wall or battered no steeper than 2H:1V and protected from erosion.

Engineering supervision and testing will be required where fill is to be regarded as "controlled fill" in accordance with AS2870 "Residential Slabs and Footings". Allowance should be made for an average 0.5m depth of stripping within the flat Unit B alluvial areas and for a 0.2m to 0.4m depth of stripping within Unit A hillslope areas. A prepared surface will need to be benched/stepped into the natural slope when placing fills on slopes exceeding 4H:IV (14°). Fill should be placed in layers having a maximum loose thickness of 200mm to 300mm depending on the type of fill and compaction equipment. Each fill layer should be thoroughly and uniformly compacted to a minimum dry density ratio (AS1289 5.4.1-1982) of 95% Standard within 2% of Standard Optimum moisture content. Further advice should be sought if deep gully areas are to be infilled as higher compaction standards may be warranted.

Residual clay soils and weathered rock excavated during road construction would be suitable for use as fill on residential lots if placed at a moisture content within 2% of Standard Optimum. However, consideration should be given to the reactivity of clay fills in relation to potential shrink-swell movements. Further investigation and advice will be required to enable comment on the suitability of the above materials for use in water retaining embankments. As a guideline, such materials should have at least 30% passing the 75 micron sieve, a Plasticity Index not less than 15% and should be non-dispersive (Emerson Class 3 or better).



4.2.6 Retaining Walls

Retaining walls should be designed for surcharge loading from sloping ground and/or structures above the wall. Adequate subsurface and surface drainage must be provided behind all retaining walls. Retaining walls in excess of 1.5m in height should be designed by an engineer.

8.

4.2.7 Access/Site Clearance

The subdivision layout should be such that all residential lots have potential driveway access at a grade of 4H:1V or less. Any required slope modifications should comply with the above recommendations.

4.2.8 Drainage & Sewerage Disposal

Stormwater should be prevented from ponding adjacent to structures. All collected stormwater runoff should be piped into a street or inter-allotment drainage system that discharges into existing watercourses in a controlled manner that limits erosion.

Domestic effluent should be connected to a reticulated sewerage system or to a pump-out septic system. There should be no on-site disposal of domestic effluent.

For and on behalf of COFFEY PARTNERS INTERNATIONAL PTY LTD

IMPORTANT INFORMATION ABOUT YOUR GEOTECHNICAL ENGINEERING REPORT

More construction problems are caused by site subsurface conditions than any other factor. As troublesome as subsurface problems can be, their frequency and extent have been lessened considerably in recent years, due in large measure to programs and publications of ASFE/ The Association of Engineering Firms Practicing in the Geosciences.

The following suggestions and observations are offered to help you reduce the geotechnical-related delays, cost-overruns and other costly headaches that can occur during a construction project.

A GEOTECHNICAL ENGINEERING REPORT IS BASED ON A UNIQUE SET OF PROJECT-SPECIFIC FACTORS

A geotechnical engineering report is based on a subsurface exploration plan designed to incorporate a unique set of project-specific factors. These typically include: the general nature of the structure involved, its size and configuration: the location of the structure on the site and its orientation; physical concomitants such as access roads, parking lots, and underground utilities, and the level of additional risk which the dient assumed by virtue of limitations imposed upon the exploratory program. To help avoid costly problems, consult the geotechnical engineer to determine how any factors which change subsequent to the date of the report may affect its recommendations.

Unless your consulting geotechnical engineer indicates otherwise, your geotechnical engineering report should not be used:

- When the nature of the proposed structure is changed, for example, if an office building will be erected instead of a parking garage, or if a refrigerated warehouse will be built instead of an unrefrigerated one;
- when the size or configuration of the proposed structure is altered;
- when the location or orientation of the proposed structure is modified;
- when there is a change of ownership, or
- for application to an adjacent site.

Geotechnical engineers cannot accept responsibility for problems which may develop if they are not consulted after factors considered in their report's development have changed.

MOST GEOTECHNICAL "FINDINGS" ARE PROFESSIONAL ESTIMATES

Site exploration identifies actual subsurface conditions only at those points where samples are taken, when they are taken. Data derived through sampling and subsequent laboratory testing are extrapolated by geo-

technical engineers who then render an opinion about overall subsurface conditions, their likely reaction to proposed construction activity, and appropriate foundation design. Even under optimal circumstances actual conditions may differ from those inferred to exist. because no geotechnical engineer, no matter how qualified, and no subsurface exploration program, no matter how comprehensive, can reveal what is hidden by earth, rock and time. The actual interface between materials may be far more gradual or abrupt than a report indicates. Actual conditions in areas not sampled may differ from predictions. Nothing can be done to prevent the ununticipated, but steps can be taken to help minimize their impact. For this reason, most experienced owners retain their geotechnical consultants through the construction stage, to identify variances, conduct additional tests which may be needed, and to recommend solutions to problems encountered on site.

SUBSURFACE CONDITIONS CAN CHANGE

Subsurface conditions may be modified by constantlychanging natural forces. Because a geotechnical engineering report is based on conditions which existed at the time of subsurface exploration. *construction decisions should not be based on a geotechnical engineering report whose adequacy may have been affected by time.* Speak with the geotechnical consultant to learn if additional tests are advisable before construction starts.

Construction operations at or adjacent to the site and natural events such as floods, earthquakes or groundwater fluctuations may also affect subsurface conditions and, thus, the continuing adequacy of a geotechnical report. The geotechnical engineer should be kept apprised of any such events, and should be consulted to determine if additional tests are necessary.

GEOTECHNICAL SERVICES ARE PERFORMED FOR SPECIFIC PURPOSES AND PERSONS

Geotechnical engineers' reports are prepared to meet the specific needs of specific individuals. A report prepared for a consulting civil engineer may not be adequate for a construction contractor, or even some other consulting civil engineer. Unless indicated otherwise, this report was prepared expressly for the client involved and expressly for purposes indicated by the client. Use by any other persons for any purpose, or by the client for a different purpose, may result in problems. No individual other than the client should apply this report for its intended purpose without first conferring with the geotechnical engineer. No person should apply this report for any purpose other than that originally contemplated without first conferring with the geotechnical engineer.

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A GEOTECHNICAL ENGINEERING REPORT IS SUBJECT TO MISINTERPRETATION

Costly problems can occur when other design professionals develop their plans based on misinterpretations of a geotechnical engineering report. To help avoid these problems, the geotechnical engineer should be retained to work with other appropriate design professionals to explain relevant geotechnical findings and to review the adequacy of their plans and specifications relative to geotechnical issues.

BORING LOGS SHOULD NOT BE SEPARATED FROM THE ENGINEERING REPORT *

Final boring logs are developed by geotechnical engineers based upon their interpretation of field logs (assembled by site personnel) and laboratory evaluation of field samples. Only final boring logs customarily are included in geotechnical engineering reports. *These logs should not under any circumstances be redrawn* for inclusion in architectural or other design drawings, because drafters may commit errors or omissions in the transfer process. Although photographic reproduction eliminates this problem, it does nothing to minimize the possibility of contractors misinterpreting the logs during bid preparation. When this occurs, delays, disputes and unanticipated costs are the all-too-frequent result.

To minimize the likelihood of boring log misinterpretation, give contractors ready access to the complete geotechnical engineering report prepared or authorized for their use. Those who do not provide such access may proceed un-

* 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. der the *mistaken* impression that simply disclaiming responsibility for the accuracy of subsurface information always insulates them from attendant liability. Providing the best available information to contractors helps prevent costly construction problems and the adversarial attitudes which aggravate them to disproportionate scale.

READ RESPONSIBILITY CLAUSES CLOSELY

Because geotechnical engineering is based extensively on judgment and opinion, it is far less exact than other design disciplines. This situation has resulted in wholly unwarranted claims being lodged against geotechnical consultants. To help prevent this problem, geotechnical engineers have developed model clauses for use in written transmittals. These are not exculpatory clauses designed to foist geotechnical engineers' liabilities onto someone else. Rather, they are definitive clauses which identify where geotechnical engineers' responsibilities begin and end. Their use helps all parties involved recognize their individual responsibilities and take appropriate action. Some of these definitive dauses are likely to appear in your geotechnical engineering report, and you are encouraged to read them closely. Your geotechnical engineer will be pleased to give full and frank answers to your questions.

OTHER STEPS YOU CAN TAKE TO REDUCE RISK

Your consulting geotechnical engineer will be pleased to discuss other techniques which can be employed to mitigate risk. In addition, ASFE has developed a variety of materials which may be beneficial. Contact ASFE for a complimentary copy of its publications directory.

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TABLE 1. CLASSIFICATION OF RISK OF SLOPE INSTABILITY

ASSESSMENT OF RISK

A landslip (or landslide) is a downslope movement of a soil or rock mass as a result of shear failure at the boundaries of the moving mass. The dominant movement is lateral and failure takes place over a relatively short period. Soil creep, which is slow and occurs without a well defined failure surface, is not included as a landslip.

Natural hill slopes are formed by processes which reflect the site geology, environment and climate. These processes include downslope movement of the near surface soil and rocks; in geological time all slopes are unstable. The area of influence of these downslope movements may range from local to regional and are rarely related to property boundaries. The natural processes may be affected by human intervention in the form of construction and related activities.

It is not technically feasible to assess the stability of a particular site in absolute terms such as stable or unstable. However the degree of risk of slope movement can be assessed by the recognition of surface features supplemented by limited information on the regional and local subsurface profile and with the benefit of experience gained in similar geological environments. The degree of risk is categorised below.

CLASSIFICATION OF RISK OF LANDSLIP WITHOUT DEVELOPMENT

CLASS	EXPLANATION
LOW	A landslip is very unlikely
MODERATE	A landslip is unlikely
HIGH	There is some risk of a landslip

CONSEQUENCES OF HILLSIDE CONSTRUCTION

It must be accepted that the risks associated with hillside construction are greater than construction on level ground in the same geological environment. The impact of development may be adverse and imprudent construction techniques can increase the potential for movement.

Australian Standard AS 2870 - 1986 provides a damage classification that relates to essentially vertical movements of masonry walls and is thus not directly applicable to hillside movements. In the absence of a suitable classification for hillside movements the range of damage categories from negligible to very severe can be used as a general guide for damage potential related solely to landslip.

CLASS	DEVELOPMENT CONSTRAINTS	DAMAGE P EXTENT	OTENTIAL PROBABILITY
LOW	Good Hillside Practice	Slight	Very Low
MODERATE	Good Hillside Practice and site specific restrictions	Slight Moderate	Low Very Low
HIGH	No development unless major engineering remedial works	Moderate Severe	High Moderate

Damage to structures may occur due to a number of causes additional to that attributable to landslip. In the absence of a landslip slight damage might be expected even for good construction. If a landslip occurs damage would probably reach at least a moderate level.

GCOD ENGINEERING PRACTICE

	GCOD ENGINEERING PRACTICE	
ADVICE		
GEOTECHNICAL ASSESSMENT	Obtain advice from a qualified, experienced geotechnical consultant at early stage of planning and before site works.	Prepare detailed plan and start site works before geotechnical advice.
PLANNING		
SITE PLANNING	Having obtained geotechnical advice, plan the development with the Risk of Instability and Implications for Development in mind.	Plan development without regard for the Risk of Instability.
DESIGN AND CONSTRU	ICTION	
HOUSE DESIGN	Use flexible structures which incorporate properly designed brickwork, timber or steel frames, timber or panel cladding. Consider use of split levels. Use decks for recreational areas where appropriate.	Floor plans which require extensive cutting and filling. Movement intolerant structures.
SITE CLEARING	Retain natural vegetation wherever practicable.	Indiscriminately clear the site.
ACCESS & DRIVEWAYS	Satisfy requirements below for cuts, fills, retaining walls and drainage. Council specifications for grades may need to be modified. Driveways and parking areas may need to be fully supported on piers.	Excavate and fill for site access before geotechnical advice.
EARTHWORKS	Retain natural contours wherever possible.	
CUTS	Minimise depth. Support with engineered retaining walls or batter to appropriate slope. Provide drainage measures and erosion control.	Large scale cuts and benching, Unsupported cuts. Ignore drainage requirements.
FILLS	Minimise height. Strip vegetation and topsoil and key into natural slopes prior to filling. Use and compact clean fill materials. Batter to appropriate slope or support with engineered retaining wall. Provide surface drainage and appropriate subsurface drainage.	Loose or poorly compacted fill. Block natural drainage lines. Fill over existing vegetation and topsoil. Include stumps, tress, vegetation, top- soil, boulders, building rubble atc in fill.
	Remove or stabilise boulders which may become unstable. Support rock faces where necessary.	Disturb or undercut detached blocks or boulders.
RETAINING WALLS	Engineer design to resist applied soil and water forces. Found on rock where practicable. Provide subsurface drainage within wall backfill and surface drainage on slope above. Construct wall as soon as possible after cut/fill operation.	Construct a structurally inadequate wall such as sandatone flagging, brick or unreinforced blockwork. Lack of subsurface drains and weepholes.
FOUNDATIONS	Support on or within rock where practicable. Use rows of piers or strip foundations oriented up and down slope. Design for lateral creep pressures. Backfill foundation excavations to exclude ingress of surface water.	Found on topsoil, loose fill, detached boulders or undercut cliffs.
SWIMMING POOLS	Engineer designed. Support on piers to rock where practicable. Provide with under-drainage and gravity drain outlet where practicable. Design for high soil pressures which may develop on uphill side whilst there may be little or no lateral support on downhill side.	
DRAINAGE		
SURFACE	Provide at tops of cut and fill slopes. Discharge to street dramage or natural water courses. Provide generous falls to prevent blockage by siltation and incorporate silt traps. Line to minimize infiltration and make flexible where possible. Special structures to disipate energy at changes of slope and/or direction.	Discharge at top of fills and cuts. Allow water to pond on bench areas.
SUBSURFACE	Provide filter around subsurface drain. Provide drain behind retaining walls. Use flexible pipelines with access for maintenance. Prevent inflow of surface water.	
	Usually requires pump-out or mains sewer systems; absorption trenches may be possible in some low risk areas. Storage tanks should be water-light and adequately founded.	Discharge sullage directly onto and into slopes.
EROSION CONTROL & LANDSCAPING	Control erosion as this may lead to instability. Revegetate cleared orea.	Fallure to observe earthworks and drain- age recommendations when landscaping.
DRAWINGS AND SITE VI	SITS DURING CONSTRUCTION	
DRAWINGS	Building Application drawings should be viewed by geotechnical consultant.	
SITE VISITS	Site Visits by consultant may be appropriate during construction.	
NSPECTION AND MAIN	TENANCE BY OWNER	
OWNER'S	Clean drainage systems: repair broken joints in drains and	

This table is an extract from GEOTECP-NICAL RUSKS ASSOCIATED WITH MILLSIDE DEVELOPMENT as presented in Australian Geomechanics News, Number 10, 1985 which discusses the matter more fully.

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APPENDIX A results of field investigation

descriptive terms soil and rock

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Explanation
• Sheet 1

No. 1 Table C	n of Material bas	ed on Unified Class	ification System	i (refer SAA Site In	vestigation Code	A\$1726-197	5 Add.
Moisture Co	ndition based on a	opearance of soil					
moist		ened in colour; co	hesive soils usu	dery or friable, gran ally weakened by m			
	Soil feels cool, dark lands when remoul		hesive soils wea	kened, granular soil	s tend to cohere,	free water col	lects on
Consistency	based on unconfine	d compressive stre	ength (Qu) (gene	erally estimated or r	neasured by hand	j penetrometer	·).
term Qu kPa	ver	y soft soft 25	firm 50 100	stiff very stif	f hard		
lf soil crun	ables on test without	ıt meaningful resul	t, it is described	as friable.			
Density Inde	×	(generally estin	nated or based o	on penetrometer res	ults).		
term	very J	oose loose	medium	dense de	nse very de	nse	
density in	dex D %	15	35	65	85		
ROCK DESCRIPT	IONS						
Weathering b	ased on visual asses	sment					
term		criterion					
Fresh:		Rock subst	ance unaffected	by weathering.			
Slightly We	athered :	discolourat and texture	ion of the rock	y weathering to the substance usually b ck is recognisable;	y limonite has ta	ken place. The	e colour
Moderately	Weathered:			y weathering to the e and the original c			
Highly Wea	thered :	affects the of individu decreased v or depositio	whole of the ro al minerals are u vhen compared	y weathering to the ck substance and sig sually evident. Por to the fresh rock su colour and strength	ins of chemical o osity and strengt bstance, usually :	r physical deco h may be incre as a result of th	exposition ased or ne leaching
Extremely	Weathered:	i.e. it can b	e remoulded an	vweathering to the d can be classified a nal rock is still evid	ccording to the l		
of Laboratory	and Field Tests, Su	ngth index, correct gested Methods fo	ted to 50 mm d or Determining (iameter - Is(50) (rei he Uniaxial Compr ent No. 1), (Genera	ier I.S.R.M., Con essive Strength o	f Rock Materia	ils and the
classificat	ion extrem	ely low very lo	w low	medium	high	very high	extremely hig
ls (50) M	Pa	0.03	0.1	0.3	1	3 1	10
to as high as 30).	gth is typically abo	out 20 x I _S 50 b	ut the multiplier ma	ly range, for diff	erent rock typ	as, from as low a
Defect Spaci	nġ						
classificati	on avtrem	ely close very clo	ose close	medium	wido I	very wide	automake wid
spacing n		0.03	0.1	0.3	wide 3	Very Wide 10	extremely wide
Defect descri seam (etc.) and	ption uses terms of character (roughne	ontained on AS17 ss, extent, coating	26 table D2 to etc.).	describe nature of	defect (fault, jo	int, crushed 2	one, clay

graphic symbols soil and rock



Explanation Sheet 2

SOIL						
	Asphaltic Concrete or Hotmix Concrete Topsoil Fill Peat, Organic Clays and Silts (P Clay (CL, CH) Silt (ML, MH) Sandy Clay (CL, CH) Silty Clay (CL, CH)	Pt, OL, OH)		Gravelly Clay (Cl Sandy Silt (ML) Clayey Sand (SC) Silty Sand (SM) Sand (SP, SW) Clayey Gravel (G Silty Gravel (GM) Gravel (GP, GW)	C)	
ROCK	Claystone (massive) Siltstone (massive) Shale (laminated) Sandstone (undifferentiated) Sandstone, fine grained Sandstone, coarse grained		Limestone Coal Dolerite, Ba Tuff Porphyry Granite	isalt	Schist Gneiss Quartzite Talus Alluvium	
8261 OLI YIA	Conglomerate Seam >0.1 m thick (on a scale 1:50)	+++++	Pegmatite			
COPYRIGHT © COFFEY PARTNERS INTERNATIONAL PT INCTOR	Seam 0.01 m to 0.1 m thick (on a scale 1:50) (Special purposes only) Rock Fragments Swamp			iravel, Laterite ia in Sandstone		
Water L Water L Surfaces	 . ¥ ————————————————————————————————		- Probable B	oundary ~	?? Possible	Boundary

engineering log excavation

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TP1 sheet I of 1

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inethod	2 penetration	lioddus		notes samples, tests,etc.	⊥j deptri Œ metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency. density index	100 - hand 200 - hand 300 - penetro 400 - meter	structure and additional observations
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ļ					- 1			fine, fine to coarse gravel	Wp			One floating bould and some cobbles
					-					VSt/ H		
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engineering log excavation



TEP2 sheet 1 of 1

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engineering log excavation



TP3 sheet lof 1

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	CL/CH	to coarse gravel	M VSt	RESIDUAL
	1 -	plasticity, yellow, some silt /fine sand		Numerous large tre roots
D		CLAY, as above but becoming re brown mottled yellow-white	d-	
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	2	•	Fb	ROCK Extremely to highl, weathered
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key N natural Axposure X existing excavatio BH Backhoe pucket B holkdozer biade B ripper	T :moving N penetration : 2 3	diameter D disturbed sample nging to N standard penetration tests:	classification symbols and soil description based on unified classification system moisture D dry	consisten y/density inde VS very soft S soft F firm St stift VSt very stift H hard Fb friable
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engineering log excavation



TP4

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sheet 1 of 1

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engineering log excavation



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engineering log excavation



1126 sheet 1 of 1

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engineering log excavation



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engineering log excavation



TP8 sheet 1 of 1

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engineering log excavation



TP11 sheet l of l

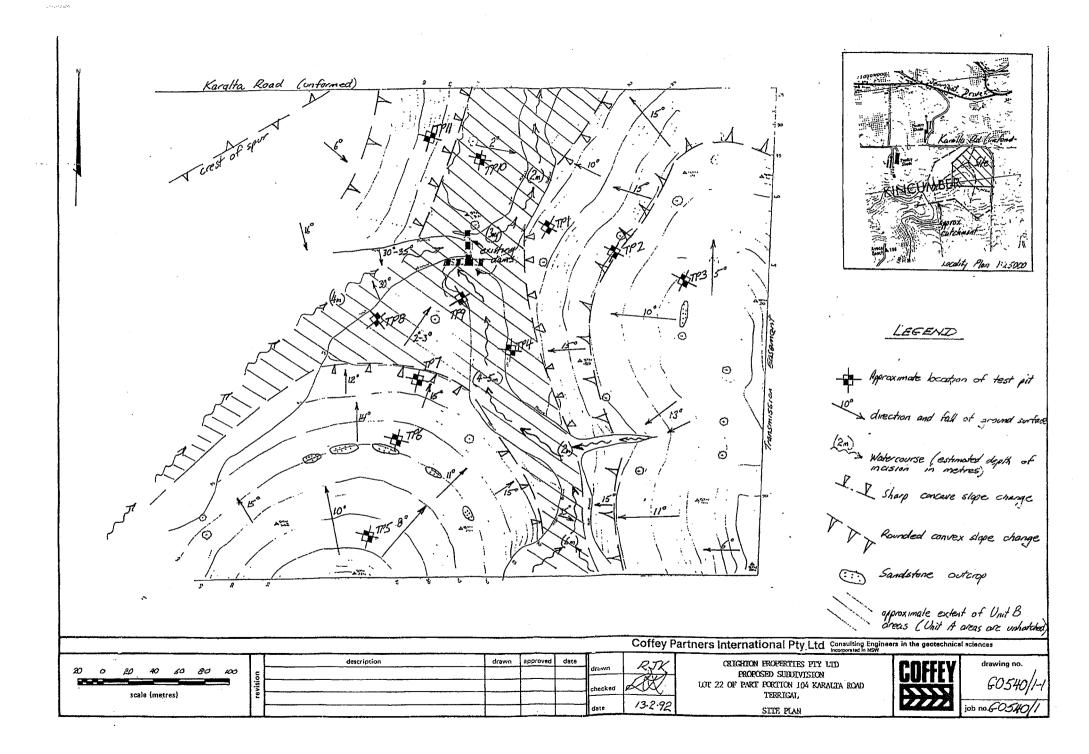
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engineering log excavation



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CRIGHTON PROPERTIES PTY LTD PROPOSED SUBDIVISION LOT 2 BELAR AVENUE, TERRIGAL

STABILITY ASSESSMENT

REPORT NO GO652/1-AB 7 MAY 1993



Consulting Engineers in the Geotechnical Sciences

Coffey Partners International Pty Ltd

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L W Drury, esc. MSc. PhD DipHyo N S Mattes, DAM BE PhD MIEAUS A T Moon, BSc MSc ARSM

Associates J G Lucas, de Mieansi R J Best, de Mengse Mieansi I A Hosking, de Mengengi dic Mieansi



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42 Hills Streat **Gosford New South Wales** Australia 2250

(043) 23 6477 Fax Telephone (043) 23 3585

Your Reference

Our Reference GO652/1-AB Date 6 May 1993

BAS:EB

Coffey Partners International Pty Ltd

The Manager Crighton Properties Pty Ltd 28 Dalgetty Crescent GREEN POINT NSW <u>2251</u>

ATTENTION: MR GEOFFREY COX

Dear Sir

RE: PROPOSED SUBDIVISION - LOT 2 BELAR AVENUE, TERRIGAL

We are please to submit our report on geotechnical studies carried out for the above proposed subdivision.

The site is assessed to have a Medium Risk of overall slope instability and is unlikely to be affected by landslip provided development is carried out in accordance with the recommendations of this report. Geotechnical constraints on residential development have been outlined in Section 4.2.

Please do not hesitate to contact the undersigned should you have any queries regarding this report.

For and on behalf of COFFEY PARTNERS INTERNATIONAL PTY LTD

B A STEPHENS

Soit and rock engineering Environmental technology Engineering geology Groundwater hydrology Foundation engineering Mining geolecthnics Dam engineering



Offices and NATA Registered Laboratories Adelaide Albury-Wodonga Alsionville Brisbane Canberra Goslord Logan City Melbourne Newcastle Panrih Perh Sydney Townsville Wollongono

2.



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Appendix A - Engineering Logs - TP1 to TP14

Table 1 - Classification of Risk of Slope Instability

Table 2 - Some Guidelines For Hillside Construction

Drawing No. G0652/1-1 - Site Plan

3.



1.0 INTRODUCTION

This report presents an assessment of slope stability carried out for Crighton Properties Pty Ltd on Lot 2 Belar Avenue, Terrigal. The work was commissioned by Mr Geoffrey Cox of Crighton Properties Pty Ltd. A 1:1000 scale contour plan of the lot was provided by Cahill & Cameron Pty 1td.

It is understood that development plans have not been finalised for the site. However, it is understood the proposed development is to comprise approximately 60 residential allotments. It is understood from the supplied drawings that the roads are to be aligned generally across the hillslopes in the steeper sections of the site.

This report assesses the suitability of the lot for development from a geotechnical viewpoint, provides a risk assessment in relation to slope stability and provides geotechnical constraints for development.

2.0 FIELDWORK

Fieldwork involved a walk over assessment, surface mapping and a program of test pitting to assess surface features and subsurface profiles. This work was carried out on the 4th May, 1993 by a Geotechnical Engineer from this Company.

Fourteen test pits (TP1 to TP14) were excavated to depths ranging from 0.6m to 3.3m by a rubber tyred backhoe. The locations of the test pits are shown on Drawing No. G0652/1-1, together with the results of the surface mapping. Test pit levels have been interpolated from the contour plan provided. The test pits were located by Cahill & Cameron Pty Ltd.

Engineering logs of the test pits are presented in Appendix A, together with explanation sheets defining the terms and symbols used in their preparation.

3.0 SITE DESCRIPTION

1

3.1 Topography, Drainage and Vegetation

Lot 2 occupies an "L" shaped area of approximately eight hectares. Topographically, the site comprises a valley with a generally north-west to north aspect. The terrain is moderate to steeply sloping around the central drainage depression which crosses the site in a north-westerly direction. A northerly trending spur is located in the west of the site adjacent to the western boundary. Coney Partners international Pty Ltd

GO652/1-AB 6 May 1993

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Groundslopes at the site vary from about 3° to 7° to the horizontal near the drainage depression, to 15° to 18° to the horizontal in the higher slopes. The contour plan provided shows the site elevation to vary from about RL22m AHD in the north of the site to greater than RL70m in the south of the site.

4.

The area of the proposed residential development is generally open and well grassed, with the exception of an area to the east of the site and on a northerly facing slope towards the centre of the site where these areas are moderately wooded. Heavily wooded areas with thick undergrowth, generally corresponding to the steeper areas, are located on the properties adjoining the site.

Existing development comprises a dwelling and horse stable located in the north-east of the site. Cuts of up to 3m are located to the east of the above structures. The horse stable appears to be founded partly on fill materials won from these cuts.

Access to the site is via a dirt track from the end of Belar Avenue located to the north. This track appears to have been formed by cutting and filling and runs across the slope of the hill.

Other man made features on the site include an existing farm dam located near the centre of the northern boundary.

3.2 Geology and Subsurface Conditions

The 1:25000 Geological Map of Gosford indicates the site to be underlain by lithic-quartz to quartz sandstone, siltstone, minor sedimentary breccia, claystone and conglomerate of the Terrigal Formation.

On the basis of the surface features and the subsurface conditions encountered in the test pits, the site can be divided into two units, namely;

•	Unit A	-	Comprising predominantly slopewash and residual soils overlying sandstone/siltstone rock at
÷	Unit B	-	about 0.7m to 1.7m depth; and Comprising alluvial soils up to or greater than 2.4m in depth, overlying deeply weathered
			residual soils to depths in excess of 3.3m.

The approximate extent of the above units is shown on Drawing No. GO652/1-1.

The subsurface profile encountered in Unit A (Test Pits 3 to 14) can be summarised as follows;

TOPSOIL/SLOPEWASH: Comprising Silty Sand, fine to medium grained, light grey and grey, some roots, observed unit depth varied from 0.2m to 0.8m; overlying

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RESIDUAL:

BEDROCK:

CLAY, medium plasticity, orange brown and red brown, very stiff, observed unit thickness varied from 0 to 1.3m; overlying

SANDSTONE and SILTSTONE, extremely to highly weathered. Backhoe refusal on sandstone was encountered in Test Pits 4, 6 to 10 and 12 to 14.

The subsurface profile encountered within Unit B (Test Pits 1 and 2) can be summarised as follows;

5.

TOPSOIL: Silty SAND, fine to medium grained, light grey to grey, some roots, observed unit thickness varied from 0.2m to 0.3m; overlying

SLOPEWASH/ALLUVIUM: Clayey SAND/Sandy CLAY, fine to medium grained, medium plasticity, orange brown and red brown, observed unit thickness varied from 0.7m to 1.6m; overlying

RESIDUAL: CLAY, medium plasticity, red brown, orange brown and light grey, observed unit thickness was approximately 1m; overlying

BEDROCK: SANDSTONE, fine to coarse grained, extremely to highly weathered, orange brown and red brown. Bedrock was encountered at depths between 2.0m to greater than 3.3m.

No groundwater inflows were observed during the test pitting. It should be noted that pits were open only for a short time and variations may occur due to fluctuations in rainfall, temperature and other factors.

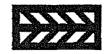
4.0 SLOPE STABILITY ASSESSMENT

4.1 Risk Assessment

No evidence of overall slope instability was observed during the walk over assessment and backhoe test pitting. Minor localised instability was observed in steep cuts upslope of the horse stable where slumping appears to have occurred.

On the basis of the features of geology, topography and drainage presented in Section 3.0, the site is assessed as having a Medium Risk of overall slope instability as defined in the attached Table 1. The risk of localised instability associated with future cuts and fills in assessed as moderate and can be limited by adopting the recommendations of this report.

6.



4.2 Geotechnical Constraints on Development

4.2.1 Area for Development

From a slope stability viewpoint, the entire site is considered suitable for development undertaken in accordance with good hillside construction practices and sound engineering principles as outline in the attached Table 2.

4.2.2 Type of Structure

Flexible structures of timber, brick veneer or similar construction would be preferred on the Unit A hillslopes. Development should be designed to accommodate natural slope profiles with split level or suspended designs so as to limit the need for slope modification.

There are no particular geotechnical constraints on the type of structures within the flat Unit B alluvial area or for structures founded on rock on the Unit A hillslopes, provided they are supported on footings designed and constructed in accordance with AS2870 "Residential Slabs and Footings".

4.2.3 Foundation Types

Foundations should be designed and constructed in accordance with the recommendations and advice of AS2870 "Residential Slabs and Footings".

Further site specific assessment will be required to assess foundation characteristics within the Unit B alluvial soils. In particular, shrink-swell potential of these soils should be addressed due to the thickness of alluvial and residual soils.

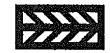
Pad/strip or pier and beam footing systems are considered appropriate for split level structures on Unit A moderate to steep hillslopes. Stiffened raft or piered slab footing systems may also be adopted provided the resulting slope modifications comply with the geotechnical constraints set out below. It is recommended that foundations for structures on slopes in excess of 4H:1V (14°) be taken to rock.

Strip/pad, stiffened raft or piered footing systems would be appropriate for residential structures located within the flat Unit B alluvial areas.

4.2.4 Excavation

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Excavations in soil should preferably not exceed 1.0m depth and battered no steeper than 2H:1V and protected from erosion. Excavations greater than 1.0m should be supported by a properly designed and constructed retaining wall.



Excavations exceeding the above recommended depths should be supported by engineer designed retaining walls or battered as directed after assessment by a qualified Geotechnical Engineer.

7.

4.2.5 Filling

The maximum depth of fill on residential lots should preferably be limited to 1.0m and battered no steeper than 2H:1V and protected from erosion. Filling greater than 1.0m should be supported by a properly designed and constructed retaining wall.

Engineering supervision and testing will be required where fill is to be regarded as "controlled fill" in accordance with AS2870 "Residential Slabs and Footings". Allowance should be made for an average 0.5m depth of stripping within the flat Unit B alluvial areas and for a 0.2m to 0.4m depth of stripping within Unit A hillslope areas. A prepared surface will need to be benched/stepped into the natural slope when placing fills on slopes exceeding 4H:1V (14°). Fill should be placed in layers having a maximum loose thickness of 200mm to 300mm depending on the type of fill and compaction equipment. Each fill layer should be thoroughly and uniformly compacted to a minimum dry density ratio (AS1289 5.4.1-1982) of 95% Standard within 2% of Standard Optimum moisture content.

Residual clay soils and weathered rock excavated during road construction would be suitable for use as fill on residential lots if placed at a moisture content within 2% of Standard Optimum. However, consideration should be given to the reactivity of clay fills in relation to potential shrink-swell movements.

4.2.6 Retaining Walls

Retaining walls should be designed for surcharge loading from sloping ground and/or structures above the wall. Adequate subsurface and surface drainage must be provided behind all retaining walls. Retaining walls in excess of 1.0m in height should be designed by an engineer.

4.2.7 Access/Site Clearance

The subdivision layout should be such that all residential lots have potential driveway access at a grade of 4H:1V or less. Any required slope modifications should comply with the above recommendations.

8.



4.2.8 Drainage and Sewerage Disposal

Stormwater should be prevented from ponding adjacent to structures. All collected stormwater runoff should be piped into a street or interallotment drainage system that discharges into existing watercourses in a controlled manner that limits erosion.

Domestic effluent should be connected to a reticulated sewerage system or to a pump-out septic system. There should be no on-site disposal of domestic effluent.

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For and on behalf of COFFEY PARTNERS INTERNATIONAL PTY LTD

IMPORTANT INFORMATION ABOUT YOUR GEOTECHNICAL ENGINEERING REPORT

As the client of a consulting geotechnical engineer, you should know that site subsurface conditions cause more construction problems than any other factor. ASFE/The Association of Engineering Firms Practicing in the Geosciences offers the following suggestions and observations to help you manage your risks

A GEOTECHNICAL ENGINEERING REPORT IS BASED ON A UNIQUE SET OF PROJECT-SPECIFIC FACTORS

Your geotechnical engineering report is based on a subsurface exploration plan designed to consider a unique set of project-specific factors. These factors typically include: the general nature of the structure involved, its size, and configuration; the location of the structure on the site; other improvements, such as access roads, parking lots, and underground utilities: and the additional risk created by scope-of-service limitations imposed by the client. To help avoid costly problems, ask your geotechnical engineer to evaluate how factors that change subsequent to the date of the report may affect the report's recommendations.

Unless your geotechnical engineer indicates otherwise. do not use your geotechnical engineering report

- when the nature of the proposed structure is changed, for example, if an office building will be erected instead of a parking garage, or a refrigerated warehouse will be built instead of an unrefrigerated one;
- when the size, elevation, or configuration of the proposed structure is altered;
- when the location or orientation of the proposed structure is modified;
- when there is a change of ownership; or
- for application to an adjacent site.

Geotechnical engineers cannot accept responsibility for problems that may occur if they are not consulted after factors considered in their report's development have changed.

SUBSURFACE CONDITIONS CAN CHANGE

A geotechnical engineering report is based on conditions that existed at the time of subsurface exploration. Do not base construction decisions on a geotechnical engineering report whose adequacy may have been affected by time. Speak with your geotechnical consultant to learn if additional tests are advisable before construction starts.Note, too, that additional tests may be required when subsurface conditions are affected by construction operations at or adjacent to the site, or by natural events such as floods, earthquakes, or ground water fluctuations. Keep your geotechnical consultant apprised of any such events.

MOST GEOTECHNICAL FINDINGS ARE PROFESSIONAL JUDGMENTS

Site exploration identifies actual subsurface conditions only at those points where samples are taken. The data were extrapolated by your geotechnical engineer who then applied judgment to render an opinion about overall subsurface conditions. The actual interface between materials may be far more gradual or abrupt than your report indicates. Actual conditions in areas not sampled may differ from those predicted in your report. While nothing can be done to prevent such situations, you and your geotechnical engineer can work together to help minimize their impact. Retaining your geotechnical engineer to observe construction can be particularly beneficial in this respect.

A REPORT'S RECOMMENDATIONS CÁN ONLY BE PRELIMINARY

The construction recommendations included in your geotechnical engineer's report are preliminary, because they must be based on the assumption that conditions revealed through selective exploratory sampling are indicative of actual conditions throughout a site. Because actual subsurface conditions can be discerned only during earthwork, you should retain your geotechnical engineer to observe actual conditions and to finalize recommendations. Only the geotechnical engineer who prepared the report is fully familiar with the background information needed to determine whether or not the report's recommendations are valid and whether or not the contractor is abiding by applicable recommendations. The geotechnical engineer who developed your report cannot assume responsibility or liability for the adequacy of the report's recommendations if another party is retained to observe construction.

GEOTECHNICAL SERVICES ARE PERFORMED FOR SPECIFIC PURPOSES AND PERSONS

Consulting geotechnical engineers prepare reports to meet the specific needs of specific individuals. A report prepared for a civil engineer may not be adequate for a construction contractor or even another civil engineer. Unless indicated otherwise, your geotechnical engineer prepared your report expressly for you and expressly for purposes you indicated. No one other than you should apply this report for its intended purpose without first conferring with the geotechnical engineer. No party should apply this report for any purpose other than that originally contemplated without first conferring with the geotechnical engineer.

GEOENVIRONMENTAL CONCERNS ARE NOT AT ISSUE

Your geotechnical engineering report is not likely to relate any findings, conclusions, or recommendations

about the potential for hazardous materials existing at the site. The equipment, techniques, and personnel used to perform a geoenvironmental exploration differ substantially from those applied in geotechnical engineering. Contamination can create major risks. If you have no information about the potential for your site being contaminated, you are advised to speak with your geotechnical consultant for information relating to geoenvironmental issues.

A GEOTECHNICAL ENGINEERING REPORT IS SUBJECT TO MISINTERPRETATION

Costly problems can occur when other design professionals develop their plans based on misinterpretations of a geotechnical engineering report. To help avoid misinterpretations, retain your geotechnical engineer to work with other project design professionals who are affected by the geotechnical report. Have your geotechnical engineer explain report implications to design professionals affected by them, and then review those design professionals' plans and specifications to see how they have incorporated geotechnical factors. Although certain other design professionals may be familiar with geotechnical concerns, none knows as much about them as a competent geotechnical engineer.

BORING LOGS SHOULD NOT BE SEPARATED FROM THE REPORT *

Geotechnical engineers develop final boring logs based upon their interpretation of the field logs (assembled by site personnel) and laboraton, evaluation of field samples. Geotechnical engineers customarily include only final boring logs in their reports. Final boring logs should not under any circumstances be redrawn for inclusion in architectural or other design drawings, because drafters may commit errors or omissions in the transfer process. Although photographic reproduction eliminates this problem, it does nothing to minimize the possibility of contractors misinterpreting the logs during bid preparation. When this occurs, delays, disputes, and unanticipated costs are the all-too-frequent result.

To minimize the likelihood of boring log misinterpretation, give contractors ready access to the complete geotechnical engineering report prepared or authorized for their use. (If access is provided only to the report prepared for you, you should advise contractors of the report's limitations, assuming that a contractor was not one of the specific persons for whom the report was prepared and that developing construction cost esti-

mates was not one of the specific purposes for which it was prepared. In other words, while a contractor may gain important knowledge from a report prepared for another party, the contractor would be well-advised to discuss the report with your geotechnical engineer and to perform the additional or alternative work that the contractor believes may be needed to obtain the data specifically appropriate for construction cost estimating purposes.) Some clients believe that it is unwise or unnecessary to give contractors access to their geotechnical engineering reports because they hold the mistaken impression that simply disclaiming responsibility for the accuracy of subsurface information always insulates them from attendant liability. Providing the best available information to contractors helps prevent costly construction problems. It also helps reduce the adversarial attitudes that can aggravate problems to disproportionate scale.

READ RESPONSIBILITY CLAUSES CLOSELY

Because geotechnical engineering is based extensively on judgment and opinion, it is far less exact than other design disciplines. This situation has resulted in wholly unwarranted claims being lodged against geotechnical engineers. To help prevent this problem, geotechnical engineers have developed a number of clauses for use in their contracts, reports, and other documents. Responsibility clauses are not exculpatory clauses designed to transfer geotechnical engineers' liabilities to other parties. Instead, they are definitive clauses that identify where geotechnical engineers' responsibilities begin and end. Their use helps all parties involved recognize their individual responsibilities and take appropriate action. Some of these definitive clauses are likely to appear in. your geotechnical engineering report. Read them closely. Your geotechnical engineer will be pleased to give full and frank answers to any questions.

RELY ON THE GEOTECHNICAL ENGINEER FOR ADDITIONAL ASSISTANCE

Most ASFE-member consulting geotechnical engineering firms are familiar with a variety of techniques and approaches that can be used to help reduce risks for all parties to a construction project, from design through construction. Speak with your geotechnical engineer not only about geotechnical issues, but others as well, to learn about approaches that may be of genuine benefit. You may also wish to obtain certain ASFE publications. Contact a member of ASFE of ASFE for a complimentary directory of ASFE publications.

* 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.



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descriptive terms soil and rock



Classificati No. 1 Table	ion of Mate D1).	rial based on l	Unified Classi	fication S	ystem (refer	SAA Site Inve	stigation Co	da AS1726—197	5 Add.
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dry	Looks and f	feels dry; cohe	sive soils usu	ally hard,	powdery or	frieble, granu	ar soils run f	reely through h	and s.
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term			criterion						
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Incorporated in NSW

graphic symbols soil and rock



Explanation Sheet 2

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	Asphaltic Concrete or Hotmix Concrete Topsoil Fill Peat, Organic Clays and Silts (Pt, OL, OH) Clay (CL, CH) Silt (ML, MH) Sandy Clay (CL, CH) Silty Clay (CL, CH)	Gravelly Clay (CL, CH) Sandy Silt (ML) Clayey Sand (SC) Silty Sand (SM) Sand (SP, SW) Clayey Gravel (GC) Silty Gravel (GM) Gravel (GP, GW)
ROCK		
	Claystone (massive) Siltstone (massive) Shale (laminated) Sandstone (undifferentiated) Sandstone, fine grained Sandstone, coarse grained Conglomerate	Limestone Coal Dolerite, Basalt Tuff P Porphyry Granite Pegmatite Schist Gneiss Quartzite Talus Alluvium
SEAMS	Seam >0.1 m thick (on a scale 1:50) Seam 0.01 m to 0.1 m thick (on a scale 1:50)	· · · · · · · · · · · · · · · · · · ·
INCLUSIONS	(Special purposes only) Rock Fragments Swomp	Ironstone Gravel, Laterite Shale Breccia in Sandstone
Water Level	<u></u>	-
Surfaces	Known Boundary	Probable Boundary ? Possible Boundary



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APPENDIX A results of field investigation

engineering log excavation

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pit no: TP1 sheet 1 of 1

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project: PROFOSED RESIDENTIAL SUBDIVISION logged by: BAS pit location: IOT 2 BELAR A'ENUE, 'TERRIGAL checked by: PJNP equipment type and model: CASE 580E BACKHOE R.L. surface: m excavation dimensions: 3 m long, 0.8 m wide datum: indication dimensions: 3 m long, 0.8 m wide datum: indication dimensions: 3 m long, 0.8 m wide datum: indication dimensions: 3 m long, 0.8 m wide datum: indication dimensions: 0 motes soil type: plasticity or particle characteristics, drop of the particity of the particle characteristics, drop of the particity of the							
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Some sandstone models in matrix	-						
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CL CLAY, medium plasticity, red M VSt RESIDU,	AL -						
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w key T timbering N nil U50 undisturbed sample 50mm and soil description VS	- - - - - - - - - - - - - - - - - - 						
W N natural exposure Penetration 1 2 3 Ø X existing excavation Penetration 1 2 3 Ø BH Backhoe bucket D disturbed sample Classification system St ranging to N standard penetration tests: VSt	sistency/donsity Index very soft						
Br Balkinge blade ranging to N° Strand participation (state) VSt B Buildozer blade N° SPT + sample recovered Moisture H B R ripper Vst N° SPT with solid cone D G R ripper Vst Vst Vst	very soft soft firm						
E E excavator HA hand auger HA hand auger Water inflow W view of the shown P pressurementer W wet MO	very soft soft firm stiff very stiff hard friable						
B B bulk sample Water out/low B bulk sample Wp plastic limit D VD	very soft soft firm stiff very stiff hard						

179-003

engineering log excavation



pit no: TP2 sheet . 1 of 1

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engineering log excavation



TP3

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	BH							Silty Clayey SAND, fine to medium grained, light grey, some rounded gravel				TOPSOIL/SLOPEWASH
					-	刿						RESIDUAL
	Υ.					$\langle \rangle$		CLAY, medium plasticity, orange brown & red brown	1			KEOTDOAL
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engineering log excavation



pit no: TP4 sheet 1 of 1

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COPYRIGHT©COFFEY PARTNERS INTERNATIONAL PTY புராமயில் குக்கிஜ் []	natu exis H Bacl bull ripp exca A han	ting kho doz er avat d au	exca e bui er bl or ger	osure avation cket ade	support T penetration water TO Jan J water in water of	nflow	3 ri ri er level on	o resistance anging to slusal	U5 D N N Nc	iO undi dian distr stan SPT SPT vane pres	aples and te isturbed samp teter urbed samp dard peneto + sample r with solid shear suremeter sample	mple 50 le ration to ecovere	ests: d	M n W y	descrip n unifie ation sy	otion ed ystem		istency/den very soft soft firm stiff very stiff hard friable very loos loose medium dense very dense	e dense

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engineering log



pit no: TP5 sheet]

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method	5 penetration	support	waler	notes samples, tests,etc		graphic log	classification symbol		material e: plasticity or partic secondary and minor		moisture condition	consistency. density index	100 x hand 200 x penetro 300 w penetro 400 meter		ucture and nal observatio	о л\$
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engineering log excavation



pit no: TP6 sheet] of]

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diameter D disturbe N standard N SPT + sa Nc SPT with	ONE, fine t Weathered, ST PIT TP6 L ON SANDST	Clayey SAND ed, grey, so CLAY, mediu e brown & re	mate e: plasticity or p secondary and p	0.8 ^{m wide}		
bed sample 50mr 5 sample penetration test mple recovered 1 solid cone ar meter	AT 1.7m	ne roots n to high p	particle charact			
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ת וא א א	M	D ityM	moisture conditiou	R.L. su datum	pit co loggec check	
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d d stem	× ×	, x	100 x hand 200 x hand 300 a penetro- 400 meter		ed: 4. BA PJ	ced: 4.
Consistency/density index VS very soft S soft F firm VSt stiff VSt very-stiff H hard Fb friable VL very loose L loose MD medium dense D dense VD very dense	BEDROCK -	TOPSOIL/SLOPEMASH	structure and additional observations	៣		

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engineering log excavation



pit no: TP7 sheet 1 of 1

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method	noitertanud S 1	support	water	notes samples, tests,etc.	⊥į depth ⊈ metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics colour, secondary and minor components	moisture condition	consistency, density index	100 × hand 200 × panetro- 300 × penetro- 400 meter	structure and additional observations
BH		N	(MB)					Silty Clayey SAND, fine to medium grained, grey, brown Silty CLAY, medium to high plasticity, orange brown & red brown	n			TOPSOIL -
			NONE ORSERVED				-	Gravel fragments near base of uni SANDSTONE, fine to coarse grained extremely to highly weathered, light grey & orange brown	_		•	BEDROCK -
	<u> </u>				2.0			END TEST PIT TP7 AT 1.7m REFUSAL ON SANDSTONE			· · · · · · · · · · · · · · · · · · ·	
SINTERNALIUNAL FIT LIV 1373								 			· · · · · · · · · · · · · · · · · · ·	
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engineering log excavation



pit no: TP8 sheet ¹ of 1

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engineering log excavation



pit no: TP9 sheet 1 of 1

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ZY SANDSTONE, fine to coerse, orange D # BEDROCK D REFUSAL ON SANDSTONE # # # L.O. FND TEST PIT TP9. AT 0.6m # # # ZY ZY # # # # ZY ZY # # # # L.O. FND TEST PIT TP9. AT 0.6m # # # ZY ZY # # # # # ZY ZY # # # # # # ZY ZY #	method		support	water	samples,		graphic log	classification symbol	soil typ colour,		ristics, Its	moisture condition	consistency, density index	100 hand 2005 penetro 400 meter	structure and additional observations
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engineering log excavation



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engineering log excavation

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engineering log excavation



pit no: TP13 sheet 1 of 1

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engineering log excavation



pit no: TP14 sheet 1 of 1

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TABLE 1

CLASSIFICATION OF RISK OF SLOPE INSTABILITY

RISK OF INSTABILITY	EXPLANATION	IMPLICATIONS FOR DEVELOPMENT
VERY HIGH	EVIDENCE OF ACTIVE OR PAST LANDSLIPS OR ROCXFACE FAILURE; EXTENSIVE INSTABILITY MAY OCCUR	
HIGH	EVIDENCE OF ACTIVE SOIL CREEP OR MINOR SLIPS OR ROCKFACE INSTABILITY; SIGNIFICANT INSTABILITY MAY OCCUR DURING AND AFTER EXTREME CLIMATE CONDITIONS	NECESSARY. RISK AFTER DEVELOPMENT MAY BE
MEDIUM	EVIDENCE OF FOSSIBLE SOLL CREEP OR A STEEP SOLL COVERED SLOPE; SIGNIFICANT INSTABILITY CAN BE EXPECTED IF THE DEVELOPMENT DOES NOT HAVE DUE REGARD FOR THE SITE CONDITIONS.	DEVELOPMENT RESTRICTIONS MAY BE REQUIRED. ENGINEERING PRACTICES SUITABLE TO HILLSIDE CONSTRUCTION NECESSARY. GEOTECHNICAL INVESTIGATION MAY BE NEEDED. RISK AFTER DEVELOPMENT GENERALLY NO HIGEER THAN USUALLY ACCEPTED.
LOW	NO EVIDENCE OF INSTABILITY OBSERVED; INSTABILITY NOT EXPECTED UNLESS MAJOR SITE CHANGES OCCUR.	GOOD ENGINEERING FRACTICES SUITABLE FOR HILLSIDE CONSTRUCTION REQUIRED. RISK AFTER DEVELOPMENT NORMALLY ACCEPTABLE.
VERY LOW	TYPICALLY SHALLOW SOIL COVER WITH FLAT TO GENTLY SLOPING TOPOGRAPHY.	GOOD ENGINEERING PRACTICES SHOULD BE FOLLOWED.

THIS TABLE IS AN EXTRACT FROM "GEOTECHNICAL RISKS ASSOCIATED WITH HILLSIDE DEVELOPMENT" AS PRESENTED IN "AUSTRALIAN GEOMECHANICS NEWS", NUMBER 10, DECEMBER, 1985, WHICH DISCUSSES THE MATTER MORE FULLY.



TABLE 1. CLASSIFICATION OF RISK OF SLOPE INSTABILITY

ASSESSMENT OF RISK

A landslip (or landslide) is a downslope movement of a soil or rock mass as a result of shear failure at the boundaries of the moving mass. The dominant movement is lateral and failure takes place over a relatively short period. Soil creep, which is slow and occurs without a well defined failure surface, is not included as a landslip.

Natural hill slopes are formed by processes which reflect the site geology, environment and climate. These processes include downslope movement of the near surface soil and rocks; in geological time all slopes are unstable. The area of influence of these downslope movements may range from local to regional and are rarely related to property boundaries. The natural processes may be affected by human intervention in the form of construction and related activities.

It is not technically feasible to assess the stability of a particular site in absolute terms such as stable or unstable. However the degree of risk of slope movement can be assessed by the recognition of surface features supplemented by limited information on the regional and local subsurface profile and with the benefit of experience gained in similar geological environments. The degree of risk is categorised below.

CLASSIFICATION OF RISK OF LANDSLIP WITHOUT DEVELOPMENT

CLASS	EXPLANATION
LOW	A landslip is very unlikely
MODERATE	A landslip is unlikely
HIGH	There is some risk of a landslip

CONSEQUENCES OF HILLSIDE CONSTRUCTION

It must be accepted that the risks associated with hillside construction are greater than construction on level ground in the same geological environment. The impact of development may be adverse and imprudent construction techniques can increase the potential for movement.

Australian Standard AS 2870 - 1986 provides a damage classification that relates to essentially vertical movements of masonry walls and is thus not directly applicable to hillside movements. In the absence of a suitable classification for hillside movements the range of damage categories from negligible to very severe can be used as a general guide for damage potential related solely to landslip.

CLASS	DEVELOPMENT CONSTRAINTS	DAMAGE P EXTENT	OTENTIAL PROBABILITY
LOW	Good Hillside Practice	Slight	Very Low
MODERATE	Good Hillside Practice and site specific restrictions	Slight Moderate	Low Very Low
HIGH	No development unless major engineering remedial works	Moderate Severe	High Moderate

Damage to structures may occur due to a number of causes additional to that attributable to landslip. In the absence of a landslip slight damage might be expected even for good construction. If a landslip occurs damage would probably reach at least a moderate level.

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SOME GUIDELINES FOR HILLSIDE CONSTRUCTION

GOOD ENGINEERING PRACTICE

POOR ENGINEERING PRACTICE

•	GOOD ENGINEERING PRACTICE	POUR ENGINEERING PRACTICE
ADVICE		
GEOTECHNICAL ASSESSMENT	Obtain advice from a qualified, experienced geotechnical consultant at early stage of planning and before site works.	Prepare detailed plan and start site works before geotechnical advice,
PLANNING		
SITE PLANNING	Having obtained geotechnical advice, plan the development with the Risk of Instability and Implications for Development in mind.	Plan development without regard for the Risk of Instability.
DESIGN AND CONSTRU	ICTION	
HOUSE DESIGN	Use flexible structures which incorporate properly designed brickwork, timber or steel frames, timber or panel cledding. Consider use of split levels. Use decks for recreational areas where appropriate.	Floor plans which require extensive cutting and filling. Movement intolerant structures.
SITE CLEARING	Retain natural vegetation wherever practicable.	Indiscriminately clear the site.
ACCESS & DRIVEWAYS	Satisfy requirements below for cuts, fills, retaining walls and drainags. Council specifications for grades may need to be modified. Driveways and parking areas may need to be fully supported on plans.	Excavate and fill for site access before geotechnical advice.
EARTHWORKS	Retain natural contours wherever possible.	
CUTS	Minimise depth. Support with engineered retaining walls or batter to appropriate alope. Provide drainage measures and erosion control.	Large scale cuts and benching. Unsupported cuts. Ignore drainage requirements.
FILLS	Minimise height. Strip vegetation and topsoil and key into natural slopes prior to filling. Use and compact clean fill materials. Batter to appropriate slope or support with engineered retaining wall. Provide surface drainage and appropriate subsurface drainage.	Loose or poorly compacted fill. Block natural drainage lines. Fill over existing vegetation and topsoil. Include stumps, trees, vegetation, top- soil, boulders, hullding rubble etc in fill.
ROCK OUTCROPS & BOULDERS	······································	Disturb or undercut detached blocks or boulders.
RETAINING WALLS	Engineer design to resist applied soil and water forces. Found on rack where practicable. Provide subsurface drainage within wall backfill and surface drainage on slope above. Construct wall as soon as possible after cut/fill operation.	Construct a structurally insdequate wall such as sandstone flagging, brick or unreinforced blockwork. Lack of subsurface drains and weepholes.
FOUNDATIONS	Support on or within rock where practicable. Use rows of piers or strip foundations oriented up and down slope. Design for lateral creep pressures. Backfill foundation excavations to exclude ingress of surface water.	Found on topsoil, toose fill, detached boulders or undercut cliffs.
SWIMMING POOLS	Engineer designed. Support on piers to rock where practicable. Provide with under-drainage and gravity drain outlet where practicable. Design for high soil pressures which may develop on uphili side whilst there may be little or no lateral support on downhill side.	
DRAINAGE SURFACE	Provide at tops of cut and fill slopes. Discharge to strest drainage or natural water courses. Provide generous fails to prevent blockage by siltation and incorporate silt traps. Line to minimise infiltration and make flexible where possible. Special structures to disipate energy at changes of slope and/or direction.	Discharge at top of fills and cuts. Allow water to pond on bench areas.
SUBSURFACE	Provide filter around subsurface drain. Provide drain behind retaining walls, Use flexible pipelines with access for maintenance. Prevent inflow of surface water.	
SEPTIC & SULLAGE	Usually requires pump-out or mains sewer systems; absorption trenches may be possible in some low risk areas. Storage tanks should be water-tight and adequately founded.	Discharge sullage directly onto and into slopes.
EROSION CONTROL &	Control erosion as this may lead to instability. Revegetate clearad area.	Failure to observe earthworks and drain- age recommendations when landscaping.
	SITS DURING CONSTRUCTION	
DRAWINGS AND SITE VIS	SITS DURING CONSTRUCTION Building Application drawings should be viewed by geotechnical consultant.	
	Building Application drawings should be viewed by geotechnical	
DRAWINGS AND SITE VIS DRAWINGS	Building Application drawings should be viewed by geotechnical consultant. Site Visits by consultant may be appropriate during construction.	

This table is an extract from GEOTECX-NICAL RISKS ASSOCIATED WITH HILLSIDE DEVELOPMENT as presented in Australian Geomechanice News, Number 10, 1985 which discusses the matter more fully.

