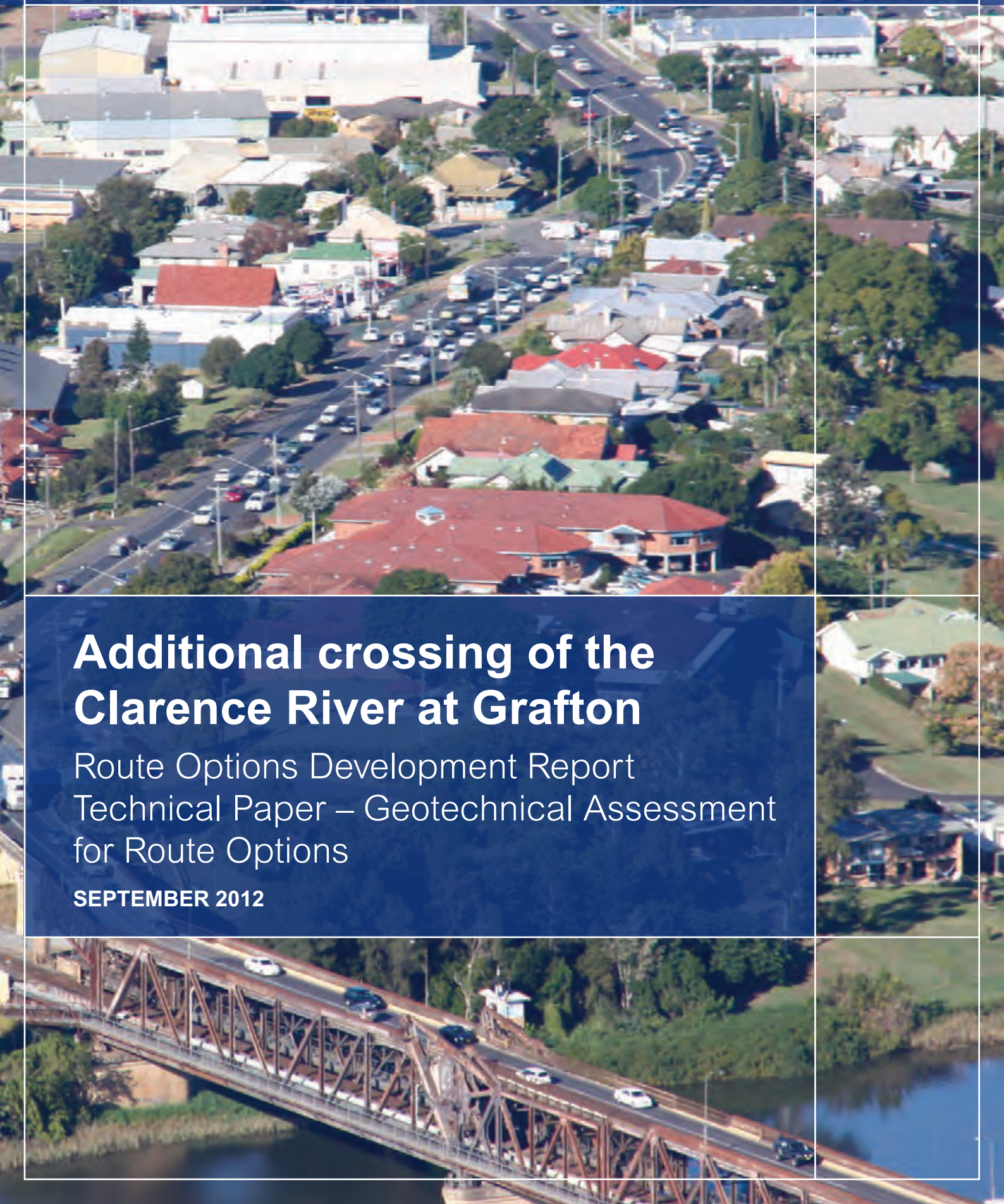

NSW GOVERNMENT
Transport Roads & Maritime Services

Additional crossing of the Clarence River at Grafton

Route Options Development Report Technical Paper – Geotechnical Assessment for Route Options

SEPTEMBER 2012

Roads and Maritime Services

Main Road 83 Summerland Way - Additional Crossing of the Clarence River at Grafton

Geotechnical Assessment for Route Options

August 2012

Job number 220422/00

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Executive Summary

Roads and Maritime Services (RMS) are currently undertaking investigations to identify an additional crossing of the Clarence River at Grafton to address short-term and long-term transport needs. The objective of this report is to provide a geotechnical assessment of the foundation conditions associated with the six short-listed route options so they can be reasonable compared.

A review of the existing geotechnical information within the vicinity of the preferred route options is presented in this technical paper, and incorporates the results of a geotechnical investigation conducted by Arup in 2012. Geotechnical issues that should be considered for the constructability of the bridge foundations and approaches at each of the route options are:

- The existence of gravel and cobbles immediately above the rock.
- The existence of any loose sand below embankments.
- The existence of any soft clay and organic soils below embankments.
- The depth and quality of rock below the bridge and viaducts.
- Potential ground improvement requirements below proposed approach embankments due to the presence of any soft clay deposits;
- Presence of acid sulphate soils.
- Salinity of channel water and groundwater for durability design.
- The extent of river scour that could be associated around potential piers within the river channel.

It is anticipated that piled foundations will be required for the river crossing piers and approach viaducts associated with each of the route options.

The approximate reduced level (m AHD) for the pile toe for each option, for the approach viaducts and river crossing is shown below.

Route Option	Southern approach viaduct	River crossing piers	Northern approach viaduct
E	-18	-18 to -33	-33
A	About +5 to -18	-18 to -26	-26
C	-18	-18 to -26	-26
11	-15 to -21	-21 to -23	N/A
14,15	-15 to -23	-23	-23

Ground settlement associated with embankments may be an issue at Options 11, 14 and 15, where some ground improvement may be required. However, these issues are considered manageable.

1 Introduction

Roads and Maritime Services (RMS) are currently undertaking investigations to identify an additional crossing of the Clarence River at Grafton to address short-term and long-term transport needs. The objective of this report is to provide a geotechnical assessment of the foundation conditions associated with the six short-listed route options so they can be compared.

This technical paper is an attachment to the Route Options Development Report and will be used to define the preliminary geotechnical conditions for these six short-listed route options. The findings of these investigations will be used as part of the selection of a recommended preferred option.

A desk study review of the existing geotechnical information within the vicinity of the preferred route options is presented in this technical paper, which also incorporates the results of a geotechnical investigation conducted by Arup in 2012.

1.1 Project appreciation

1.1.1 Project background

Since the early 1970s there have been various discussions and studies into an additional crossing of the Clarence River near Grafton. A number of these studies have been carried out during the past ten years and provide the background to the current investigation.

In December 2010, RMS commenced a revised process to work more closely with the community to determine the preferred location for an additional crossing. As part of this revised process, a series of public surveys, community forums and meetings with residents and community groups have been held and various studies and project documents released for public viewing and comment.

In June 2011, RMS released the Feasibility Assessment Report, which describes the assessment undertaken by RMS on the 41 route suggestions identified by the community following the announcement of the revised process in December 2010. The report identifies 25 preliminary options within five strategic corridors to go forward for further engineering and environmental investigation.

Between June 2011 and January 2012, RMS carried out investigations in the Grafton area and surrounds to identify constraints relevant to an additional crossing of the Clarence River. The outcomes of these investigations, community comment and a community and stakeholder evaluation workshop provided the inputs to the selection of the short-list of options.

In January 2012, six route options to be investigated further as part of the process to identify a location for the crossing were announced (as shown in Figure 1). The short-listed options were identified in the *Preliminary Route Options Report – Final* (RMS, January 2012) which also provided details of the technical investigations undertaken on the 25 preliminary options and the process to select the short-listed options.

Figure 1 Route Options Location Plan

1.1.2 Route options

The proposed form of the approaches and bridge for each option (as presented on Figure 1) has been described below.

For the purposes of this investigation, the results are discussed relevant to three areas:

- Northern Bank (Grafton side of the Clarence River);
- River Channel;
- Southern Bank (South Grafton side of the Clarence River).

Table 1 Route option features

Route Option	Proposed features		
	Southern bank approach	**River channel crossing**	**Northern bank approach**
E	High approach embankment over paddocks from Cowan Street, South Grafton.	The proposed bridge would be 618 metres long and 15.9 metres wide and would be on a constant large radius horizontal curve (1400 metres radius) over the Clarence River for the majority of its length; with a horizontal curve on the last two spans on the Grafton side. The current preliminary concept design for the bridge would provide a 39.5 metre span on the South Grafton side, followed by 11 spans of 49 metres across the river, and another 39.5 metre span on the Grafton side. There would also be a 68 metre long approach viaduct (with two 34 metre long spans) on the Grafton side.	Small viaduct structure (on piers) that grades into minor embankment onto Villiers Street, Grafton.
A	Generally at grade with some minor earthworks associated with the abutment on Bent Street, South Grafton.	The proposed bridge would be approximately 471 metres long and 17.7 metres wide, and would be a straight crossing of the Clarence River. The current preliminary concept design for the bridge would provide five 74.6 metre long spans across the river to match the existing bridge, and another 61 metre span on the South Grafton side, followed by a 37.5 metre long span on the Grafton side. There would also be a 145 metre long approach viaduct (with five 29 metre long spans) on the Grafton side.	Viaduct (on piers) grading into a minor embankment into Fitzroy Street, Grafton.

Table 1 Route option features

Route Option	Proposed features		
	Southern bank approach	**River channel crossing**	**Northern bank approach**
C	Approach embankment located within paddocks. A high embankment is also associated with the connection to the Pacific Highway to the south.	The proposed bridge would be approximately 458 metres long and 15.9 metres wide and would be on a constant very large radius horizontal curve (4500 metres radius) over the Clarence River. The current preliminary concept design for the bridge would provide a 44 metre span on the South Grafton side, followed by five 74 metre long spans across the river to match the existing bridge, and a 44 metre long span on the Grafton side. There would also be approach viaducts on either side of the bridge; 64 metres long (with two 32 metre long spans) on the South Grafton side, and 58 metres long (with two 29 metre long spans) on the Grafton side.	Viaduct (on piers) grading into a minor embankment between the river bank and Pound Street, Grafton.
11	High approach embankment associated with the connection to the Pacific Highway, extending half way across the flood plain. The remaining half of the flood plain approaching the river is a large viaduct structure on piers.	The proposed bridge would be approximately 387 metres long and 15.9 metres wide, and would be a straight crossing of the Clarence River. The current preliminary concept design for the bridge would provide eight spans of 48.4 metres across the river. There would also be a 340 metre long approach viaduct on the South Grafton side across the floodplain (with ten 34 metre long spans). In addition to these structures, an additional shorter 110 metre long viaduct would be required to cross a small creek on the South Grafton side, near the Pacific Highway.	High embankment grading to existing road level on Fry Street, Grafton.

Table 1 Route option features

Route Option	Proposed features		
	Southern bank approach	**River channel crossing**	**Northern bank approach**
14	High approach embankment associated with the connection to the Pacific Highway. Over the flood plain, a high viaduct structure on piers extends to the river crossing bridge.	The proposed bridge would be 617 metres long and 16.3 metres wide and would be a straight crossing of the Clarence River. The current preliminary concept design for the bridge would provide eleven spans of 53 metres across the river, followed by a 34 metre long span on the Grafton side. There would also be a 782 metre long approach viaduct (with 23 spans of 34 metres) on the South Grafton side across the floodplain. On the Grafton side, there would be a 136 metre long approach viaduct (with four spans of 34 metres). In addition to these structures, there would also be three other shorter bridges for creek crossings.	Small viaduct structure (on piers) that grades into a low embankment onto Kirchner Street, Grafton. Further low embankments are associated with the proposed road and two short creek crossings along North Street, Grafton.
15		The proposed river bridge would be the same as in Option 14 (617 metres long and 16.3 metres wide and would be a straight crossing of the Clarence River). The current preliminary concept design for the bridge would also be the same as Option 14; with eleven spans of 53 metres across the river, followed by a 34 metre long span on the Grafton side. The approach viaducts would also be the same as Option 14; with a 782 metre long approach viaduct (with 23 spans of 34 metres) on the South Grafton side across the floodplain, and a 136 metre long approach viaduct (with four spans of 34 metres) on the Grafton side. In addition to these structures, there would also be four other shorter bridges for creek crossings.	Small viaduct structure (on piers) that grades into a low embankment onto Kirchner Street, Grafton. Further low embankments beyond the bridge approach associated with a new road linking to the Summerland Way north of Grafton. One area has higher embankments associated with an un-named creek crossing.

1.2 Scope of report

This report supports the Route Options Development Report and will be used to define the geotechnical foundation conditions for the six short-listed route options and used as part of the selection of a preferred option.

A number of geotechnical investigations have been carried out across the area covered by the route options since 1975. An additional geotechnical investigation was carried out by Arup in March 2012 to supplement the existing geotechnical information, particularly where gaps in data existed. A summary is provided of all geotechnical information relevant to the project in Section 3 of this report.

This report presents a geotechnical assessment of the foundation conditions for each of the route options. The assessment is a high level review to provide founding levels and to identify high risk areas to input into the costing of each of the route options.

No geotechnical parameters for design are presented as part of this report. Once the preferred route option is identified, a detailed geotechnical investigation will be carried out and design parameters will be developed.

1.3 Limitations

This report contains an interpretation of existing available geotechnical information of the site. The ground is a product of continuing natural and man-made processes and therefore exhibits a variety of characteristics and properties which vary from place to place and can change with time. No warrantee can be given for the information used and no responsibility is undertaken.

The geotechnical assessment was based on the current preliminary concept design for the bridge and may be refined with further development of the option during the detailed design of the preferred route. The work undertaken, combined with information available from other sources and previous field investigations, is considered suitable for a comparative assessment of the six route options.

2 Desk study review

2.1 Topography

The route options are located within the flood plain of the Clarence River. The Clarence River forms a meander between Grafton and South Grafton where the river runs through the Clarence Valley. The Clarence River and Grafton are at reduced levels of below 10m AHD and are flanked to the east, south and west by hillsides that gently rise to an approximate elevation of 70m AHD.

A number of natural water courses and artificial drainage channels are present within the area.

Historical air photos from 1964 and 1979 have been reviewed as part of the desk study. No significant development has occurred within the area between 1964 up to the present day. In terms of the floodplain morphology, the southern bank area has remained as open paddocks.

A review of historical bank erosion as part of the South Grafton Levee scheme (Cameron McNamara Consultants, 1987) has indicated that no significant widening of the Clarence River has occurred from 1870 to 1979. Between the current rail bridge and the Alipou Creek confluence, approximately 5m of bank erosion has occurred in this time period.

2.2 Geology

2.2.1 Regional geology

The route options are located within the Clarence-Moreton Basin that has been described by McEvilly *et al* (2004) as a broad, gently dipping basin with localised areas of fold and fault zones. The basin axis trends north-south and runs in close proximity to Grafton. Geological units in the basin comprise terrestrial sandstone and shale with minor conglomerate and coal (McEvilly *et al* (2004)).

2.2.2 Local geology

The Grafton 1:250 000 scale geological Sheet 56-6 (Brunker and Chesnut, 1976), indicates that the bedrock underlying the route options is the Jurassic to Cretaceous period, Grafton Formation, comprising sandstone, siltstone, claystone and minor coal.

The geological map indicates that Quaternary Alluvium overlies the Grafton Formation at the route options. The Alluvium is described as stream alluvial deposits that are sandy to silty with minor gravels. In addition, Packham (1969), states that boulder beds are present in the Clarence River near Grafton.

The anticipated geology underlying the route options is presented as Figure 2.

The Grafton Area 1:25,000 Coastal Quaternary Geology Map (2008) indicates the route options are underlain by alluvial deposits that have been sub-classified depending on their position relative to the Clarence River. The surface alluvial deposits are Holocene in age and occur within the active depositional system associated with the Clarence River flood plain.

Figure 2 Anticipated Site Geology

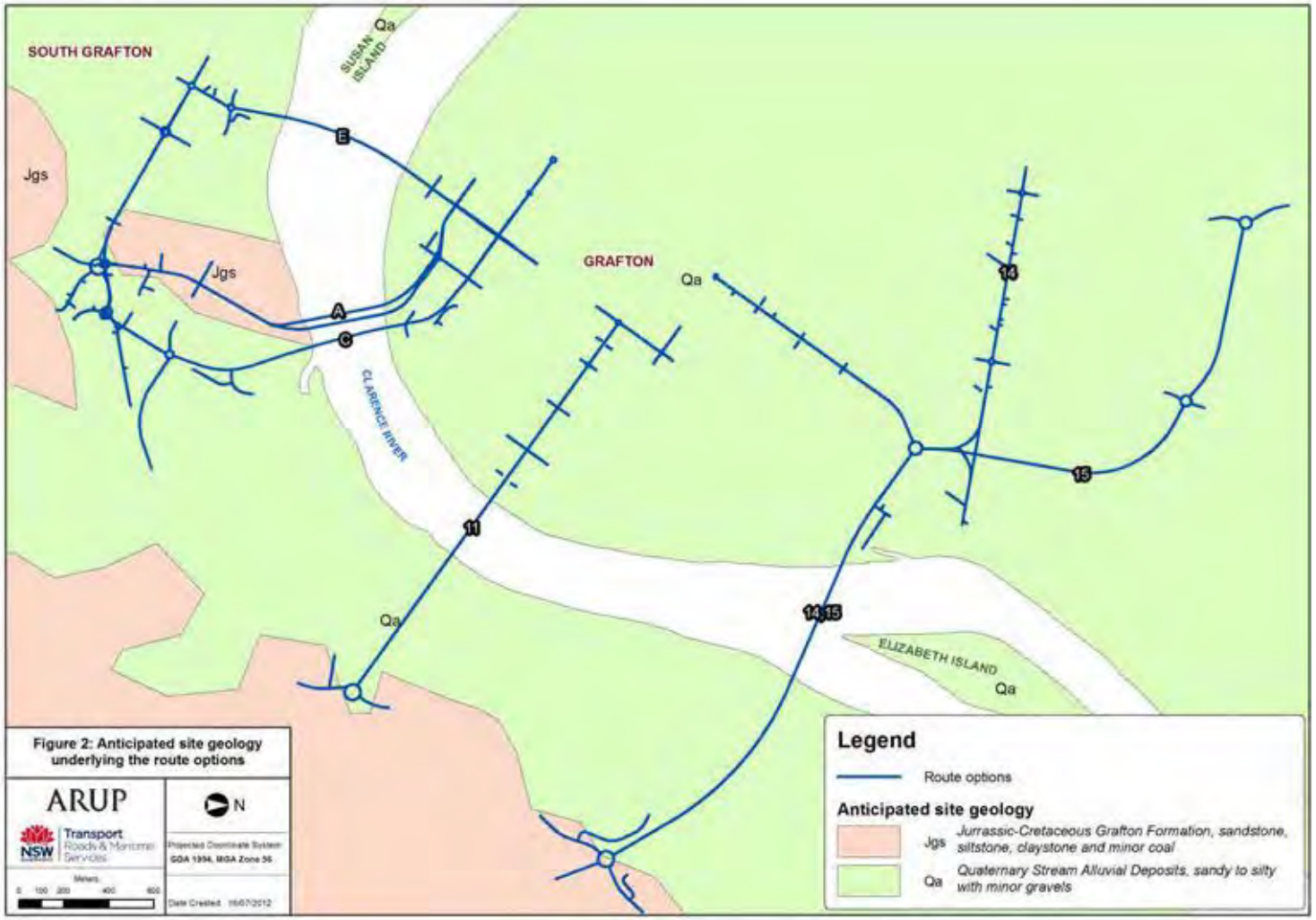


Figure 3 Schematic Cross Section of Meandering River System Morphology and Ground Conditions

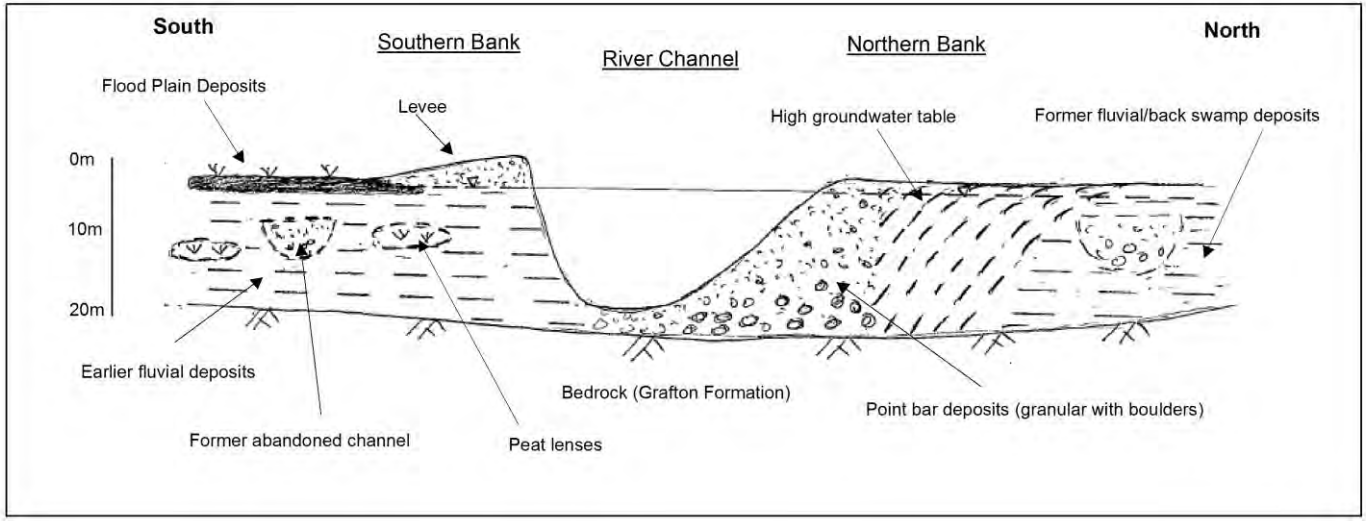


Figure 3 presents a conceptual schematic cross section detailing the anticipated ground conditions associated with meandering river systems.

It is anticipated that towards the north of the river, Holocene channel levee deposits (fluvial sand, silt and clay) overlie Holocene in channel bar deposits (fluvial sand, silts, gravels and clay). The river channel is anticipated to comprise fluvial sand, gravel, silt and clay. To the south of the river, Holocene levee deposits are anticipated to overlie Holocene in channel bar deposits beyond which Holocene flood plain deposits (fluvial sand, silt and clay) overlie Pleistocene deposits (clay, silt, fluvial sand and marine sand).

An extract of the Grafton Quaternary geology map is presented as Figure 4.

It is anticipated that the geotechnical characteristics between the Holocene and Pliestocene deposits would differ. A generalised distinction between the Holocene and Pleistocene deposits is summarised as follows (Troesdson and Hashimoto (2008)):

Holocene alluvial deposits have minimal weathering, are generally loose to firm in consistency, friable when moist, and brown to brown grey in colour.

Pleistocene alluvial deposits exhibit substantial dissection and weathering, are generally stiff to very stiff in consistency with well defined soil structure, plastic when moist and orange to red orange brown in colour and intensely mottled.

2.3 Acid sulfate soil

Typically acid sulphate soils are found in the following environments/conditions:

- Holocene (most recent part of Quarternary) sediments.
- Soil horizons less than 5mAHD.
- Marine or estuarine sediments and tidal lakes.
- Coastal wetlands or back-swamp area, coastal sand dunes.
- Mangrove or other swamp-tolerant or marine vegetation is dominant.
- Deep older (Holocene or Pleistocene) estuarine sediments >10m below ground surface.
- Sediments/rock with sulphide bearing minerals, coal deposits or former marine shales/sediments.

The 1:25,000 scale Grafton Acid Sulfate Risk Soil Map (1997) indicates that the route options are in areas of high and low probability of acid sulphate soil risk (Figure 5).

Figure 4 Anticipated Quaternary Geology

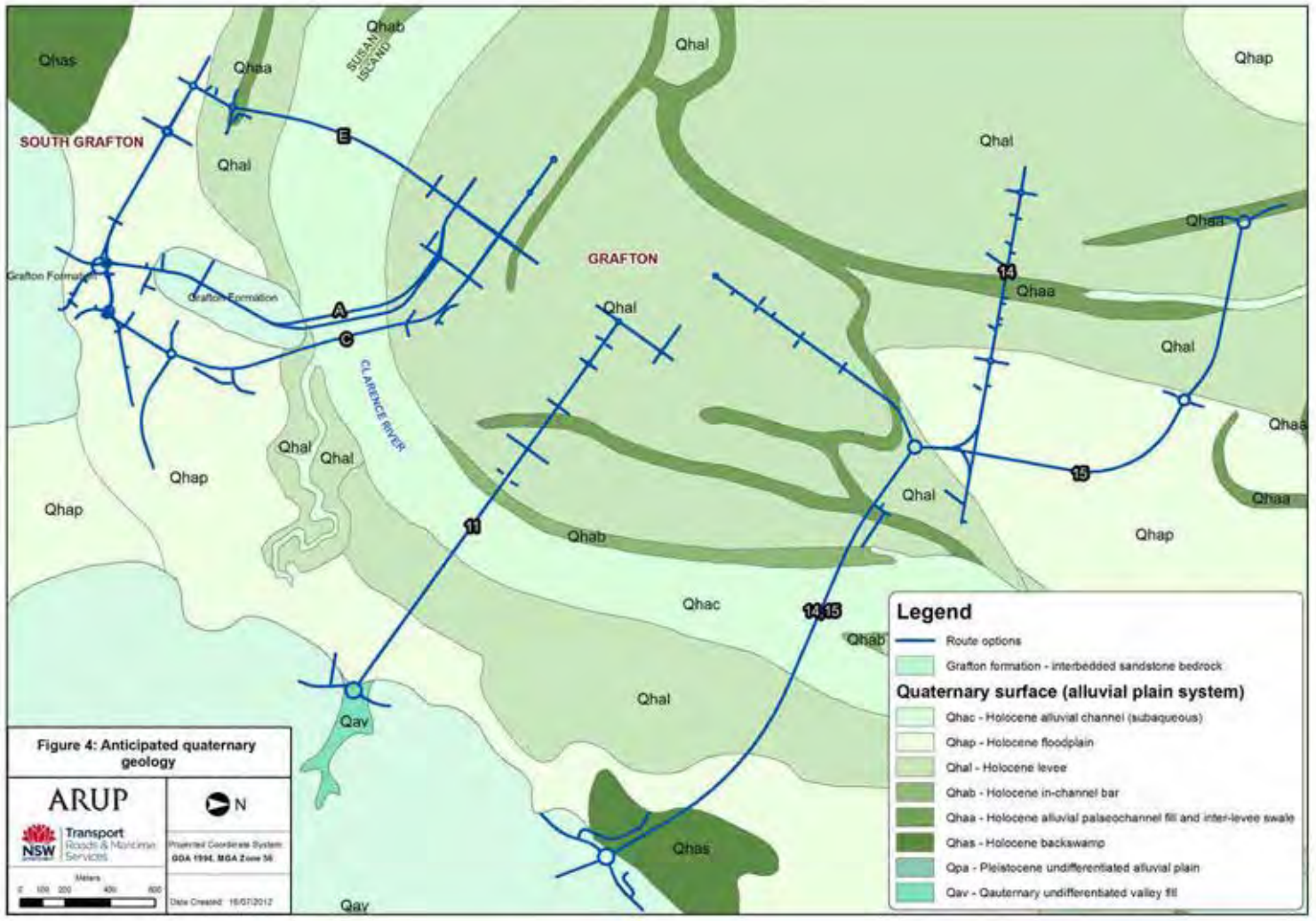
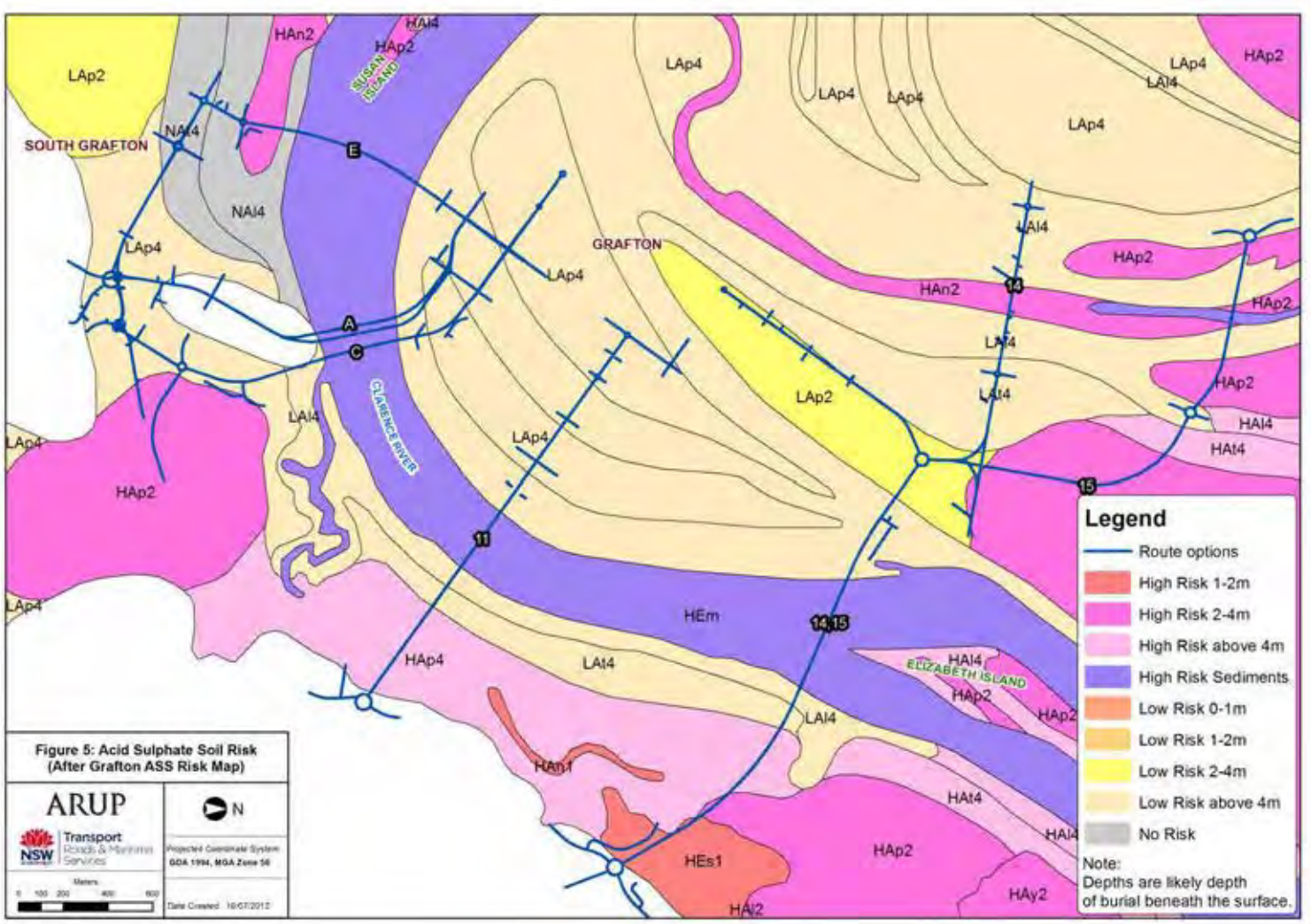


Figure 5 Acid Sulfate Soil Risk



A high probability of acid sulphate soil is associated with the river channel sediments and the alluvial plain deposits beyond the southern bank adjacent to the Pacific Highway. A low probability of acid sulphate soil is associated with the alluvial levee and alluvial plain deposits on the northern bank, through Grafton, and the alluvial levee and alluvial plain deposits along the southern bank adjacent to the river.

Limited existing acid sulphate soil screening has indicated a low potential for acid sulphate soil and pH testing generally indicates that the alluvial deposits are acidic. Groundwater testing recorded pH over 6.

2.4 Salinity

The Australian Dryland Salinity Risk for 2000, 2020 and 2050 (NLWRA, 2000) does not indicate a high hazard or risk of dryland salinity within the area of the route options.

Based on the Clarence River Fact Sheet (produced by oceanwatch.org), the tidal limit reaches over 100km inland up to Copmanhurst and it is therefore anticipated that the channel water and groundwater at Grafton may be saline.

2.5 River scour

A scour investigation carried out by the Bridge Maintenance Engineer in 2003 recorded up to 7m and 5m of scour on the downstream and upstream sides (respectively) of Piers 2, 3 and 4. A gap was reported under part of an unspecified pier.

Based on the assumed as built drawing, one pier location was constructed within the river channel deposits (towards the north of the bridge). Based on the anticipated river erosion (towards the southern bank) it is considered that the formation of a gap below this pier would be unlikely as further sediment deposition is likely to occur towards the northern river bank.

3 Geotechnical investigations

3.1 Existing geotechnical information

As part of the 2003 Route Selection Study a desk study and geotechnical investigation was carried out by the then Roads and Traffic Authority (RTA) for seven crossing locations between Susan Island and Elizabeth Island. The following information from the RTA 2003 Geotechnical Investigation Route Selection Report (refer to Appendix F of the Environmental Overview Report, RTA, January 2004) has been reviewed:

- Seven boreholes from a geotechnical investigation carried out in 1975. Five of which are located within the river channel to the east (downstream) of route options A and C;
- A geological cross-section marked on an assumed as-built drawing for the original bridge based on 17 boreholes (attached to RTA report G3510, Geotechnical Investigation at Concept Stage dated 26 October 2003, of which the cross section is produced in Appendix A of this report);
- Four boreholes and seven test pits carried out by the RTA as part of the route selection investigation, 2003;
- Limited geotechnical laboratory testing carried out on test pit samples from the 2003 investigation;
- Bridge pier scour depth investigation.

The existing borehole and test pit locations from both the 1975 and 2003 investigations are presented on Figure 6 and copies of the borehole logs, test pits, as-built cross-section and scour report are reproduced in Attachment A.

In addition to the 2003 route selection geotechnical investigation the following historical geotechnical investigations have been reviewed:

Coffey and Partners Pty Ltd (1981), Clarence River Flood Mitigation Assessment of Bank Stability (part of which is attached to RTA Report G3510 in Attachment A). The investigation comprised 12 boreholes, with associated laboratory testing, along the alignment of the proposed levees in close proximity to the current route options. Acid sulphate soil screening was carried out that generally indicated a low potential for acid sulphate soil. However, two samples showed reaction and were scheduled for laboratory testing. Only the sample from GB7 showed actual acid sulphate soil. Thirteen soil samples were tested for pH with results ranging between 3.5 to 5 and two samples from the boreholes that recorded pH over 5. The results generally indicate that the alluvial deposits are acidic. Groundwater testing recorded pH over 6;

Peter J.Burgess & Associates Pty Ltd (1987), South Grafton Levee Geotechnical Investigation Report (part of which is attached to RTA Report G3510 in Attachment A). The investigation comprised 7 boreholes along the proposed levee upgrade alignments, of which BHSG1 to BHSG5 (with associated laboratory testing) are located near current route options E, A and C.

3.2 Supplementary geotechnical investigation

A supplementary geotechnical investigation was carried out by Arup in March 2012. The investigation was carried out to supplement the existing data, particularly where gaps in knowledge from previous investigations exist.

The March 2012 geotechnical investigation locations are presented on Figure 6.

The supplementary geotechnical investigation was to provide a comparable level of geotechnical information for each route option so a comparative assessment can be made.

Prior to this route options investigation, there was sufficient existing geotechnical information as follows:

- In the vicinity of the existing Grafton Bridge;
- For the flood plain area on the south side of the river, downstream of the existing Grafton Bridge and this can be extrapolated, to an extent, to interpret ground conditions along the three route options that cross the flood plain (Options 11 and 14/15).

There was no existing geotechnical borehole data for the Grafton side of the river and the area north to Great Marlow.

Therefore, to supplement the existing information, the supplementary investigation concentrated on the northern bank with five boreholes located at route options E, 11, 14 and 15. One borehole was located on the floodplain on the southern river bank in close proximity to route Options 14/15 to provide information on the anticipated rock level in this area.

A land based gravity survey was carried out on the south side of the Clarence River for route options 11 and 14/15. The aim of the gravity survey was to profile the top of the bedrock to the south east of the river up to the Pacific Highway and correlate the findings to the nearest boreholes. This will enable a more accurate estimation of the depth of piles along the floodplain covered by these options.

The factual geotechnical information associated with the current investigation is presented in Arup's Ground Investigation Data Report. The information regarding the type of investigation, methodology, in situ testing, borehole logs and laboratory test results will not be repeated herein and the reader is referred to the factual report presented in Attachment B for these details.

Figure 6 Existing and Current Geotechnical Investigation Location Plan

3.3 Geotechnical laboratory testing

Geotechnical laboratory testing was carried out as part of the existing and current investigations on the alluvial deposits. Testing included Atterberg Limits, particle size distributions, oedometer testing, triaxial testing (both quick undrained and consolidated undrained with pore water measurements) and California Bearing Ratios (CBRs). The laboratory testing conducted as part of the March 2012 investigation is presented in Arup's Ground Investigation Data Report in Attachment B.

No interpretation of the laboratory testing has been carried out in this report.

4 Ground conditions

4.1 General

The sub-surface ground conditions have been split into three geomorphological areas of the Clarence River flood plain, namely;

- Northern Bank (Grafton side of the Clarence River);
- River Channel;
- Southern Bank (South Grafton side of the Clarence River).

Information related to the river channel is limited to near route options A and C. The ground conditions for the river channel are presented as a separate section below (Section 4.2) and will be assumed to apply to all route options at this stage.

The anticipated ground conditions for the northern and southern river banks will be presented for each of the route options (Section 4.3) using the existing and current geotechnical investigation data.

4.2 River channel deposits

BH1 to BH5 from the 1975 geotechnical investigation were located within the river channel. The alignment of these boreholes is directly downstream of the current route options A and C. The ground conditions encountered within these boreholes is summarised below.

Table 2 River channel sub-surface conditions

Unit	Description	Reduced level at top of surface (m AHD)	Thickness (m)
Alluvium	Sand with some gravels and trace soft clay.	-3.3 to -12.2	4.5 to 9
	Gravel and sand and gravel with cobbled sized material Not encountered in BH3 and BH5	-6.9 to -9.8	8.5 to 10.2
Bedrock	Sandstone with siltstone layers		
	Assumed extremely weathered (soil strength). Not encountered in BH5.	-19.1 to -21.6	1.3 to 6
	Assumed highly weathered, very low strength, cracked with clay seams	-20.4 to -26.8	-

The material descriptions were based on drillers logs. No in-situ testing was recorded on the logs.

In general, a thicker sequence of gravel / sand and gravel with cobble sized material was recorded towards the northern bank. A similar geological sequence is marked on the assumed as-built drawing in Appendix A. The section indicates a thicker sequence of gravel and boulder deposits to the north of the river channel as recorded in the 1975 boreholes summarised above.

The top of rock levels have been presented in the RTA 2003 Geotechnical Investigation Route Selection Report and vary between -14.8m to -22.8m AHD. In general, based on the as-built cross-section of the existing bridge in Appendix A, the rock level shallows towards the south side of the river channel.

4.3 Ground conditions at the route options

A preliminary assessment of the anticipated sub-surface conditions at the six route options, utilising the existing and current borehole information is presented in Table 3.

The anticipated ground conditions have been presented as the southern and northern banks. As mentioned in Section 4.1 above, the ground conditions for the river channel will be assumed to apply to all options at this stage.

Table 3 Anticipated ground conditions of routes E, A, C, 11, 14 and 15

Route option	Southern Bank		Northern Bank	
	Geotechnical information in close proximity	**Anticipated ground conditions**	**Geotechnical information in close proximity**	**Anticipated ground conditions**
E	BHSG3(1987), BHSG4(1987), BHSG5(1987) & BH4(2003) considered, offset up to 500m upstream	Approximately 5.5m of firm to very stiff silty clay, overlying; Very loose becoming medium dense clayey sand to sand from RL 1m AHD. No bedrock encountered (borehole depth RL -6m AHD). Groundwater level at RL 0.5m AHD. Boreholes offset from the option recorded: Up to 7m of loose to medium dense clayey silty sand to silty sand, overlying; Up to 6.5m of loose to medium dense sand with silty clay interbeds from RL 0m AHD Stiff silty clay with organic layers from RL 1.5m AHD was noted in BHSG5 with a thickness of 7m. The clay was encountered as very soft in BH4(2003). Very dense sandy gravel was noted at RL -12m AHD in BH4 (2003). No bedrock encountered (borehole depths ranged between RL -7m AHD to -13m). Groundwater at approximately RL 0mAHD.	BH101 (2012)	Approximately 17m of loose becoming medium dense silty sand overlying; Approximately 14m of medium dense to very dense gravel, gravelly sand and clayey gravel encountered at approximately RL -15.5m AHD, overlying; Claystone recovered as stiff to very stiff high plasticity clay at approximately RL -29.5m AHD. Groundwater level encountered at RL 1m AHD.

Route option	Southern Bank		Northern Bank	
	Geotechnical information in close proximity	**Anticipated ground conditions**	**Geotechnical information in close proximity**	**Anticipated ground conditions**
A, C	BH7(1981), BH10(1981), BHSG1(1987), BHSG2 (1987) Existing as-built bridge cross-section.	Based on as-built cross-section: material overlying bedrock comprises interbedded clays and sand (possible levee deposits). Based on the boreholes the material overlying the bedrock is interbedded silty clay and clay, firm to very stiff in consistency with an approximate thickness 14m. Clayey gravel / gravelly clay between -8m to -10m AHD was noted above the bedrock in the boreholes further south. Maximum depth of rock up to -15m AHD. Groundwater level varies between RL 1.1m AHD to -0.2m AHD.	BH1(1975), BH3(1975), BH2(1975), Existing as-built bridge cross-section.	Sand 4.6m to 5.6m thickness, overlying; Gravel with cobble sized material, maximum thickness of approximately 10m, overlying; Interbedded sandstone bedrock at a maximum reduced level of approximately -23m AHD. No groundwater information.

Route option	Southern Bank		Northern Bank	
	Geotechnical information in close proximity	**Anticipated ground conditions**	**Geotechnical information in close proximity**	**Anticipated ground conditions**
11	Gravity survey (2012) (lines 3 and 4) No borehole information on the alignment. The following exploratory holes are within 500m: BH8(1981), BH9(1981), BH11(1981), GB7 (2003),	Up to 5m of loose to medium dense silty sand to clayey sand, overlying; Firm to very stiff sandy clay to silty clay and clay, from RL 3.1m to 0.5m AHD. Localised very soft band from RL -0.5 to -2m AHD, overlying; Medium dense becoming very dense silty sand becoming sandy gravel to gravel from RL -10m AHD. Gravel not encountered in BH8(1981). Interbedded siltstone and sandstone from RL -17.7m AHD. Medium strength, fresh rock. Only encountered in BH2(2003). Gravity survey indicates rock level to vary between RL 0m AHD (at the Pacific Highway) to RL -12.8m AHD near the river bank. Groundwater from RL-0.6m to 1.2m AHD.	BH102(2012)	Very soft sandy clay, 1.2m in thickness overlying; Very loose to loose sand and silty sand from RL 2.2m AHD, with a thickness of approximately 6m, overlying; Medium dense silty sand from RL -2.1m AHD, overlying Medium dense to very dense clayey gravel from RL -13m AHD, overlying; Interbedded claystone/sandstone from RL -20m AHD. Encountered as distinctly weathered to slightly weathered, high strength. No groundwater noted.

Route option	Southern Bank		Northern Bank	
	Geotechnical information in close proximity	**Anticipated ground conditions**	**Geotechnical information in close proximity**	**Anticipated ground conditions**
14,15	BH106 (2012); Gravity survey (2012) (lines 1 and 2); BH1(2003) closest to southern bank; GB1(2003), GB2(2003), GB3(2003), GB4(2003) considered but offset up to 400m downstream.	BH106 encountered: Soft to firm silty clay approximately 10m in thickness, overlying; Very loose becoming medium dense silty sand from RL -5.7m AHD, overlying; Dense to very dense sandy gravel and gravel from RL -15m AHD, overlying; Interbedded siltstone/sandstone from RL -20.7m AHD. The rock was encountered as fresh, medium to high strength. The existing information suggests: Up to 20m of firm to hard silty clay. Locally clay very soft to soft at or below the groundwater level within the test pits. Peat layer from RL -2.2 to -3.9m AHD recorded in BH1(2003). Very dense sandy gravel from RL -14.2m AHD, overlying; Possible siltstone bedrock from RL -21.4m AHD. Groundwater from RL -0.5m AHD. Gravity survey indicates rock level to vary between RL 7m AHD (at the Pacific Highway) to RL -19m AHD near the river bank.	BH103 (2012), BH104 (2012), BH105 (2012) (for Option 15 only)	Soft to firm silty clay, ranging in thickness of 2m to 5m (in BH104 clay is firm to stiff), overlying; Very loose to loose silty sand encountered from RL -0.2 to -3m AHD, overlying; Medium dense silty sand encountered from RL -4.7m to -10.7m AHD, overlying; Dense to very dense sandy gravel encountered from RL -13m to -14.4m AHD. Interbedded claystone/sandstone was encountered in BH103 at RL -20m AHD. The rock was encountered as extremely weathered becoming slightly weathered, very low to low strength. Groundwater encountered at RL-2.3m AHD in BH104.

5 Geotechnical assessment for route options

5.1 General geotechnical considerations

The information in Table 3 is approximate only and is based on limited geotechnical information. The following issues should be considered for the constructability of the bridge foundations and approaches at each of the route options:

- Thickness of gravels and possible boulders within the river channel and the extent of these deposits beyond the northern and southern banks. This could result in problems with soil backfill into pile excavations in uncased holes and also issues with the driving or boring of deep foundations.
- Thickness and density of alluvial sand deposits within the river channel and beyond the river banks.
- Thickness of cohesive alluvial deposits beyond the river channel towards the north and south and extent of peat layers/pockets which will decay over time and will result in associated settlement. They also provide negligible shaft resistance for deep foundations.
- Thickness of weathered bedrock (if present) and uniformity of bedrock including strength of bedrock. Pile construction may be more difficult if rock is encountered at a shallower depth or if the rock is more competent than has been interpreted from the investigation. In this case a larger piling rig and drilling components may be required.
- Potential ground improvement requirements below proposed approach embankments due to the presence of any soft alluvial clay deposits;
- Presence of acid sulphate soils.
- Salinity of channel water and groundwater for durability design.
- The extent of river scour that could be associated around potential piers within the river channel.

5.2 Bridge structures

It is considered that the proposed river crossing structure will require geotechnical solutions for the following structures:

- Deep foundations for the proposed piers and abutments of the river crossing bridge and approach viaducts;
- Approach embankment design incorporating slope stability and settlement.

The following geotechnical constraints could be associated with the above structures based on the review of the geotechnical data.

5.2.1 Pier foundations

Pier installation costs within the river channel are anticipated to be high in addition to difficult ground conditions to the north of the river channel in the form of boulder obstructions within thicker granular alluvium deposits.

Pier spacing should give consideration to the potential difficulty of constructing foundation piles through thicker gravel deposits in the northern part of the river channel.

Generic foundation options for the pier and viaduct localities are discussed below.

Shallow Foundations

Shallow foundations have been considered not to be viable because of the following:

- Soft and loose alluvial soils on both the northern and southern river banks;
- Scour associated with the river channel.

Piled foundations socketing into the bedrock are considered the most suitable option for piers located within the river channel and the viaduct structures.

Deep Foundations

It is anticipated that deep piled foundations would be founded in the bedrock. Optimisation of the pile design by use of the alluvial sand and gravel in shaft friction may be feasible for the viaduct structures. For the river channel this would depend on the change in thickness of the deposits across the river channel and degree of scour anticipated. This may reduce the number of piles required.

The following geotechnical issues are associated with the following piling methodologies.

Driven Piles

Driven piles (precast concrete piles, H section or tubular steel piles) would be suitable to achieve the required capacity. These could be used for the viaduct structures on the southern river bank. However, the presence of boulders within the alluvial gravel in the river channel may inhibit the required penetration depth. The verification of the required penetration in relation to the scour depth would be difficult and post construction scour may reduce the capacity of the piles in the river channel.

H section piles are used in marine environments and the toe can be strengthened to allow the pile to punch through thin layers of boulders. However, the H section piles can deflect along the weak axis and if penetrated into rock, the pile driving can shatter the rock and degrade the bearing capacity (Tomlinson, 1996).

Hollow tubular steel piles may be driven in conjunction with drilling out the basal section of the pile prior to successive drives. Construction delay may be associated with this methodology.

Continuous Flight Auger (CFA) Piles

CFA piles may be a suitable option in the granular alluvium as to avoid the installation of permanent casing, for example on the southern and northern river

banks. The boulders that were recorded within the alluvial gravel deposits in the river channel may prevent the piles being installed to the desired depth for the river crossing piers. If piles refuse at shallow depths, the required bearing capacities may not be achieved and scour may reduce the capacity of the piles.

Bored Piles

Large diameter bored piles could be a viable option but the presence of granular alluvium deposits would necessitate lining of bored piles to avoid shaft collapse. Lining of the piles by use of permanent casing would be required to allow formation of the pile within the granular deposits on the southern and northern river bank areas and partly within the water column in the river channel.

5.2.2 Durability

No information regarding the salinity of the river channel and groundwater was determined as part of the ground investigations. It is considered that the river channel may be saline due to the extent of the tidal range and may cause corrosion and durability issues.

Further information regarding durability will be required to aid foundation design once a preferred location for an additional crossing is identified.

5.3 Approach embankments

The existing geotechnical information suggests that compressible alluvium is isolated to lenses of peat and localised very soft to soft areas. It is not anticipated that settlements will be a significant issue and slope stability will be a function of the embankment fill material, slope angles and slope heights adopted.

Construction related settlements may also be associated with the loose granular alluvial deposits identified over the southern river bank flood plain and predominantly within the northern river bank area.

Future geotechnical investigation for the preferred option will need to address these issues and determine the need for ground treatment to avoid the need for lengthy construction staging and avoid potential instability and excessive settlement.

Construction details of the existing flood levees towards the northern and southern banks are unknown. Details regarding the construction of the levees would be valuable if the proposed approach embankments are to incorporate the existing levees. If the levees were not engineered, issues regarding slope stability and settlement may occur. This is applicable to all route options. Further investigation for the preferred option would be required.

5.4 Option specific considerations

A high level geotechnical assessment for each of the route options is summarised below based on the assumed geology presented in Section 4.2.

5.4.1 Option E

Southern Bridge Approach

On the southern approach to the bridge, a short low approach embankment is proposed. This will be underlain by a crust of stiff clay and very loose to medium dense sand deposits.

Minor ground settlement issues will need to be considered in detailed design, but are not likely to be significant. Short term settlement is likely to occur due to the very loose sand but this is likely to be driven out during construction. Longer term settlement may be associated with near surface organic layers and potentially soft clay lenses/bands.

Bridge

The abutments and piers for the bridge will probably be founded in rock, which is likely to vary in depth from about RL -15m AHD on the southern bank to about RL -29.5m AHD on the north bank. No information is present within the river channel, however a rock level of about RL -23m AHD is anticipated based on information for Options A and C.

A risk in the form of the thickness and extent of the gravel/cobble deposits and the rock level will need to be investigated further if Option E is identified as the preferred option.

Northern Bridge Approach

A short viaduct and minor earthworks are proposed on the north side of the river. The ground conditions in this area comprise the thickest layer of sand/gravel and deepest bedrock of any route option.

The short section of viaduct may require piled foundations due to the presence of loose granular deposits. The piers for this viaduct could be founded within the gravels or, depending on loading, could be founded in the rock.

5.4.2 Option A

Southern Bridge Approach

The southern bridge approach will likely be at grade and underlain by residual soil and rock. The bridge abutment could be founded on shallow footings or short piles.

Bridge

The piers for the bridge will require piled foundations. Gravel with cobbled sized material increases in thickness across the river from south to north and in addition, the rock level drops. Cased bored piles (potentially large diameter) would be a suitable option due to the gravel/cobble deposits. The maximum rock level is anticipated to be RL -23m AHD.

Northern Bridge Approach

On the northern bank it is assumed that the gravel/cobble layer is continuous. In addition it is assumed that predominantly granular (sand) deposits could be encountered.

A small viaduct is proposed for the approach and the piers would be founded within gravel or, depending on loading, could be founded in the rock.

5.4.3 Option C

Southern Bridge Approach

The bridge approach and connection to the Pacific Highway is proposed to be formed on embankment and viaduct, which will be underlain by about 14m of stiff clay above the bedrock. Consolidation settlement of the stiff clay is likely to be minor and manageable.

For the short viaduct, piers may be constructed on piles founded in rock at approximately RL -15m AHD. Shorter piles may be suitable depending on the design loadings of the viaduct.

Bridge

The piers and abutments for the bridge will require piled foundations probably founded in rock. The rock is anticipated to be at about RL-23m AHD and may increase with depth to the north. Gravel with cobbles increases in thickness toward the north. Cased bored piles (potentially large diameter) would be a suitable option due to the gravel/cobble deposits.

Northern Bridge Approach

It is anticipated that the gravel and cobble layer continues under the northern approach and that granular (sand) deposits are dominant.

A small viaduct is proposed for the approach and the piers could be founded within the gravels or, depending on loading, could be founded in the rock.

5.4.4 Option 11

Southern Bridge Approach

This bridge approach will comprise a high embankment over half of the length and the remaining half, towards the river, will be supported on viaduct.

The rock level drops from near surface at the Pacific Highway, to between RL -13m and -18m AHD near the river bank. The alluvial deposits over the southern approach are anticipated to comprise an upper layer of stiff clay with localised soft bands that overlie medium dense sands and gravels with depth.

Ground settlement beneath the embankment may be an issue and will need to be considered in the detailed investigation and design. However, any issues are likely to be manageable.

It is likely that the viaduct structure will require piles founded in the rock at approximately RL -12m to -18m AHD. Shorter piles founding within gravels may be suitable depending on the design loading of the viaduct.

There is a higher risk of acid sulphate soils on the southern bank as compared to other route options.

Bridge

There is no information on the ground conditions within the river, but it is anticipated that conditions will be similar to those at Option C. The bridge will need to be supported on piles probably founded in rock. It is anticipated that the rock level across the river channel varies between about RL -18m to -20m AHD. A risk in the form of the thickness and extent of the gravel/cobble deposits and the rock level will need to be investigated further if Option 11 is identified as the preferred option.

Northern Bridge Approach

A short high embankment is proposed for the northern approach. A 1m to 1.5m thick layer of soft clay may be present at the ground surface that overlies very loose to medium dense sand with depth. Dense gravels are anticipated to overlie the bedrock at RL -20m AHD.

The soft clay may need to be removed to avoid excessive settlement. Construction related settlements associated with the loose granular material may occur during construction.

5.4.5 Option 14 and Option 15

Southern Bridge Approach

A high embankment and viaduct structure is proposed over the southern approach for both options.

The rock level varies from ground level at the Pacific Highway dropping to RL -19m AHD near the river bank. The alluvial deposits comprise up to 10m of soft to firm clays, overlying dense gravels that overlie the bedrock.

Ground settlement beneath the embankment associated with the soft clay is likely to be an issue and will need to be considered in the detailed investigation and design. Some ground improvement may be required. However, any issues are likely to be manageable.

The viaduct over the floodplain will require piles probably founded in the rock. The rock level varies under the viaduct from about RL -12m to -20m AHD. The piles could be founded in the gravel layers depending on the viaduct loading.

Bridge

There is no information on the ground conditions within the river, but it anticipated that conditions will be similar to those at Option C. The bridge will need to be supported on piles probably founded in rock. It is anticipated that the rock level across the river channel varies between about RL -18m to -20m AHD. A risk in the form of the thickness and extent of the gravel/cobble deposits and the

rock level will need to be investigated further if Option 14 or Option 15 is identified as the preferred option.

Northern Bridge Approach

For both options, the northern approach is in the form of a small viaduct grading into minor earthworks. For each option further embankments are proposed that are associated with new roads and creek crossing upgrades.

Soft to firm clay is present at the ground surface overlying very loose granular material, which become dense with depth. Gravels were found to overlie the bedrock.

It is anticipated that the viaduct structure will require piled foundations bearing onto the bedrock at RL -20m AHD or within the gravel.

Embankment settlements associated with the soft clay will need to be considered at detailed investigation and design. This soft material may need to be improved if either of these options are identified as the preferred option. Construction related settlements may also be associated with the loose granular materials underlying the clay.

6 Conclusions

6.1 Preliminary piled foundation lengths

It is anticipated that piled foundations will be required for the river crossing piers and the approach viaducts associated with each of the route options.

To provide a costing comparison between the route options, bored piled foundations should be assumed for the river crossing and approach viaducts at this stage. There may be scope on the southern river bank to utilise alternative piling methods for the viaducts such as driven piles. This would need verification once a preferred option is chosen.

The approximate reduced level (m AHD) for the pile toe for each option, for the approach viaducts and river crossing is shown in Table 4.

Table 4 Approximate pile toe reduced level (m AHD) for the route options

Route Option	Southern approach viaduct	River crossing piers	Northern approach viaduct
E	-18	-18 to -33	-33
A	+5 to -18	-18 to -26	-26
C	-18	-18 to -26	-26
11	-15 to -21	-21 to -23	N/A
14,15	-15 to -23	-23	-23

Note: An increase in bedrock depth occurs progressively from south to north across each route option

It should be noted that the pile toe levels presented in Table 4 incorporate the following assumptions:

- The pile toe level incorporates an assumed 3m rock socket, i.e. the pile will be embedded 3m into the bedrock.
- The pile size and length will be reviewed once bridge loading and design refinements are undertaken for the preferred option.
- The pile toe levels are indicative and are subject to further geotechnical investigation to confirm the ground conditions assumed once a preferred location is identified.

6.2 Approach embankment considerations

Table 5 summarises the geotechnical considerations associated with the approach embankments for each of the options.

Table 5 Approach embankment considerations

Route Option	Geotechnical considerations
E	No significant issues
A	No significant issues
C	*Southern Bridge Approach* Minor long term settlement associated with localised soft/organic bands/lenses, which can be managed. *Northern Bridge Approach* No significant issues
11	*Southern Bridge Approach* May have long term settlement issues associated with localised soft bands/lenses, which will need to be managed. *Northern Bridge Approach* Minor settlement associated with soft soils, which can be managed.
14/15	*Southern Bridge Approach* Long term settlement associated with soft to firm clay is likely to be an issue and will need to be addressed during detailed investigation and design. Ground improvement may be required. *Northern Bridge Approach* Long term settlement associated with soft clay is likely to be an issue and will need to be addressed during detailed investigation and design. Ground improvement may be required.

7 References

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Attachment A

Existing Geotechnical Investigation Data

APPENDIX B

Borehole Logs and Photographs-
Geotechnical Report No: G3510

NEW BRIDGE OVER CLARENCE RIVER AT GRAFTON.

GEOTECHNICAL INVESTIGATION AT CONCEPT STAGE.

Report No: G3510

26 October 2003

NEW BRIDGE OVER CLARENCE RIVER AT GRAFTON.
GEOTECHNICAL INVESTIGATION AT CONCEPT STAGE.
Report No G3510

INTRODUCTION

This report presents the results of an initial geotechnical investigation, at concept stage, for the route selection of a proposed new bridge over the Clarence River at Grafton. The locations for the investigation were chosen to give a wide perspective on the possible foundation conditions that can be expected when the actual bridge location is chosen. The work was requested by Mr Peter Black, Project Manager, Operations.

GEOLOGY

Reference to the 1:250 000 Metallogenic Series Sheet for Grafton – Maclean shows the area of interest to be underlain by undifferentiated Quaternary alluvial sediments overlying rocks of the Grafton Formation of late Jurassic age. These are described as; interbedded sandstone, clayey siltstone, claystone and minor coal. The presence of brick pits in these rocks close to Grafton is noted.

FIELDWORK

One borehole was drilled at each of four locations on the banks of the Clarence River. Borehole 1 was drilled on the left bank of the river close to the existing bridge. The other three boreholes were drilled on the right bank. Coordinates and levels of the boreholes are given in Table 1 below. The boreholes were drilled by Craig Pullman Site Investigation Pty Ltd, using a truck mounted Jackro Drilling rig for Borehole 2 and a P160 drilling rig for the other boreholes. The boreholes were started using a continuous flight auger and continued using a rock roller with water and polymer flush. Standard penetration tests were done, generally at intervals of 1.5m unless otherwise indicated. (See the log for Borehole 3.) 50mm diameter tube samples were taken in some of the clays encountered. The rock was cored only in Borehole 2 using NMLC equipment.

Table 1: Coordinates and Levels of Boreholes

BH No	Eastings	Northings	R L
1	496234.2	6717162.8	5.8
2	495613.6	6715388.3	5.9
3	494311.0	6714884.0	1.7
4	493099.9	6714527.5	1.7

RESULTS

Borehole 1 encountered very stiff silty sandy clay with some stiff and firm material with peat over hard silty clay. From a depth of 16m, the material becomes progressively more sandy and has a lower cohesive strength. A very dense sandy silty gravel was encountered below 20m depth. A material thought to be siltstone was encountered below 27.2m.

Borehole 2 encountered a clayey and silty sand close to the surface and then clayey silt and silty clay, some of which was very soft or firm. Loose silty sand was encountered below 12.6m and very dense sandy gravel below 15.8m. Medium strength sandstone was encountered below 23.6m. This was found to be interbedded with siltstones and laminite. The borehole was cored to almost 30m.

Borehole 3 encountered firm silty clay at the surface. There was a gradational change from 1.7m to 2.65m below which was found loose sand with some gravely sand. Medium dense gravely sand was encountered below 9.5m and sandy gravel below 11.9m. Standard penetration testing was discontinued in this borehole to enable completion of the investigation within the allotted time frame. An indication of the density of the gravels may be obtained from the column in the logs, which describes the drilling penetration. Sandstone was encountered below 20.7m

Borehole 4 encountered 0.7m of fill over very soft silty clay to a depth of 5.2m. Loose silty sand was encountered below this. At the base of this layer, the material became medium dense, and a dense to very dense sandy gravel was encountered below 10.6m. This borehole was terminated on instruction at 11.5m in the gravel.

A description of the materials encountered in the boreholes and the results of the standard penetration tests are given on the borehole log sheets. These, together with a photograph of the core from Borehole 2 and an explanatory sheet, are given in Appendix A.

DISCUSSION

From the results of the investigation it is considered that driven piles would be required at all the sites investigated. The nature of the piles and the depth of embedment will depend on the chosen bridge design. It is probable that the gravels above the rock would be of sufficient density to support the piles. This should be reassessed at the time of the actual design of the bridge at the chosen location. However, if required, bored piles to bedrock may be considered to provide a higher load bearing capacity. The design loading of the bridge will therefore dictate the type of pile that will be used. Whatever type of pile is chosen, the presence of clays that could settle under the weight of the approach embankment (see below) could be a source of negative skin friction and may require that the embankment materials be placed before the construction of the piles.

Most of the borcholes encountered very soft to firm clays and silty clays above the gravels. These will be a source of settlement in the approach embankments and should be thoroughly investigated for both settlement characteristics and stability implications once the alignment of the bridge has been chosen.

Manager Geotechnical Investigation
26 October 2003

Reviewed by:

Manager Geotechnical Engineering

APPENDIX A

BOREHOLE LOGS AND CORE PHOTOGRAPHS

EXPLANATORY NOTES - DRILL & EXCAVATION LOGS

GENERAL

Information obtained from site investigations is recorded on log sheets. The "Cored Drill Hole Log" presents data from an operation where a core barrel has been used to recover material - commonly rock. The "Non-Core Drill Hole - Geological Log" presents data from an operation where coring has not been used and information is based on a combination of regular sampling and in-situ testing. The material penetrated in non-core drilling is commonly soil but may include rock. The "Excavation Geological Log" presents data and drawings from exposures of soil and rock resulting from excavation of pits, trenches, etc.

The heading of the log sheets contains information on Project Identification, Hole or Pit Identification, Location and Elevation. The main section of the logs contains information on methods and conditions, material substance description and structure presented as a series of columns in relation to depth below the ground surface which is plotted on the left side of the log sheet. The common depth scale is 8m per drill log sheet and about 3-5m for excavation logs sheets.

As far as is practicable the data contained on the log sheets is factual. Some interpretation is inevitable in the identification of material boundaries in areas of partial sampling, the location of areas of core loss, description and classification of material, estimation of strength and identification of drilling induced fractures. Material description and classifications are based on SAA Site Investigation Code AS 1726 - 1993 with some modifications as defined below.

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

DRILLING

Drilling & Casing

AS	Auger Screwing
AD/V	Auger Drilling with V-Bit
AD/T	Auger Drilling with TC Bit
WB	Wash bore drilling
RR	Rock Roller
NMLC	NMLC core barrel
NQ	NQ core barrel
HMLC	HMLC core barrel
HQ	HQ core barrel

Drilling Fluid/Water

The drilling fluid used is identified and loss of return to the surface estimated as a percentage.

Drilling Penetration/Drill Depth

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

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

Groundwater Levels

Date of measurement is shown.

▼ Standing water level measured in completed borehole

▽ Level taken during or immediately after drilling

Samples/Tests

D	Disturbed
U	Undisturbed
C	Core Sample
SPT	Standard Penetration Test
N	Result of SPT (*sample taken)
VS	Vane Shear Test
IMP	Borehole Impression Device
PBT	Plate Bearing Test
PZ	Piezometer Installation
HP	Hand Penetrometer Test

EXCAVATION LOGS

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

MATERIAL DESCRIPTION - SOIL

Classification Symbol - In accordance with the Unified Classification System (AS 1726-1993, Appendix A, Table A1)

Material Description - In accordance with AS 1726-1993, Appendix A2.3

Moisture Condition

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

Consistency - In accordance with AS 1726-1993, Appendix A2.5

VS	Very Soft	< 25kPa
S	Soft	25 - 50kPa
F	Firm	50 - 100kPa
St	Stiff	100 - 200kPa
VSt	Very Stiff	200 - 400kPa
H	Hard	≥ 400kPa

Strength figures quoted are the approximate range of Unconfined Compressive Strength for each class.

Density Index (%) is estimated or is based on SPT results. Approximate N Value correlation is shown in right column.

VL	Very Loose	< 15%	0 - 4
L	Loose	15 - 35%	4 - 10
MD	Medium Dense	35 - 65%	10 - 30
D	Dense	65 - 85%	30 - 50
VD	Very Dense	> 85%	> 50

NON-CORE DRILL HOLE-GEOLOGICAL LOG

HOLE NO : 1

PROJECT : GRAFTON BRIDGE SITES
LOCATION :

FILE / JOB NO : G3510
SHEET : 1 of 4

POSITION : SURFACE ELEVATION : ANGLE FROM HORIZONTAL : 90°

RIG TYPE : F 400 MOUNTING : TRUCK CONTRACTOR : PULLMAN DRILLING DRILLER : H. KENNEDY

DATE STARTED : 23/9/03 DATE COMPLETED : 25/9/03 DATE LOGGED : 23/9/03 LOGGED BY : J. T. CHECKED BY :

DRILLING | MATERIAL

SCALING & CASING	DRILLING FLUID TYPE & LOSS	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES, TEST, ETC	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION (Soil Type, Colour, Plasticity or Particle Characteristic, Secondary & Minor Components)	MOISTURE CONDITION	CONSISTENCY / RELATIVE DENSITY	STRUCTURE & Other Observations
4" HSSR, C, BIT	N/A	E			0.0			SANDY SILT : BROWN, FINE GRAINED, LOW PLASTICITY, SLIGHTLY MOIST.	M		ALLUVIUM
					0.70						
				1.00 SPT 2,3,2 N*=5 1.45	1.0			SILTY SANDY CLAY : DARK BROWN, MEDIUM PLASTICITY, FINE GRAINED SAND	M	VSt (HP) or F (SPT)	HP = 270 kPa
		F			2.0						
				2.50 SPT 4,4,5 N*=9 2.95	2.60				M to W	H (HP) or St (SPT)	HP = 490 kPa
	N/A				3.0			SILTY SANDY CLAY : BROWN & PALE BROWN MOTTLED, HIGH PLASTICITY, SOME FINE & MEDIUM GRAINED SAND.			
				4.00 SPT 2,3,2 N*=5 4.45	4.0			SILTY SANDY CLAY : PALE GREY & ORANGE BROWN MOTTLED, HIGH PLASTICITY, SOME FINE & MEDIUM GRAINED SAND WITH A TRACE OF COARSE GRAIN ALSO	M	VSt (HP) or F (SPT)	HP = 290 kPa
		L			5.0						
	N/A			5.50 SPT 2,3,5 N*=8 5.95				AS ABOVE, EXCEPT GREY & ORANGE BROWN MOTTLED, SOME ROOT FIBRES PRESENT.	M	VSt-St (HP) or St (SPT)	HP = 167 - 245 kPa
			6.30m ▽		6.0						
		VF							W		
					7.0			SILTY CLAY : PALE BLUISH GREY, HIGH PLASTICITY, TRACE OF FINE GRAINED SAND			
ROCK ROLLER 3 BIT	0% LOSS			7.20 U50 7.65					M	VSt	HP = 245 - 294 kPa
					8.0						

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND TRAFFIC AUTHORITY, NSW

File: 01.dwl

NON-CORE DRILL HOLE-GEOLOGICAL LOG

HOLE NO : 1
FILE / JOB NO : G3610
SHEET : 2 of 4

PROJECT : GRAFTON BRIDGE SITES
LOCATION :

POSITION : SURFACE ELEVATION : ANGLE FROM HORIZONTAL : 90°
RIG TYPE : P 400 MOUNTING : TRUCK CONTRACTOR : PULLMAN DRILLING DRILLER : R. KENNEDY
DATE STARTED : 23/9/03 DATE COMPLETED : 25/9/03 DATE LOGGED : 23/9/03 LOGGED BY : J. T. CHECKED BY :

DRILLING | MATERIAL

DRILLING & CASING	DRILLING FLUID	TYPE & LOSS	DRILLING PENETRATION	GROUNDWATER LEVELS	SAMPLES, TEST, ETC	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION (Soil Type, Colour, Plasticity or Particle Characteristic, Secondary & Minor Components)	MOISTURE CONDITION	CONSISTENCY / RELATIVE DENSITY	STRUCTURE & Other Observations
ROCK ROLLER BIT	WATER	5%LOSS	VS		8.00 SPT 2,2,3 N*=5 8.05	8.0			SILTY CLAY / PEAT : DARK GREY & DARK BROWN MOTTLED, HIGH PLASTICITY. ORGANIC MATTER PRESENT EMITTING A VERY STRONG ODOUR.	M	F-St (HP) or F (SPT) HP = 50 - 100 kPa	ALLUVIUM
			VL			9.0						
					10.00 U50 10.35	10.0			SILTY CLAY : DARK GREY, HIGH PLASTICITY, SOME DARK BROWN PEAT FRAGMENTS PRESENT.	M	F (HP)	HP = 98 kPa
			VF			11.0						
					11.50 SPT 4,4,8 N*=12 11.95	12.0			SILTY CLAY : PALE GREEN & GREY MOTTLED, HIGH PLASTICITY.	M	F-St (SPT) VSt (HP) or St (SPT)	HP = 245 kPa
			F		13.00 SPT 7,9,13 N*=22 13.45	13.0			AS ABOVE EXCEPT WITH SOME BROWN	M	VSt-H (HP) or VSt (SPT)	HP = 343 - 490 kPa
			F		14.50 SPT 6,8,14 N*=23 14.95	14.0			SILTY CLAY : YELLOW BROWN & PALE GREY MOTTLED, HIGH PLASTICITY, SOME FINE & MEDIUM GRAINED SAND.	M	H (HP) or VSt (SPT)	HP = 490 kPa
			F			15.0						
						16.0						

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND TRAFFIC AUTHORITY, NSW

File: 01.dwl

NON-CORE DRILL HOLE-GEOLOGICAL LOG

PROJECT : GRAFTON BRIDGE SITES
LOCATION :
POSITION :
RIG TYPE : P 400 MOUNTING : TRUCK
DATE STARTED : 23/9/03 DATE COMPLETED : 25/9/03

HOLE NO : 1
FILE / JOB NO : G3510
SHEET : 3 of 4

SURFACE ELEVATION :
ANGLE FROM HORIZONTAL : 90°
CONTRACTOR : PULLMAN DRILLING DRILLER : H. KENNEDY
DATE LOGGED : 23+24/9/03 LOGGED BY : J. T. CHECKED BY :

DRILLING

DRILLING & CASING	DRILLING FLUID TYPE & LOSS	DRILLING PENETRATION	GROUNDWATER LEVELS	SAMPLES, TEST, ETC	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL
ROCK ROLLER 3 3/8"	2% LOSS POLYMER	F		16.00 SPT 5,7,8 N*=15 16.45	16.0		
		F		17.50 SPT 4,6,6 N*=11 17.95	17.0		
		F		19.00 SPT 3,3,3 N*=9 19.45	18.0		
		VH with 40mm + layers >60mm	SPT 10 / 70mm Refusal N*>50	20.60 20.67	19.0		
		As above	SPT 30 / 100mm Refusal N*>50	22.00 22.10	20.0		
ROCK ROLLER 2 1/8"	2% LOSS POLYMER	As above	SPT 22,27 / 150mm N*>50	23.10 23.60	21.0		
					22.0		
					23.0		
					24.0		

MATERIAL

MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary & Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
SILTY SANDY CLAY : GREY & ORANGE BROWN MOTTLED. HIGH PLASTICITY, SOME FINE & MEDIUM GRAINED SAND	M	St (HP) or St (SPT)	HP = 310 kPa ALLUVIUM
GRADUAL CHANGE WITH DEPTH.			
SANDY SILTY CLAY : GREY & ORANGE BROWN MOTTLED. HIGH PLASTICITY, PREDOMINANTLY FINE GRAINED SAND WITH SOME MEDIUM GRAIN ALSO.	M	St (HP) or St (SPT)	HP = 123 - 190 kPa
18.90			
SANDY SILTY CLAY : DARK GREY, MEDIUM TO LOW PLASTICITY, FINE GRAINED SAND.	M	F (HP) or F (SPT)	HP = 50 - 74 kPa NW CASING RUNS 20.0 - 20.60m 24.0 - 24.60m 24.0 - 25.10m 24.0 - 25.50m 24.0 - 27.70m
20.60			
SANDY SILTY GRAVEL : PALE GREEN & YELLOW BROWN, GRAVEL IS DARK GREY, FINE TO COARSE GRAINED SAND PRESENT. GRAVEL BOUND BY A SAND / SILT MATRIX.	VD		NO SAMPLE RECOVERED
VERY DENSE GRAVEL, POSSIBLY COBBLES PRESENT ALSO. SOME VERY HARD TYPE PENETRATION LAYERS AHE >60mm - MAY WELL BE AN INDICATION OF COBBLES.			
AS ABOVE.	VD		NO SAMPLE RECOVERED
	VD		

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND TRAFFIC AUTHORITY, NSW

File: 01.dgd

NON-CORE DRILL HOLE-GEOLOGICAL LOG

HOLE NO : 1

PROJECT : GRAFTON BRIDGE SITES
LOCATION :

FILE / JOB NO : G3510
SHEET : 4 of 4

POSITION : SURFACE ELLVATION : ANGLE FROM HORIZONTAL : 90°

RIG TYPE : P 400 MOUNTING : TRUCK CONTRACTOR : PULLMAN DRILLING DRILLER : H. KENNEDY

DATE STARTED : 23/9/03 DATE COMPLETED : 25/9/03 DATE LOGGED : 24+25/9/03 LOGGED BY : J. T. CHECKED BY :

DRILLING | MATERIAL

DRILLING & CASING	DRILLING FLUID	TYPE & LOSS	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES, TEST, ETC	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION (Soil Type, Colour, Plasticity or Particle Characteristic, Secondary & Minor Components)	MOISTURE CONDITION	CONSISTENCY / RELATIVE DENSITY	STRUCTURE & Other Observations
300K ROLLER BIT 115/8"	10% LOSS		VH with some 'T' layers <50mm			24.0			SANDY SILTY GRAVEL : AS PREVIOUS.		VD	ALLUVIUM
						25.0						NO SPT AT 25.00m DUE TO PROBLEMS WITH GRAVEL CAVE IN & CASING ADVANCEMENT
									25.30			
	100% LOSS		VH with some 'T' layers up to 100mm			26.0			SANDY GRAVEL : BROWN & DARK GREY, FINE TO COARSE GRAINED SAND, FINE TO COARSE SIZE GRAVEL WITH COBBLE PRESENT ALSO. SIZE OF COBBLES DIFFICULT TO DETERMINE. VERY LITTLE OR NO COHESIVE MATERIAL.			NEW ROCK SEEPER
			SPT 14,7,11 / 150mm Refusal N*=60		26.00 26.05						VD	VERY LITTLE SAMPLE RECOVERED
						27.0			27.20			
			'T' accounting for F - H						POSSIBLY SILTSTONE : PALE GREY. THE POSSIBILITY OF THIS BEING BEDROCK IS VERY HIGH.			BEDROCK
									END OF BOREHOLE 1 AT 27.70m			
						28.0						
						29.0			PROBLEMS ADVANCING CASING THROUGH GRAVEL DUE TO COMPLETELY WORN OUT CASING SHOE. BIT ADVANCEMENT OF BOREHOLE WOULD REQUIRE REMOVAL OF CASING & REPLACE SHOE. NIL DUE TO BUDGET RESTRAINTS IT WAS DECIDED TO DISCONTINUE THE BOREHOLE			
						30.0						
						31.0						
						32.0						

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND TRAFFIC AUTHORITY, NSW

File: 01.dwl

NON-CORE DRILL HOLE-GEOLOGICAL LOG

HOLE NO : 2
FILE / JOB NO : G3510
SHEET : 1 of 4

PROJECT : GRAFTON BRIDGE SITES
LOCATION :

POSITION : SURFACE ELEVATION : ANGLE FROM HORIZONTAL : 90°

RIG TYPE : JACRO MOUNTING : TRUCK CONTRACTOR : PULLMAN DRILLING DRILLER : S. SIMON

DATE STARTED : 16/9/03 DATE COMPLETED : 16/9/03 DATE LOGGED : 16-16/9/03 LOGGED BY : T. W. CHECKED BY :

DRILLING

DRILLING & CASING	DRILLING FLUID	TYPE & LOSS	DRILLING PENETRATION	GROUNDWATER OBS.	SAMPLES, TEST, ETC	DEPTH (m)
AUGER T.C. W/CASING	N/A		E		1.00 SPT 3,4,3 N*=7 1.45	0.0
					2.50 SPT 3,2,2 N*=4 2.95	1.0
					4.00 U50 4.25	2.0
ROCKROLLER	W/CASING	0% LOSS (POLYMER)	F		5.50 SPT 3,5,9 N*=14 6.05 U50 6.25	3.0
			VE		7.00 SPT 0,0,0 N*=0 7.45	4.0
						5.0
						6.0
						7.0
						8.0

MATERIAL

GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION (Soil Type, Colour, Plasticity or Particle Characteristic, Secondary & Minor Components)	MOISTURE CONDITION	CONSISTENCY / RELATIVE DENSITY	STRUCTURE & Other Observations
		0.20 CLAYEY SILT : BROWN, TRACE OF FINE SAND.			
		CLAYEY SAND / SILTY SAND : BROWN, FINE GRAINED SAND. INTERMITTENT LAYERS OF CLAYEY SAND & SILTY SAND. PLASTICITY VARYING FROM NON-PLASTIC TO LOW PLASTICITY MICACEOUS.	D		
		1.80 CLAYEY SILT : YELLOW / ORANGE BROWN, SOME FINE SAND, MICACEOUS, LOW PLASTICITY.	M	VSt to St	
		2.80 SILTY CLAY : GREY & RED BROWN MICACEOUS. MEDIUM PLASTICITY.		F	HP = 75 kPa
		5.25 SILTY CLAY : GREY & YELLOW BROWN HIGH PLASTICITY.		VSt	HP = 80 kPa HP = 250 - 320 kPa
		6.40 SILTY CLAY : AS ABOVE EXCEPT PREDOMINANTLY GREY.		VSt	SPT ADVANCED 450mm UNDER HAMMER WEIGHT ONLY HP = 25 kPa

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND TRAFFIC AUTHORITY, NSW

File: 02.dwl

NON-CORE DRILL HOLE-GEOLOGICAL LOG

HOLE NO : 2

PROJECT : GRAFTON BRIDGE SITES
LOCATION :

FILE / JOB NO : G3510
SHEET : 2 of 4

POSITION : SURFACE ELEVATION : ANGLE FROM HORIZONTAL : 90°

RIG TYPE : JACRO MOUNTING : TRUCK CONTRACTOR : PULLMAN DRILLING DRILLER : S. SIMON

DATE STARTED : 16/9/03 DATE COMPLETED : 18/9/03 DATE LOGGED : 16-18/9/03 LOGGED BY : I. W. CHECKED BY :

DRILLING | MATERIAL

DRILLING & CASING	DRILLING FLUID TYPE & LOSS	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES TEST, ETC	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION (Soil Type, Colour, Plasticity or Particle Characteristic, Secondary & Minor Components)	MOISTURE CONDITION	CONSISTENCY / RELATIVE DENSITY	STRUCTURE & Other Observations
ROCK ROLLER / NW CASING	(% LOSS (POLYMER))	F		8.70 SPT 6,8,14 N*=22 8.95	8.0			SILTY CLAY : YELLOW BROWN & BROWN, HIGH PLASTICITY.	M	VSt	HP = 300 - 350 kPa
		VSt		10.00 SPT 2,3,4 N*=7 10.45	9.0						
					10.0			CLAYEY SILT : BROWN WITH FINE SAND, MICACEOUS, LOW TO MEDIUM PLASTICITY.		F	HP = 50 - 60 kPa
				11.00 SPT 1,1,1 N*=2 11.05	11.0					S	HP < 25 kPa
		F to F		13.00 SPT 2,2,5 N*=7 13.45	12.0			12.60		L	
		F			13.0			SILTY SAND : ORANGE BROWN, FINE, MEDIUM & COARSE GRAINED SAND, MICACEOUS, NON-PLASTIC.			SMALL GRAVEL LAYERS
		E		14.00 SPT 4,4,5 N*=9 14.05	14.0			14.30			
					15.0			SILTY SAND : ORANGE BROWN, FINE TO MEDIUM GRAINED SAND, MICACEOUS, OCCASIONAL CLAYEY SAND LAYERS, PLASTICITY VARYING FROM NON-PLASTIC TO BORDERLINE.			
		VH			16.0			16.00 SANDY GRAVEL : YELLOW BROWN, DARK GREY, GREEN GREY & RED BROWN, FINE, MEDIUM & COARSE GRAVEL WITH COBBLES.		VD	

See Explanatory Notes for details of abbreviations & limits of descriptions.

ROADS AND TRAFFIC AUTHORITY, NSW

File: 02.dwl

NON-CORE DRILL HOLE-GEOLOGICAL LOG

HOLE NO : 2
FILL / JOB NO : 03510
SHEET : 3 of 4

PROJECT : GRAFTON BRIDGE SITES
LOCATION :

POSITION : SURFACE ELEVATION : ANGLE FROM HORIZONTAL : 90°

RIG TYPE : JACROP160 MOUNTING : TRUCK CONTRACTOR : PULLMAN DRILLING DRILLER : S SIMON / T KENNEDY

DATE STARTED : 16/9/03 DATE COMPLETED : 18/9/03 DATE LOGGED : 16-18/9/03 LOGGED BY : T. W. CHECKED BY :

DRILLING | MATERIAL

DRILLING & CASING	DRILLING FLUID TYPE & LOSS	DRILLING PENETRATION	GROUNDWATER LEVELS	SAMPLES, TEST, ETC	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION (Soil Type, Colour, Plasticity or Particle Characteristic, Secondary & Minor Components)	MOISTURE CONDITION	CONSISTENCY / RELATIVE DENSITY	STRUCTURE & Other Observations
				16.00 SPT 30 R 16.15	16.0			SANDY GRAVEL : AS PREVIOUS.	M	VD	ALLUVIUM
		VH									
	30% LOSS (POLYMER)				17.0						
				17.50 SPT 12,7,7 N=14 17.95				SILTY SAND : ORANGE BROWN, FINE, MEDIUM & COARSE GRAINED SAND. NON-PLASTIC.		MD	NO SAMPLE RECOVERED
					18.0						
								GRAVEL : DARK GREY & YELLOW BROWN. MEDIUM & COARSE GRAVEL WITH FREQUENT COBBLES & BOULDERS.		VD	NO SAMPLE RECOVERED
				19.00 SPT 34R 19.16	19.0						
ROCK ROLLER											
NW CASING	80% LOSS (POLYMER)				20.0						
					21.0						NO SAMPLE RECOVERED
				21.60 SPT 60R 21.85							
					22.0						
AZ/CASING											
NW CASING	10% LOSS (POLYMER)			SPT 23.00 60R 23.19	23.0						NO SAMPLE RECOVERED
											START OF BEDROCK
								SANDSTONE : LIGHT GREY, FINE GRAINED SAND. OCCASIONAL THIN CLAY LAYERS.			
					24.0			END OF NON CORE DRILLING AT 24.00m			

SEE CORED DRILL LOG SHEET FOR DETAILS

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND TRAFFIC AUTHORITY, NSW

File: 02.dwl

CORED DRILL HOLE LOG

HOLE NO : 2
FILE / JOB NO : G3510
SHEET : 4 of 4

PROJECT : GRAFTON BRIDGE SITES
LOCATION :

POSITION : SURFACE ELEVATION : ANGLE FROM HORIZONTAL : 90°

RIG TYPE : P 150 MOUNTING : TRUCK CONTRACTOR : C. PULLMAN DRILLER : H. KENNEDY

CASING DIAMETER : NW BARREL (Length) : 1.5m + 3.0m BIT : IMPREG / STEP FACED BIT CONDITION : GOOD

DATE STARTED : 16/9/03 DATE COMPLETED : 18/9/03 DATE LOGGED : 16-18/9/03 LOGGED BY : T. W. CHECKED BY :

DRILLING | MATERIAL | FRACTURES

PROGRESS: DRILLING & CASING; WATER; CORE RECOVERY (%); SAMPLES & FIELD TESTS; DEPTH (m); GRAPHIC LOG

DESCRIPTION
ROCK TYPE : Colour, Grain size, Structure
(texture, fabric, mineral composition, hardness, alteration, cementation, etc as applicable)

WEATHERING; CST STRENGTH $I_s(50)$ MPa; NATURAL FRACTURING SPACING (mm); VISUAL

ADDITIONAL DATA
(joints, bandings, seams, zones, etc)
Description, orientation, infilling (coating, shape, roughness, thickness), other

START CORING AT 24.00m

SANDSTONE : LIGHT GREY FINE GRAINED.

24.07

SILTSTONE :
DARK GREY, INDISTINCT BEDDING.

LAMINITE :
INTERBEDDED DARK GREY SILTSTONE & LIGHT GREY FINE GRAINED SANDSTONE AT 0° - 10°.

25.70 Is(50) a=0.56 MPa

26.35

SANDSTONE :
LIGHT GREY WITH OCCASIONAL DARK GREY SILTY LAMINAE. BEDDED AT 0° - 10°.

Is(50) a=0.41 MPa

27.02

LAMINITE :
INTERBEDDED DARK GREY SILTSTONE & LIGHT GREY FINE GRAINED SANDSTONE.

27.36

27.48

SILTSTONE :
DARK GREY, INDISTINCT BEDDING.

Is(50) a=0.33 MPa

28.34

LAMINITE :
INTERBEDDED DARK GREY SILTSTONE & LIGHT GREY FINE GRAINED SANDSTONE AT 0° - 10°.

Is(50) a=0.64 MPa

28.94

END OF BOREHOLE 2 AT 28.94m

10mm CLAY LAYER

70mm CLAYEY LAYER

40mm CLAY LAYER

HANDLING BREAK

DRILL LIFT

HANDLING BREAK

DRILL BREAK

DRILL BREAK

KMC CORING

10% CSS POLYMER

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND TRAFFIC AUTHORITY, NSW

File: 02_c.dwl


RTA
G 3510
GRAFTON BRIDGES
BH:2
24.00 - 28.94 M
24
25
26
27
28
END
28.94 M

NON-CORE DRILL HOLE-GEOLOGICAL LOG

HOLE NO : 3
FILE / JOB NO : G3510
SHEET : 1 of 3

PROJECT : GRAFTON BRIDGE SITES
LOCATION : WEST SIDE OF NORTHERN PIER, EXISTING STEEL BRIDGE
POSITION :
SURFACE ELEVATION :
ANGLE FROM HORIZONTAL : 90°
RIG TYPE : P 400 MOUNTING : TRUCK
CONTRACTOR : PULLMAN DRILLING DRILLER : T. KENNEDY
DATE STARTED : 26/9/03 DATE COMPLETED : 26/9/03 DATE LOGGED : 26/9/03 LOGGED BY : J. T. CHECKED BY :

DRILLING | MATERIAL

DRILLING & CASING	SPILLING FLUID	TYPE & LOSS	DRILLING PENETRATION	GROUNDWATER LEVELS	SAMPLES, TEST, ETC	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION (Soil Type, Colour, Plasticity or Particle Characteristic; Secondary & Minor Components)	MOISTURE CONDITION	CONSISTENCY / RELATIVE DENSITY	STRUCTURE & Other Observations
4" AUGER T.C. BIT	N/A	E				0.0			SILTY CLAY : BROWN, HIGH PLASTICITY, SOME FINE & MEDIUM GRAINED SAND	M		ALLUVIUM
						0.80						
		E			1.00 SPT 1,1,1 N*=2 1.45	1.0			SILTY CLAY : DARK BROWN, MEDIUM TO HIGH PLASTICITY, SOME FINE & MEDIUM GRAINED SAND.	M	F (H.P.) q_u (SPT)	HP = 90 kPa
	N/A					1.70						
		VE				2.0			SANDY SILTY CLAY : DARK GREY, FINE & MEDIUM GRAINED SAND, MEDIUM PLASTICITY.	W	VS / F	ESTIMATION
						2.20			SILTY SAND : GREY, FINE & MEDIUM GRAINED.			
					2.50 SPT 0,1,1 N*=2 2.95	2.80			SAND : YELLOW BROWN / PALE BROWN, PREDOMINANTLY MEDIUM GRAINED, SOME FINE & COARSE GRAIN PRESENT.		L	
		E				3.0						NW CASING RUNG 26/9 - 5.50m - 7.00m - 8.50m - 10.00m
					4.00 SPT 3,5,5 N*=10 4.45	4.0			AS ABOVE EXCEPT FINE TO COARSE GRAINED SAND.	W	L / MD	
		E				5.0						
100% ROLLER BIT	25%-30% LOSS (POLYMER)				5.50 SPT 3,3,4 N*=7 6.05	6.0			AS ABOVE EXCEPT WITH A TRACE OF COARSE SIZED GRAVEL	W	L	
		F				6.40			GRAVELLY SAND : YELLOW BROWN, FINE TO COARSE GRAINED SAND, SOME FINE TO COARSE SIZED GRAVEL.			
						6.70						
		E			7.00 SPT 6,6,7 N*=13 7.45	7.0			SAND : BROWN, FINE TO COARSE GRAINED		MD	
						8.0						

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND TRAFFIC AUTHORITY, NSW

File: 03.dwl

NON-CORE DRILL HOLE-GEOLOGICAL LOG

HOLE NO : 3

PROJECT : GRAFTON BRIDGE SITES
FILE / JOB NO : G3510

LOCATION : WEST SIDE OF NORTHERN PIER, EXISTING STEEL BRIDGE
SHEET : 2 of 9

POSITION : SURFACE ELEVATION : ANGLE FROM HORIZONTAL : 90°

RIG TYPE : P 400 MOUNTING : TRUCK CONTRACTOR : PULLMAN DRILLING DRILLER : H. KENNEDY

DATE STARTED : 26/9/03 DATE COMPLETED : 26/9/03 DATE LOGGED : 26/9/03 LOGGED BY : J. T. CHECKED BY :

DRILLING | MATERIAL

DRILLING & CASING	DRILLING FLUID & % LOSS	DRILLING PENETRATION	GROUNDWATER LEVELS	SAMPLES, TEST, ETC	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION (Soil Type, Colour, Plasticity or Particle Characteristic, Secondary & Minor Components)	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
ROCK ROLLER 2 15/16"	50% LOSS	E		9.50 SPT 6,8,6 N=14 9.95	9.0			SAND : YELLOW BROWN, FINE TO COARSE GRAINED SAND.			ALLUVIUM
		E with some H bands		10.10 SPT 4,7,9 N=16 10.55	10.0			GRAVELLY SAND : AS ABOVE, FINE & MEDIUM SIZE GRAVEL SOME SANDY GRAVEL LAYERS <100mm.			
	100% LOSS	H & F layers	NO SPT TESTING - SEE NOTE		11.0						NOTE : BOREHOLE CAVED IN PRIOR TO SPT TESTING FROM 9.0m. EVERY ADVANCEMENT OF 1.50m THE HOLE HAD TO BE CASED TO ALLOW TESTING. IT WAS DECIDED TO ADVANCE THE HOLE THROUGH THE OVERBURDEN & PROVE BEDROCK WITH THE ROCK ROLLER. TIME & BUDGET CONSTRAINTS WERE ALSO A FACTOR.
		H - VH with F layers <100mm			12.0			SANDY GRAVEL WITH LAYERS OF GRAVELLY SAND THROUGHOUT : GRAVEL MOSTLY FINE & MEDIUM SIZE, SOME COARSE SIZE, SOME COBBLES PRESENT.			
		VH E & F layers some H bands			13.0						
					14.0						
					15.0			100mm COBBLE			
					16.0			SAND & GRAVELLY SAND LAYERS : SOME SANDY GRAVEL LAYERS			

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND TRAFFIC AUTHORITY, NSW

File: 03.dwl

NON-CORE DRILL HOLE-GEOLOGICAL LOG

HOLE NO : 3
FILE / JOB NO : 03510
SHEET : 3 of 3

PROJECT : GRAFTON BRIDGE SITES
LOCATION : WEST SIDE OF NORTHERN PIER, EXISTING STEEL BRIDGE

POSITION : SURFACE ELEVATION : ANGLE FROM HORIZONTAL : 90°

RIG TYPE : F400 MOUNTING : TRUCK CONTRACTOR : PULLMAN DRILLING DRILLER : H. KENNEDY

DATE STARTED : 26/9/03 DATE COMPLETED : 26/9/03 DATE LOGGED : 26/9/03 LOGGED BY : J. T. CHECKED BY :

DRILLING | MATERIAL

DRILLING & CASING	DRILLING FLUID	TYPE & LOSS	DRILLING PENETRATION	GROUNDWATER LEVELS	SAMPLES TEST, ETC	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION (Soil Type, Colour, Plasticity or Particle Characteristic, Secondary & Minor Components)	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
						16.0			SANDY GRAVEL / GRAVELLY SAND LAYERS. NO WATER RETURN			ALLUVIUM
			15 Blows at various intervals			17.0						
ROCKROLLER 15"	100% LOSS		VH			18.0			200mm COBBLE			
			5 blows 5mm layers						PREDOMINANTLY GRAVELLY SAND WITH OCCASIONAL SANDY GRAVEL LAYERS.			
			VH			19.0						
						20.0						
			VH						200mm COBBLE			
			F						COBBLES AT 20 - UP TO 200mm			
			VH	Rapidly bouncing					20.70			
			VH	Even penetration		21.0			POSSIBLY FINE GRAINED SANDSTONE : THE POSSIBILITY OF THIS BEING BEDROCK IS VERY HIGH DUE TO THE LOW PENETRATION OF THE ROCK ROLLER.			BEDROCK
									END OF BOREHOLE 3 AT 21.35m			
						22.0						
						23.0						
						24.0						

See Explanatory Notes for details of abbreviations & basis of description.

ROADS AND TRAFFIC AUTHORITY, NSW

File: 03.dwf

NON-CORE DRILL HOLE-GEOLOGICAL LOG

HOLE NO : 4
FILE / JOB NO : G3510
SHEET : 1 of 2

PROJECT : GRAFTON BRIDGE SITES
LOCATION :

POSITION : SURFACE ELEVATION : ANGLE FROM HORIZONTAL : 90°

RIG TYPE : P400 MOUNTING : TRUCK CONTRACTOR : PULLMAN DRILLING DRILLER : H. KENNEDY

DATE STARTED : 25/8/03 DATE COMPLETED : 26/8/03 DATE LOGGED : 25+26/9/03 LOGGED BY : J. L. CHECKED BY :

DRILLING

DRILLING & CASING	DRILLING FLUID TYPE & LOSS	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES, TEST, ETC	DEPTH (m)
4" AUGER	N/A	E	1.80m ▽ 12/9/03	1.00 SPT 1,0,1 N*=1 1.45	0.0
		VE			1.0
	N/A			2.50 SPT 0,0,0 N*=0 2.95	2.0
		VE			3.0
				4.00 SPT 0,0,0 N*=0 4.45	4.0
ROCK ROLLER 3 7/8"	2% LOSS	VE			5.0
		E		5.50 SPT 3,1,5 N*=6 5.95	6.0
				7.00 SPT 4,2,5 N*=7 7.45	7.0
		E			8.0

MATERIAL

GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION (Soil Type, Colour, Plasticity or Particle Characteristic, Secondary & Minor Components)	MOISTURE CONDITION	CONSISTENCY / RELATIVE DENSITY	STRUCTURE & Other Observations
		SANDY CLAY : BROWN, FINE & MEDIUM GRAINED SAND, LOW & LOW TO MEDIUM PLASTICITY.	D		FILL
		0.70 SILTY SANDY CLAY : DARK BROWN, MEDIUM TO HIGH PLASTICITY, SOME FINE & MEDIUM GRAINED SAND.	M		ALLUVIUM
		1.20 SILTY CLAY : DARK GREY, MEDIUM PLASTICITY, SOME FINE GRAINED SAND.	M	(PP)	HP = 90 kPa
			W		
		AS ABOVE	M	VS (HP)	SPT PENETRATES UNDER THE WEIGHT OF SPT HP = 10 kPa
			M	VS	SPT PENETRATES UNDER THE WEIGHT OF SPT HP = 0 kPa
		5.20 SILTY SAND : GREY, PREDOMINANTLY MEDIUM GRAINED WITH SOME SILT & FINE GRAINED SAND, SOME SANDY CLAY LAYERS (DARK GREY)	W	L (SPT)	
		AS ABOVE	W	L (SPT)	

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND TRAFFIC AUTHORITY, NSW

File: 04.dwl

NON-CORE DRILL HOLE-GEOLOGICAL LOG

HOLE NO : 4

PROJECT : GRAFTON BRIDGE SITES
LOCATION :

FILE / JOB NO : G3510
SHEET : 2 of 2

POSITION : SURFACE ELEVATION : ANGLE FROM HORIZONTAL : 90°

RIG TYPE : P 400 MOUNTING : TRUCK CONTRACTOR : FULLMAN DRILLING DRILLER : H. KENNEDY

DATE STARTED : 25/9/03 DATE COMPLETED : 26/9/03 DATE LOGGED : 26/9/03 LOGGED BY : J. T. CHECKED BY :

DRILLING | MATERIAL

DRILLING & CASING	DRILLING FLUID TYPE & LOSS	PENETRATION	GROUNDWATER LEVELS	SAMPLES, TEST, ETC	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION (Soil Type, Colour, Plasticity or Particle Characteristic, Secondary & Minor Components)	MOISTURE CONDITION	CONSISTENCY / RELATIVE DENSITY	STRUCTURE & Other Observations
ROCK ROLLER 215/16"	5% LOSS POLYMER			6.50 SPT 7,7,6 N*=13 8.0m 10.00 SPT 8,11,13 N*=24 10.45	8.0			SILTY SAND : GREY, FINE & MEDIUM GRAINED SAND SMALL PERCENTAGE OF CLAY PRESENT.	W	L (SPT)	ALLUVIUM
					9.0						Material is usually coarser with depth
					10.0			AS ABOVE EXCEPT CLEAN SAND.		MD (SPT)	
								10.60			
	100% LOSS				11.0			SANDY GRAVEL : GREY, FINE TO COARSE GRAINED SAND. FINE TO COARSE SIZE GRAVEL. POSSIBLE COBBLE SIZE FROM 11.20m		D VD	DENSITY ESTIMATION
								END OF BOREHOLE 4 AT 11.50m			
					12.0			HOLE COMPLETED IN THIS STRATUM AS INSTRUCTED			DENOTES GRADUAL CHANGE WITH DEPTH
					13.0						
					14.0						
					15.0						
					16.0						

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND TRAFFIC AUTHORITY, NSW

File: 04.dwl

APPENDIX C

Test Pit Logs and Photographs

EXPLANATORY NOTES - DRILL & EXCAVATION LOGS

GENERAL

Information obtained from site investigations is recorded on log sheets. The "Cored Drill Hole Log" presents data from an operation where a core barrel has been used to recover material - commonly rock. The "Non-Core Drill Hole - Geological Log" presents data from an operation where coring has not been used and information is based on a combination of regular sampling and insitu testing. The material penetrated in non core drilling is commonly soil but may include rock. The "Excavation - Geological Log" presents data and drawings from exposures of soil and rock resulting from excavation of pits, trenches, etc.

The heading of the log sheets contains information on Project Identification, Hole or Pit Identification, Location and Elevation. The main section of the logs contains information on methods and conditions, material substance description and structure presented as a series of columns in relation to depth below the ground surface, which is plotted on the left side of the log sheet. The common depth scale is 8m per drill log sheet and about 3-5m for excavation logs/sheets.

As far as is practicable the data contained on the log sheets is factual. Some interpretation is inevitable in the identification of material boundaries in areas of partial sampling, the location of areas of core loss, description and classification of material, estimation of strength and identification of drilling induced fractures. Material description and classifications are based on SAA Site Investigation Code AS 1726 - 1993 with some modifications as defined below.

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

DRILLING

Drilling & Casing

AS	Auger Screwing
ADV	Auger Drilling with V-Bit
ADT	Auger Drilling with TC Bit
WB	Wash-bore drilling
RR	Rock Roller
NMLC	NMLC core barrel
NQ	NQ core barrel
HMLC	HMLC core barrel
HQ	HQ core barrel

Drilling Fluid/Water

The drilling fluid used is identified and loss of return to the surface estimated as a percentage.

Drilling Penetration/Drill Depth

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

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

Groundwater Levels

Date of measurement is shown.

▼ Standing water level measured in completed borehole

▽ Level taken during or immediately after drilling

Samples/Tests

D	Disturbed
U	Undisturbed
C	Core Sample
SPT	Standard Penetration Test
N	Result of SPT (*sample taken)
VS	Vane Shear Test
IMP	Borehole Impression Device
PBT	Plate Bearing Test
PZ	Piezometer Installation
HP	Hand Penetrometer Test

EXCAVATION LOGS

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

MATERIAL DESCRIPTION - SOIL

Classification Symbol - In accordance with the Unified Classification System (AS 1726-1993, Appendix A, Table A1)

Material Description - In accordance with AS 1726-1993, Appendix A2.1

Moisture Condition

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

Consistency - In accordance with AS 1726-1993, Appendix A2.5

VS	Very Soft	< 25kPa
S	Soft	25 - 50kPa
F	Firm	50 - 100kPa
St	Stiff	100 - 200kPa
VSt	Very Stiff	200 - 400kPa
H	Hard	> 400kPa

Strength figures quoted are the approximate range of Unconfined Compressive Strength for each class.

Density Index. (%) is estimated or is based on SPT results. Approximate N Value correlation is shown in right column.

VL	Very Loose	< 15%	0 - 4
L	Loose	15 - 35%	4 - 10
MD	Medium Dense	35 - 65%	10 - 30
D	Dense	65 - 85%	30 - 50
VD	Very Dense	> 85%	> 50

MATERIAL DESCRIPTION -ROCK

Material Description

Identification of rock type, composition and texture based on visual features in accordance with AS 1726-1993, Appendix A3.1-A3.3 and Tables A6a, A6b and A7

Core Loss

Is shown at the bottom of the run unless otherwise indicated

Bedding

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

Weathering - No distinction is made between weathering and alteration. Weathering classification assists in identification but does not imply engineering properties.

Fresh (FR)	Rock substance unaffected by weathering
Slightly Weathered (SW)	Rock substance partly stained or discoloured. Colour and texture of fresh rock recognisable.
Moderately Weathered (MW)	Staining or discolouration extends throughout rock substance. Fresh rock colour not recognisable.
Highly Weathered (HW)	Stained or discoloured throughout. Signs of chemical or physical alteration. Rock texture retained.
Extremely Weathered (EW)	Rock texture evident but material has soil properties and can be remoulded.

Strength - The following terms are used to described rock strength:

Rock Strength Class	Abbreviation	Point Load Strength Index Is(50) (MPa)
Extremely Low	EL	< 0.03
Very Low	VL	0.03 to 0.1
Low	L	0.1 to 0.3
Medium	M	0.3 to 1
High	H	1 to 3
Very High	VH	3 to 10
Extremely High	EH	> 10

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

- Diametral Point Load Test
- Axial Point Load Test

Where the estimated strength bog covers more than one range it indicate the rock strength varies between the limits shown.

MATERIALS STRUCTURE/FRACTURES

ROCK

Natural Fracture Spacing - A plot of average fracture spacing excluding defects known or suspected to be due to drilling, core boxing or testing.

Visual Log - A diagrammatic plot of defects showing type, spacing and orientation in relation to core axis. *Closed defects* are shown as dashed lines

Additional Data - Description of individual defects by type, orientation, in-filling, shape and roughness in accordance with AS 1726-1993, Appendix A Table A10, notes and Figure A2

Type	BP	Bedding Parting
	JT	Joint
	SM	Seam
	FZ	Fracture Zone
	SZ	Shear Zone
	VN	Vein
	FL	Foliation
	CL	Cleavage

Orientation - angle relative to the plane normal to the core axis.

Infilling	CN	Clean
	X	Carbonaceous
	Clay	Clay
	CT	Chlorite
	CA	Calcite
	Fe	Iron Oxide
	Qz	Quartz
	MS	Secondary Mineral
	MU	Unidentified Mineral
Shape	PR	Planar
	CU	Curved
	UN	Undulose
	ST	Stepped
	IR	Irregular
	DIS	Discontinuous
Roughness	POL	Polished
	SL	Slickensided
	S	Smooth
	RF	Rough
	VR	Very Rough

SOIL

Structures - Fissuring and other defects are described in acc... AS 1726-1993, Appendix A2.6, using the terminology for ...

Origin - Where practicable an assessment is provided ... origin of the soil, eg fill, topsoil, alluvium, colluvium, resi...

RTA TECHNICAL SERVICES NORTHERN

EXCAVATION – GEOLOGICAL LOG

PIT No. GB1
JOB No. H/40600
SHEET 1 OF 2

PROJECT: Grafton Bridge Duplication Realignment Options
LOCATION:
EQUIPMENT TYPE: Venlon 923
METHOD: BACKHOE
EXCAVATION DIMENSIONS: 0.45m wide, 3.7m long

SURFACE ELEVATION:
POSITION:
DATE OF EXCAVATION: 17/9/03

BASE OF EXCAVATION 1 2 3	SUPPORT	GROUND WATER LEVELS	NOTES, SAMPLES, TESTS, ETC.	DEPTH (METRES)	CLASSIFICATION SYMBOL	MOISTURE CONDITION	CONSISTENCY / RELATIVE DENSITY	STRUCTURE & OTHER OBSERVATIONS
					CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION Based on Unified Classification System MATERIAL DESCRIPTION SOIL TYPE, PLASTICITY OR PARTICLE CHARACTERISTIC, COLOUR, SECONDARY AND MINERAL COMPONENTS			
			0.15		Clayey SILT – light grey-brown, low plasticity	-	D to M	L	TOPSOIL and GRASS
			GB1A	0.15	Silty CLAY/Clayey SILT - grey-brown, low plasticity	OL to CL	M	H	ALLUVIAL RIVER SILT Trace Charcoal HP: 400+Kpa
	Ni	Nil	0.5	-0.5-					
				-1.0-					
				-1.5-					
			2.0	-2.0-				VST	HP: 300 to 400Kpa
			GB1B						
			2.3						
				-2.5-	- as above except light orange brown, low plasticity			VST	HP: 200 to 300KPa

PHOTOGRAPHS ■ YES □ NO

SUPPORT: 1 = Timbering
BASE OF EXCAVATION 1 = Easy 2 = Moderate 3 = Hard
WATER → Water Inflow ← Water Outflow

MOISTURE: D = Dry M = Moist W = Wet

CONSISTENCY / RELATIVE DENSITY
VS – Very Soft VST – Very Stiff L = Loose
S = Soft H – Hard MD – Moderately Dense
F – Firm Gd – Gravelly D – Dense
ST – Stiff VL – Very Loose VD – Very Dense

LOGGED: DAVID GROTH
DESIGNATION: SCIENTIFIC OFFICER
CHECKED: DAVID GROTH

RTA TECHNICAL SERVICES NORTHERN

EXCAVATION – GEOLOGICAL LOG

PIT No. GB1

JOB No. HV40856

SHEET 2 OF 2

PROJECT: Grafton Bridge Duplication Realignment Options
LOCATION:
EQUIPMENT TYPE: Voniori 923
METHOD: BACKHOE
EXCAVATION DIMENSIONS: 0.45m wide, 3.7m long

SURFACE ELEVATION:
POSITION:
DATE OF EXCAVATION: 17/9/03

EASE OF EXCAVATION 1 2 3	SUPPORT	GROUND WATER LEVELS	NOTES, SAMPLES, TESTS, ETC.	DEPTH (METRES)	CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION Based on Unified Classification System. MATERIAL DESCRIPTION. SOIL TYPE, PLASTICITY OR PARTICLE CHARACTERISTIC, COLOUR, SECONDARY AND MINERAL COMPONENTS	CLASSIFICATION SYMBOL	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & OTHER OBSERVATIONS
			3.0 GB1C 3.3	-3.5-	A.F.D	CL to CL	M	VST	
	Nil	Nil	4.0 GB1D 4.3	-4.0-	Silty CLAY – grey mottled orange, medium plasticity	CI	M	VST	HP: 200 to 300KPa
				-4.5-	Test Pit ends at 4.3m (Limit of Reach)				
				-5.0-					
				-5.5-					

PHOTOGRAPHS ■ YES □ NO

SUPPORT – T – Timbering
EASE OF EXCAVATION 1 – Easy 2 – Moderate 3 – Hard
WATER → Water Inflow ← Water Outflow

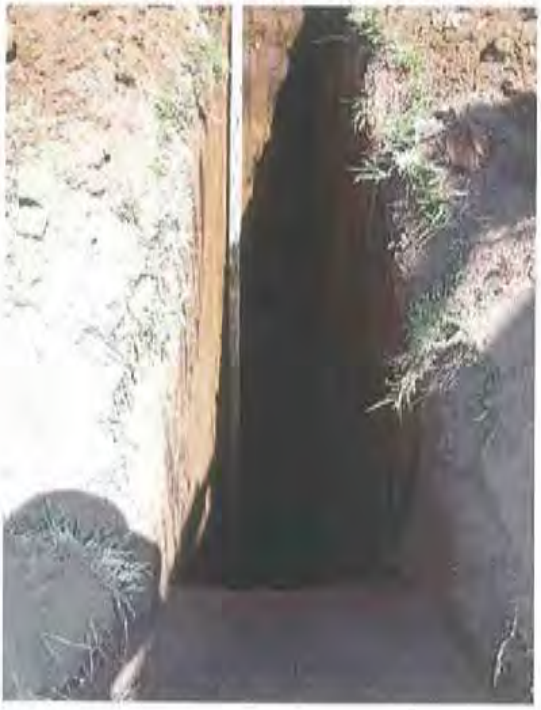
MOISTURE
D – Dry
M – Moist
W – Wet

CONSISTENCY / RELATIVE DENSITY
VS – Very Soft VST – Very Stiff F – Loose
S – Soft H – Hard MD – Moderately Dense
F – Firm FR – Friable D – Dense
ST – Stiff VL – Very Loose VD – Very Dense

LOGGED: DAVID GHOTH
DESIGNATION: SCIENTIFIC OFFICER
CHECKED: DAVID GHOTH

Grafton Bridge Route Selection – Test Pitting

TEST PIT 1



RTA TECHNICAL SERVICES NORTHERN

PIT No. GB2

EXCAVATION – GEOLOGICAL LOG

JOB No. H/40856

SHEET 1 OF 2

PROJECT: Grafton Bridge Duplication Realignment Options
LOCATION:
EQUIPMENT TYPE: Venieri 923
METHOD: BACKHOE
EXCAVATION DIMENSIONS: 0.45m wide, 3.9m long

SURFACE ELEVATION:
POSITION:
DATE OF EXCAVATION: 17/9/03

EASE OF EXCAVATION 1 2 3	SUPPORT	GROUND WATER LEVELS	NOTES, SAMPLES, TESTS, ETC.	DEPTH (METRES)	CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION Based on Unified Classification System MATERIAL DESCRIPTION SOIL, TYPE, PLASTICITY OR PARTICLE CHARACTERISTIC, COLOUR, SECONDARY AND MINERAL COMPONENTS	CLASSIFICATION SYMBOL	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & OTHER OBSERVATIONS
					Ironstone Gravel and Clayey SILT – orange and grey-brown, low plasticity, trace river gravel cobbles	-	D to M	L	TOPSOIL and Road Gravel Grass roots and root fibres
			0.25	0.25					
			GB2A		Clayey SILT/Silty CLAY – dark grey-brown, low plasticity	OL to CL	D to M	H	ALLUVIUM Root Fibres and trace Charcoal HP: 500+KPa
			0.5	-0.5-					
			0.95		- as above except brown , low to medium plasticity				
			GB2B	-1.0-					
			1.3					H	HP: 500+KPa
				-1.5-					
				-2.0-					
			2.1	2.05					
			GB2C		Silty CLAY – grey mottled orange, medium to high plasticity, trace fine gravel	CI to CH	M	ST to VST	HP: 180 to 300KPa
			2.5	-2.5-					
								ST	HP: 120 to 200KPa
			2.75	2.75					
			GB2D		Silty CLAY – light grey mottled red, high plasticity	CH	M to W	F	HP: 50 to 100KPa
			3.0						

PHOTOGRAPHS ■ YES ☐ NO

SUPPORT – T = Timbering
EASE OF EXCAVATION 1 – Easy 2 – Moderate 3 – Hard
WATER ▶ Water Inflow ◀ Water Outflow

MOISTURE
D – Dry
M – Moist
W - Wet

CONSISTENCY / RELATIVE DENSITY
VS – Very Soft VST – Very Stiff L – Loose
S – Soft H – Hard MD – Moderately Dense
F – Firm FB – Friable D – Dense
ST – Stiff VL – Very Loose VD – Very Dense

LOGGED: DAVID GROTH
DESIGNATION: SCIENTIFIC OFFICER
CHECKED: DAVID GROTH

RTA TECHNICAL SERVICES NORTHERN

EXCAVATION – GEOLOGICAL LOG

PIT No. GB2
JOB No. 10/40856
SHEET 2 OF 2

PROJECT: Grafton Bridge Duplication Realignment Options
LOCATION:
EQUIPMENT TYPE: Venieri 923
METHOD: BACKHOE
EXCAVATION DIMENSIONS: 0.45m wide, 3.9m long

SURFACE ELEVATION:
POSITION:
DATE OF EXCAVATION: 17/9/03

BASE OF EXCAVATION 1 2 3	SUPPORT	GROUND WATER LEVELS	NOTES, SAMPLES, TESTS, ETC.	DEPTH (METRES)	CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION Based on Unified Classification System MATERIAL DESCRIPTION SOIL TYPE, PLASTICITY OR PARTICLE CHARACTERISTIC, COLOUR, SECONDARY AND MINERAL COMPONENTS	CLASSIFICATION SYMBOL	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & OTHER OBSERVATIONS
					A.P.D	CH	W	F	
			3.42						HP: 50 to 60KPa
	Nil		GB2E	-3.5-	CLAY – dark grey with yellow and red mottles, high plasticity	CH	W	VS to S	Clay appears to have EW rock structure, and appears fissured.
			3.8						HP: 10 to 50KPa
			4.0	-4.0-					HP: 30 to 70KPa
			GB2F						
			4.35						
				-4.5-	Test Pit ends at 4.35m (Limit of Reach)				Test Pit in-filled with water. Standing water level at a depth of 3.4m.
				-5.0-					
				-5.5-					

PHOTOGRAPHS ■ YES □ NO

LOGGED: DAVID GROTH

SUPPORT – T = Timbering
BASE OF EXCAVATION
1 – Easy 2 – Moderate 3 – Hard
WATER
Water Inflow ← Water Outflow

DESIGNATION: SCIENTIFIC OFFICER

MOISTURE
D – Dry
M – Moist
W – Wet

CONSISTENCY / RELATIVE DENSITY

VS = Very Soft	VST – Very Stiff	L – Loose
S – Soft	H – Hard	MD – Moderately Dense
F – Firm	FR – Friable	D – Dense
ST – Stiff	VL – Very Loose	VD – Very Dense

CHECKED: DAVID GROTH

Grafton Bridge Route Selection – Test Pitting

TEST PIT 2

Grafton Bridge Route Selection – Test Pitting

TEST PIT 2

RTA TECHNICAL SERVICES NORTHERN

EXCAVATION – GEOLOGICAL LOG

PIT No. GB3
JOB No. 11/40856
SHEET 1 OF 2

PROJECT: Grafton Bridge Duplication Realignment Options
LOCATION:
EQUIPMENT TYPE: Venteri 928
METHOD: BACKHOE
EXCAVATION DIMENSIONS: 0.45m wide, 4.0m long

SURFACE ELEVATION:
POSITION:
DATE OF EXCAVATION: 17/9/03

EASE OF EXCAVATION 1 2 3	SUPPORT	GROUND WATER LEVELS	NOTES, SAMPLES, TESTS, ETC.	DEPTH (METRES)	CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION Based on Unified Classification System MATERIAL DESCRIPTION SOIL TYPE, PLASTICITY OR PARTICLE CHARACTERISTIC, COLOUR, SECONDARY AND MINERAL COMPONENTS	CLASSIFICATION SYMBOL	MOISTURE CONDITION	CONSISTENCY / RELATIVE DENSITY	STRUCTURE & OTHER OBSERVATIONS
					Ironstone GRAVEL – orange-brown, non-plastic, ironstone gravel and cobbles to 100mm Ø	-	D to M	L	TOPSOIL and Road Gravel Grass roots and fibres
			0.18 GB3A ASS 1	0.18	Silty CLAY – dark grey-brown, low to medium plasticity, trace fine to medium gravel	CL to CI	M	H	Root Fibres and Charcoal HP: 400+KPa
			0.40	-0.5-					
	NIL		0.78 GB3B ASS 2		Silty CLAY – brown, medium plasticity	CI	M	H	ALLUVIUM HP: 400+KPa
			1.00	-1.0-					
			GB3C ASS 3 1.3		CLAY – brown mottled orange, medium to high plasticity	CI to CH	M	H	Contains Charcoal HP: 400+KPa
			1.6	-1.5-					
			GB3D ASS 4		Silty CLAY – grey mottled orange, medium to high plasticity, trace fine gravel	CI to CH	M to W	VST	HP: 200 to 300KPa Some pockets of F-W rock fragments
			2.1	-2.0-					
			2.4		- light grey mottled orange			ST	HP: 100 to 130KPa
			ASS 5 2.6	-2.5-			W		

GRAPHS ■ YES ☐ NO

SUPPORT – 1 = Unheading
EASE OF EXCAVATION
1 – Easy 2 – Moderate 3 – Hard
WATER
Water Inflow ◄ – Water Outflow

MOISTURE
D – Dry
M – Moist
W – Wet

CONSISTENCY / RELATIVE DENSITY
VS – Very Soft VSt – Very Stiff L – Loose
S – Soft H – Hard MD – Moderately Dense
F – Firm Fb – Friable D – Dense
St – Stiff VL – Very Loose VD – Very Dense

D: DAVID GROTH
DESIGNATION: SCIENTIFIC OFFICER
CHECKED: DAVID GROTH

RTA TECHNICAL SERVICES NORTHERN

EXCAVATION – GEOLOGICAL LOG

PIT No. GB3
JOB No. H/40856
SHEET 2 OF 2

PROJECT: Grafton Bridge Duplication Realignment Options
LOCATION:
EQUIPMENT TYPE: Vanori 923
METHOD: BACKHOE
EXCAVATION DIMENSIONS: 0.45m wide, 4.0m long

SURFACE ELEVATION:
POSITION:
DATE OF EXCAVATION: 17/9/03

EASE OF EXCAVATION 1 2 3	SUPPORT	GROUNDWATER LEVELS	NOTES, SAMPLES, TESTS, ETC	DEPTH (METRES)	CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION Based on Unified Classification System MATERIAL DESCRIPTION SOIL TYPE, PLASTICITY OR PARTICLE CHARACTERISTIC, COLOUR, SECONDARY AND MINERAL COMPONENTS	CLASSIFICATION SYMBOL	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & OTHER OBSERVATIONS
					A.P.D	CI to CH	W	ST	
			3.2	3.2					
			ASS 6		Sandy CLAY – light grey mottled orangn with fine size gravel, high plasticity	CI	W	VS to F	HP: 20 to 60KPa Clay appears to have EW ferruginous pockets
		Ni →	3.4	-3.5-					Strong water inflow
			3.8						
			ASS 7	-4.0-					
			4.1						
					Test Pit ends at 4.10m (Limit of Reach)				Test Pit in-filled with water. Standing water level at a depth of 3.6m.
				-4.5-					
				-5.0-					
				-5.5-					

PHOTOGRAPHS ■ YES ☐ NO

SUPPORT – T = Timbering
EASE OF EXCAVATION 1 – Easy 2 – Moderate 3 – Hard
WATER → Water Inflow ← Water Outflow

MOISTURE: D = Dry M = Moist W = Wet

CONSISTENCY / RELATIVE DENSITY
VS = Very Soft S = Soft F = Firm ST = Stiff
VST = Very Stiff H = Hard FR = Friable VL = Very Loose
L = Loose MD = Moderately Dense D = Dense VD = Very Dense

LOGGED: DAVID GROTH
DESIGNATION: SCIENTIFIC OFFICER
CHECKED: DAVID GROTH

Grafton Bridge Route Selection – Test Pitting

TEST PIT 3

Grafton Bridge Route Selection – Test Pitting

TEST PIT 3

RTA TECHNICAL SERVICES NORTHERN

EXCAVATION – GEOLOGICAL LOG

PIT No. GB4
JOB No. H/40856
SHEET 1 OF 2

OJECT: Gratton Bridge Duplication Realignment Options
CATION:
UIPMENT TYPE: Venieri 923
THOD: BACKHOE
CAVATION DIMENSIONS: 0.45m wide, 3.8m long

SURFACE ELEVATION:
POSITION:
DATE OF EXCAVATION: 17/9/03

EASE OF EXCAVATION 2 3	SUPPORT	GROUNDWATER LEVELS	NOTES, SAMPLES, TESTS, ETC.	DEPTH (METRES)	CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION Based on Unified Classification System MATERIAL DESCRIPTION SOIL TYPE, PLASTICITY OR PARTICLE CHARACTERISTIC, COLOUR, SECONDARY AND MINOR COMPONENTS	CLASSIFICATION SYMBOL	MOISTURE CONDITION	CONSISTENCY / RELATIVE DENSITY	STRUCTURE & OTHER OBSERVATIONS
					Clayey SILT – grey, low plasticity	-	D to M	L	TOPSOIL and Grass
				0.22					
					Clayey SILT – grey, low plasticity	-	D to M	MD	Secondary Soil Horizon Root Fibres
				0.4					
			0.50	-0.5-	CLAY – dark grey mottled orange, high plasticity	CH	M	ST	ALLUVIUM Root fibres throughout HP: 150 to 200 KPa
	Nil		GB4A						
			0.80						
				-1.0-					
				1.2					
					CLAY – grey mottled orange brown, high plasticity	CH	W	F to ST	HP: 80 to 150KPa Some pockets of EW rock fragments
				-1.5-				F	HP: 80KPa
			1.7						
			GB4B ASS 1						
			2.0						
				-2.0-	CLAY – dark grey mottled orange, high plasticity	CH	W	VS	HP: 10Kpa Pit walls collapsing
			2.5						
				-2.5-					
			GB4C ASS 2		CLAY – light grey mottled red and orange, high plasticity	CH	W	ST	HP: 120 to 180Kpa Gypsum crystals in clay matrix
			3.8						

S ■ YES ☐ NO

SUPPORT: 1 = Timbering
EASE OF EXCAVATION
1 – Easy 2 – Moderate 3 – Hard
WATER
Water Inflow ← Water Outflow

MOISTURE
D – Dry
M – Moist
W – Wet

CONSISTENCY / RELATIVE DENSITY
VS – Very Soft VST – Very Stiff L – Loose
S – Soft H – Hard MD – Moderately Dense
F – Firm Fb – Friable D – Dense
ST – Stiff VL – Very Loose VD – Very Dense

D GROTH

DESIGNATION: SCIENTIFIC OFFICER

CHECKED: DAVID GROTH

RTA TECHNICAL SERVICES NORTHERN

EXCAVATION – GEOLOGICAL LOG

Pit No. GB4
JOB No. H/40856
SHEET 2 OF 2

PROJECT: Grafton Bridge Duplication Realignment Options
LOCATION:
EQUIPMENT TYPE: Venlon 923
METHOD: BACKHOE
EXCAVATION DIMENSIONS: 0.45m wide, 3.0m long

SURFACE ELEVATION:
POSITION:
DATE OF EXCAVATION: 17/9/03

EASE OF EXCAVATION 1 2 3	SUPPORT	GROUNDWATER LEVELS	NOTES, SAMPLES, TESTS, ETC.	DEPTH (METRES)	CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION Based on Unified Classification System MATERIAL DESCRIPTION SOIL TYPE, PLASTICITY OR PARTICLE CHARACTERISTIC, COLOUR, SECONDARY AND MINERAL COMPONENTS	CLASSIFICATION SYMBOL	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & OTHER OBSERVATIONS
					A.P.D.				
				3.1	Sandy Silty CLAY – light grey mottled orange, fine grained sand	CI	M to W	VST	HP: 200 to 300KPa
	NT		3.5 ASS 3 3.7	-3.5-	CLAY – light grey mottled red-orange, with fine grained sand	CI	M to W	ST	HP: 165 to 200KPa
			4.2 GB4D ASS 4	-4.0- -4.5-	Sandy Silty CLAY – orange-brown and grey, medium to high plasticity	CI	W	ST	RESIDUAL? HP: 120 to 170KPa
			4.6		Test Pit ends at 4.55m (Limit of Reach)				Test Pit in-filled with water and collapsed walls.
				-5.0-					
				-6.5-					

PHOTOGRAPHS ■ YES ☐ NO

LOGGED: DAVID GROTH

SUPPORT – T = Timbering
EASE OF EXCAVATION 1 – Easy 2 – Moderate 3 – Hard
WATER: Water Inflow ◄ Water Outflow

MOISTURE: D – Dry; M – Moist; W – Wet

CONSISTENCY / RELATIVE DENSITY
VS – Very Soft; S – Soft; F – Firm; ST – Stiff; VST – Very Stiff; H – Hard; FR – Friable; VL – Very Loose; L – Loose; MD – Moderately Dense; D – Dense; VD – Very Dense

DESIGNATION: SCIENTIFIC OFFICER

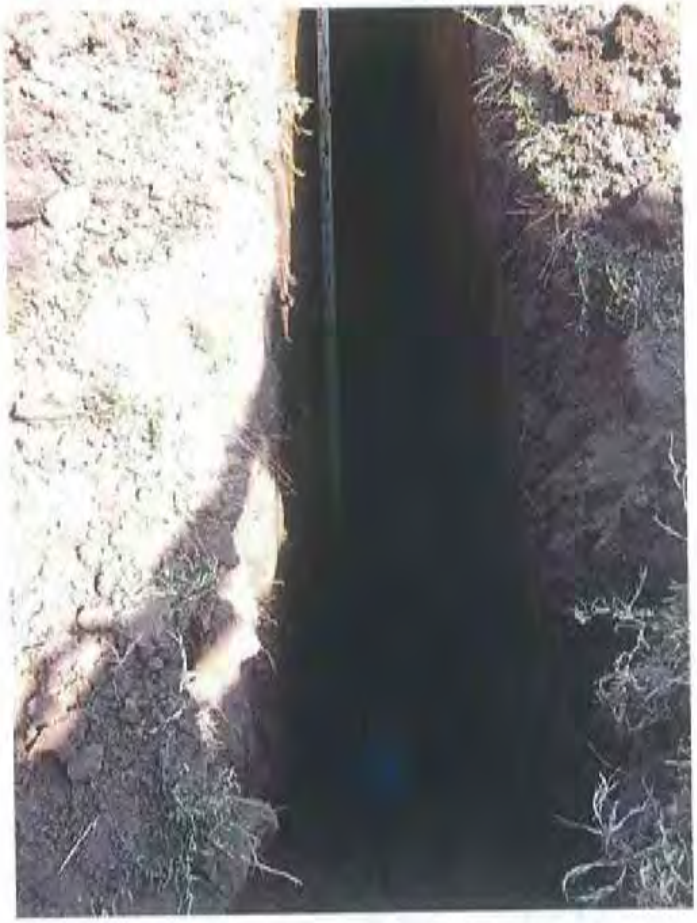
CHECKED: DAVID GROTH

Grafton Bridge Route Selection – Test Pitting

TEST PIT 4

Grafton Bridge Route Selection – Test Pitting

TEST PIT 4



RTA TECHNICAL SERVICES NORTHERN

EXCAVATION – GEOLOGICAL LOG

PIT No. GB5
JOB No. H/40056
SHEET 1 OF 2

PROJECT: Grafton Bridge Duplication Realignment Options
LOCATION:
EQUIPMENT TYPE: Venlori 923
METHOD: HACKHOE
EXCAVATION DIMENSIONS: 0.45m wide, 4.0m long

SURFACE ELEVATION:
POSITION:
DATE OF EXCAVATION: 17/9/03

EASE OF EXCAVATION 1 2 3	SUPPORT	GROUND WATER LEVELS	NOTES, SAMPLES, TESTS, ETC.	DEPTH (METRES)	CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION Based on Unified Classification System. MATERIAL DESCRIPTION. SOIL TYPE, PLASTICITY OR PARTICLE CHARACTERISTIC, COLOUR, SECONDARY AND MINERAL COMPONENTS	CLASSIFICATION SYMBOL	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & OTHER OBSERVATIONS
				0	Clayey SILT – light grey-brown, low plasticity	-	D	L	TOPSOIL Grass roots and root fibres
				0.20	Clayey SILT / Silty CLAY – dark brown, low to medium plasticity	Cl.	D to M	VST	ALLUVIUM HP: 200 to 300 KPa
				-0.5-					
	KI		0.70	0.7					
			GB5A		Silty CLAY – dark brown, medium plasticity	Cl	M	ST	HP: 100 to 130KPa Charcoal and root fibres
			1.00	-1.0-					
				-1.5-					
				1.65	Silty CLAY – orange-brown, medium plasticity	Cl	M	ST	HP: 100Kpa Trace root fibres
			2.0	-2.0-				VST	HP: 340 to 370Kpa
			GB5B						
			2.3						
				-2.5-					HP: 300Kpa
									HP: 200KPa

PHOTOGRAPHS ■ YES □ NO

SUPPORT – T = Timbering
DANGE OF EXCAVATION
1 – Easy 2 – Moderate 3 – Hard
WATER
Water Inflow ◀ Water Outflow

MOISTURE
D – Dry
M – Moist
W – Wet

CONSISTENCY/RELATIVE DENSITY
VS – Very Soft VST – Very Stiff L – Loose
S – Soft H – Hard MD – Moderately Dense
F – Firm FR – Friable D – Dense
ST – Stiff VL – Very Loose VD – Very Dense

DAVID GROTH
DESIGNATION: SCIENTIFIC OFFICER
CHECKED: DAVID GROTH

RTA TECHNICAL SERVICES NORTHERN

PIT No. GB5

EXCAVATION – GEOLOGICAL LOG

JOB No. H/40656

SHEET 2 OF 2

PROJECT: Grafton Bridge Duplication Realignment Options
LOCATION:
EQUIPMENT TYPE: Vonlorl 923
METHOD: BACKHOE
EXCAVATION DIMENSIONS: 0.45m wide, 4.0m long

SURFACE ELEVATION:
POSITION:
DATE OF EXCAVATION: 17/9/03

EASE OF EXCAVATION 1 2 3	SUPPORT	GROUNDWATER LEVELS	NOTES, SAMPLES, TESTS, ETC.	DEPTH (METRES)	CLASSIFICATION SYMBOL	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & OTHER OBSERVATIONS
								CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION Based on Unified Classification System MATERIAL DESCRIPTION SOIL TYPE, PLASTICITY OR PARTICLE CHARACTERISTIC, COLOUR, SECONDARY AND MINERAL COMPONENTS
					CI	M	VST	A.P.D.
				3.3				
	N3		3.5 GB5C	-3.5-	CI	M	VST	Silty CLAY – grey mottled orange-brown, medium plasticity HP: 250KPa
			3.8		CI to CH	M to W	ST	Silty CLAY - grey mottled orange, medium to high plasticity HP: 150 to 200KPa
				-4.0-				
			4.3	4.3				
			GB5B	-4.5-	CH	M to W	F to ST	CLAY –dark grey and black, high plasticity Charcoal throughout HP: 100KPa
			4.6					
								Test Pit ends at 4.60m (Limit of Reach)
				-5.0-				
				-5.5-				

GRAPHS ■ YES ☐ NO

SUPPORT – T = Timbering
EASE OF EXCAVATION 1 – Easy 2 – Moderate 3 – Hard
WATER Water Inflow ◀ Water Outflow

MOISTURE
D – Dry
M – Moist
W – Wet

CONSISTENCY / RELATIVE DENSITY
VS – Very Soft VST – Very Stiff L – Loose
S – Soft H – Hard MD – Moderately Dense
F – Firm FR – Friable D – Dense
ST – Stiff VL – Very Loose VD – Very Dense

DAVID GROTH
DESIGNATION: SCIENTIFIC OFFICER
CHECKED: DAVID GROTH

Grafton Bridge Route Selection – Test Pitting

TEST PIT 5

RTA TECHNICAL SERVICES NORTHERN

EXCAVATION – GEOLOGICAL LOG

PIT No. GB6
JOB No. 40856
SHEET 1 OF 1

PROJECT: Grafton Bridge Duplication Realignment Options
LOCATION:
EQUIPMENT TYPE: Venieri 923
METHOD: BACKHOE
EXCAVATION DIMENSIONS: 0.45m wide, 3.5m long

SURFACE ELEVATION:
POSITION:
DATE OF EXCAVATION: 17/9/03

EASE OF EXCAVATION 1 2 3	SUPPORT	GROUND WATER LEVELS	NOTES, SAMPLES, TESTS, ETC.	DEPTH (METRES)	CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION Based on Unified Classification System MATERIAL DESCRIPTION SOIL TYPE, PLASTICITY OR PARTICLE CHARACTERISTIC, COLOUR, SECONDARY AND MINERAL COMPONENTS	CLASSIFICATION SYMBOL	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & OTHER OBSERVATIONS
					Silty CLAY / Clayey SILT – light grey-brown, low to medium plasticity, with cobbles (ex road?)	-	D to M	I	TOPSOIL and Grass
				0.20	Sandy Silty CLAY – orange-brown, low to medium plasticity, fine to coarse sand, with fine gravel and trace cobbles and small boulders	CL	M	H	FILL
	Nil			-0.5-					
				0.70					
			GB6A	0.7	Silty CLAY – grey mottled orange-brown, medium to high plasticity, with fine grained sand	CI	M	VST	ALLUVIUM HP: 220KPa
				-1.0-					
				1.10					
				1.1	Sandy CLAY – light grey mottled orange, high plasticity, fine grained sand, trace hard ferruginous nodules	CH to SC	M to W	S	HP: 20KPa
				-1.5-					
				1.8					
			GB6B		Clayey SAND – light grey mottled orange, fine to medium grained sand	SC	W	VL	
				-2.0-					
				2.2					
				2.4					
				2.4	SAND – light grey, fine to medium grained	SC to SM	W	VL	Saturated sand was extremely fluid
			GB6C	-2.5-					
				2.6					
					Test Pit discontinued at 2.6m (test pit walls collapsing and pit filling with water)				

HS ■ YES ☐ NO

SUPPORT – T = Timbering
EASE OF EXCAVATION 1 = Easy 2 = Moderate 3 = Hard
WATER ▶ Water Inflow ◀ Water Outflow

MOISTURE
D – Dry
M – Moist
W – Wet

CONSISTENCY / RELATIVE DENSITY
VS – Very Soft VST – Very Stiff I – Loose
S – Soft H – Hard MD – Moderately Dense
F – Firm VS – Very Loose D – Dense
ST – Stiff VD – Very Dense

DESIGNATION: SCIENTIFIC OFFICER
CHECKED: DAVID GROTH

Grafton Bridge Route Selection – Test Pitting

TEST PIT 6

Grafton Bridge Route Selection – Test Pitting

TEST PIT 6

RTA TECHNICAL SERVICES NORTHERN

EXCAVATION – GEOLOGICAL LOG

PIT No. GB7
JOB No. H/40856
SHEET 1 OF 2

PROJECT: Grafton Bridge Duplication Realignment Options
LOCATION:
EQUIPMENT TYPE: Venieri 923
METHOD: BACKHOE
EXCAVATION DIMENSIONS: 0.45m wide, 3.8m long

SURFACE ELEVATION:
POSITION:
DATE OF EXCAVATION: 17/9/03

EASE OF EXCAVATION 1 2 3	SUPPORT	GROUNDWATER LEVELS	NOTES, SAMPLES, TESTS, ETC.	DEPTH (METRES)	CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION Based on Unified Classification System MATERIAL DESCRIPTION SOIL TYPE, PLASTICITY OR PARTICLE CHARACTERISTIC, COLOUR, SECONDARY AND MINERAL COMPONENTS	CLASSIFICATION SYMBOL	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & OTHER OBSERVATIONS
					Silty CLAY – light grey-brown, low plasticity		D	MD to L	TOPSOIL Grass roots and root fibres
				0.25	Silty CLAY – brown, medium plasticity	CI	M	H	ALLUVIUM HP: 400+ KPa
				-0.5-					
				0.85					
			1.00	-1.0-	Silty CLAY – dark grey mottled orange-brown, medium plasticity	CI	M	VST	HP: 300 to 400KPa
			GB7A						
			1.40						
				-1.5-					
					- dark grey, high plasticity				HP: 250KPa
				-2.0-					
								ST	HP: 120 to 140Kpa
				-2.5-					
			2.6	2.6					
			GB7B		CLAY – grey mottled orange, high plasticity	CH	M to W	ST	HP: 150 to 200KPa
			2.9						

NIL

NOTES, SAMPLES, TESTS ■ YES □ NO

SUPPORT – T – Timbering
EASE OF EXCAVATION
1 – Easy 2 – Moderate 3 – Hard
WATER
← Water Inflow ← Water Outflow

MOISTURE
D – Dry
M – Moist
W – Wet

CONSISTENCY / RELATIVE DENSITY
VS – Very Soft VST – Very Stiff L – Loose
S – Soft H – Hard MD – Moderately Dense
F – Firm VL – Very Loose D – Dense
St – Stiff VD – Very Dense

DESIGNATED: DAVID GROTH
DESIGNATION: SCIENTIFIC OFFICER
CHECKED: DAVID GROTH

RTA TECHNICAL SERVICES NORTHERN

PIT No. GB7

EXCAVATION – GEOLOGICAL LOG

JOB No. H/40856

SHEET 2 OF 2

PROJECT: Grafton Bridge Duplication Realignment Options
LOCATION:
EQUIPMENT TYPE: Venlori 923
METHOD: BACKHOE
EXCAVATION DIMENSIONS: 0.45m wide, 3.8m long

SURFACE ELEVATION:
POSITION:
DATE OF EXCAVATION: 17/9/03

BASE OF EXCAVATION 1 2 3	SUPPORT	GROUNDWATER LEVELS	NOTES, SAMPLES, TESTS, ETC	DEPTH (METRES)	CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION Based on Unified Classification System MATERIAL DESCRIPTION SOIL TYPE, PLASTICITY OR PARTICLE CHARACTERISTIC, COLOUR, SECONDARY AND MINERAL COMPONENTS	CLASSIFICATION SYMBOL	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & OTHER OBSERVATIONS
					A.P.D.	CH	M to W	ST	Heating Water table depth (confined by clay)
	Nil			-3.5-					
			3.7	3.7					
			GB7C		CLAY – dark grey mottled orange, high plasticity	CH	M to W	St	HP: 120 to 170KPa
			4.0	-4.0-					
					CLAY – dark grey and black, high plasticity, with fine (carbonaceous) concretions	CH	W	S to F	HP: 30 to 80KPa Strong sulfuric odour Strong reaction to hydrogen peroxide
			4.3	4.3					
			GB7D	-4.5-					
			4.6		Test Pit ends at 4.60m (Limit of Roach)				
				-5.0-					
				-5.5-					

HS ■ YES ☐ NO

SUPPORT – 1 = Timbering
EASE OF EXCAVATION
1 – Easy 2 – Moderate 3 – Hard
WATER
Water Inflow ◀ Water Outflow

MOISTURE
D – Dry
M – Moist
W – Wet

CONSISTENCY / RELATIVE DENSITY
VS – Very Soft VST – Very Stiff L – Loose
S – Soft H – Hard MD – Moderately Dense
F – Firm FR – Friable D – Dense
ST – Stiff VL – Very Loose VD – Very Dense

DESIGNATION: SCIENTIFIC OFFICER

CHECKED: DAVID GROTH

O GROTH

Grafton Bridge Route Selection – Test Pitting

TEST PIT 7

APPENDIX E

Original Bridge Section (Work as Executed Plan?)

App No. 233084

N.S.W. G.R. GRAFTON TO SOUTH GRAFTON

BRIDGE OVER CLARENCE RIVER

(ROAD & RAIL)

ELEVATION & DETAILS OF CONCRETE PIERS

DRAWING NO. 1.

SCALE 1:500 FT.

PIERS Nº1 & 7

PIERS Nº2 & 5

PIERS Nº3 & 4

PIERS Nº4, 5 & 6

CONSTRUCTION PLANS

GRAFTON TO S.TH GRAFTON

BRIDGE OVER CLARENCE RIVER

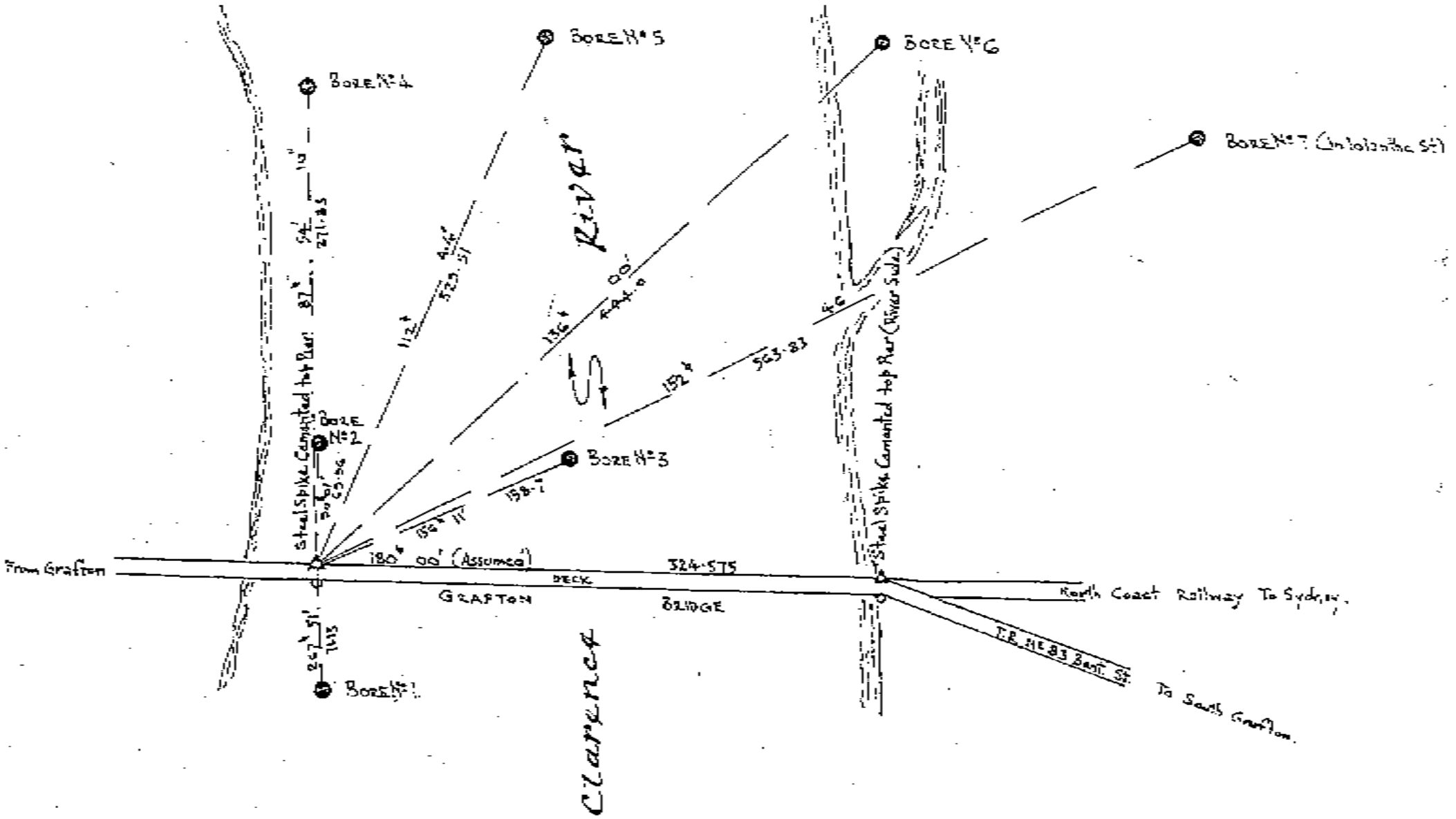
SHEET 1 OF 50

0681 173BC0402 FRAME 2 OF 2

REDUCTION RATIO

APPENDIX G

Borehole Logs and Site Plan – 1975 Investigation

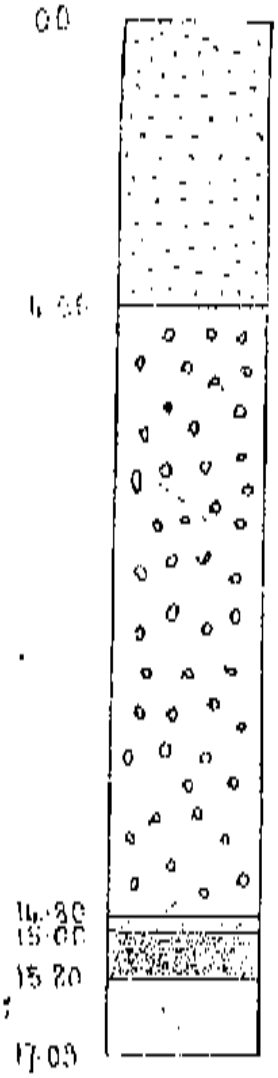


NOTE:
Both Steel Spikes Directly under Footway (East Side)

SKETCH
Showing Position of Bores for Proposed Bridge over the Clarence River at Grafton.
T.R. No 83 City of GRAFTON.
Scale: 1:3000

HOLE 1A

(On ℄ of purple line in Vicinity of Northern Bank RL 96.68
Bearing 267° 53' ; Chainage [illegible])



Sand Bed - brown, grey with various sized gravels scattered throughout. Evidence of odd thin lenses of soft muds occurring at various depths.

Gravel Bed - sand bound and dense with fair percentage of cobble sized material throughout (up to 10cms in size recovered intact).

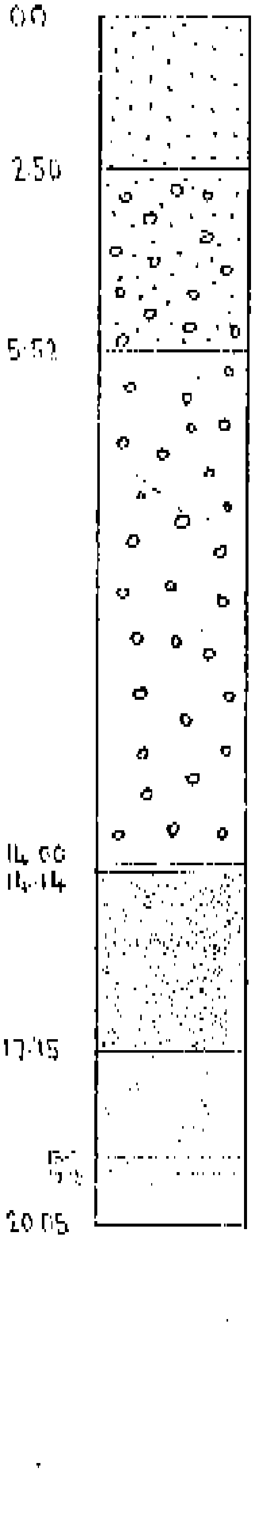
Gritty Clays - soft, sticky, greenish grey.

Sandstone - fairly hard, gray; medium grained with odd minor weak seams occurring. Bedding regular and tending to horizontal.

Lithic Sandstone - very highly weathered layers of soft and Medium hard, grey-brown. This whole zone is "Below very Weak"

HOLE 2

(On ℄ of Green Line in vicinity of Northern Bank)
(Bearing 90° 0' chainage [illegible])



Sand Bed - medium grained, mud bound in initial stage

Sand Bed - medium grained with vegetation fragments thin black soft sandy mud stringers and small gravels throughout. Denseness of gravels increases with depth.

Gravel Bed - sand bound.

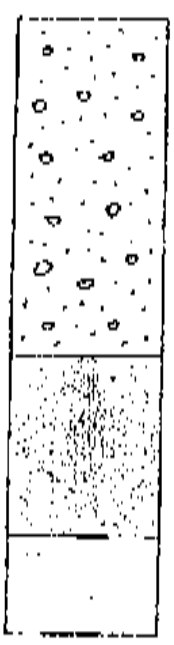
Sandy Clay - soft, greenish, sticky.
Lithic Sandstone - fairly hard, greenish gray, weathered, heavily cracked, medium and fine grained (probably Grafton beds. Material appears to get harder (cont' below)

Lithic Sandstone - hard, gray, fine grained, cracked. Cracks ranging from horizontal to vertical. A weak seam of carboniferous material comprising [illegible] multiple water thin lignite and sandstone [illegible]. Horizontally laminated which tend to part [illegible] occurs at interval 18.90 to 19.15. Bedding generally regular and horizontal.

ϕ with depth and contains traces of mica and [illegible] thin soft sticky clay seams. Cracks run from horizontal to vertical with bedding tending to horizontal.

HOLE 3

(on ℄ of Gwenn Line in vicinity of Southern Bank)
(Bearing 156° 11' - Chainage 158·70 - R.L. 5·76)



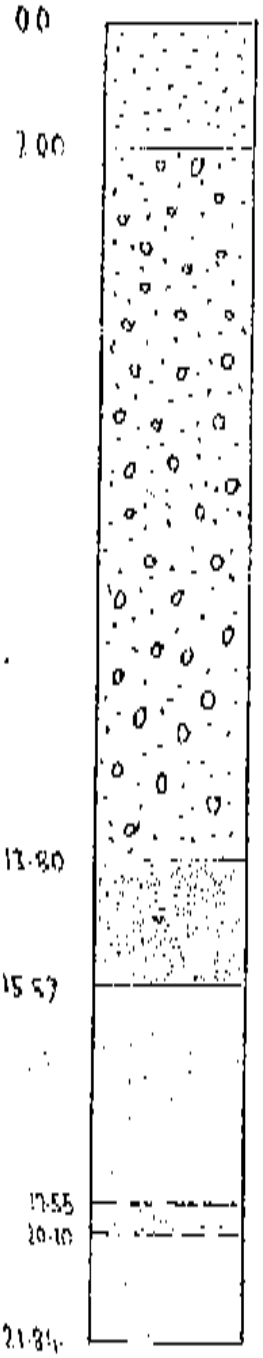
Sand Bed - grey, brown, medium to course grained. Slightly mud bound in initial stages and with odd small gravels scattered throughout

Lithic - Sandstone - very highly weathered insitu. Now resembling layers of decomposed soft to firm cohesive black and grey clay-like material with thin layers of hard sandstone & siltstone scattered throughout. Colour very w

Sandstone - hard, grey, fine grained. Showing mi cracking and bedding tending to horizontal. Last 2 m of core recovered & sighted but not boxed.

HOLE 4.

(In Vicinity of Rad line in Vicinity of Northern Bank)
(Bearing 87° 54' Chainage 2116.3 R.L. 25.01)



River muds and sands - soft and black.

Sand and Gravel Bed - gravels well rounded and up to 65mm in size recovered but suspect that cobbles also present. A thin soft black sandy clay stringer at 12.61 m.

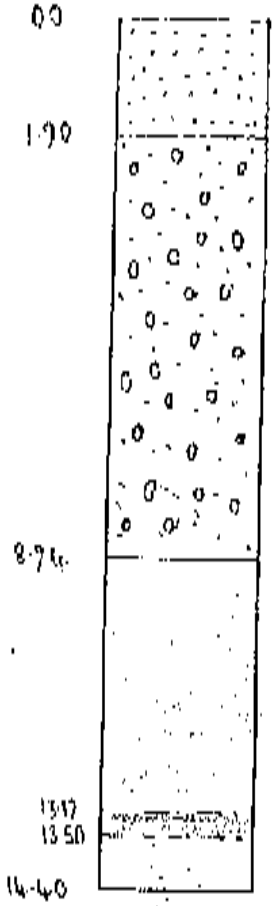
Lithic Sandstone - Gray, soft running quickly to Medium Hard weathered. At best very weak

Sediments (comprising Lithic Sandstones and clayey siltstones - probably Grafton formation) Generally very hard, grey cracked, fine grained. With bedding horizontally inclined and parallel. Material contains a partially decomposed seam at 19.55 to 20.10 which shows minor seams of soft clay-like material and lignite. also minor lignite veins scattered throughout except for zone 19.55 - 20.10. Rock appears to improve in hardness with debth.

N.B. Shrinkage cracks appeared upon drying out of initial rock.

HOLE 5

(In vicinity of Red Line in vicinity of Southern Yard).
(Bearing 112°44', Chainage 329.50, R.L. 69.70).



Sand Bed - gray, brown, mud bound, median grained

Sand Bed - gray, brown, medium grained, with small gravels scattered throughout (up to 5cm in diameter recovered

Lithic Sandstone - Alternate layers of fairly hard, gray, fine & medium grained sandstones and dark gray mudstones of varying hardnesses (from medium hard through to hard. Whole zone a lithic Sandstone (probably Grafton Beds) containing minor weak seams, but with a major soft decomposed fairly cohesive clay-like seam at 13.12m - 13.50m. Material generally cracked with bedding dipping to horizontal with traces of lignite & pyrites scattered throughout.

HOLE 6

(On ℄ of Red Line in vicinity of Southern Bank)
(Bearing 136°00' ; Chainage 4444·60 ; R.L. 106·76).

Topsoil - brown, silty, loamy, organic.

Silty Sandy Clays - stiff, brown, fine grained.

Clays and Peats - alternative layers of firm to stiff, dark grey-blackish greasy clays and multiplad finely layered clay bound peats.

Clays - alternate layers of stiff bluey-grey greasy clays and brown-grey fine grained slightly sandy clays tending to become silty clays with debth. Lost water at 10·85m.

Silty Clays - soft to firm dark grey.

Sand Bed - medium grained with small pebbles scattered throughout

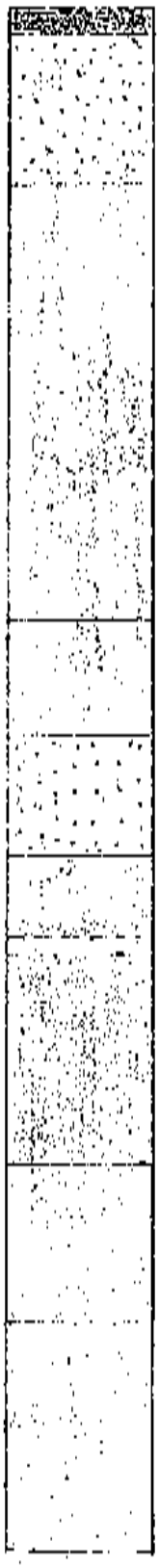
Lithic Sandstone (insitu) highly weathered. Now resembling layers of grey and greenish grey heavily cracked fine grained sandstone of varying hardnesses (fairly soft and fairly hard to hard) with weak partially (cont'd ↓

Lithic Sandstone - grey, fairly hard to hard, cracked (generally horizontal), fine grained with bedding inclined to horizontal and containing minute traces of pyrites and lignite.

↓ decomposed seams of varying thicknesses scattered throughout. Bedding tending to horizontal and mottled

HOLE 7

(East of Rod Line on Southern Bank)
(Bearing 151°46' ; Chainage 563·83 ; RL 106·19)



Loamy Topsoil - firm, brown, fine grained, organic

Loamy Sandy Clays - firm to stiff, light cunning to dark, fine grained.

Clays - firm to stiff, light grey to olive mottled, fairly sticky greasy.

Sandy Clays - firm to stiff, brown, fine grained.

Clays - alternative multiple layers of light and dark brown clay bound gravels and stiff, fine grained sandy loamy clays.

Sediment (insitu) - very highly weathered, now resembling layers of varying thicknesses of brown medium hard to fairly hard generally fine grained "sandstone." (bedding from horizontal to 10°) with seams of partially decomposed and decomposed sandstone throughout. A very hard layer of fine grained sandstone at (cont→

Sediment - (insitu) - very highly weathered, now resembling layers of varying thicknesses of medium hard & fairly firm grey, fine to medium grained sandstone with seams of partially decomposed sandstone and decomposed sandy clay-like material throughout. "Below very weak"

Lithic Sandstone - fairly hard to hard, grey, fine to medium grained, cracked with horizontally inclined bedding and containing a decomposed seam at 22·35 to 22·70. Comprising multiple, minor sandy clay-like material seams alternatively with fairly hard sandstone

→ interval 15·90 to 16·20. Initially rock at best "very weak" but tending to deteriorate within depth and whole zone 14·50 to 19·85 appears to be "below very weak"

APPENDIX B

BOREHOLE LOGS - BHSG1 TO BHSG7

Borehole Log

Borehole No.	BHSG 1
Sheet	1 of 1
CLIENT:	CAMERON McNAMARA PTY. LTD.
Job No.	2417
PROJECT:	SOUTH GRAFTON LEVEE - GEOTECHNICAL INVESTIGATION
Location :	E 712 405.331N 294 749.576E
Collar Level :	R.L. 9.17m
Angle From Vertical :	0°
Bearing :	
Equipment Type :	TRUCK MOUNTED EDSON 3000
Hole Diameter :	100mm

Samples	Water	Casing	R.L. / Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure (Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure)	Consistency or Relative Density	Field Test Results	Geological Profile
U1 SPT1			1.0		OH/ OL	SILTY CLAY, medium plasticity, dark brown, organic, with fibrous roots. Moist.	FIRM	SPT, N = 11	
02 U07			2.0		CH	CLAY, medium to high plasticity, brown and orange brown, becoming grey brown with depth. Moist.	STIFF	TV:65 HP:160	
03 SPT2			3.0			NOTE: Groundwater Intersected at 4.10 metres.		SPT, N = 8	
04 U02			4.0			CLAY, as above, becoming green brown.	VERY STIFF	TV:70 HP:270	LAYERED ALLUVIAL DEPOSITS
U03			5.0		CL CH	SANDY CLAY, medium plasticity, green brown, fine grained Sand, with some fine Gravel to 3mm. Wet.	SOFT	TV:>100 HP:360	
05 U04			6.0			CLAY, as above, brown and orange grey. Moist.	VERY STIFF	TV:>100 HP:300	
D6			7.0		CH/ CL	CLAY and SILTY CLAY, high plasticity, grey and brown, with some thin dark brown organic bands. Also some fine Gravel to 3mm. Wet.			
07 U05			8.0		CL CH/ CI	SILTY CLAY, medium plasticity, grey and brown, with some fine Sand and Gravel.	FIRM	TV:>100 HP:320	
			9.0			CLAY and SILTY CLAY, as from 6 to 7.5 metres.	VERY STIFF		
D8 U06			10.0		CL/ CH	SILTY CLAY, medium to high plasticity, brown, with some fine grained Sand. Moist to wet. (Slightly less stiff from 10 to 11 metres).		TV:90 HP:220	
			11.0			SILTY CLAY, as above, becoming orange brown.			
SPT3			12.0			SILTY CLAY, medium to high plasticity, brown and grey brown, with some fine Sand and a trace of fine rounded Gravel. Moist.	VERY STIFF	SPT, N = 16	
D9 U07			13.0						
			14.0		CL/ GC	GRAVELLY SILTY CLAY, medium to high plasticity, brown and grey, with rounded Gravel increasing in size and density with depth, to Gravelly Clay and Clayey Gravel. Moist.	HARD	TV:>100 HP:>500	
						V-BIT REFUSAL AT 14.64 METRES IN CLAYEY GRAVEL OVERLYING HIGHLY WEATHERED ROCK. END OF HOLE AT 14.64 METRES.			

Logged By :	G.P.K.	Date : 9.12.86	Checked By : G.P.K. Date : 16-12-86

Borehole Log

Borehole No. BHSG 2

Sheet 1 of 1

CLIENT: CAMERON McNAMARA PTY. LTD.

Job No. 2417

PROJECT: SOUTH GRAFTON LEVEE - GEOTECHNICAL INVESTIGATION

Location : 1 712 634.893 N
294 624.615 E

Collar Level : R.L. 3.26m

Equipment Type : TRUCK MOUNTED EDSON 3000

Angle From Vertical : 0°

Hole Diameter : 100mm

Bearing :

Samples	Water	Casing	R.L. / Depth (Metres)	Graphic Log	U.S.C.S.	Material Description, Structure (Soil Type : Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure.)	Consistency or Relative Density	Field Test Results	Geological Profile
D 1			0.0						
SPT 1			1.0		OH/ OL	SILTY CLAY, medium plasticity, dark brown, organic, with fibrous roots. Moist.	SOFT TO FIRM		
D 2						SILTY CLAY, as above, becoming grey brown less Silty with depth.		SPT, N = 7	
UD 1			2.0						
D 3						CLAY, high plasticity, grey brown and light brown. Moist. Becoming light grey with some Silty bands from 2.8 metres.	STIFF	TV:65,HP:130	
SPT 2			3.0			NOTE: Groundwater intersected at 3.65 metres.		SPT, N = 8	
D 4	▽				CH				
UD 2			4.0			CLAY, as above, with Silty Clay bands, high plasticity, green-grey-brown, with some dark brown organic bands and inclusions.	VERY STIFF	TV:69,HP:280	
D 5									
UD 3			5.0					TV:>100 HP:400	
D 6							SOFT		
D 7			6.0			SILTY GRAVELLY CLAY, medium plasticity, green brown, with some fine rounded Gravel to 5mm. Wet.			LAYERED ALLUVIAL DEPOSITS
UD 4					CH		VERY STIFF TO HARD	TV:>100 HP: 400	
			7.0			CLAY and SILTY CLAY, high plasticity, green-grey-brown, with some fine rounded Gravel fragments to 3mm. Wet.			
D 8									
UD 5			8.0		CL	GRAVELLY SILTY CLAY, medium plasticity, green-brown, with rounded Gravel fragments to 10mm. Wet.	VERY STIFF	TV:80,HP:250	
			9.0		CH	CLAY and SILTY CLAY, high plasticity, orange-brown, Wet.			
D 9					CL	GRAVELLY SILTY CLAY, as from 7.7 to 8.9 metres.			
UD 6			10.0		CH	CLAY and SILTY CLAY, high plasticity, orange brown. Moist to wet.		TV:70,HP:240	
			11.0						
D 10						GRAVELLY SILTY CLAY, high plasticity, brown with rounded Gravel fragments to 10mm. Moist. Becoming more Gravelly from 12.9 metres.			
SPT 3			12.0		CL			SPT, N = 14	
			13.0				VERY STIFF TO HARD		
D 11									
UD 7			14.0		CL		HARD	TV:80,HP:400	
						V-BIT REFUSAL AT 14.6 METRES IN GRAVELLY CLAY. END OF HOLE AT 14.6 METRES.			

Logged By : G.P.K. Date : 10.12.86

Checked By : G.P.K. Date : 16-12-'86

PJB

Peter J Burgess & Associates Pty Ltd

Borehole Log

Borehole No. BHSG 3

Sheet 1 of 1

CLIENT: CAMERON McNAMARA PTY. LTD.

Job No. 2417

PROJECT: SOUTH GRAFTON LEVEE - GEOTECHNICAL INVESTIGATION

Location : 1 713 028.182 N
293 671.842 E
Collar Level : R.L. 6.47m
Angle From Vertical : 0°
Bearing :

Equipment Type : TRUCK MOUNTED EDSON 3000
Hole Diameter : 100mm

Samples	Water	Casing	R.L / Depth (Metres)	Graphic Log	U.S.C.S.	Material Description, Structure (Soil Type : Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure)	Consistency or Relative Density	Field Test Results	Geological Profile
					SW	BITUMEN ROAD PAVEMENT.			
					GP	GRAVELLY SAND, fine to medium grained sand, red-brown, with fine Gravel. Dry. Grading into rounded Gravel (to 40mm), from 0.6 to 0.9 metres.	LOOSE / MED. DEN.		FILL
			1.0		CH	Dry.	FIRM TO STIFF		
SPT 1								SPT, N = 7	
			2.0			SILTY CLAY, medium to high plasticity, dark brown, organic. Moist.	VERY STIFF		ALLUVIUM
UDT 1					CH/CL			TV:80,HP:220	
			3.0			SILTY CLAY, medium to high plasticity, grey and green-brown, with some Gravel fragments to 6mm decreasing with depth. Moist. Increasing in stiffness with depth.			
UD 2			4.0				HIGHLY WEATHERED	TV:>100 HP:>500	SANDSTONE FLOATER
D 1					NA	SANDSTONE, fine grained, orange and yellow. Dry. V-Bit refusal, I.C. Bit required.	FIRM TO STIFF		
UD 3			5.0		CL/ML	SILTY CLAY/CLAYEY SILT, low plasticity, dark brown, with some fine Sand from 5.0 metres. Moist.		TV:25,HP:100	
D 2							VERY LOOSE		
SPT 2			6.0		SC	CLAYEY SAND, fine to very fine grained Sand, dark brown-grey, with low plasticity Clay, and some Silt. Organic. Wet.		SPT, N = 3	
D 3						Becoming less Clayey with depth.			
SPT 3			7.0			Sand size increasing with depth.		SPT, N = 7	
D 4					SM		LOOSE		ALLUVIUM
SPT 4			8.0			SILTY SAND, fine to medium grained Sand, dark grey, low to non-plastic fines. Wet.		SPT, N = 15	
					SP	SAND, medium grained, dark grey. Wet. Poorly graded.	MEDIUM DENSE.		
SPT 5			9.0					SPT, N = 17	
			10.0						
SPT 6								SPT, N = 14	
			11.0						
			12.0						
SPT 7								SPT, N = 18	
						END OF HOLE AT 12.45 METRES.			

Logged By : G.P.K. Date : 10.12.86 Checked By : G.P.K. Date : 16.12.86

PJB Peter J. Burgess & Associates Pty. Ltd.

Borehole Log

Borehole No. BHSG4

Sheet 1 of 1

CLIENT: CAMERON McNAMARA PTY. LTD.

Job No. 2417

PROJECT: SOUTH GRAFTON LEVEE - GEOTECHNICAL INVESTIGATION

Location : 1 713 189.873 N
293 057.883 E

Collar Level : R.L. 7.53 m
Angle From Vertical : 0°
Bearing :

Equipment Type : TRUCK MOUNTED EDSON 3000
Hole Diameter : 100mm

Samples	Water	Casing	R.L / Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure (Soil Type : Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure)	Consistency or Relative Density	Field Test Results	Geological Profile
D 1 SPT 1			1.0		ML/OL	CLAYEY SANDY SILT/CLAYEY SILTY SAND, fine grained Sand, low plasticity Clay, dark brown, Moist. Organic, with some fibrous roots. Becoming Sandier with depth.	MEDIUM DENSE	SPT, N = 16	LEVEE BANK
D 2 UD 1			2.0		ML/SM	SILTY SAND, fine grained Sand, dark brown, with low to non-plastic fines. Partially dry.		TV:>100 HP:>500	? ?
D 3 SPT2			3.0			SILTY SAND/SANDY SILT, as above, with progressively less Sand.		SPT, N = 10	
SPT3			4.0					SPT, N = 10	
D 4 SPT4			5.0		ML/SM	CLAYEY SANDY SILT/CLAYEY SILTY SAND, fine grained Sand, low plasticity Clay, dark brown, Moist. Organic. Some thin bands of higher Clay content from 5.5 to 6.4 metres. Becoming Sandier from 7.0 metres. NOTE: Groundwater intersected at 7.10 metres.	LOOSE	SPT, N = 10	
D 5 SPT5	▽		6.0					SPT, N = 7	ALLUVIUM
D 6 SPT6			7.0		SM	SILTY SAND, fine to medium Sand, low plasticity fines, Wet.		SPT, N = 9	
D 7 SPT7			8.0			SAND, fine to medium grained, brown-grey and grey. Wet.		SPT, N = 15	
SPT8			9.0			SAND, grey, as above.		SPT, N = 12	
SPT9			10.0		SP		MEDIUM DENSE	SPT, N = 17	
SPT10			11.0			SAND, grey, as above.		SPT, N = 13	
SPT11			12.0					SPT, N = 17	
			13.0						
			14.0			END OF HOLE AT 14.45 METRES.			

Logged By : C.P.K. Date : 11.12.86

Checked By : C.P.K. Date : 16-12-'86

Peter J. Burgess & Associates Pty. Ltd.

Borehole Log

Borehole No. BHSG 5

Sheet 1 of 1

CLIENT: CAMERON McNAMARA PTY. LTD.

Job No. 241/

PROJECT: SOUTH GRAFTON LEVEE - GEOTECHNICAL INVESTIGATION

Location : 1 713 049.596 N
292 937.773 E

Collar Level : R.L. 7.52m

Angle From Vertical : 0°

Bearing :

Equipment Type : TRUCK MOUNTED RIDSON 3000

Hole Diameter : 100mm

Samples	Water	Casing	R.L. / Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure (Soil Type : Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure)	Consistency or Relative Density	Field Test Results	Geological Profile
D 1						CLAYEY SANDY SILT/CLAYEY SILTY SAND, fine grained Sand, low plasticity Clay. Dark brown. Moist. Organic, with some fibrous roots.			
SPT 1			1.0					SPT, N = 21	LEVEE BANK
D 2									
UD 1			2.0				MEDIUM DENSE	TV:>100 HP:>500	
D 3					ML/OL	CLAYEY SANDY SILT/CLAYEY SILTY SAND, fine grained Sand, low plasticity Clay. Dark brown. Organic. Moist.			
SPT 3			3.0					SPT, N = 24	
D 4									
UD 2			4.0					TV:>100 HP:>500	
			5.0			As above, grading progressively to Clayey Silt, with some thin Sandy Silt layers.			
SPT 3									
			6.0					SPT, N = 13	? — ?
D 5						SILTY CLAY, medium plasticity, grey brown-black. Moist. Organic.			
UD 3	▽		7.0					TV:40 HP:110	
			8.0						
D 6									
UD 4								TV:45 HP:110	
			9.0		CI/CH	SILTY CLAY, as above, becoming high plasticity from around 9.0 metres.	STIFF		LAYERED ALLUVIAL DEPOSITS
D 7									
UD 5			10.0			SILTY CLAY, medium to high plasticity, dark grey. Wet. Organic. Some thin grey Sandy layers.		TV:30 HP:110	
D 8			11.0						
UD 6									
			12.0			SILTY CLAY, as above, with some layers of grey Sandy Clay and grey medium grained Sand.		TV:95 HP:120	
D 9									
			13.0						
			14.0						
SPT 4						Thin (upto 100mm) interbeds of SILTY CLAY, as above, and grey medium grained SAND. Wet.	LOOSE	SPT, N = 7	
			15.0						
D 10									
SPT 5			16.0			SILTY CLAY becoming less predominant with depth.		SPT, N = 8	
			17.0		SP (CH)				
			18.0			Interbeds (upto 300mm) of SILTY CLAY, as above, in grey, medium grained SAND. Wet.		SPT, N = 6	
SPT 6									
			19.0						
SPT 7			20.0			END OF HOLE AT 20.45 METRES.		SPT, N = 8	

Logged By : G.P.K. Date : 11.12.86

Checked By : G.P.K. Date : 16.12.86

Peter J. Burgers & Associates Pty. Ltd.

Borehole Log

Borehole No.	BHSG 6
Sheet	1 of 1
Job No.	241/

CLIENT: CAMERON McNAMARA PTY. LTD.

PROJECT: SOUTH GRAFTON LEVEE - GEOTECHNICAL INVESTIGATION

Location : 1 714 341.012 N
291 065.664 E
Collar Level : R.L.6.58m
Angle From Vertical : 0°
Bearing :

Equipment Type : TRUCK MOUNTED FUSON 3000
Hole Diameter : 100mm.

Samples	Water	Casing	R.L. Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure (Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure.)	Consistency or Relative Density	Field Test Results	Geological Profile
			1.0		SM/ML	SANDY SILT, fine grained Sand, non-plastic fines, brown, Dry. Becoming Sandier with depth.			
D 1 SPT 1			2.0		SM	SILTY SAND, fine grained Sand, non-plastic fines, brown, Dry.	MEDIUM DENSE	SPT, N = 13	
			3.0			SILTY SAND, as above.			
SPT 2			4.0					SPT, N = 12	
			5.0			SILTY SAND, medium grained Sand, low to non-plastic fines. Brown and orange brown, Dry. Becoming moist from 5.4 metres.			LAYERED ALLUVIAL DEPOSITS
SPT 3			6.0		SP (SM)	SAND, medium grained, brown and grey, with some layers of non-plastic Silty Sand. Wet.		SPT, N = 16	
			7.0						
SPT 4			8.0		CH	SILTY CLAY, high plasticity, dark grey, Moist.	STIFF	SPT, N = 8	
			9.0		SP	SAND, as from 6.0 to 8.2 metres.	LOOSE		
D 2 UD 1			10.0		CH	SILTY CLAY, high plasticity, dark grey. Moist.	VERY STIFF	UW:80 UC:220	
D 3			11.0		ML	CLAYEY SILT, medium plasticity with some fine Sand, Wet.	LOOSE		
D 4			12.0		CH	SILTY CLAY, as from 8.7 to 11.0 metres.	V. STIFF		
					SP	SAND, fine to medium grained, grey-brown. Wet.	LOOSE		
SPT 5			13.0		SW (CH)	Interbeds (upto 200mm) of SAND, fine to medium grained, grey and brown, wet, and SILTY CLAY, high plasticity, grey and brown, moist. (Sand is wet and loose, Silty Clay is moist and very stiff).	LOOSE	SPT, N = 9	
			14.0						
SPT 6			15.0		SW (SC)	SAND, fine to medium grained, grey and brown, Wet. With some thin interbeds of Clayey Sand, fine to medium grained Sand, low plasticity Clay, Wet.		SPT, N = 6	
			16.0						
SPT 7			17.0		GW	SANDY GRAVEL, rounded to 30mm, grey and brown, with fine to medium grained Sand. Wet.	DENSE	SPT, N = 42	
						V-BIT REFUSAL AT 17.9 METRES IN SANDY GRAVEL. END OF HOLE AT 17.9 METRES.			

Logged By : G.P.K. Date : 12.12.86

Checked By : G.P.K. Date : 16-12-'86

PB

Peter J. Burgess & Associates Pty. Ltd.

Borehole Log

Borehole No.	BHSG 7
Sheet	1 of 1
Job No.	2417

CLIENT: CAMERON McNAMARA PTY. LTD.

PROJECT: SOUTH GRAFTON LEVEE - GEOTECHNICAL INVESTIGATION

Location : N 716 847.939 N
E 480 801.094 E
Collar Level : R.L. 7.76m
Angle From Vertical : 0°
Bearing :

Equipment Type : TRUCK MOUNTED EDSON 3000
Hole Diameter : 100mm

Samples	Water	Casing	R.L. / Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure (Soil type : Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure)	Consistency or Relative Density	Field Test Results	Geological Profile
D1			1.0		ML/SM	SANDY SILT, fine grained Sand and non-plastic fines, brown. Dry. Some rounded Gravel to 8mm.			
D2			2.0		ML	CLAYEY SANDY SILT, fine grained Sand, low plasticity Clay. Brown and dark brown. Moist.	MEDIUM DENSE.		LEVEE BANK
SPT1			3.0			CLAYEY SILT, medium plasticity Clay, dark grey brown, with some fine grained Sand. Moist.		SPT, N = 18	
D3			4.0						
SPT2			5.0		SP	SAND, fine to medium grained, grey. Moist.		SPT, N = 11	
			6.0		SW/SM	SAND and SILTY SAND, fine grained, with some low to non-plastic fines. Dark grey. Moist.	LOOSE		? ?
SPT3			7.0					SPT, N = 5	LAYERED ALLUVIAL DEPOSITS
UD 1	▽		8.0		CL	SILTY CLAY, medium plasticity, grey and grey brown. Moist.	VERY STIFF	TV:>100 HP:330	
			9.0			Becoming slightly Sandy.			
UD 2			10.0		CL (SC)	SILTY CLAY, as above, with interbeds of SANDY CLAY and CLAYEY SAND, fine to medium grained Sand, medium to high plasticity Clay. Grey and dark grey. Wet. (Sand is loose/Clay is firm).	FIRM	TV:15 HP:90	
			11.0						
SPT4			12.0		SW (SC)	SAND, fine to medium grained, grey. Wet. With interbeds of CLAYEY SAND and SANDY CLAY, fine to medium grained Sand, medium plasticity Clay, grey. Wet.	LOOSE TO MEDIUM DENSE	SPT, N = 10	
			13.0			SAND, fine to medium grained, grey. Wet. With some thin Clayey Sand interbeds from 12.6 to 13.0 metres.			
			14.0		SW/GW	GRAVELLY SAND and SANDY GRAVEL, fine to medium grained Sand, rounded Gravel to 40mm. Grey and brown. Wet.	DENSE		
SPT5			15.0					SPT, N = 29	
						END OF HOLE AT 15.45 METRES			

Logged By : C.P.K. Date : 12.12.86 Checked By : C.P.K. Date : 16-12-'86

PJB

Peter J. Burgess & Associates Pty. Ltd.

APPENDIX C

TEST PIT LOGS - RUSHFORTH ROAD TP1 TO TP6

Excavation Log

Excavation No. TP 1

Sheet 1 of 1

CLIENT: CAMERON McNAMARA PTY. LTD.

Job No. 2417

PROJECT: SOUTH GRAFTON LEVEE

Location : RUSHFORTH ROAD C.R.C.C. LAND.

Equipment Type : MASSEY FERGUSON 50H BACKHOE
Excavation Dimensions : 0.45 x 3.6m

Surface Level : -
BEARING: 32°

Samples	Water	R.L. Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type - Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure.	Consistency or Relative Density	Field Test Results	Geological Profile
		0.2			SILT, low plasticity, brown, dry, numerous roots.	FRIABLE		TOPSOIL
		0.5		CL	CLAY, low plasticity, grey brown, dry to moist, numerous roots.	FRIABLE		ALLUVIUM
10				CH	CLAY, high plasticity, dark grey with some brown mottling, dry to moist, numerous roots and dessication cracks, FMC ≤ Wp.	HARD TO FRIABLE		
		1.0		CH	CLAY, as above, but moist, becoming less stiff with depth, FMC > Wp.	VERY STIFF		
20		1.9						
		2.0		CH	CLAY, high plasticity, light grey and brown mottled, moist, FMC > Wp, some discontinuous fissures, trace gravel: calcareous nodules upto 15mm.	STIFF		
30	NO WATER ENCOUNTERED	3.0						
		3.4			TEST PIT TP1 TERMINATED AT 3.4 METRES. LIMIT OF REACH.			

Logged By : I.A.H. Date : 25.11.86

Checked By : P.J.B. Date : DEC '86

Peter J. Burgess & Associates Pty. Ltd.

Excavation Log

Excavation No.	TP 2
Sheet	1 of 1
Job No.	2417
CLIENT: CAMERON McNAMARA PTY. LTD.	
PROJECT: SOUTH GRAFTON LEVEE	Location : RUSHFORTH ROAD C.R.C.C. LAND
Equipment Type : MASSEY FERGUSON 50H BACKHOE Excavation Dimensions : 0.45 x 3.1m	Surface Level : - BEARING: 55°

Samples	Water	R.L. Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type - Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure.	Consistency or Relative Density	Field Test Results	Geological Profile
	NO WATER ENCOUNTERED	0.4		CH	CLAY, high plasticity, grey brown, dessication cracks to 0.4m, dry, some roots.	HARD		ALLUVIUM
1D		0.5 1.0 1.5		CH	CLAY, high plasticity, light grey and brown mottled, moist, FMC > Wp, some roots, some dull, undulose, striated fissures, some calcareous nodules to 50mm.	FIRM TO STIFF		
2D		2.0			SANDY CLAY, yellow brown and grey mottled, moist, medium plasticity, FMC ≈ Wp.	FIRM		
		2.7			TEST PIT TP2 TERMINATED AT 2.7 METRES AT REQUIRED DEPTH.			

NOTES: TEST PIT TP2 WAS DUG INTO THE SIDE OF A BANK. THE LOG IS OF THE HIGH END OF THE PIT.

Logged By : I.A.H.	Date : 25.11.86	Checked By : P.J.B.	Date : DEC. '86

Excavation Log

Excavation No. TP 3

Sheet 1 of 1

CLIENT: CAMERON McNAMARA PTY. LTD.

Job No. 2417

PROJECT: SOUTH GRAFTON LEVEE

Location : RUSHFORTH ROAD BROTHERSON'S PROPERTY

Equipment Type : MASSEY FERGUSON 50H BACKHOE

Excavation Dimensions : 0.45 x 3.0m

Surface Level : -

Samples	Water	R.L / Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type : Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure.	Consistency or Relative Density	Field Test Results	Geological Profile
		0.3		CH	CLAY, high plasticity, light brown, dry, numerous dessication cracks to 10mm wide.	HARD		ALLUVIUM
		0.5		CH	CLAY, high plasticity, grey, dry, numerous dessication cracks to 15mm wide, cracks extending to 1.4m.	HARD		
		1.0						
		1.4			Depth of dessication cracks (from top of bank)			
10	NO WATER ENCOUNTERED	1.5		CH	CLAY, high plasticity, light grey with some brown mottling, trace black pisoliths to 5mm, FMC > Wp.	VERY STIFF		
		2.0			Slickensided fissures at 2.1-2.4m, dipping 45-60° shiny, undulose, continuous for 0.5m.	STIFF TO FIRM		
		2.5		CL	CLAY, medium plasticity, grey and brown mottled, moist, FMC > Wp, trace Sand.	FIRM		
		3.0			TEST PIT TP3 TERMINATED AT 3.0 METRES, REQUIRED DEPTH.			

NOTES: TEST PIT TP3 WAS DUG INTO THE SIDE OF A BANK. THE LOG IS OF THE HIGH END OF PIT.

Logged By : I.A.R. Date : 25.11.86 Checked By : P.J.B. Date : DEC. '86

PB Peter J. Burgess & Associates Pty. Ltd.

Excavation Log

Excavation No.	TP 4
Sheet	1 of 1
CLIENT: CAMERON McNAMARA PTY. LTD.	Job No. 241/
PROJECT: SOUTH GRAFTON LEVEE	Location : RUSHFORTH ROAD BROTHERSON'S PROPERTY
Equipment Type : MASSEY FERGUSON 150 BACKHOE Excavation Dimensions : 0.45m x 3.6m	Surface Level : - BEARING: 292°

Samples	Water	R.L / Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type : Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure.	Consistency or Relative Density	Field Test Results	Geological Profile
		0.25		OL	SILT, with trace Sand, low plasticity, black, numerous roots and root holes, dry to moist.	FRIABLE		TOPSOIL
		0.5		CH	CLAY, high plasticity, grey brown, moist, FMC > Wp.	VERY STIFF		ALLUVIUM
		0.6		CH	CLAY, high plasticity, light grey and brown mottled, moist, FMC > Wp	STIFF		
		1.0						
1D		1.5						
		2.0						
		2.1		CH/CL	CLAY, medium to high plasticity, grey and brown mottled, calcareous nodules to 15mm dia. at 2.2m, moist, FMC > Wp, calcareous nodules to 10mm dia. at 2.4m.	FIRM TO STIFF		
2D	NO WATER ENCOUNTERED	2.5						
		3.0						
		3.4			TEST PIT TP4 TERMINATED AT 3.4 METRES. LIMIT OF REACH.			

Logged By : I.A.H.	Date : 25.11.86	Checked By : P.J.B.	Date : DEC. '86

Excavation Log

Excavation No. TP 5

Sheet 1 of 1

CLIENT: CAMERON McNAMARA PTY. LTD.

Job No. 2417

PROJECT: SOUTH GRAFTON LEVEE

Location : RUSHFORTH ROAD BROTHERSON'S PROPERTY

Equipment Type : MASSEY FERGUSON 50H BACKHOE

Excavation Dimensions : 0.45m x 3.5m

Surface Level : -

BEARING: 295°

Samples	Water	R.L. / Depth (Metres)	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type, Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure.	Consistency or Relative Density	Field Test Results	Geological Profile
		0.2		OL	SILT, with some Sand, low plasticity, dark brown, dry, numerous roots.	FRIABLE		TOPSOIL
		0.45		OL	SILT, medium plasticity, black, dry, numerous roots.	FRIABLE		
		0.5		CH	CLAY, with some Sand, high plasticity, grey and brown mottled, moist, FMC > Wp.	VERY STIFF TO STIFF		ALLUVIUM
		1.0						
		1.5						
1D								
		2.0						
		2.35						
		2.5			SANDY SILT, low plasticity, yellow brown with light grey mottling, trace Gravel, moist. FMC > Wp	FIRM		
2D								
	NO WATER ENCOUNTERED	3.0			Gravelly band at 3.05m, 40mm thick, chert, siltstone, sub-rounded fragments to 10mm dia.			
		3.1		CH	CLAY, high plasticity, light grey with brown mottling.	FIRM TO STIFF		
		3.5			TEST PIT TP5 TERMINATED AT 3.5 METRES, LIMIT OF REACH.			

Logged By : I.A.H. Date : 25.11.86

Checked By : P.J.B. Date : DEC. '86

Peter J. Burgess & Associates Pty. Ltd.

Excavation Log

Excavation No.	TP 6
Sheet	1 of 1
Job No.	2417
Location :	RUSHFORTH ROAD BROTHERSON'S PROPERTY
Surface Level :	
BEARING:	203°

CLIENT: CAMERON McNAMARA PTY. LTD.

PROJECT: SOUTH GRAFTON LEVEE

Equipment Type : MASSEY FERGUSON 50H BACKHOE
Excavation Dimensions : 0.45m x 3.6m

Samples	Water	R.L. Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure (Soil Type : Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure.)	Consistency or Relative Density	Field Test Results	Geological Profile
		0.1		OL	SILT, with some Sand, dark brown, non-plastic, numerous roots.	FRIABLE		TOPSOIL
				CH	CLAY, high plasticity, dark grey, dry to moist, FMC > Wp, numerous roots.	FRIABLE TO HARD		ALLUVIUM
		0.5		CH	CLAY, high plasticity grey and brown mottled, FMC > Wp.	STIFF		
1D		1.0				FIRM TO STIFF		
	NO WATER ENCOUNTERED	1.5			Calcareous nodules to 15mm dia. at 1.7m.			
		2.0			Calcareous nodules to 15mm dia. at 2.15m.			
2D		2.5			Calcareous nodules to 20mm dia. at 2.4m.			
		3.0						
		3.25			TEST PIT TP6 TERMINATED AT 3.25 METRES. LIMIT OF REACH.			

Logged By : I.A.H. Date : 25.11.86 Checked By : P.J.B. Date : DEC. '86

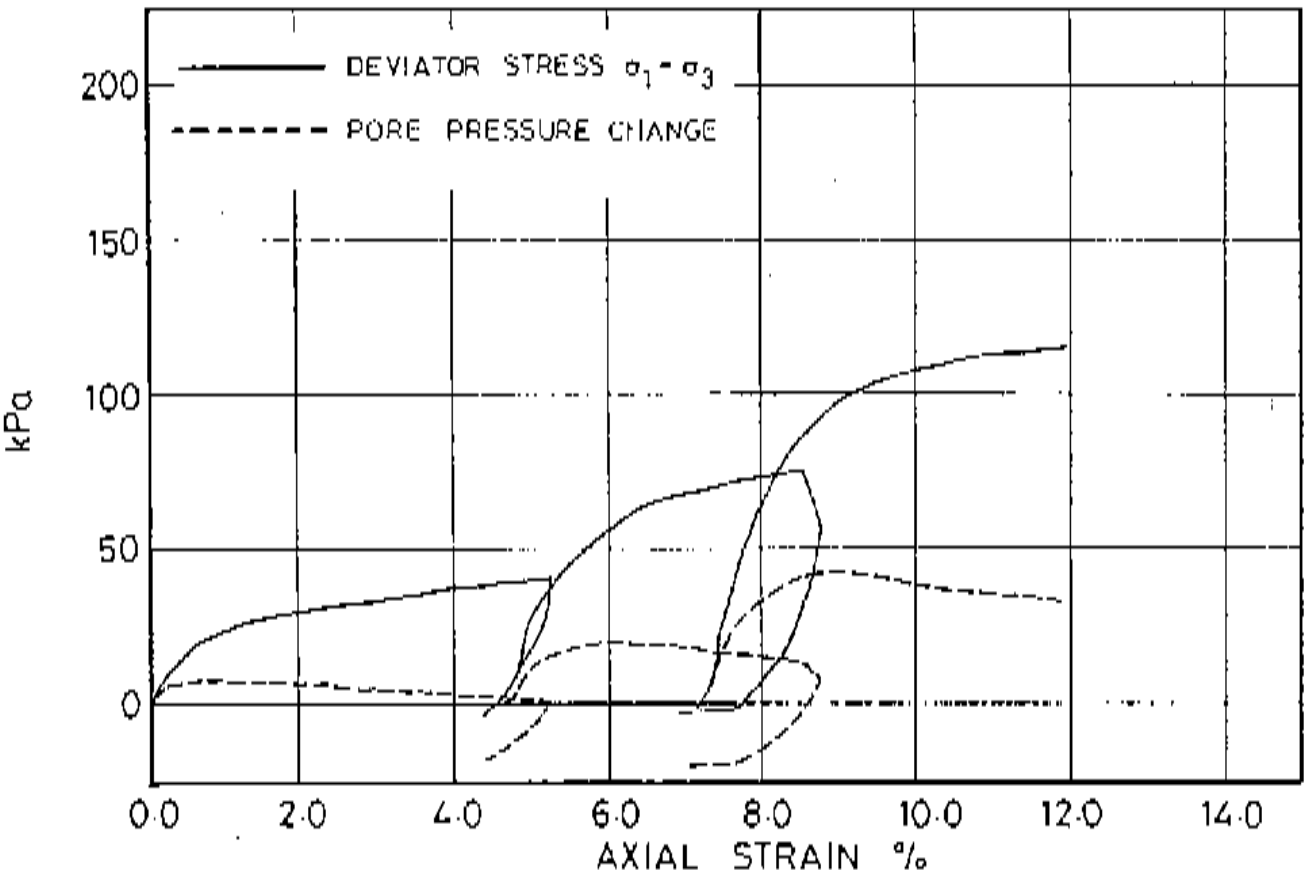
PJB Peter J. Burgess & Associates Pty. Ltd.

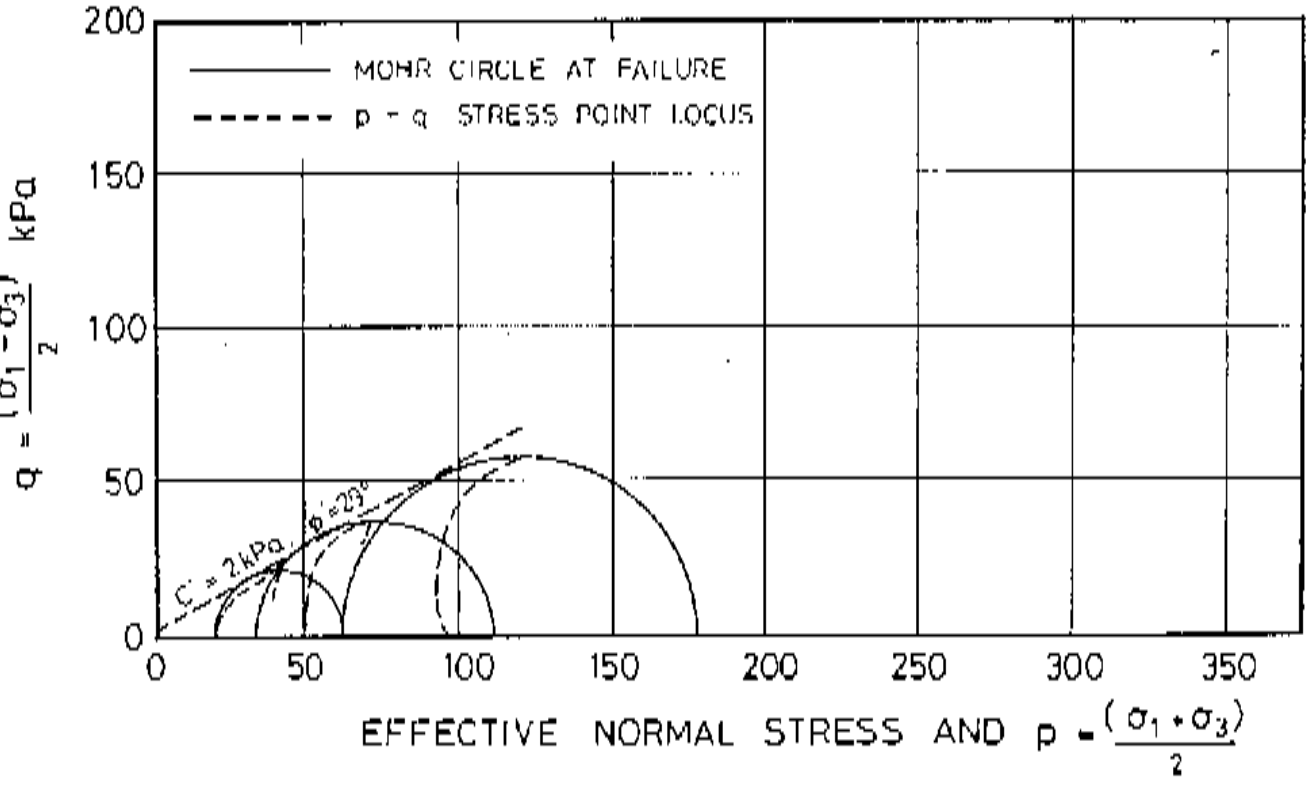
APPENDIX D

RESULTS OF LABORATORY TESTS ON BOREHOLE SAMPLES

A programme of laboratory testing was carried out on soil samples recovered from the boreholes. Testing comprised:

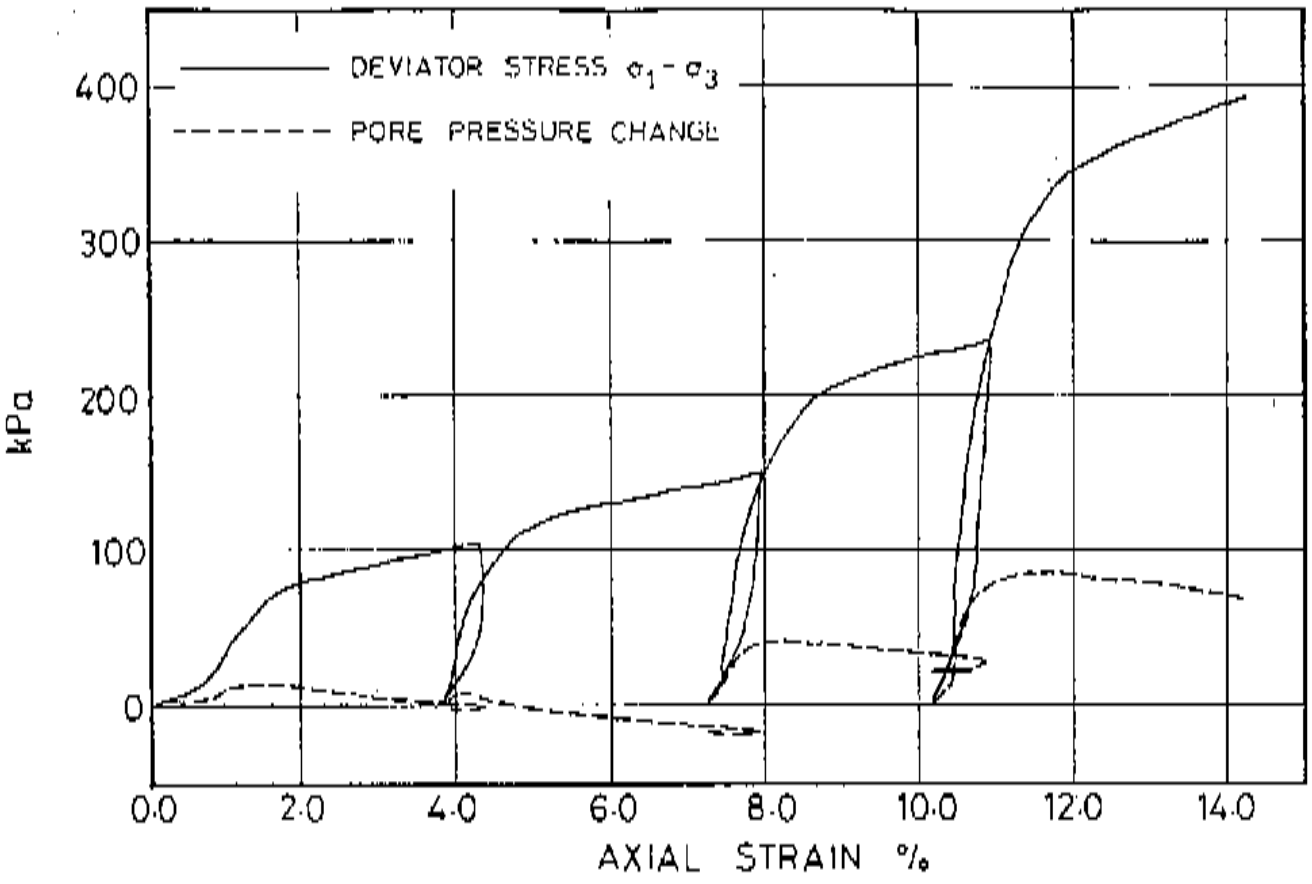
Test Description	No. of Tests	
Field Moisture Content	33	(See Table 4)
Atterberg Limits	5	(See Table 4)
Particle Size Distribution	11	(See Table 4)
Hydrometer Analysis	-	
Confined Compression	3	
Consolidated Undrained Triaxial with Pore Pressure Measurement	4	
Direct Shear	2	
Oedometer	2	

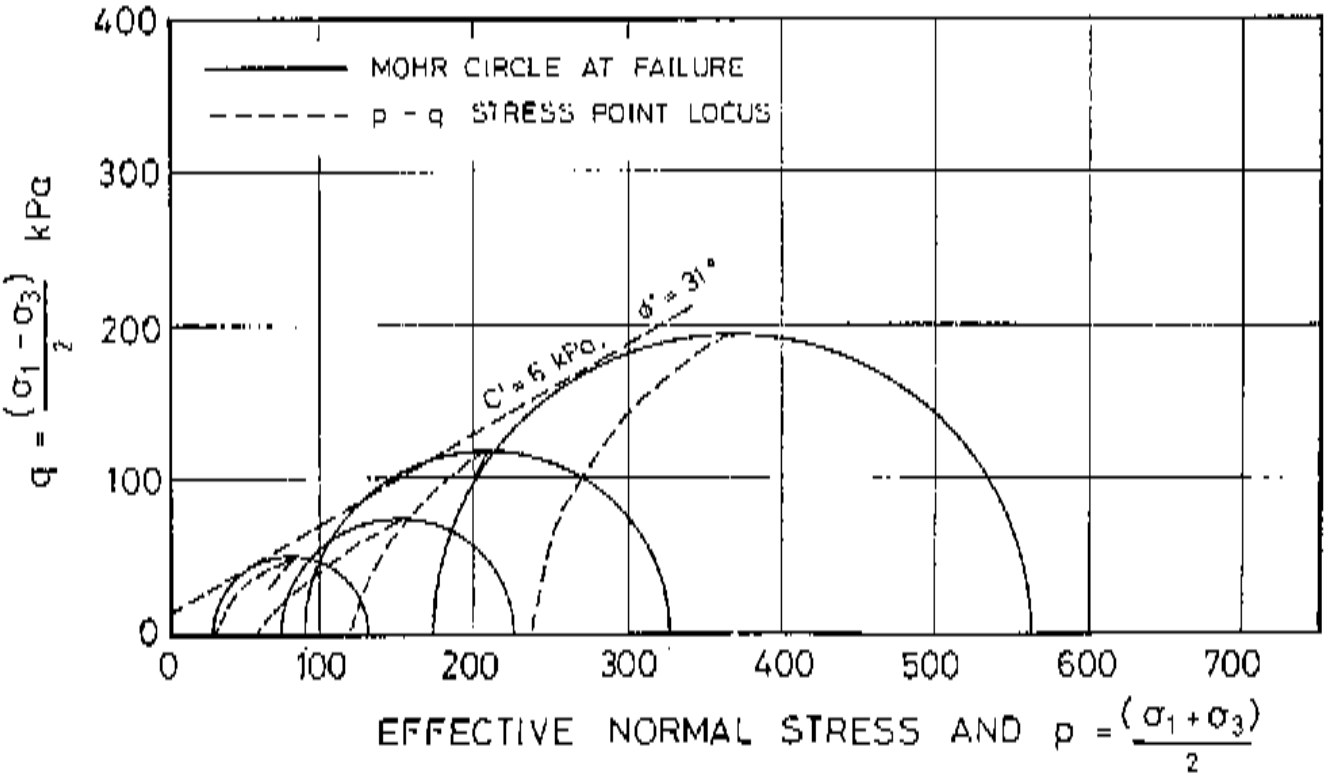




CAMERON McNAMARA PTY. LTD.
SOUTH GRAFTON LEVEE - GEOTECHNICAL INVESTIGATION
C.U. TRIAXIAL TEST RESULT - SAMPLE BH SG3/UD1

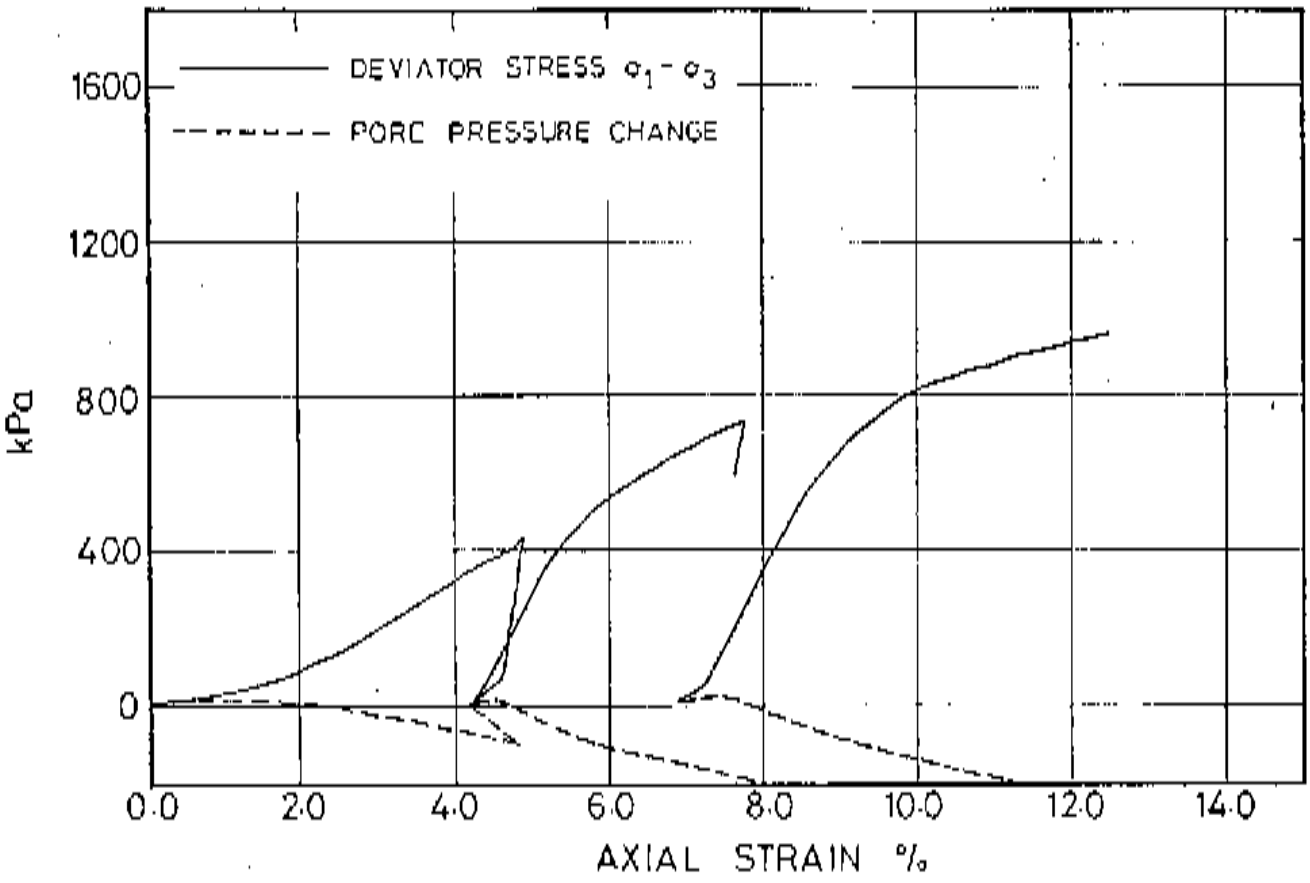
Peter J. Burgess & Associates Pty Ltd	2417	FIGURE D1

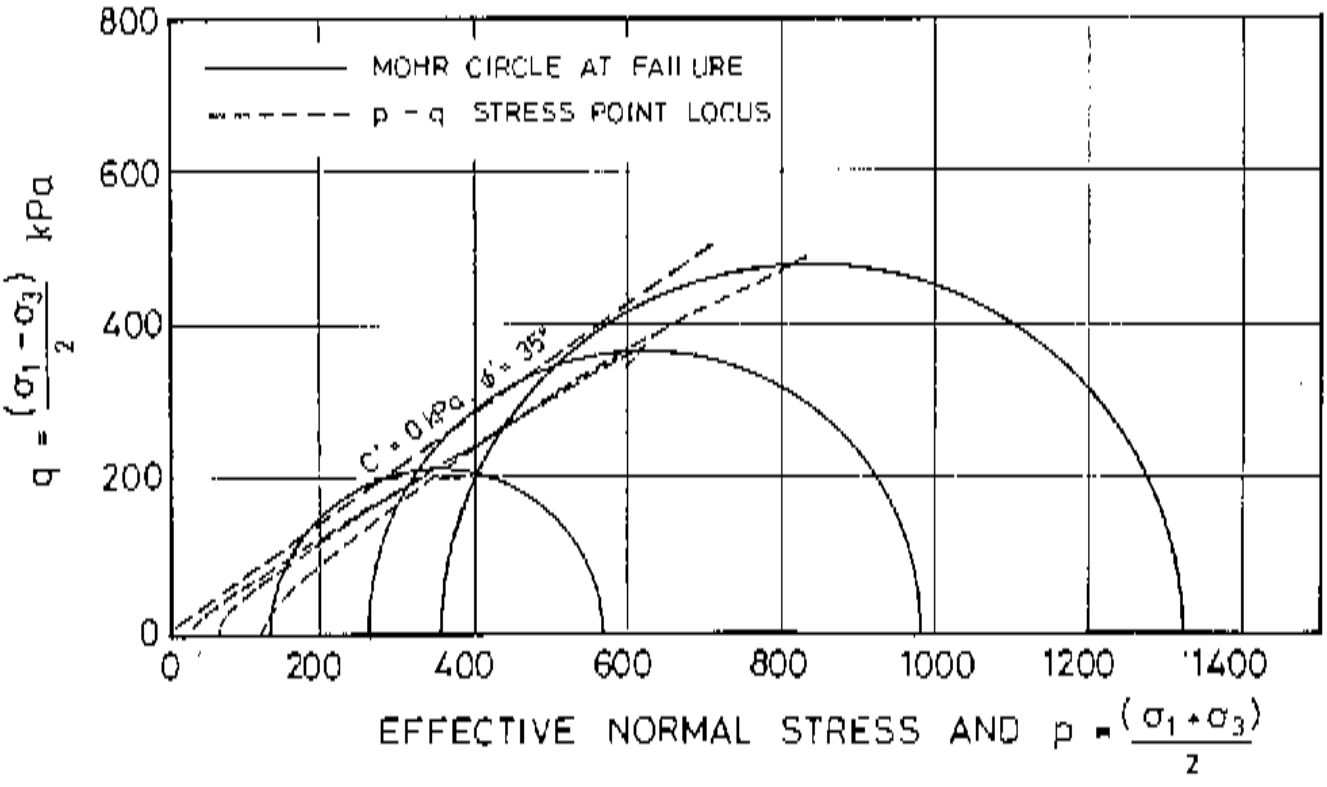




CAMERON McNAMARA PTY. LTD.
SOUTH GRAFTON LEVEE - GEOTECHNICAL INVESTIGATION
C.U. TRIAXIAL TEST RESULT - SAMPLE BH SG5/UD2

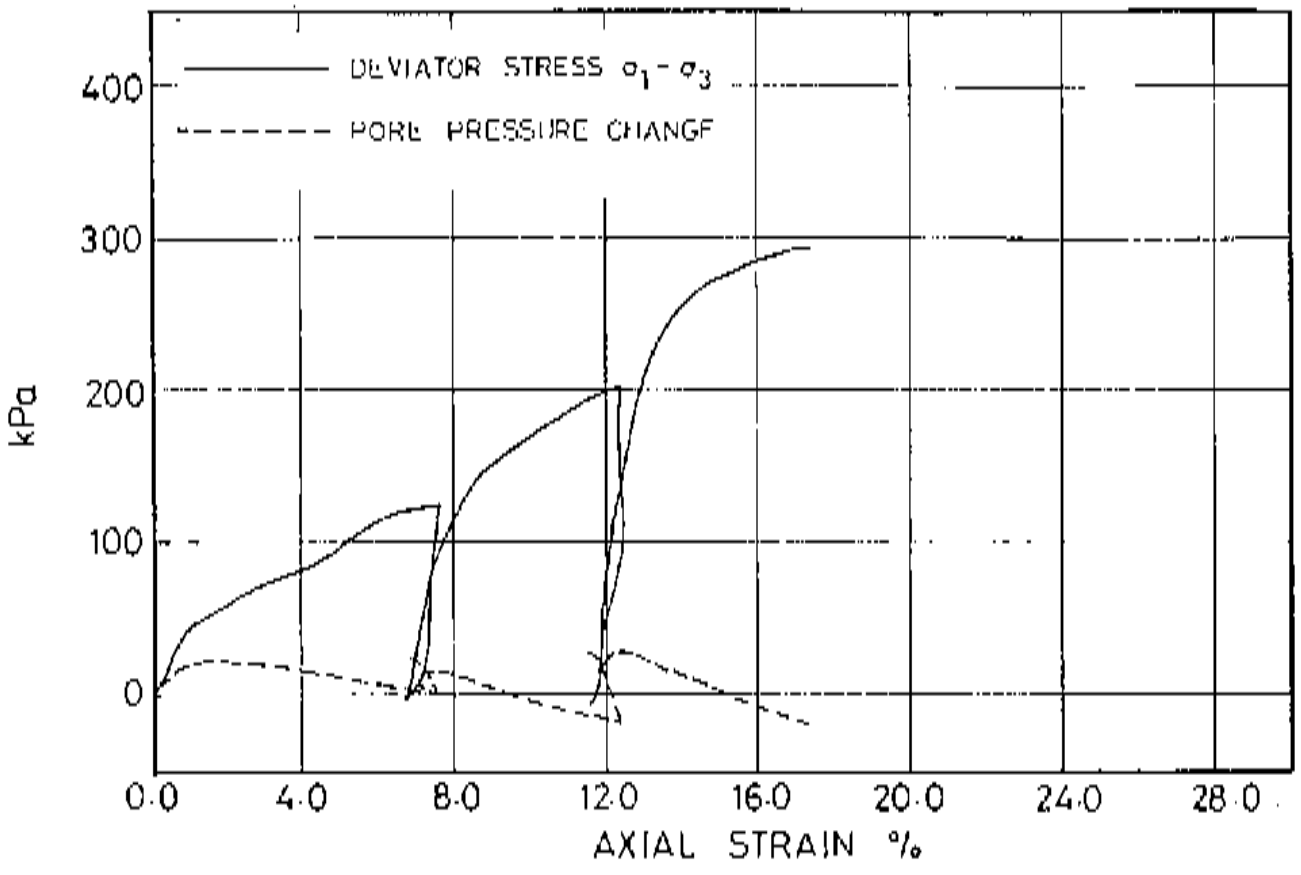
Peter J. Burgess & Associates Pty Ltd	2417	FIGURE D2

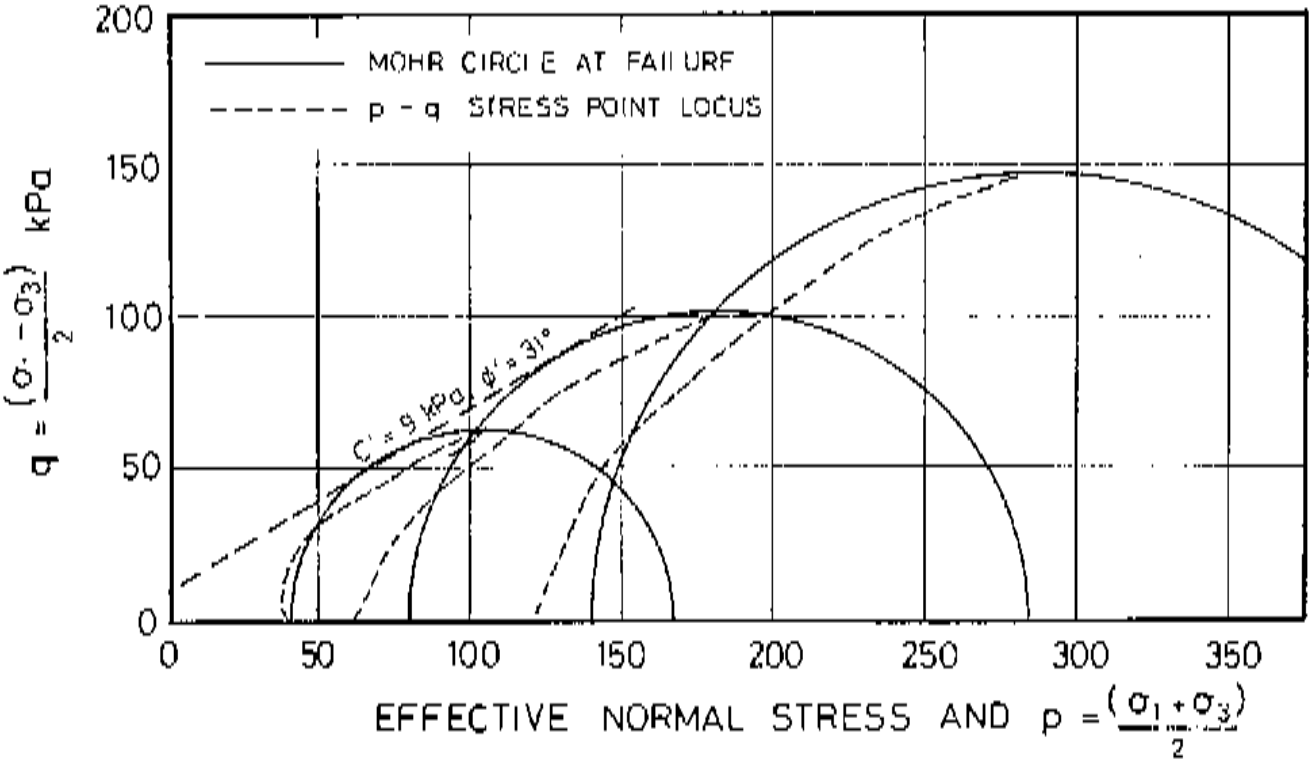




CAMERON McNAMARA PTY. LTD.
SOUTH GRAFTON LEVEE - GEOTECHNICAL INVESTIGATION
C.U. TRIAXIAL TEST RESULT - SAMPLE BH SG6/UD1

Peter J. Burgess & Associates Pty Ltd	2417	FIGURE 03

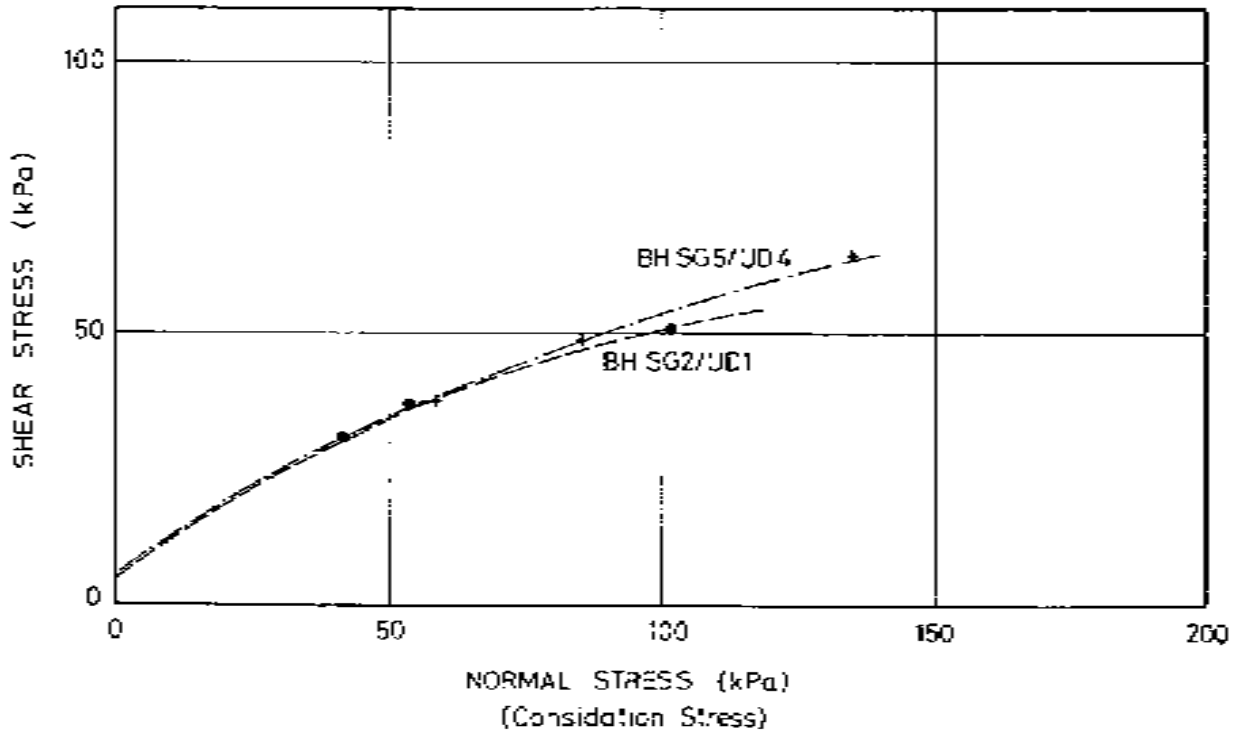




CAMERON McNAMARA PTY. LTD.
SOUTH GRAFTON LEVEE - GEOTECHNICAL INVESTIGATION
C.U. TRIAXIAL TEST RESULT - SAMPLE BH SG7/UD2

Peter J. Burgess & Associates Pty Ltd	2417	FIGURE D4

BOREHOLE	FEATURE	EFFECTIVE STRESS RANGE IN SLOPE ANALYSIS	EQUIVALENT MOHR-COULOMB PARAMETERS	
			C' (kPa)	ø' (degrees)
BH SG2/UD1	HEBER ST. LEVEE	0 - 60 kPa	5	28°
BH SG5/UD4	ARDENT ST. LEVEE	0 - 60 kPa	5	29°



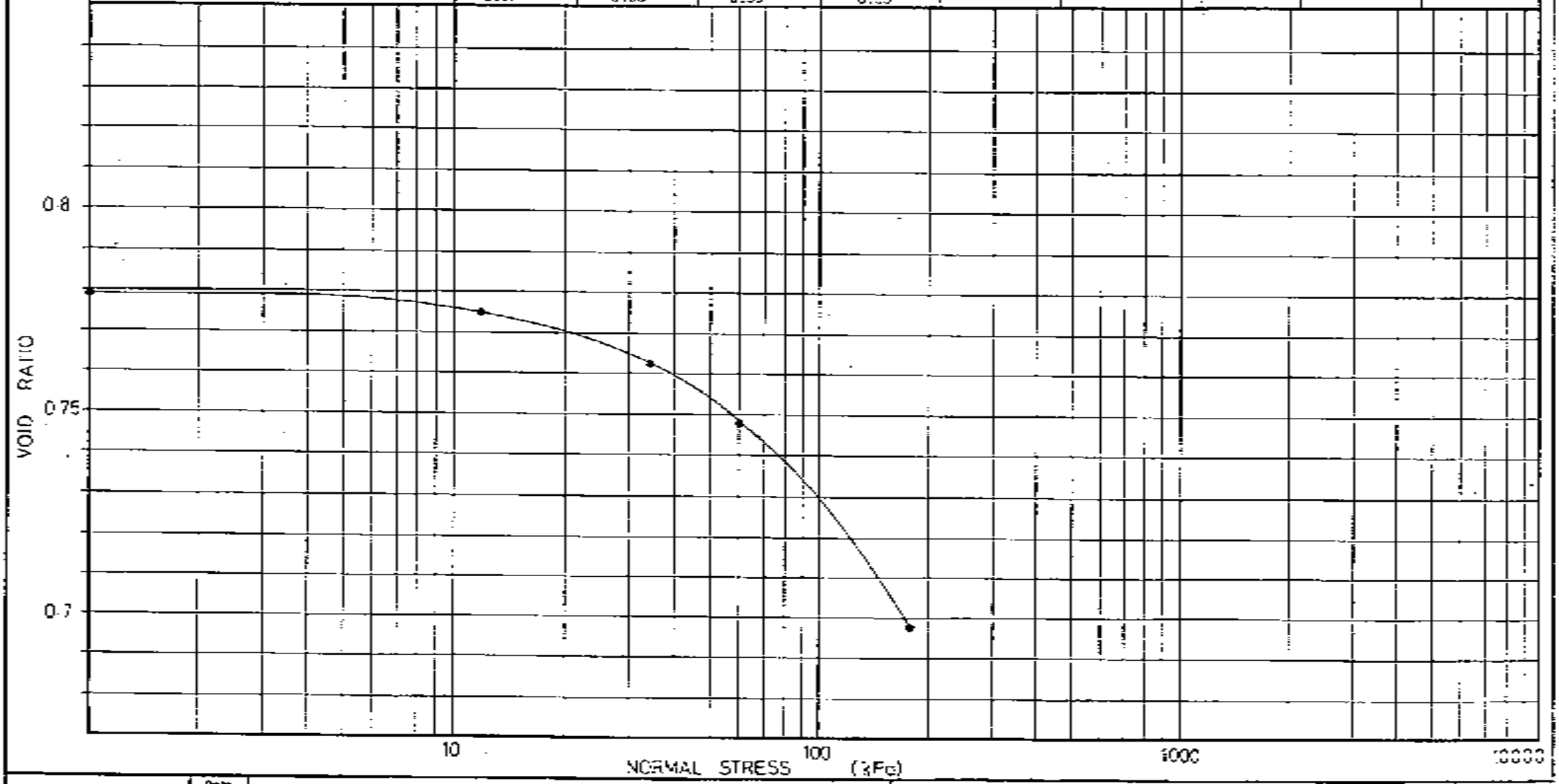
	Date
Revision	

CAMERON McNAMARA PTY. LTD.
SOUTH GRAFTON LEVEE - GEOTECHNICAL INVESTIGATION
DRAINED DIRECT SHEAR TESTS - BH SG2/UD1 & BH SG5/UD4

Peter F. Burgess & Associates Pty Ltd | 2417 | FIGURE D5

GEOLOGICAL DESCRIPTION:	ALLUVIAL CLAY			SAMPLE No: BH SG1/UD1	DEPTH: 2.2m
INITIAL DRY DENSITY:	1.45 g/cm^3	INITIAL MOISTURE CONTENT:	28.9%	SAMPLE HEIGHT:	15.80mm
SOIL PARTICLE DENSITY:	2.69 g/cm^3	FINAL MOISTURE CONTENT:	28.8%	SAMPLE DIAMETER:	50.46mm

NORMAL STRESS RANGE (kPa)	0 - 11.7	11.7 - 35.8	35.8 - 60.0	60.0 - 160.0
C_c	0.034	0.027	0.067	0.103
M_v m^2/kN	2.1×10^{-4}	3.0×10^{-4}	3.5×10^{-4}	2.3×10^{-4}
C_v m^2/Yr	1.37	0.58	3.35	0.35



Date	
Revision	

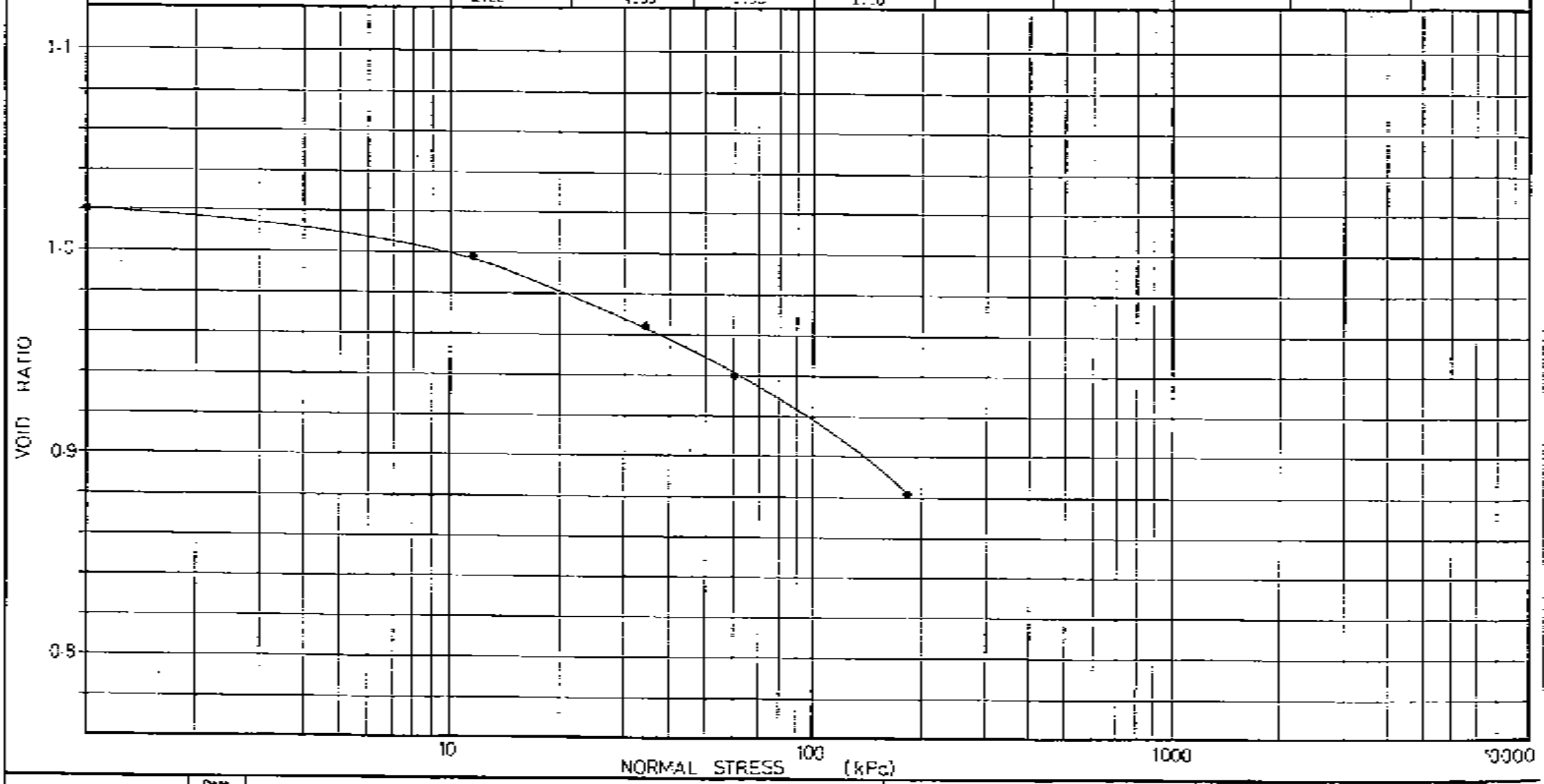
CAMERON McNAMARA PTY LTD.
SOUTH GRAFTON LEVEE - GEOTECHNICAL INVESTIGATION
OEDOMETER TEST RESULT - SAMPLE BH SG1/UD1

Peter J. Burgess & Associates	2417	FIGURE 06

GEOLOGICAL DESCRIPTION: ALLUVIAL SILTY CLAY

SAMPLE No: BH SG5/UC4 DEPTH: 6.6m

INITIAL DRY DENSITY:	1.28 g/cm^3	INITIAL MOISTURE CONTENT:	41.0%	SAMPLE HEIGHT:	19.80mm		
SOIL PARTICLE DENSITY:	2.65 g/cm^2	FINAL MOISTURE CONTENT:	36.2%	SAMPLE DIAMETER:	50.82mm		
NORMAL STRESS RANGE (kPa)	1 - 11.7	11.7 - 35.8	35.8 - 50.0	50.0 - 180.5			
C_c	0.022	0.070	0.098	0.123			
M_v m^2/kN	11.1 x 10^{-4}	7.07 x 10^{-4}	4.35 x 10^{-4}	2.52 x 10^{-4}			
C_v m^2/Yr	2.22	4.33	1.95	1.10			



Date	
Revision	

CAMERON McNAMARA PTY. LTD.
SOUTH GRAFTON LEVEE - GEOTECHNICAL INVESTIGATION
OEDOMETER TEST RESULT - SAMPLE BH SG5/UC4

Peter J. Burgess & Associates | 2417 | FIGURE C7

APPENDIX E

RESULTS OF LABORATORY TESTS ON BORROW MATERIAL

A programme of laboratory testing was carried out on disturbed samples recovered from test pits in the proposed Rushforth Road borrow area. Testing comprised:

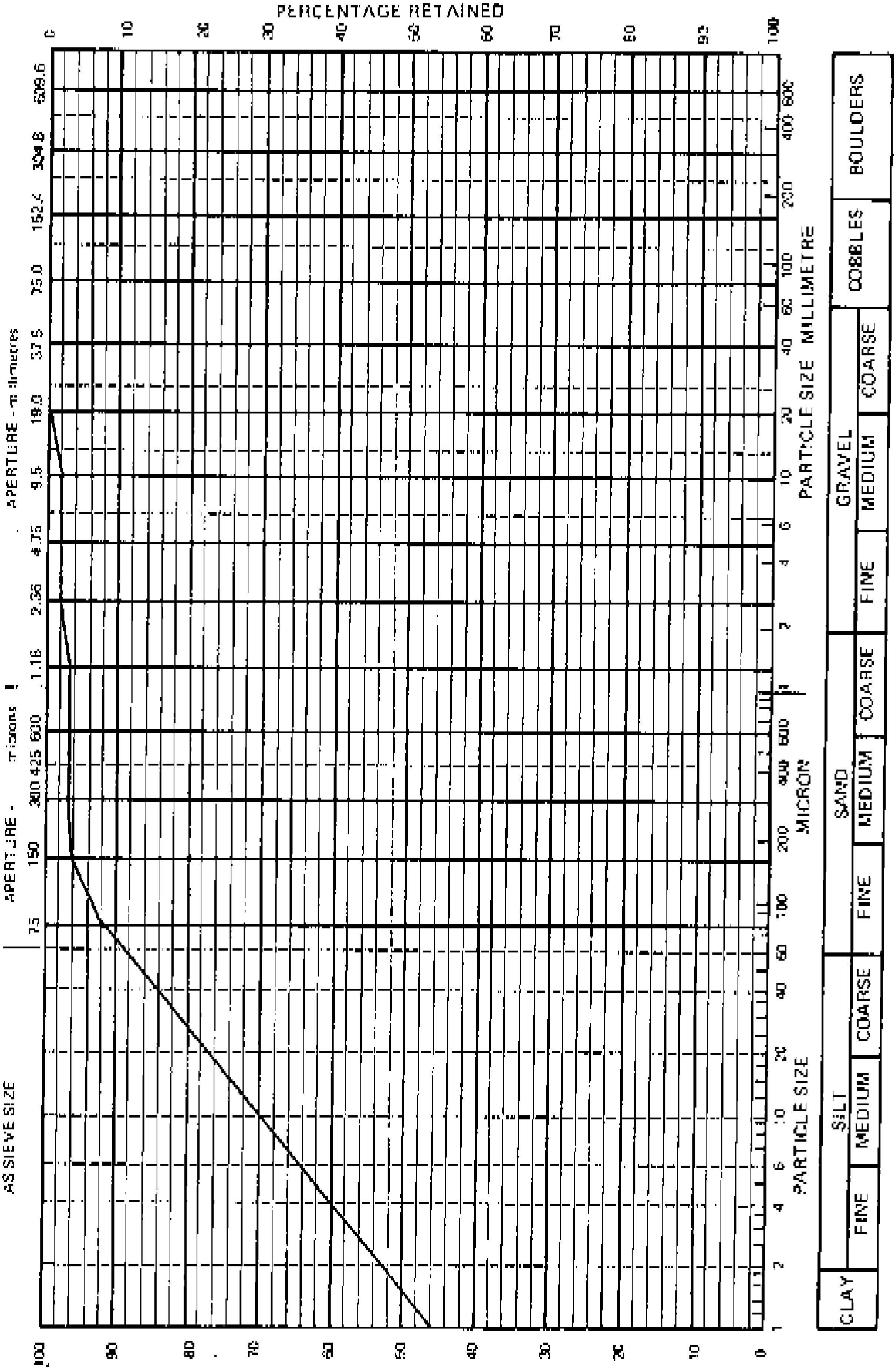
Test Description	No. of Tests	
Field Moisture Content	12	(See Table 5)
Atterberg Limits	4	(See Table 5)
Particle Size Distribution	4	
Hydrometer Analysis	2	
Confined Compression	1	
Consolidated Undrained Triaxial with Pore Pressure Measurement	1	
Emmerson Dispersion	5	(See Table 5)
Standard Compaction Tests	3	

Peter J. Burgess & Associates

PARTICLE SIZE DISTRIBUTION CHART

Tested by S.C.C. Plotted by S.C.C. Checked by I.A.H. SAMPLE NO. TP1/30

Date 10.12.86 Date 11/12/86 Date 15/12/86 REGISTRATION



D_{10} .... D_{30} .... D_{60} .... C_L .... C_C .... Classification ....

Description of material ....

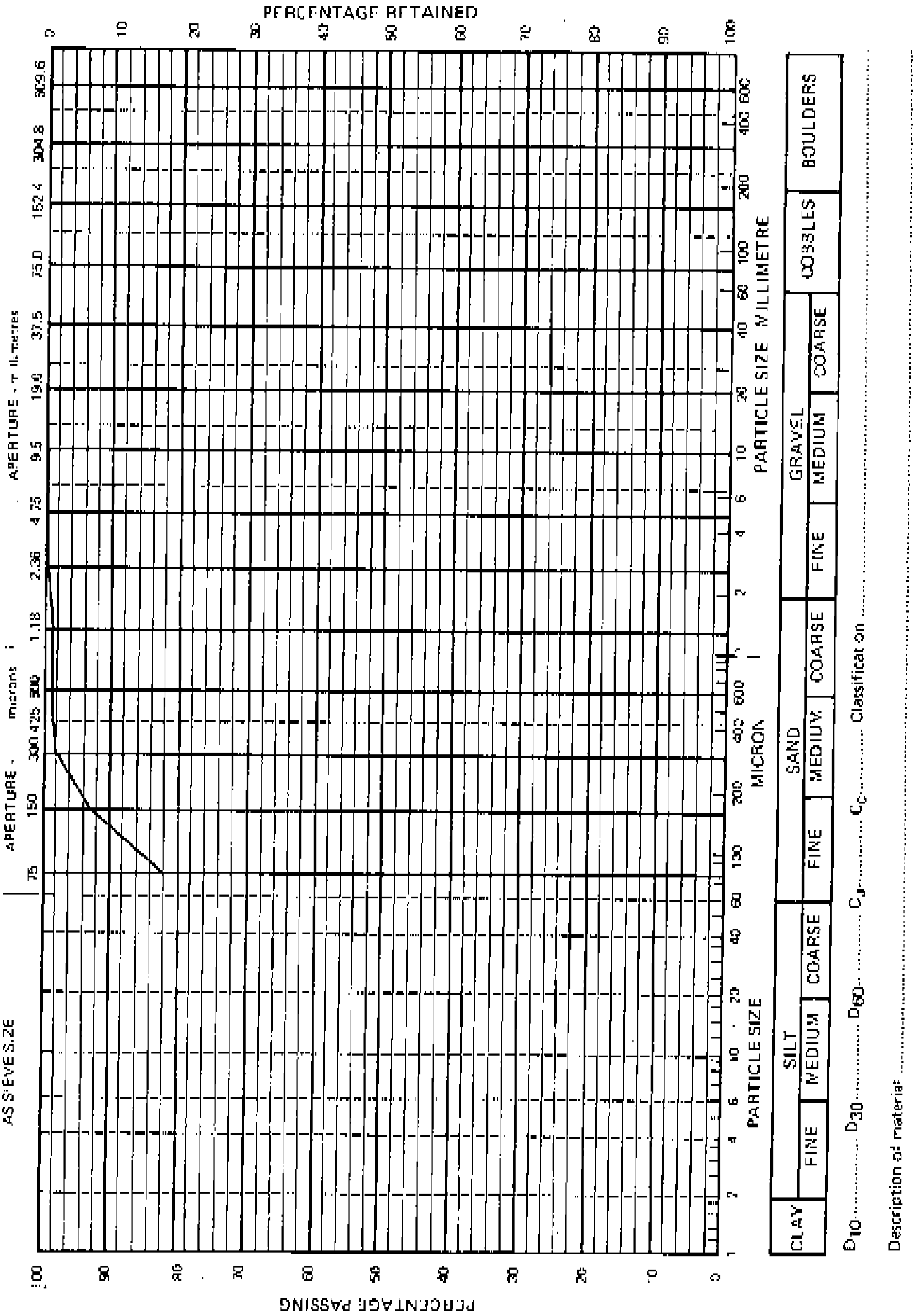
Report No. .... Sheet ....

Peter J. Burgess & Associates

PARTICLE SIZE DISTRIBUTION CHART

Tested by S.C.C. Plotted by S.C.C. Checked by I.A.H. SAMPLE NO. TP2/2D

Date 10.12.86 Date 10.12.86 Date 15.12.86 REGISTRATION ....



D_{10} .... D_{30} .... D_{60} .... C_u .... C_c .... Classification ....

Description of material ....

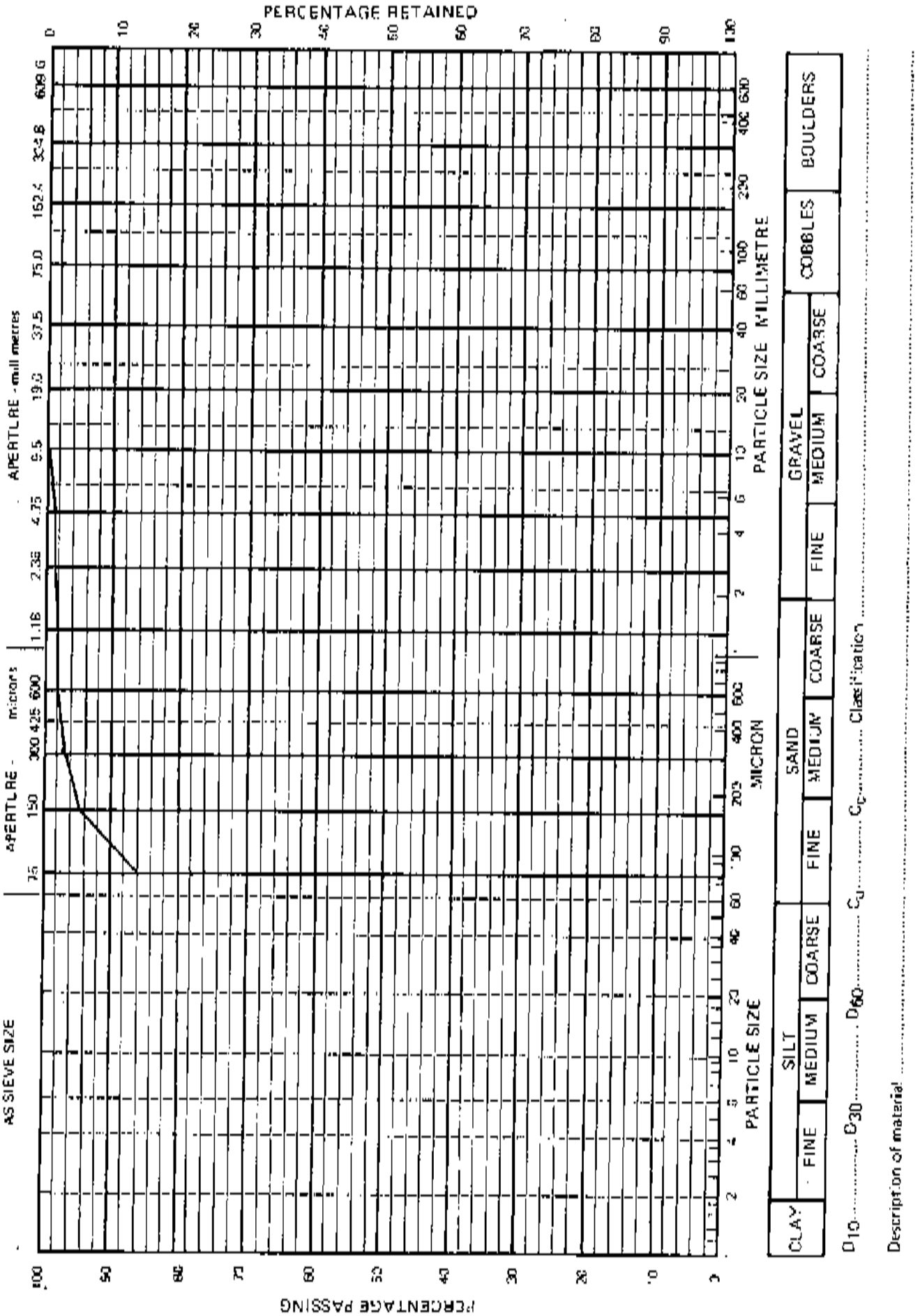
Report No. .... Sheet ....

Peter J. Burgess & Associates

PARTICLE SIZE DISTRIBUTION CHART

Tested by S.C.C. Plotted by S.C.C. Checked by I.A.H. SAMPLE NO. TP5/10

Date 10.12.86 Date 11.12.86 Date 15.12.86 REGISTRATION



D_{10} ..... D_{30} ..... D_{60} ..... C_u ..... C_c ..... Classification .....

Description of material .....

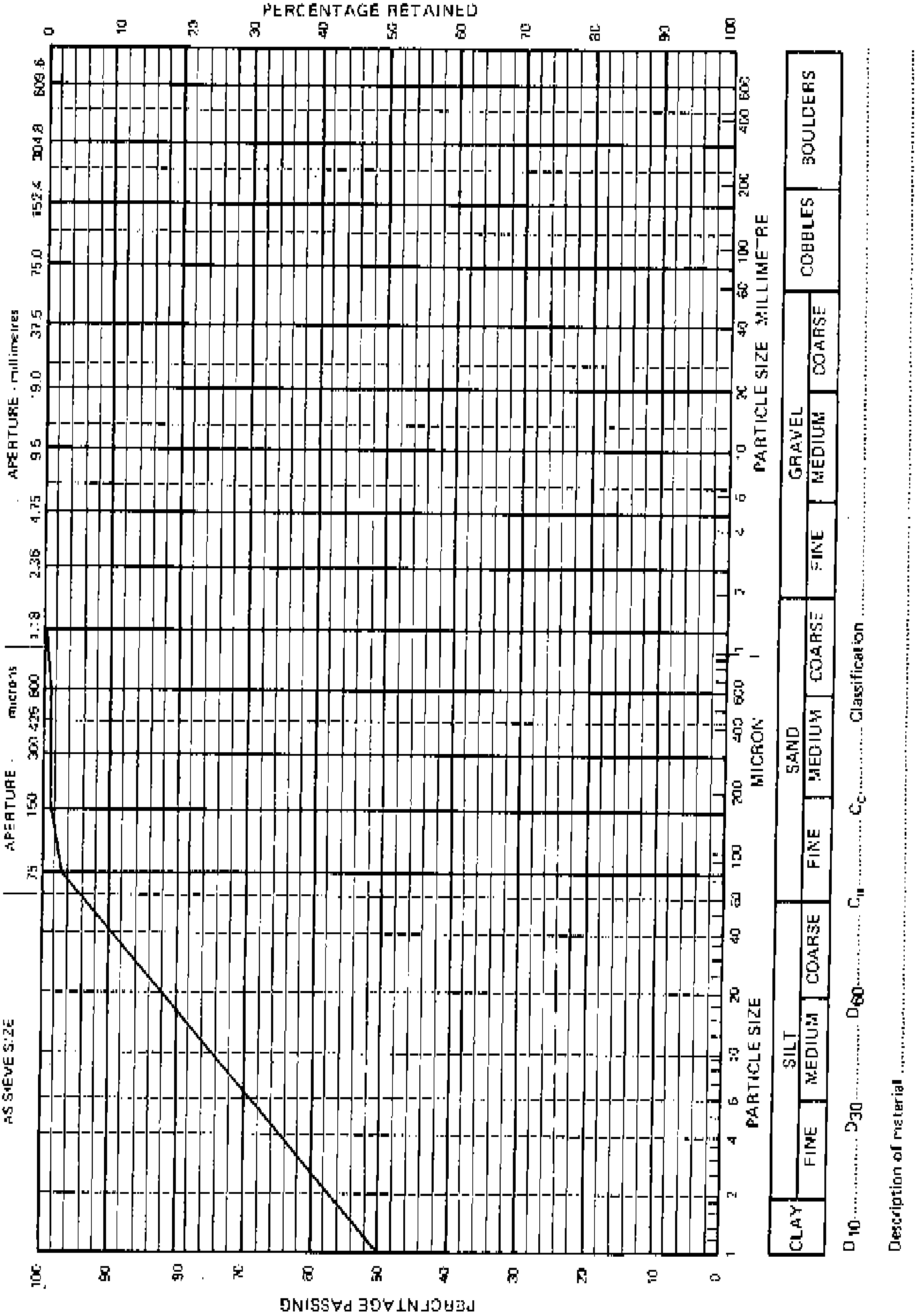
Project No. ..... Sheet .....

Peter J. Burgess & Associates

PARTICLE SIZE DISTRIBUTION CHART

Tested by S.C.C. Plotted by S.C.C. Checked by I.A.H SAMPLE NO. TP6/1D

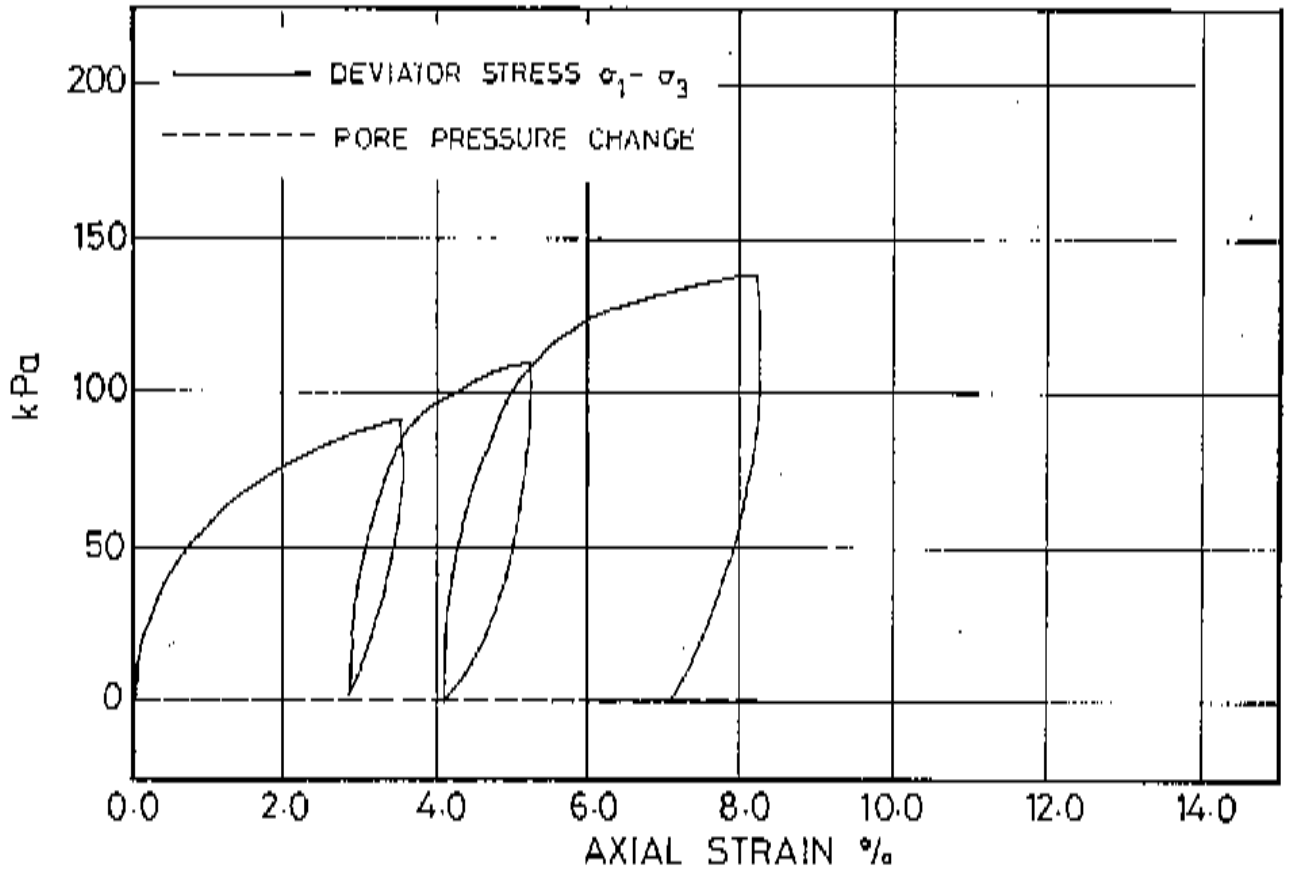
Date 10.12.86 Date 11.12.86 Date 15.12.86 REGISTRATION

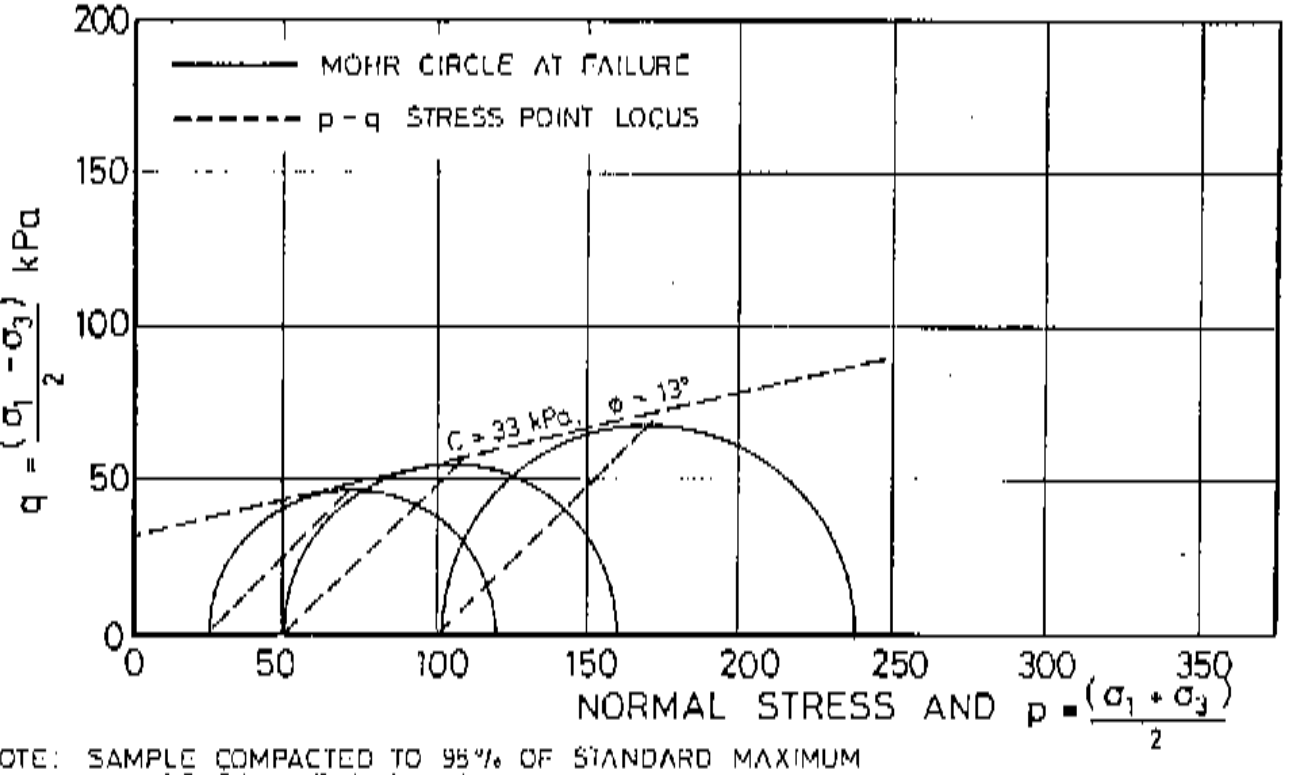


D_{10} .... D_{30} .... D_{60} .... C_u .... C_c .... Classification ....

Description of material ....

Report No. .... Sheet ....

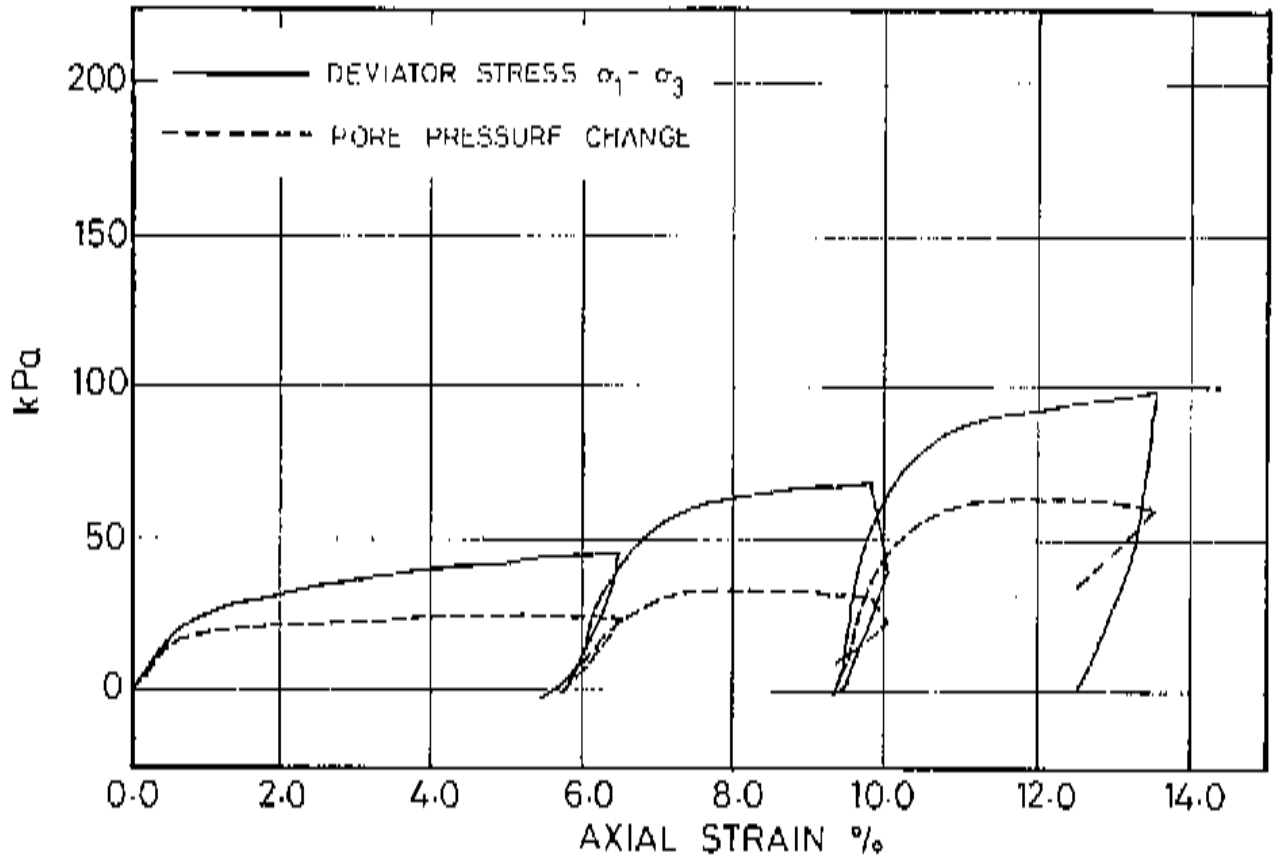


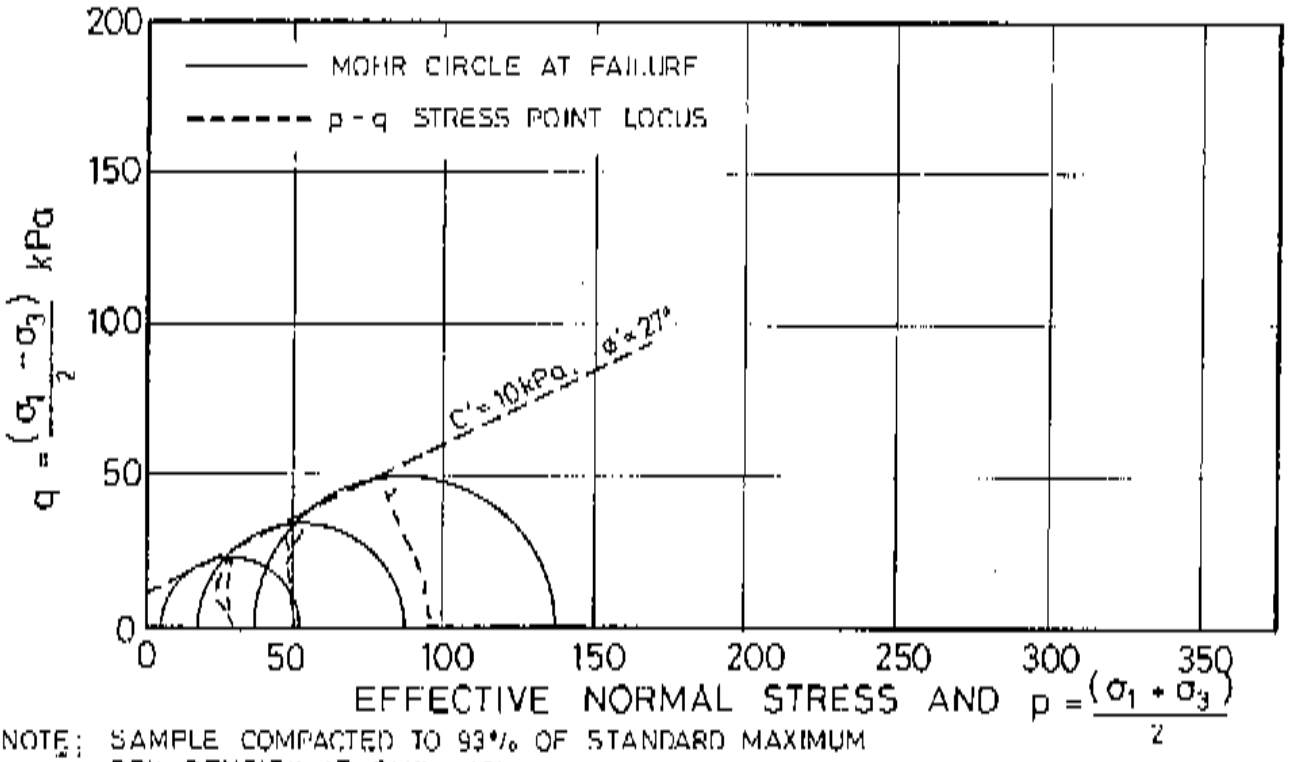


NOTE: SAMPLE COMPACTED TO 95% OF STANDARD MAXIMUM DRY DENSITY AT OMC + 4%

CAMERON McNAMARA PTY. LTD.
SOUTH GRAFTON LEVEE - RUSHFORTH ROAD
REMOULDED U.U. TRIAXIAL TEST - SAMPLE TP1/3D

Peter J. Burgess & Associates Pty Ltd	2417	FIGURE E1





NOTE: SAMPLE COMPACTED TO 93% OF STANDARD MAXIMUM DRY DENSITY AT OMC + 4%

CAMERON McNAMARA PTY. LTD.
SOUTH GRAFTON LEVEE - RUSHFORTH ROAD
REMOULDED C.U. TRIAXIAL TEST - SAMPLE TP6/1D

Peter J. Burgess & Associates Pty Ltd	2417	FIGURE E2

Peter J. Burgess & Associates Pty. Ltd.

Consulting Engineers & Geologists

PROJECT SOUTH GRAFTON LEVEE

FEATURE FISHER ST – WATERVIEW No. 1 of 2

SUMMARY OF FIELD & LABORATORY SOIL TEST RESULTS (1)

Borehole	Sample No.	Depth m	Unified Classification	Gradation (% of total dry mass smaller) Max. size mm	9.5 mm	4.75 mm	2.36 mm	1.18 mm	600 µm	300 µm	150 µm	75 µm	2 µm	Linear Shrinkage %	Atterberg w_L %	Atterberg w_P %	G_s	Compaction (2) MDD t/m³	OMC %	Field Density t/m³	Field Moisture Content %	Shear (3) U.U. tubes Effective Stress c' kPa	φ' °	Total Stress c kPa	φ °	U.U. tubes Effective Stress c' kPa	φ' °	Total Stress c kPa	φ °	Permeability	Consolidation (4)	
BHSG1/	SPT1	1.0 - 1.3																			30.7											
	UD1	2.0 - 2.3																			26.9											
	SPT2	3.0 - 3.4																			30.9											
	UD2	4.0 - 4.3																			30.9											
	UD3	5.0 - 5.3																			32.9											
	UD4	6.0 - 6.3																														
	UD5	8.0 - 8.3																			23.6											
	UD6	10.0-10.4																		1.58	25.4							43	150			
	SPT3	12.0-12.3																														
	UD7	14.0-14.3																			17.3											
BHSG2/	SPT1	1.0 - 1.3																			28.8											
	UD1	2.0 - 2.3																			22.4	7	28									
	SPT2	3.0 - 3.4																			24.9											
	UD2	4.0 - 4.2													39	14					28.2											
	UD3	5.0 - 5.2																														
	UD4	6.0 - 6.3																														
	UD5	8.0 - 8.3																		1.56	26.8							73	130			
	UD6	10.0-10.3																														
	SPT3	12.0-12.4																														
	UD7	14.0-14.3																														
BHSG3/	SPT1	1.5 - 1.8													55	35					20.3											
	UD1	2.6 - 2.8																		1.60	22.1	2	25(?)									
	UD2	4.0 - 4.3																														
	UD3	5.0 - 5.3																														
	SPT2	6.0 - 6.3			100	100	99	95	91	71	36	18									42.2											
	SPT3	7.0 - 7.4																														
	SPT4	8.0 - 8.4			100	100	100	100	93	26	6	2									24.4											

PRETREATMENT

NOTES:
(1) All tests in accordance with Australian Standards AS1289, unless otherwise stated.
(2) Compaction type .... unless otherwise stated.
(3) Shear strength results are from triaxial compression tests unless otherwise stated. Failure defined by ($\sigma_1 - \sigma_3$) max.
(4) Consolidation under ..... kPa, unless otherwise stated.

COMPILED	IAH	CHECKED	IAH	TESTING OFFICER	VARIOUS
DATE	13.1.86	DATE	10.2.86	DATE	-
		REPORT No.	2417	SHEET	1 of 2

TABLE 4

Peter J. Burgess & Associates Pty. Ltd.

PJB

Consulting Engineers & Geologists

SUMMARY OF FIELD & LABORATORY SOIL TEST RESULTS (1)

PROJECT SOUTH GRAFTON LEVEE

FEATURE HEBER ST - WATERVIEW No. 2 of 2

Borehole	Sample No.	Depth m	Unified Classification	Max Size mm	Gravel 9.5 mm	Gravel 4.75 mm	Sand 2.36 mm	Sand 1.18 mm	Sand 600 µm	Sand 300 µm	Sand 150 µm	Silt 75 µm	Clay 2 µm	Linear Shrinkage %	Atterberg W_L %	Atterberg I_p %	G_s	Compaction (2) MDD t/m³	Compaction (2) OMC %	Field Density t/m³	Field Moisture Content %	Shear (3) U.D. tubes Effective Stress c' kPa	Shear (3) U.D. tubes Effective Stress φ' °	Shear (3) U.D. tubes Total Stress c kPa	Shear (3) U.D. tubes Total Stress φ °	Shear (3) U.D. tubes Effective Stress c' kPa	Shear (3) U.D. tubes Effective Stress φ' °	Shear (3) U.D. tubes Total Stress c kPa	Shear (3) U.D. tubes Total Stress φ °	Permeability (at … kPa) Saturation %	Permeability (at … kPa) k m/s	Permeability (at … kPa) Saturation %	Permeability (at … kPa) k m/s	Consolidation (4) %
BHSG3/	SPT7	12.1 - 12.4																																
BHSG4/	SPT1	1.0 - 1.4																			14.1													
	UD1	2.0 - 2.3																																
	SPT2	3.0 - 3.4																																
	SPT4	5.1 - 5.4			100	100	100	98	96	91	67	42									26.5													
	SPT6	7.6 - 8.0																																
	SPT8	9.5 - 9.9			100	100	100	95	93	66	15	5									24.9													
	SPT10	12.5 - 12.8																																
BHSG5/	SPT1	1.0 - 1.4																			9.6													
	UD1	2.0 - 2.3																		1.69	17.6							225	30					
	SPT2	3.0 - 3.4																			17.8													
	JD2	4.0 - 4.3						100	99	97	80	54								1.79	15.6	6	31											
	SPT3	5.5 - 5.9																			22.0													
	JD3	7.0 - 7.3																																
	LD4	8.5 - 8.9																			41.0	3	31											
	LD5	10.1 - 10.4													56	40					50.0													
	LD6	11.5 - 11.9																																
	SPT5	16.0 - 16.4			100	100	94	87	84	79	47	30									46.3													
	SPT7	19.6 - 20.0																																
BHSG6/	SPT4	8.0 - 8.4																			27.1													
	UD1	10.0 - 10.3																		1.42	25.5	0	35											
	SPT6	15.0 - 15.4			100	100	95	92	91	80	41	15									27.4													
BHSG7/	SPT3	6.5 - 6.9			100	100	100	98	95	89	51	28									17.2													
	UD1	8.2 - 8.4																			35.8													
	JD2	10.25 - 10.4																		1.53	23.9	9	31											
BHSG8/	SPT2	4.0 - 4.2			100	100	100	100	99	96	74	47																						
	SPT3	6.0 - 6.2			100	100	100	100	99	89	43	25																						

PRETREATMENT

NOTES:
(1) All tests in accordance with Australian Standard AS1289 unless otherwise stated.
(2) Compaction type .... unless otherwise stated.
(3) Shear strength results are from triaxial compression tests unless otherwise stated. Failure defined by ($\sigma_1 - \sigma_3$) max.
(4) Consolidation under .... kPa unless otherwise stated.

COMPILED TAH CHECKED EAH TESTING OFFICER VARIOUS

DATE 13.1.86 DATE 10.2.86 DATE -

REPORT No 2417 SHEET 2 of 2

TABLE 4 (cont'd)

Peter J. Burgess & Associates Pty. Ltd.

Consulting Engineers & Geologists

SUMMARY OF FIELD & LABORATORY SOIL TEST RESULTS (1)

PROJECT SOUTH GRAFTON LEVEE
FEATURE RUSHFORTH ROAD No. 2417

Sample No.	Depth m	Unified Classification	Max size mm	Gravel 9.5 mm	Gravel 4.75 mm	Sand 2.36 mm	Sand 1.18 mm	Sand 600 µm	Sand 300 µm	Sand 150 µm	Silt 75 µm	Clay 2 µm	Linear Shrinkage %	Atterberg w_L %	Atterberg I_P %	G_s	Compaction (2) MDD t/m³	Compaction OMC %	Field Density t/m³	Field Moisture Content %	Shear (3) UU Total Stress c kPa	φ °	CU Effective Stress c' kPa	φ' °	CU Total Stress c kPa	φ °	Permeability	Consolidation (4) %	Emerson Class No.
TP1/ 1D	0.6 - 0.8																			24.4									
2D	1.7 - 1.9																			32.0									
3D	2.1 - 3.0	CH	15	99	97.7	97.6	97.4	97.3	97	96	91	52	16.0	84	63	2.59	1.62	21.0		27.9					33	13	(95% Standard)		CLASS 1
TP2/ 1D	0.4 - 1.5																			26.1									
2D	1.7 - 2.5	CH	5	100	100	100	99	99	98	93	92	-	12.7	51	32					22.5									CLASS 5
TP3/ 1D	1.5 - 2.5																			29.5									
TP4/ 1D	1.5 - 1.85																			21.9									
2D	2.5 - 3.0																			25.3									
TP5/ 1D	1.5 - 2.2	CH	5	100	99	99	99	98	97	95	86	-	13.0	69	52		1.61	22.3		22.6									
2D	2.35 - 2.9																			21.1									
TP6/ 1D	0.6 - 1.1	CH	[illegible]	100	100	100	100	99	99	99	97	57	15.2	[illegible]	56	2.61	1.61	22.5		25.9			10	27	(saturated - 95% Standard)				CLASS 1
2D	2.4 - 2.7																			26.4									

PRETREATMENT
Air-Dried

NOTES:
(1) All tests in accordance with Australian Standards AS1289, unless otherwise stated.
(2) Compaction type .... unless otherwise stated.
(3) Shear strength results are from triaxial compression tests, unless otherwise stated. Failure defined by $(\sigma_1 - \sigma_3)_{max}$
(4) Consolidation under .... kPa, unless otherwise stated.

COMPILED SCC CHECKED JAF TESTING OFFICER SCC
DATE 16.12.86 DATE 16.12.86 DATE 16.12.86
REPORT No. 2417 SHEET 1 of 1

TABLE 5

Coffey & Partners Pty. Ltd.

engineering log borehole

borehole no. 1

sheet 1 of 2

office and job no: Sydney, S6568

CLARENCE RIVER COUNTY COUNCIL

project: CLARENCE RIVER FLOOD MITIGATION

borehole location: GRAFTON

hole commenced: 3 June, 1981
hole completed: 3 June, 1981
supervised by: GHD
checked by: PKH

drill model and mounting: Gemco 210B-Trailer
hole diameter: 100 mm
slope: 90 deg. bearing: - deg.
R.L. surface: Not measured
datum:

method	penetration 1 2 3	support	water	notes samples, tests, etc.	R.L. depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency, cohesive soils	hard 100 200 300 400 penetrometer	structure and additional observations
ASV		NIL		1,1,2 N = 3	1		SM	SILTY SAND, fine grained, dark brown As above, brown	M	L-MD		
				1,2,2 N = 4	2		SP	SAND, fine grained, brown, with some SILT				
				2,3,3 N = 6	3		SM	SILTY SAND, fine grained, brown, with some CLAY	D/M			
				2,2,3 N = 5	4		SP	SAND, fine grained, yellow brown, with some SILT				
				U75	5		SC	SILTY CLAYEY SAND, fine grained, dark brown, fines of medium plasticity to	M			
							CI.	SILTY SANDY CLAY, medium plasticity, dark brown. SAND fine grained.	M> PL	St-VST F/St	x	
				2,1,1 N = 2	6		SM	SILTY SAND, fine grained, brown.	M	L		
							CI.	SILTY SANDY CLAY, medium plasticity, dark brown to dark grey.	M> PL	F		minor inflow
				U75	7		CH	CLAY, high plasticity, grey, yellow-brown and red-brown.	M> PL	St-VSt F/St	x	Fissured Blocky structure dull, discontinuous surfaces
					8							

191.0(1)

Coffey & Partners Pty. Ltd.

engineering log borehole

borehole no: 1

sheet 2 of 2

office and job no. Sydney, S6568

	CLARENCE RIVER COUNTY COUNCIL	hole commenced:	3 June, 1981
project:	CLARENCE RIVER FLOOD MITIGATION	hole completed:	3 June, 1981
borehole location:	GRAFTON	supervised by:	GHD
		checked by:	PKW

drill model and mounting: Gemco 210B-Trailer | slope: 90 deg. | R.L. surface: Not measured

hole diameter: 100 mm | bearing: — deg. | datum:

method	penetration 1 2 3	support	water	notes samples, tests, etc	depth or metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency, density, rock strength	hand penetrometer kPa 100 200 300 400	structure and additional observations
ASV		b.L		U75 No Rec	8		CH	CLAY, high plasticity, yellow brown and grey	M> PL	St		
					9		ML	CLAYEY SILT, medium liquid limit, black, with some SAND	M	S/F		
				U75	10		CL-CH	SILTY CLAY, medium to high plasticity, black with some red-brown mottling. Some decayed vegetation	M> PL	F		
				6,8,9 N = 17	11		SP	SAND, fine to medium grained, grey, with some SILT.	W	D/VD		
					12			Borehole 1 terminated at 11.95 metres.				

Coffey & Partners Pty. Ltd.

engineering log borehole

borehole no: 2
sheet 1 of 2

office and job no: Sydney, S6568

	CLARENCE RIVER COUNTY COUNCIL	hole commenced	3 June, 1981
		hole completed:	3 June, 1981
project:	CLARENCE RIVER FLOOD MITIGATION	supervised by:	GHD
borehole location:	GRAFTON	checked by:	PKW

drill model and mounting	Gemco 210B-Trailer	slope:	90 deg.	R.L. surface:	Not measured
hole diameter:	100 mm	bearing:	- deg	datum:	

method	penetration 1 2 3	support	water	notes samples, tests, etc	depth m metres	graphic log	classification symbol	material: soil type, plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency, density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
ASV				2,3,4 N = 7	1		SM	SILTY SAND, fine grained, brown.	M	L		
				3,4,5 N = 9	2				D/M	MD		
				4,4,5 N = 9	3			As above, pale brown/ yellow-brown	D			
				2,3,3 N = 6	4		SP	SAND, fine to medium grained, yellow brown, with some SILT				
				2,2,2 N = 4	5		SM	SILTY SAND, fine grained, red-brown and brown.				
							SC-CL.	-CLAYEY SILTY SAND, dk brown -SILTY CLAYEY SAND) brown -SANDY SILTY CLAY) -SILTY CLAY, medium plasticity, dark grey, with some SAND.	M W	L/MD F		minor inflow
				U50	6		CH	CLAY, high plasticity, dark grey	M> PL	St	x	
				U50	7			CLAY, high plasticity, grey yellow-brown and red-brown				
								CLAY, high plasticity, grey and yellow-brown.		F/St	x	
					8			As above, grey.	D			

Coffey & Partners Pty. Ltd

engineering log borehole

borehole no: 2
sheet 2 of 2

office and job no: Sydney, S6568

	CLARENCE RIVER COUNTY COUNCIL	hole commenced:	3 June, 1981
project:	CLARENCE RIVER FLOOD MITIGATION	hole completed:	3 June, 1981
borehole location:	GRAFTON	supervised by:	GHD
		checked by:	PKW

drill model and mounting: Gemco 210B-Trailer — slope: 90 deg. — R.L. surface: Not measured
hole diameter: 100 mm — bearing: - deg. — datum:

method	preservation 1 2 3	support	water	notes samples, tests, etc.	depth in metres	graphic log	classification symbol	material: soil type, plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency, density index	kPa penetrometer 100 200 300 400	structure and additional observations
ASV		ET	▼	U50	8		CH	CLAY, high plasticity, grey	w>PL	F		some fine SAND
					9		SC	CLAYEY SAND/SILTY SAND, fine grained, brown, lines of low plasticity	w≈PL			
							SP	SAND, fine to medium grained, grey, with some SILT	W	D		collapsing
				S,7,10 N -17	10							
					11							SPT attempted - hole collapsed
								Borehole 2 terminated at 11.5 metres.				
					12							

TBI-ONE

Coffey & Partners Pty. Ltd.

engineering log borehole

borehole no: 3
sheet 1 of 2

office and job no Sydney, S6568

	CLARENCE RIVER COUNTY COUNCIL	hole commenced:	3 June, 1981
project:	CLARENCE RIVER FLOOD MITIGATION	hole completed:	3 June, 1981
borehole location:	GRAFTON	supervised by:	GHD
		checked by:	PKW

drill model and mounting: Gemco 210B-Trailer — slope: 90 deg. — R.L. surface: Not measured
hole diameter: 100 mm — bearing: – deg. — datum:

method	penetration 1 2 3	support	water	notes samples, tests, etc.	depth in metres	graphic log	classification symbol	material: soil type, plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency, density index	hand penetrometer 100 200 300 400 kPa	structure and additional observations
ASV		NIL		1,2,3 N = 5	1		ML–SM	SANDY SILT/SILTY SAND, fine grained, brown	M	L		
				2,2,3 N = 5	2		SM	SILTY SAND, fine grained, brown.		L/MD		
				1,3,3 N = 6	3							
				U50	4		SM–SC	SILTY CLAYEY SAND, fine grained, brown, fines of low plasticity.		MD		
				U50	5			and				
				U50	6		CL	SILTY SANDY CLAY, low to medium plasticity, brown, fine grained sand.	M/W			
			▼	0,0,3 N = 3	7		SP	SAND, fine to medium grained, brown, with some SILT	W	L		
					8		CH	CLAY, see below	W> PL	St		

Coffey & Partners Pty. Ltd.

engineering log borehole

COFFEY

borehole no 3

sheet 2 of 2

office and job no: Sydney, 86568

	CLARENCE RIVER COUNTY COUNCIL	hole commenced:	3 June, 1981
project:	CLARENCE RIVER FLOOD MITIGATION	hole completed:	3 June, 1981
borehole location:	GRAFTON	supervised by:	GHD
		checked by:	PKM

drill model and mounting: Comeo 210B-Trailer | slope: 90 deg. | R.L. surface: Not measured

hole diameter: 100 mm | bearing: - deg. | datum:

method	penetration 1 2 3	support	water	notes samples, tests, etc.	R.L. depth in metres	graphic log	classification symbol	material: soil type, plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency, density index	hand penetrometer 100 200 300 400 kPa	structure and additional observations
ASV		NIL		U50	9		CH	CLAY, high plasticity, black, with sand partings	M> PL	St-VSt		
					10		SC	CLAYEY SAND, fine to medium grained, black.	W	?		"squeezing"
								Borehole 3 terminated at 10.0 metres				

Coffey & Partners Pty. Ltd.

engineering log borehole

borehole no: 4

sheet 1 of 2

office and job no: Sydney, S6568

	CLARENCE RIVER COUNTY COUNCIL	hole commenced	4 June, 1981
project:	CLARENCE RIVER FLOOD MITIGATION	hole completed	4 June, 1981
borehole location:	GRAFTON	supervised by	GHD
		checked by	PKW

drill model and mounting: Gemco 2108-Trailer | slope: 90 deg. | R.L. surface: Not measured

hole diameter: 100 mm | bearing: - deg. | datum:

method	penetration 1 2 3	support	water	notes samples, tests, etc.	R.L. depth in metres	graphic log	classification symbol	material (soil type, plasticity or particle characteristics, colour, secondary and minor components)	moisture condition	consistency, density, rock strength	hand penetrometer 100 200 300 400 kPa	structure and additional observations
					1		ML-MH	CLAYEY SILT, medium liquid limit, dark brown	M	St		
				U75				SANDY SILT, low to medium liquid limit, dark brown/ brown, SAND fine grained.				
				U75	2			CLAYEY SILT, medium to high liquid limit, dark brown, some SAND.				
				U75 D	3			SILTY CLAY, medium plasticity, dark brown, with some fine SAND.	Me PL			most of sample lost
				U50	4		SM	SILTY SAND, fine grained, dark brown	M	MD		
							SP	SAND, fine grained, yellow-brown, with some SILT and CLAY fines.				
				4,3,4 N = 7	5			SAND, fine grained, red-brown and brown, with some SILT and CLAY fines	W			
				2,4,4 N = 8	6			SAND, fine to medium grained, brown, with some SILT 50mm layers of CLAY, high plasticity, dark grey, decayed vegetation.				
				0,2,4 N=6/8	7			SAND, fine to medium grained, red-brown, with some SILT.				
					8			SAND, fine to medium grained, grey, trace of SILT.				

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Coffey & Partners Pty. Ltd.

engineering log borehole

borehole no: 4

sheet 2 of 2

office and job no: Sydney, 86568

project:	CLARENCE RIVER COUNTY COUNCIL
	CLARENCE ROVER FLOOD MITIGATION
borehole location:	GRAFTON
hole commenced:	4 June, 1981
hole completed:	4 June, 1981
supervised by:	GHD
checked by:	PKW

drill model and mounting: Gemco 210B-Trailer
hole diameter: 100 mm
slope: 9° deg.
bearing: - deg.
R.L. surface: Not measured
datum:

method	penetration 1 2 3	support	water	notes samples, tests, etc.	R.L. depth (metres)	graphic log	classification symbol	material: soil type, plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency, density index	Sand Kpa penetrometer 100 200 300	structure and additional observations
ASV		NC			8		SP	SAND, fine to medium grained, grey.	W	MD		attempt SPT - hole collapsed
					9			SAND, fine to medium grained, grey-brown with some coarse grains.				
					10							
					11			As above, with some fine gravel.				
					12			Borehole 4 terminated at 11.5 metres.				

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engineering log borehole

borehole no: 5
sheet 1 of 2

office and job no: Sydney, S6568

CLARENCE RIVER COUNTY COUNCIL

project: CLARENCE RIVER FLOOD MITIGATION
borehole location: GRAFTON

hole commenced: 4 June, 1981
hole completed: 4 June, 1981
supervised by: GMD
checked by: PKW

drill model and mounting: Gemco 210B-Trailer
hole diameter: 100mm
slope: 90 deg.
bearing: - deg.
R.L. surface: Not measured
datum:

method	notes samples, tests, etc.	depth metres	classification symbol	material (soil type, plasticity or particle characteristics, colour, secondary and minor components)	moisture condition	consistency, density index	structure and additional observations
ASV		0	CH	CLAY, high plasticity, brown.	M≤PL	St	
	6,7,9 N =16	1	SP	SAND, fine grained, yellow-brown, some SILT and CLAY fines. Layered SILTY CLAYEY SAND and SILTY SANDY CLAY	M	D, D/VD	Compacted Fill?
	2,3,4 N = 7	3	ML	CLAYEY SILT, medium liquid limit, black, with some fine SAND.		MD/F	—?— —?— —?— —?—
	U75	4	CH	SILTY CLAY, high plasticity, dark grey, brown and yellow-brown. Some SAND and gravel to 15mm	M≤PL	St, VSt	Tube turned - no recovery. Natural
		5		SILTY CLAY, high plasticity, black, with some SAND, fine grained.	M>PL	F/St	
	U50	6	CL-CH	SILTY SANDY CLAY, medium to high plasticity, black, SAND fine grained.			
	U50	7	CH	CLAY, high plasticity, dark grey and red-brown, with some fine grained SAND.		St	Clayey sand in tube, fine grained brown-black.
		8					

[illegible key/legend at foot of page]

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engineering log borehole

borehole no: 5
sheet 2 of 2

office and job no Sydney, S6568

CLARENCE RIVER COUNTY COUNCIL	hole commenced: 4 June, 1981
project: CLARENCE RIVER FLOOD MITIGATION	hole completed: 4 June, 1981
borehole location: GRAFTON	supervised by: GHD
	checked by: PKW

drill model and mounting: Gemco 210B-Trailer slope: 90 deg. R.L. surface: Not measured
hole diameter: 100mm bearing: – deg. datum:

method	penetration 1 2 3	support	water	notes samples, tests, etc.	depth metres	graphic log	classification symbol	material (soil type: plasticity or particle characteristics, colour, secondary and minor components)	moisture condition	consistency, density index	hand penetrometer kPa	structure and additional observations
ASV		Nil		U50	8		CL	SILTY CLAY, medium plasticity, black, with some fine grained SAND	W>PL	F	X	
					9		SM	SILTY SAND, fine grained, grey, with layers of SILTY CLAY, black.	W			collapsing
							SC	CLAYEY SAND, fine to medium grained, grey				
				2,4,13 Nc=17/26	10		SP	SAND, fine grained, grey, with some SILT				collapsing
				4,10,15 Nc=25	11							
					12			Borehole 5 terminated at 11.95 metres.				

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engineering log borehole

borehole no: 6
sheet 1 of 2

office and job no: Sydney, S6568

	CLARENCE RIVER COUNTY COUNCIL	hole commenced:	4 June, 1981
project:	CLARENCE RIVER FLOOD MITIGATION	hole completed:	4 June, 1981
borehole location:	GRAFTON	supervised by	CHD
		checked by:	PKW

drill model and mounting: Gemco 2108-Trailer — dips: 90 deg. — R.L. surface: Not measured
hole diameter: 100 mm — bearing: deg. — datum:

method	penetration 1 2 3	support	water	notes samples, tests, etc.	R.L. depth in metres	graphic log	classification symbol	material: soil type, plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency, density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
ASV			N.L.		0			SAND and GRAVEL FILL —asphalt layer SAND and GRAVEL FILL	D	L VD		FILL
				8,8,20 N=28/49	1							
				7,7,7 N=14	2		SM	SILTY SAND, fine grained, yellow-brown		D		
				7,7,5 N=12	3							
				U75	4		SC-CL	CLAYEY SILTY SAND, fine grained, brown, to... SANDY SILTY CLAY, low plasticity, brown, fine to medium grained SAND.	M W			
				U75 Lost	5							
				U75	6		SM-SC	SILTY SAND, fine grained, grey. SILTY CLAYEY SAND, fine grained, grey, fines of medium to high plasticity.	W	L		
				U75 Lost	7							
					8			SILTY SAND, fine grained, grey.				

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engineering log borehole

borehole no. 6

sheet 2 of 2

office and job no. Sydney, 86568

project:	CLARENCE RIVER COUNTY COUNCIL CLARENCE RIVER FLOOD MITIGATION	hole commenced	4 June, 1981
borehole location:	GRAFTON	hole completed:	4 June, 1981
		supervised by:	GHD
		checked by:	PKW

drill model and mounting: Geneo 210R-Trailer — slope: 90 deg. — R.L. surface: Not measured

hole diameter: 100 mm — bearing: — deg. — datum:

method	1 2 3 generation	support	water	notes samples, tests, etc.	depth in metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency, density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
ASV		NIL			8		SM	SILTY SAND, as above, with layers of SANDY CLAY, black	W	D		
				7,10,10 N =20	9		SP	SAND, fine to medium grained, grey.				
				10,10,12 Nc=22	10							
					11			Borehole 6 terminated at 10.95 metres				

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Page 1 of 2 missing.

engineering log borehole

borehole no: 7

sheet 2 of 2

office and job no. Sydney, S6568

	CLARENCE RIVER COUNTY COUNCIL	hole commenced	4 June, 1981
project:	CLARENCE RIVER FLOOD MITIGATION	hole completed:	4 June, 1981
borehole location:	GRAFTON	supervised by:	(CHH)
		checked by:	PKW

drill model and mounting: Gemco 210B-Trailer — slope: 90 deg. — R.L. surface: Not measured

hole diameter: 100 mm — bearing: - deg. — datum:

method	penetration 1 2 3	support	water	notes samples, tests, etc.	depth in metres	graphic log	classification symbol	material: soil type, plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency, density index	hand Penetrometer kPa 100 200 300	structure and additional observations
ASV		NX		2,6,8 N = 14	8		SC-SM	CLAYEY SILTY SAND, fine grained, grey.	W	L		
					9		CH	CLAY, high plasticity, grey CLAY, high plasticity, grey and yellow-brown	M≈PL	VSt		
				U50	10			CLAY, as above				
					11			Borehole 7 terminated at 11.00 metres				

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engineering log borehole

borehole no: A

sheet 1 of 3

office and job no: Sydney, 56568

CLARENCE RIVER COUNTY COUNCIL

hole commenced: 2 June, 1981
hole completed: 2 June, 1981
supervised by: GHD
checked by: PKW

project: CLARENCE RIVER FLOOD MITIGATION
borehole location: GRAFTON

drill model and mounting: Gemco 210B-Trailer
hole diameter: 100 mm
slope: 90 deg.
bearing: - deg.
R.L. surface: Not measured
datum:

water	notes samples, tests, etc.	R.L. depth in metres	graphic log	class fraction symbol	material: soil type, plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency, density index	hand penetrometer	structure and additional observations
ASU	U75	1		SM	SILTY SAND, fine to medium grained, dark brown. Interbedded with... SANDY SILTY CLAY, medium plasticity, brown, fine grained sand.	M	L		
NU	U75	2			As above, with some CLAY, traces of CHARCOAL.		St		
	U75	3		CL	SILTY CLAY, medium plasticity, brown, fine grained sand.		St-VSt		
	U75	4							
	U75	5							
	U75	6		CL-CH	SILTY SANDY CLAY, medium to high plasticity, dark brown to black	M> PL	F/St		
	U75	7		CH	to SILTY CLAY, high plasticity, dark grey mottled red-brown, with some SAND to CLAY, high plasticity, dark grey mottled red-brown		St / VSt	x	Fissured Blocky structure dull, discontinuous surfaces
	U50	8							

Coffey & Partners Pty. Ltd.

engineering log
borehole

COFFEY

borehole no: 8
sheet 2 of 3

office and job no. Sydney, S6563

	CLARENCE RIVER COUNTY COUNCIL	hole commenced:	2 June, 1981
		hole completed:	2 June, 1981
project:	CLARENCE RIVER FLOOD MITIGATION	supervised by	GHD
borehole location	GRAFTON	checked by.	PKW

drill model and mounting: Gemco 210B Trailer; slope: 90 deg.; R.L. surface: Not measured
hole diameter: 100 mm; bearing: - deg.; datum:

method	penetration 1 2 3	support	water	notes samples, tests, etc.	depth metres	graphic log	classification symbol	material soil type, plasticity or particle characteristics colour, secondary and minor components	moisture condition	consistency, density index	hand penetrometer kPa	structure and additional observations
ASV		NIL			8		CH	CLAY, high plasticity, dark grey with some red-brown mottling	M> PL	St/ VSt		
				U50								
					9			grading to...				
								CLAY, high plasticity, grey, with some red and yellow-brown mottling				
				U50	10							
					11			CLAY, high plasticity, yellow brown and grey.				
				U50								
					12			CLAY, high plasticity, red-brown and grey.				
				U50	13							
					14							
				U50			SC-CH	SANDY CLAY/CLAYEY SAND, fine to medium grained, red brown, fines of medium to high plasticity.	M/ W	L/ F		
					15		SC	CLAYEY SAND, fine to medium grained, red-brown, fines of high plasticity.	W	MD		
					16							

Key

T91 001

Coffey & Partners Pty. Ltd.

engineering log borehole

COFFEY

borehole no: 8

sheet 3 of 3

office and job no: Sydney, S6503

CLARENCE RIVER COUNTY COUNCIL	hole commenced: 2 June, 1981
project: CLARENCE RIVER FLOOD MITIGATION	hole completed: 2 June, 1981
borehole location: GRAFTON	supervised by: GHD
	checked by: PKW

drill model and mounting: Gemco 210B-Trailer — slope: 90 deg. — R.L. surface: Not measured

hole diameter: 100 mm — bearing: — deg. — datum:

method	penetration 1 2 3	support	water	notes samples, tests, etc.	R.L. depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency, density index	hand penetrometer kPa	structure and additional observations
ASV		NIL		U50	16		SM	CLAYEY SILTY SAND, fine to medium grained, red-brown.	W	MD		
					17		CH	SANDY CLAY, high plasticity, red brown, brown and grey. SAND, fine to medium grained.	M> PL	St		
				U50			SP	SAND, fine to medium grained, red-brown, with some SILT	W	D		
					18		SG	CLAYEY SAND, fine to medium grained, dark grey & black				
							SM	SILTY SAND, fine to medium grained, pale grey.				U50 no recovery
				D SPT 50 6,6 10,15,18 Nc=33	19							
					20			Borehole 8 terminated at 19.75 metres.				

T81-QC1

Coffey & Partners Pty. Ltd.

engineering log borehole

COFFEY

borehole no: 9

sheet 1 of 3

office and job no: Sydney, S6568

	CLARENCE RIVER COUNTY COUNCIL	hole commenced:	2 June, 1981
		hole completed:	3 June, 1981
project:	CLARENCE RIVER FLOOD MITIGATION	supervised by:	GHD
borehole location:	GRAFTON	checked by:	PKW

drill model and mounting:	Gemco 210B-Trailer	slope:	90	deg.	R.L. surface:	Not measured
hole diameter:	100 mm	bearing:	–	deg.	datum:	

method	penetration 1 2 3	support	water	notes samples, tests, etc.	R.L. depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics colour, secondary and minor components	moisture condition	consistency, density index	hand penetrometer kPa	structure and additional observations
ASV		NIL					SM	SILTY SAND, fine to medium grained, brown.	M	L		
							SC-SM	CLAYEY SILTY SAND, fine to medium grained, dark brown		L/MD		
				U75	1		SM-SC	SILTY SAND, fine to medium grained, brown. Interbedded with ... SANDY SILTY CLAY, medium plasticity, brown, fine grained sand.		VSt		
				U50	2							
				U75	3		SM-ML to ... ML	SILTY SAND/CLAYEY SANDY SILT to ... CLAYEY SILT, medium liquid limit, dark brown, with a trace of fine SAND.				
			▼	2,1,2 N = 3	4							
			▶	U50	5		CH	SANDY CLAY, medium to high plasticity, grey-brown, with layer of ferruginous SAND/fine GRAVEL.	W>PL	F		Fissured Blocky structur dull, discon-tinuous surface
				U75	6				M>PL	F/St		
				U50	7			CLAY, high plasticity, grey, mottled yellow-brown		St	*	
					8							

T81-020

Coffey & Partners Pty. Ltd.

engineering log borehole

borehole no: 9

sheet 2 of 3

office and job no. Sydney, S6568

project: CLARENCE RIVER COUNTY COUNCIL
CLARENCE RIVER FLOOD MITIGATION

borehole location: GRAFTON

hole commenced: 2 June, 1981
hole completed: 3 June, 1981
supervised by: GHD
checked by: PKW

drill model and mounting: Gemco 210B-Trailer
hole diameter: 100 mm

slope: 90 deg.
bearing - deg.

R.L. surface: Not measured
datum:

method	penetration 1 2 3	support	water	notes samples, tests, etc.	depth in metres	graphic log	classification symbol	material: soil type, plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency, density index	hard penetrometer 100 kPa 200 300 400	structure and additional observations
ASV				U75	8		CH	CLAY, high plasticity, dark grey mottled yellow-brown, with some SAND.	M> PL	St/ VSt		
					9			As above, dark grey and yellow-brown.				
				U50	10			As above, grey and yellow-brown.	M= PL	VSt		
					11			As above, yellow brown and grey				Ironstone gravel layer
				U75	12			As above, dark grey, mottled yellow-brown.	M< PL			
				U50	13		CL-CH	SANDY CLAY, medium to high plasticity, red-brown, SAND fine grained.		St		
					14			Interbedded: SANDY CLAY, medium plasticity, CLAYEY SAND, fine to medium grained, red-brown.		St /D		
				U75 No Rec	15		SM	SILTY SAND, fine grained, yellow-brown, with a trace of CLAY	W	MD		
ADW					16		GC	CLAYEY GRAVEL, rounded, to 30mm, dark grey. CLAY of high plasticity.	M	VD		

Coffey & Partners Pty. Ltd.

engineering log borehole

borehole no: 9

sheet 3 of 3

office and job no: Sydney, 86568

	CLARENCE RIVER COUNTY COUNCIL	hole commenced:	2 June, 1981
project:	CLARENCE RIVER FLOOD MITIGATION	hole completed	3 June, 1981
borehole location:	GRAFTON	supervised by:	CHD
		checked by:	PKW

drill model and mounting: Gemco 210b-Trailer — slope: 90 deg. — R.L. surface: Not measured

hole diameter: 100 mm — bearing: — deg. — datum:

method	penetration 1 2 3	support	water	notes samples, tests, etc.	depth (metres)	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency - cone sensitivity	hard pan penetrometer 100 kPa 200 300 400	structure and additional observations
AD/V		NIL		2+, Nc> 80	16		GC	CLAYEY GRAVEL, as above	M	VD		
								Cobbles in CLAY matrix				
					17			Borehole 9 terminated at 16.5 metres.				

TS1-03

Coffey & Partners Pty. Ltd.

engineering log borehole

COFFEY

borehole no. 10
sheet 1 of 1

office and job no. Sydney, S6568

	CLARENCE RIVER COUNTY COUNCIL	hole commenced:	2 June, 1981
project:	CLARENCE RIVER FLOOD MITIGATION	hole completed:	2 June, 1981
borehole location:	GRAFTON	supervised by	GHD
		checked by:	PKW

drill model and mounting	Gemco 210B-Trailer	slope:	90 deg.	R.L. surface:	Not measured
hole diameter:	100 mm	bearing:	-- deg.	datum:	

method	notes samples, tests, etc.	depth (metres)	classification symbol	material	moisture condition	consistency, density index	structure and additional observations
ASV		0	CH	CLAY, high plasticity, dark brown, with some medium to coarse grained SAND.	M> PL	St-VSt	
	U50	1		CLAY, high plasticity, red and grey mottled.			
	U50	2					
	U50	3		CLAY, high plasticity, yellow-brown and grey.			Layer SANDY SILT
	U50	4	CL	SANDY SILTY CLAY, medium plasticity, grey-brown, mottled yellow-brown. SAND fine grained.			
	U50	5	CH	CLAY, high plasticity, grey-brown and yellow-brown to... dark yellow-brown and grey to... CLAY, high plasticity, grey.			
	U50	6					
	U50	7					
		8		Borehole 10 terminated at 7.8 metres			

Coffey & Partners Pty. Ltd

engineering log borehole

borehole no. 11

sheet 1 of 1

office and job no: Sydney, 86568

	CLARENCE RIVER COUNTY COUNCIL	hole commenced:	3 June, 1981
project:	CLARENCE RIVER FLOOD MITIGATION	hole completed:	3 June, 1981
borehole location:	GRAFTON	supervised by:	GHD
		checked by:	PKW

drill model and mounting: Gemco 210B-Trailer | slope: 90 deg. | R.L. surface: Not measured

hole diameter: 100 mm | bearing: - deg. | datum:

method	penetration	support	water	notes samples, tests, etc.	depth (metres)	graphic log	classification symbol	material: soil type, plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency, density index	hand penetrometer kPa	structure and additional observations
ASV				U50	1		ML-CL	CLAYEY SILT/SILTY CLAY, medium plasticity, brown, with charcoal pieces.	M> PL	F/ St		
				U50	2		CH	CLAY, high plasticity, dark grey, mottled yellow-brown and red-brown	M> PL	St - VSt		
				U50	3							
				U50	4			SILTY CLAY, high plasticity, dark grey to black	W>> PL	F- St		Some organic content - odorous
				U50	5			CLAY, high plasticity, dark grey, grey and yellow-brown	M> PL			
				U50	6			CLAY, high plasticity, yellow-brown, mottled grey		St - VSt		
				U50	7							
					8			Borehole 8 terminated at 8.3 metres.				U50 - 125mm diameter

key

73-501

Coffey & Partners Pty. Ltd.

engineering log borehole

COFFEY

borehole no. 12

sheet 1 of 1

office and job no: Sydney, S6568

	CLARENCE RIVER COUNTY COUNCIL	hole commenced	4 June, 1981
project:	CLARENCE RIVER FLOOD MITIGATION	hole completed:	4 June, 1981
borehole location:	GRAFTON	supervised by:	GHD
		checked by:	PKW

drill model and mounting: Gemco 210B-Trailer — slope: 90 deg. — R.L. surface: Not measured

hole diameter: 100 mm — bearing: - deg. — datum:

method	penetration	support	water	notes, samples, tests, etc.	depth (metres)	graphic log	classification symbol	material: soil type, plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency, density index	hand penetrometer	structure and additional observations
ASV		CIL		2,2,5 N = 7	1		SM	SILTY SAND, fine grained, brown.	M	L		
				5,6,6 N = 12	2		SP	SAND, fine grained, yellow brown, with some SILT.	D/M	MD		Partly cemented
				5,6,6 N = 12	3			As above.		D		
				4,3,5 N = 8	4		SM	As above, SILT increasing to... SILTY SAND, fine grained, yellow-brown.				
				U50	5			SILTY SAND, yellow brown and brown, with some CLAY	M	MD		
				U50	6			As above, with SAND and SILT partings? to... SILTY CLAYEY SAND, fine grained, yellow-brown and brown.				
				U50	7			SAND/SILTY SAND layers	W			
							SC	CLAYEY SAND, fine to medium grained, yellow brown.				
					8			Borehole 12 terminated at 7.8 metres				

TSI-20

Coffey & Partners Pty Ltd.

engineering log excavation

pit no: TP1
sheet 1 of 1

office and job no: Sydney, S6568

	CLARENCE RIVER COUNTY COUNCIL	pit commenced	11 August 1981
project:	CLARENCE RIVER FLOOD MITIGATTON	pit completed	11 August 1981
pit location	GRAFTON	supervised by	PKW
		log checked by:	MCE
equipment type and model:	Hand Shovel	R.L. surface:	Not mensured
excavation dimensions:	2.0 m long, 0.7 m wide	datum:	

method	penetration 1 2 3	support	water	notes samples, tests, etc	depth in metres	graphic log	class (unified) symbol	material: soil type, plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency, density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
E		NIL	MORE ENCOUNTERED	D			SM	SILTY SAND, fine grained, brown, fines of low to to medium liquid limit.	D-M	L-MD		TOPSOIL FILL
HAND DUG				U50	0.5							TOPSOIL Abundant root fibres.
				U50	1.0		SP	SAND, fine to medium grained, yellow-brown, trace to some silt				
					1.5			FILL				
					2.0			FILL				
								sheeting badly deteriorated at key timer sheet piling				

key

method: N natural exposure; E existing excavation; BH backhoe bucket; B bulldozer blade; R ripper

support: T tamping; penetration 1 2 3; no resistance ranging to refusal

water: 10 Jun 78 water level on date shown; water inflow; water outflow

notes: samples and tests; U50 undisturbed sample 50 mm diameter; D disturbed sample; H standard penetration test figure = result; P* SPT = sample; Nc cone penetrometer

moisture: D dry; M moist; W wet

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

Cuffley & Partners Pty. Ltd.

engineering log excavation

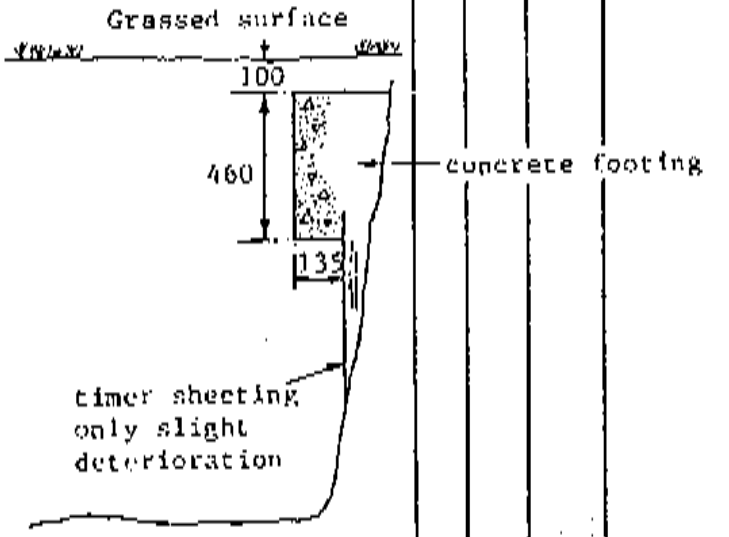
pit no: TP2

sheet 1 of 1

office and job no. Sydney, S6568

	CLARENCE RIVER COUNTY COUNCIL	pit commenced:	11 August 1981
project:	CLARENCE RIVER FLOOD MITIGATTON	pit completed:	11 August 1981
pit location:	GRAFTON	supervised by:	PKW
		log checked by:	MCE
equipment type and model	Hand Shovel	R.L. surface:	Not measured
excavation dimensions	1.2 m long, 0.8 m wide	datum	

method	penetration 1 2 3	support	water	notes samples, tests, etc.	R.L. / depth metres	graphic log	classification symbol	material: soil type, plasticity or particle characteristics, colour, secondary and minor components	moisture cond.	consistency, density index	hand penetrometer kPa	structure and additional observations
HAND DUG		NIL	NONE ENCOUNTERED	U50	0.5		ML	SANDY CLAYLY SILT, low to medium liquid limit, dark brown, fine grained sand	M< PL	St-VSt	x	TOPSOIL FILL Abundant root fibres
				D								concrete footing
				U50	1.0					St	x	+135
				U50	1.5							
					2.0							



Coffey & Partners Pty Ltd.

engineering log excavation

COFFEY

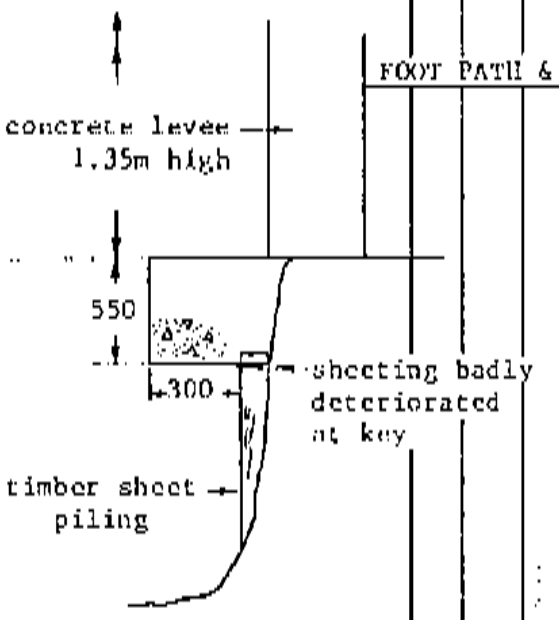
pit no TP3

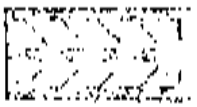
sheet 1 of 1

office and job no Sydney, S6568

	CLARENCE RIVER COUNTY COUNCIL	pit commenced	11 August 1981
project	CLARENCE RIVER FLOOD MITIGATION	pit completed	11 August 1981
pit location	GRAFTON	supervised by	PKW
		log checked by	MCE
equipment type and model	Hand Shovel	R.L. surface	Not measured
excavation dimensions	0.8 m long, 0.8 m wide	datum	

method	penetration	support	water	notes samples, tests, etc.	depth (metres)	graphic log	classification symbol	material: soil type, plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency, density index	hand penetrometer kPa	structure and additional observations
HAND DUG		NIL	NONE ENCOUNTERED	U50	0.5		SM	SILTY SAND, fine grained, brown, some rounded river gravel to 10-15mm size	D-M	L		FILL TOPSOIL. Abundant root fibres
				D			ML/SM-SC	CLAYEY SANDY SILT/CLAYEY SILTY SAND, fines of low to medium liquid limit, fine grained sand, brown.	M	St	X X	Some tree roots (decomposed). Jacaranda roots - very soft & light
				U50	1.0							
					1.5							
					2.0							





RESULTS OF LABORATORY INVESTIGATION

A programme of laboratory testing has been carried out on soil samples recovered from the field. The testing has been aimed at determination of the strength and drainage characteristics of the soils encountered, together with other indicative testing such as the determination of erodibility of the various materials. The testing has included:-

*	Visual Classification	(23)
*	Atterberg Limits	(7)
*	Moisture Content	(35)
*	Confined Compression	(7)
*	Consolidated Undrained Triaxial Testing with pore pressure measurement	(4)
*	Sherard pinhole dispersion test	(4)
*	Permeability tests (Falling head method)	(5)
*	Particle size distribution	(7)
*	% Passing 75μm	(19)

Coffey & Partners Pty. Ltd.

soil classification

COFFEY

Sheet 1 of 4

office and job no: Sydney, S6568

Clarence River County Council

project: Clarence River Flood Mitigation

location: Grafton

date: 30th July 1981

tested by: RM, MJL, JB, VT, AC

checked by: KB

sample details: location	depth m: from	depth m: to	sample type	classification symbol	material: soil type; plasticity or particle characteristics, colour, secondary and minor components, Atterberg Limits (if determined).	moisture condition and cohesive strength %	consistency, density index	unconfined compressive strength kPa	dry density t/m³	structure and additional observations
BH1	5.0	5.5	U75	SC	SILTY CLAYEY SAND, fine grained, dark brown.	29.5	VSt	230	1.25	Sherard pinhole test - class D1/D2
	7.0	7.5	U75	CL/CH	CLAY, medium plasticity, brown, some fine sand	30.3	VSt	350	1.35	Fissured, Sherard pinhole test - class ND2.
BH2	7.0	7.3	U50	CH	CLAY, high plasticity, grey, trace of fine sand.	M> Wp 22.5	VSt	240* 320	1.54	Confined at 120 kPa. Sherard pinhole test - class D1.
	8.5	8.8	U50	SC/SM	CLAYEY SAND/SILTY SAND, fine grained, dark grey, fines of medium plasticity. W_L=37, Wp 23, Ip=14, L.S.=7.0%.	M> Wp 37.4			1.31	c' = 2 kPa ϕ' = 34° Sherard pinhole test class ND1.
BH3	4.0	4.35	U50	CL	SILTY SANDY CLAY, low to medium plasticity, brown, fine grained sand.	M> Wp 20.5	VSt	380	1.62	65% passing 75µm k_v = 8x10^{-8} cm/sec
	5.0	5.3	U50	CL	SILTY SANDY CLAY, low to medium plasticity, brown, fine grained sand. W_L=35, Wp=18, Ip=17, L.S.=9.5%.	21.1			1.49	c' = 2 kPa ϕ' = 34° 57% passing 75µm
BH4	1.0	1.4	U75	ML	SANDY CLAYEY SILT, low to medium liquid limit, brown, fine grained sand.	D-M 14.0			1.32	57% passing 75µm k_v = 1x10^{-3} cm/sec Note abundant root hole channels.
	2.0	2.2	U75			20.3				77% passing 75µm
	3.0	3.5	U75			17.4				99% passing 75µm

notes (for terms see 'Explanation Sheet 1')

sample type
U – undisturbed sample
D – disturbed sample
N – standard penetration test

classification symbols and soil description based on unified classification system

moisture condition
O – dry
M – moist
W – wet
> – greater than
< – less than
W_p – plastic limit
W_L – liquid limit

consistency
VS – very soft
S – soft
F – firm
St – stiff
VSt – very stiff
H – hard
Fb – friable

density index
VL – very loose
L – loose
MD – medium dense
D – dense
VD – very dense

unconfined compressive strength
* from test; otherwise from hand penetrometer

Authorised Signature

soil classification

client: Clarence River County Council
project: Clarence River Flood Mitigation
location: Grafton

date: 30th July 1981
tested by: RM, MJL, JB, VT, AC
checked by: KB

sample details: location	sample details: depth m from	sample details: depth m to	sample details: sample type	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components, Atterberg Limits (if determined)	moisture condition and consistency	consistency - density index	unconfined compressive strength kPa	dry density t/m³	structure and additional observations
BH4	4.0	4.3								39% passing 75µm
	6.0	6.45								10% passing 75µm
BH5	5.5	5.8	U50	CL/CH	SANDY SILTY CLAY, medium to high plasticity, dark grey, fine grained sand.	M> Wp 31.6	St	165* 350	1.39	
	7.0	7.3	U50	SC	CLAYEY SAND, fine grained, brown-black, medium plasticity. W_L=46, Wp=23, Ip=23, L.S.=10%.	M> W_L 27.3			1.47	c' = 1kPa ø' = 36°
BH6	4.0	4.5	U75	CL	SANDY SILTY CLAY, low plasticity, brown, fine grained sand. W_L=29, Wp=17, Ip=12, L.S.=7.0%.					59% passing 75µm
BH7	6.0	6.5	U75	SM/SC	CLAYEY SILTY SAND, fine to medium grained, brown, fines of low plasticity. W_L=29, Wp=16, Ip 13, L.S.=5.5%.	M> Wp 29.5	S	49* 20	1.42	Confined at 120 kPa. Some organic content. 45% passing 75µm
	10.0	10.3	U50	CH	CLAY, high plasticity, brown, some fine to medium grained sand. W_L=38, Wp=18, Ip=20, L.S.=10%	M> Wp 18.5	H	680* >500	1.75	Confined at 160 kPa.
BH8	2.0	2.5	U75	CL	SILTY CLAY, medium plasticity, brown.	M> Wp 27.6	St	130		85% passing 75µm
	4.0	4.45	U75		SILTY CLAY, medium plasticity, brown.	M> Wp 29.8	St	160		97% passing 75µm

notes (for terms see 'Explanation Sheet 1')

sample type
U – undisturbed sample
D – disturbed sample
N – standard penetration test

classification symbols and soil description based on unified classification system

moisture condition
D – dry
M – moist
W – wet
> – greater than
< – less than
W_p – plastic limit
W_l – liquid limit

consistency
VS – very soft
S – soft
F – firm
St – stiff
VSt – very stiff
H – hard
Fb – friable

density index
VL – very loose
L – loose
MD – medium dense
D – dense
VD – very dense

unconfined compressive strength
* from test; otherwise from hand penetrometer

soil classification

office and job no: Sydney, S6568

Clarence River County Council

project: Clarence River Flood Mitigation

location: Grafton

date: 30th July, 1981

tested by: NM, MJL, JB, VT, AC

checked by: KB

sample details: location	sample details: depth m from	sample details: depth m to	sample details: sample type	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components. Atterberg Limits (if determined).	moisture condition and comment %	consistency, density index	unconfined compressive strength kPa	dry density t/m³	structure and additional observations
BH8	7.0	7.3	U50	CH	CLAY, high plasticity, dark grey, trace of fine sand.	M> Wp 36.0	St	150* 170	1.34	Confined at 120 kPa. Sherard pin-hole test - class D1/D2.
	8.5		U50			34.2	St	130		
	10.0		U50			20.4	H	>500		
	11.5		U50			23.0	H	430		
	13.0		U50			26.9	VSt	230		
BH9	1.0	1.5	U75			18.3				34% passing 75µm
	2.0	2.3	U50			24.7				69% passing 75µm
	3.0	3.5	U75		SANDY CLAYEY SILT/SANDY SILTY CLAY, medium plasticity, fine grained sand, brown.	72.9	VSt	260		73% passing 75µm
	5.0	5.3	U50	CH	SANDY CLAY, high plasticity, brown, fine grained sand. W_L=50, Wp=26, Ip=24, L.S.=13.0%	M> Wp 37.6			1.27	Blocky structure. Fissured. c' = 0 kPa ø = 31°
BH10	1.0		U50			23.5	H	420		
	2.0	2.3	U50	CH	CLAY, high plasticity, dark grey, trace of fine sand.	M> Wp 27.0	VSt	230* 550	1.57	Confined at 40 kPa.
	3.0		U50			30.9	VSt	240		
	5.0		U50			26.0	H	450		
	7.5		U50			33.8	H	500		

notes (for terms see 'Explanation Sheet 1')

sample type: U - undisturbed sample; D - disturbed sample; N - standard penetration test

classification symbols and soil description based on unified classification system

moisture condition: D - dry; M - moist; W - wet; > - greater than; < - less than; Wp - plastic limit; WL - liquid limit

consistency: VS - very soft; S - soft; F - firm; St - stiff; VSt - very stiff; H - hard; Fb - friable

density index: VL - very loose; L - loose; MD - medium dense; D - dense; VD - very dense

unconfined compressive strength: * from test; otherwise from hand penetrometer

Authorised Signature

soil classification

office and job no: Sydney, S6568

client: Clarence River County Council
project: Clarence River Flood Mitigation
location: Grafton

date: 30th July, 1981
tested by: RM, MJL, JB, VT, AC
checked by: KB

sample details: location	depth m from	depth m to	sample type	classification symbol	material: soil type; plasticity or particle characteristics, colour, secondary and minor components. Atterberg Limits (if determined).	moisture condition and content %	consistency, density index	unconfined compressive strength kPa	dry density t/m³	structure and additional observations
BH11	4.0	4.3	U50	CH	SILTY CLAY, high plasticity, dark grey to black.	M> Wp 28.5	St	125* 140	1.43	Confined at 80 kPa. Some root fibres.
BH12	5.0	5.3	U	ML/ SM-SC	CLAYEY SANDY SILT/CLAYEY SILTY SAND, fine grained sand, low liquid limit fines, yellow-brown and brown.	21.1				52% passing 75µm
TP1	0.6 (HOR)		U	SM	SILTY SAND, fine to medium grained, brown, fines of low to medium liquid limit.	8.1			1.45	31% passing 75µm k_H = 3x10⁻³ cm/se
	1.0 (HOR)		U	SP	SAND, fine to medium grained yellow-brown.	5.7			1.40	6% passing 75µm k_H = 1x10⁻² cm/se
TP2	1.0 (HOR)		U	ML	SANDY CLAYEY SILT, low to medium liquid limit, dark brown, fine grained sand.	22.2	VSt	300	1.62	59% passing 75µm k_H = 2x10⁻⁷ cm/se
TP3	0.5	0.8	D			12.6				52% passing 75µm

notes (for terms see 'Exploration Sheet 1')

sample type
U – undisturbed sample
D – disturbed sample
N – standard penetration test

classification symbols and soil description based on unified classification system

moisture condition
D – dry
M – moist
W – wet
> – greater than
< – less than
w_p – plastic limit
w_l – liquid limit

consistency
VS – very soft
S – soft
F – firm
St – stiff
VSt – very stiff
H – hard
Fb – friable

density index
VL – very loose
L – loose
MD – medium dense
D – dense
VD – very dense

unconfined compressive strength
* from test; otherwise from hand penetrometer

Authorised Signature

Coffey & Partners Pty. Ltd.

triaxial shear test

borehole: 2
sheet: of

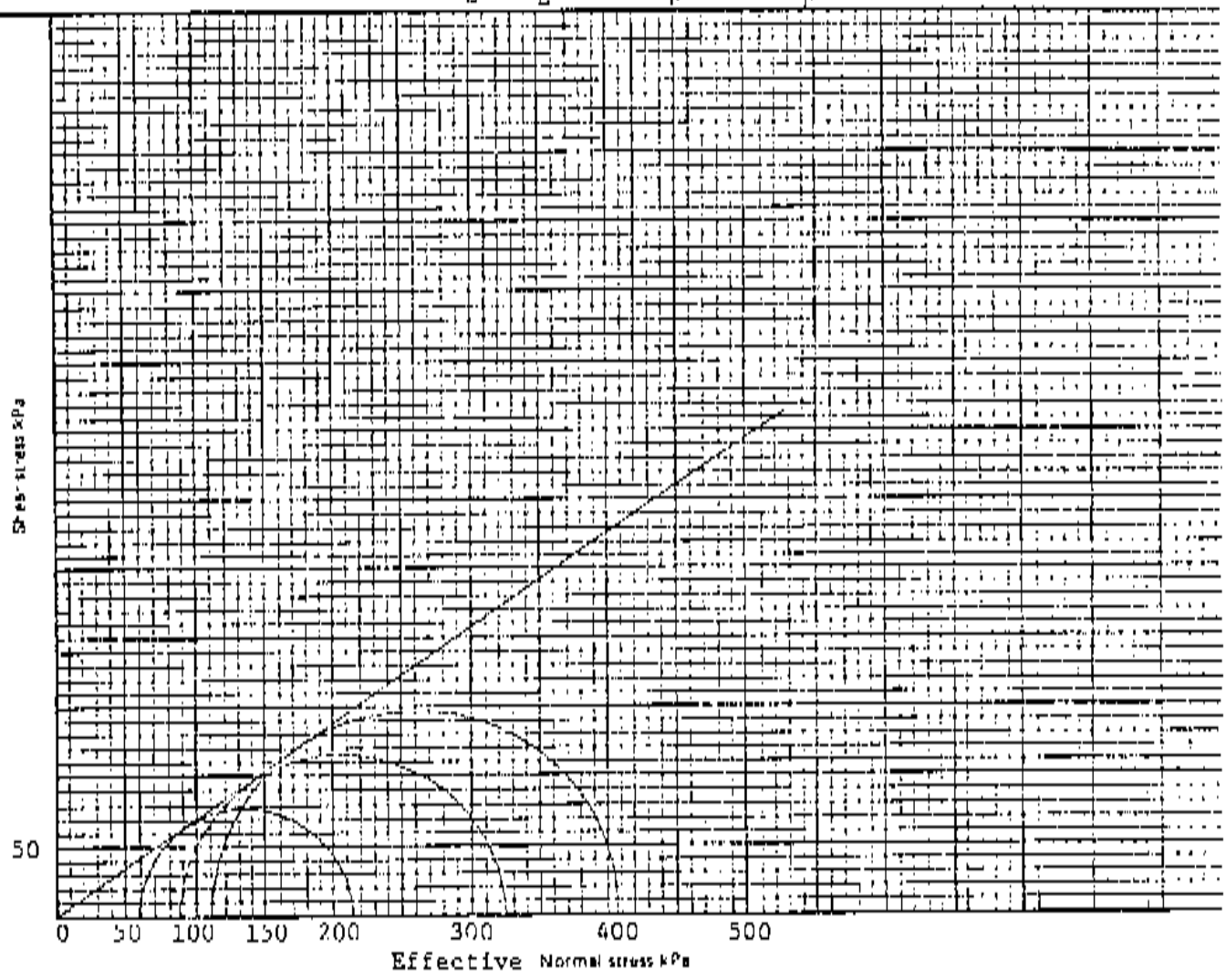
office: Sydney

client: Clarence River County Council
principal:
project: Clarence River Flood Mitigation
location: Grafton

job no: S6568
date: 1st July 1981
tested by: MJL
checked by: KB

depth: 8.5 - 8.8m sample type: Undisturbed sample size: 50 x 100mm Back pressure 200 kPa
type of test: Consolidated Undrained Stage Test with pore pressure measurements

material classification: (SC-SM) CLAYEY SAND/SILTY SAND, sand fine grained, dark grey, fines of medium plasticity.
Wet - W_L W_L - 37, W_p = 23, I_p = 14, L.S. = 7.0%



Initial moisture content 34.4 %
Initial dry density 1.31 t/m³
Cohesion C' 2 kPa
Angle of friction ϕ' 34 °

MOISTURE CONTENTS AFTER TEST

TOP	MIDDLE	BOTTOM
32.9	35.4	32.2

remarks:

failure criteria: Maximum Stress Ratio

Authorised Signatory

Coffey & Partners Pty. Ltd.

triaxial shear test

borehole: 3
sheet of

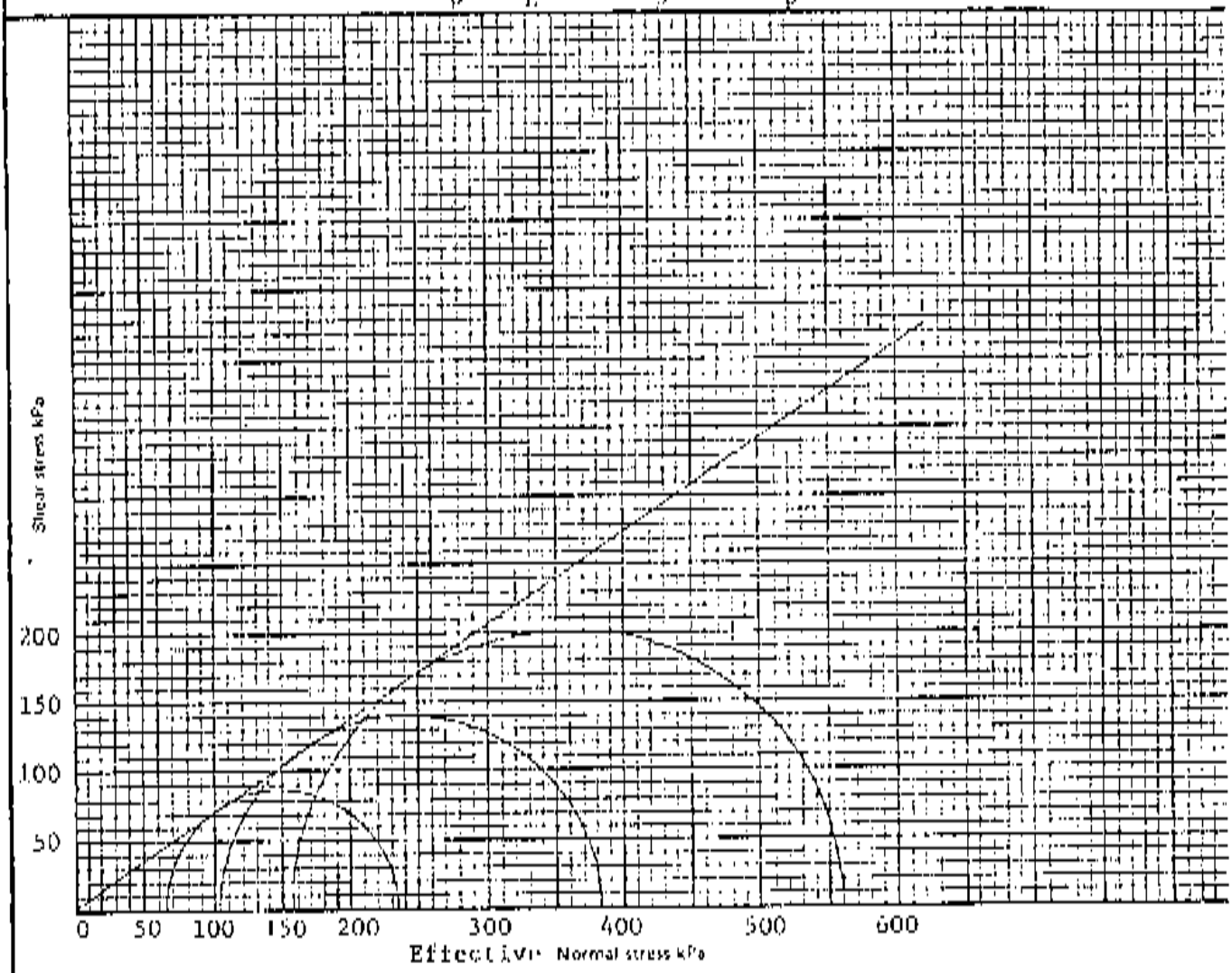
office: Sydney

client: Clarence River County Council
principal:
project: Clarence River Flood Mitigation
location: Grafton

job no: S6568
date: 1st July 1981
tested by: MJL
checked by: KB

depth: 5.0 - 5.3m sample type: Undisturbed sample size: 50 x 100mm Back pressure .....200.....kPa
type of test: Consolidated Undrained Stage Test with pore pressure measurements

material classification: (CL) SILTY SANDY CLAY, low to medium plasticity, brown, fine grained sand (57% passing 75μm).
Moist >W_p W_L - 35, W_p - 18, I_p - 17, L.S. = 9.5%



Initial moisture content .....21.3..... %
Initial dry density .....1.49..... t/m³
Cohesion C' .....2..... kPa
Angle of friction ϕ' .....34..... °

MOISTURE CONTENTS AFTER TEST

TOP	MIDDLE	BOTTOM
22.2	23.1	24.9

remarks:

failure criteria: Maximum Stress Ratio

Authorised Signature

Coffey & Partners Pty. Ltd.

triaxial shear test

borehole: 5
sheet: of

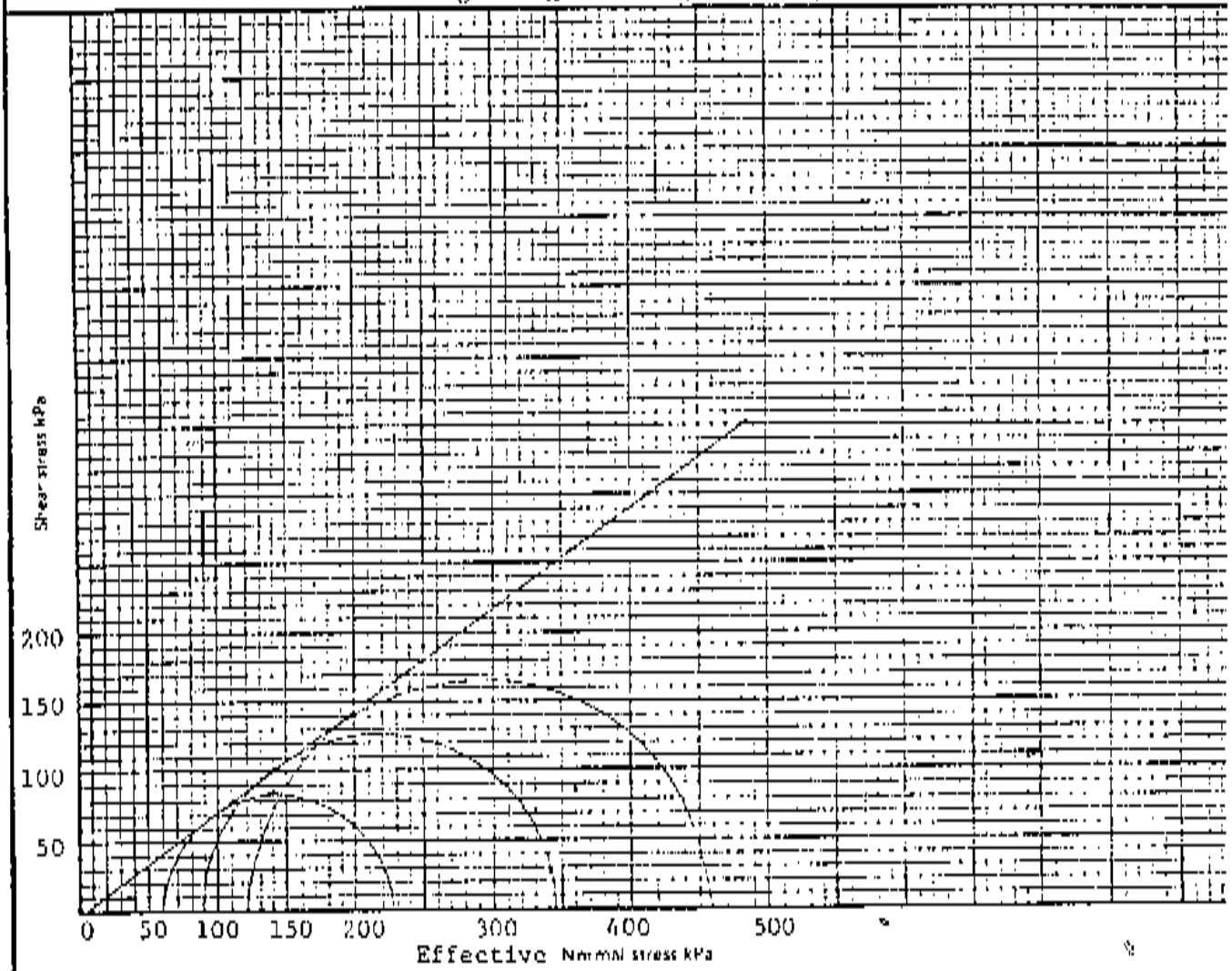
office: Sydney

client: Clarence River County Council
principal:
project: Clarence River Flood Mitigation
location: Grafton

job no: 56568
date: 3rd July 1981
tested by: MJL
checked by: KB

depth: 7.0 - 7.3m sample type: Undisturbed sample size: 50 x 100mm Back pressure 200 kPa
type of test: Consolidated Undrained Stage Test with pore pressure measurements

material classification: (SC) CLAYEY SAND, sand fine grained, brown-black, fines of medium plasticity.
Moist $>W_p$ W_L = 46, W_p - 23, I_p - 23, L.S. = 10.0%



initial moisture content 27.3 %
initial dry density 1.47 t/m³
Cohesion C' 1 kPa
Angle of friction ϕ' 36 °

MOISTURE CONTENTS AFTER TEST

TOP	MIDDLE	BOTTOM
26.3	27.6	28.9

remarks:

failure criteria: Maximum Stress Ratio

Authorised signature

Coffey & Partners Pty. Ltd.

triaxial shear test

borehole: 9
sheet: of

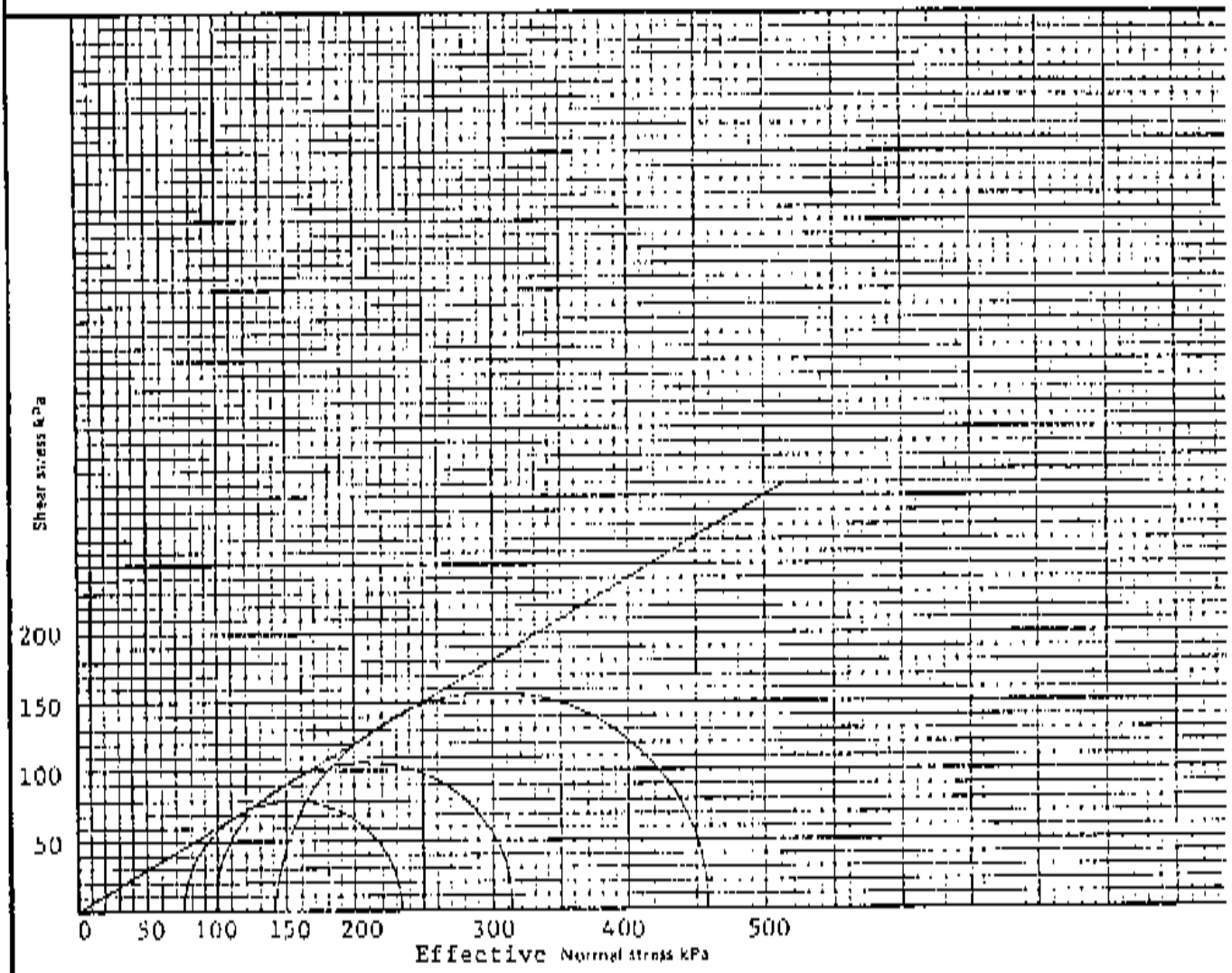
office: Sydney

client: Clarence River County Council
principal:
project: Clarence River Flood Mitigation
location: Grafton

job no: S6568
date: 3rd July 1981
tested by: MJL
checked by KB

depth: 5.0 - 5.3m sample type: Undisturbed sample size: 50 x 100mm Back pressure 200 kPa
type of test: Consolidated Undrained Stage Test with pore pressure measurements

material classification: (CH) SANDY CLAY, high plasticity, brown, fine grained sand, Moist >W_p W_L - 50, W_p = 26, I_p - 24, L.S. - 13.0%



Initial moisture content 37.6 %
Initial dry density 1.27 t/m³
Cohesion C' 0 kPa
Angle of friction ϕ' 31 °

MOISTURE CONTENTS AFTER TEST

TOP	MIDDLE	BOTTOM
34.3	33.6	36.1

remarks:

failure criteria: Maximum Stress Ratio

Authorised Signature

Coffey & Partners Pty. Ltd.

particle size distribution

COFFEY

borehole no

sheet of

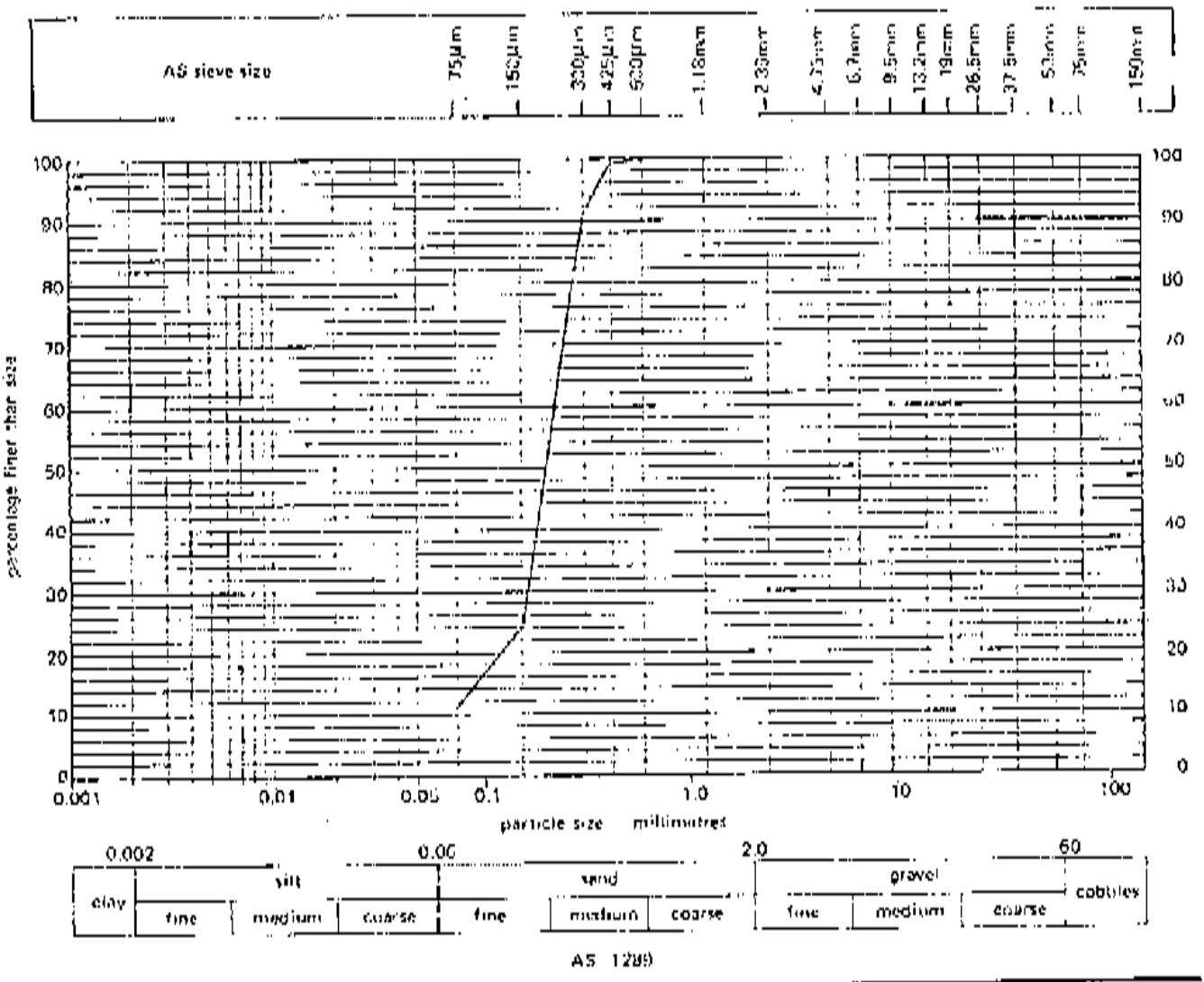
office Sydney

client Clarence River County Council
principal
project
location Crafton

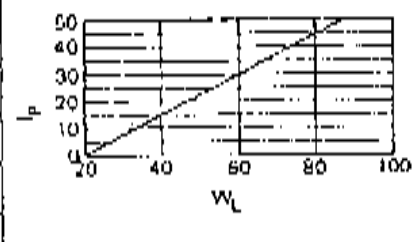
job no S6568
date 11th July 1981
tested by AC
checked by KB

sample identification BH4
test procedure

depth 6.0 - 6.45 m



liquid limit %	
plastic limit %	
plasticity index %	
linear shrinkage %	
particle density t/m³	
natural moisture %	



classification

(SP) Sand, fine to medium grained, grey.

Authorised signature

Coffey & Partners Pty. Ltd.

particle size distribution

COFFEY

borehole no

sheet of

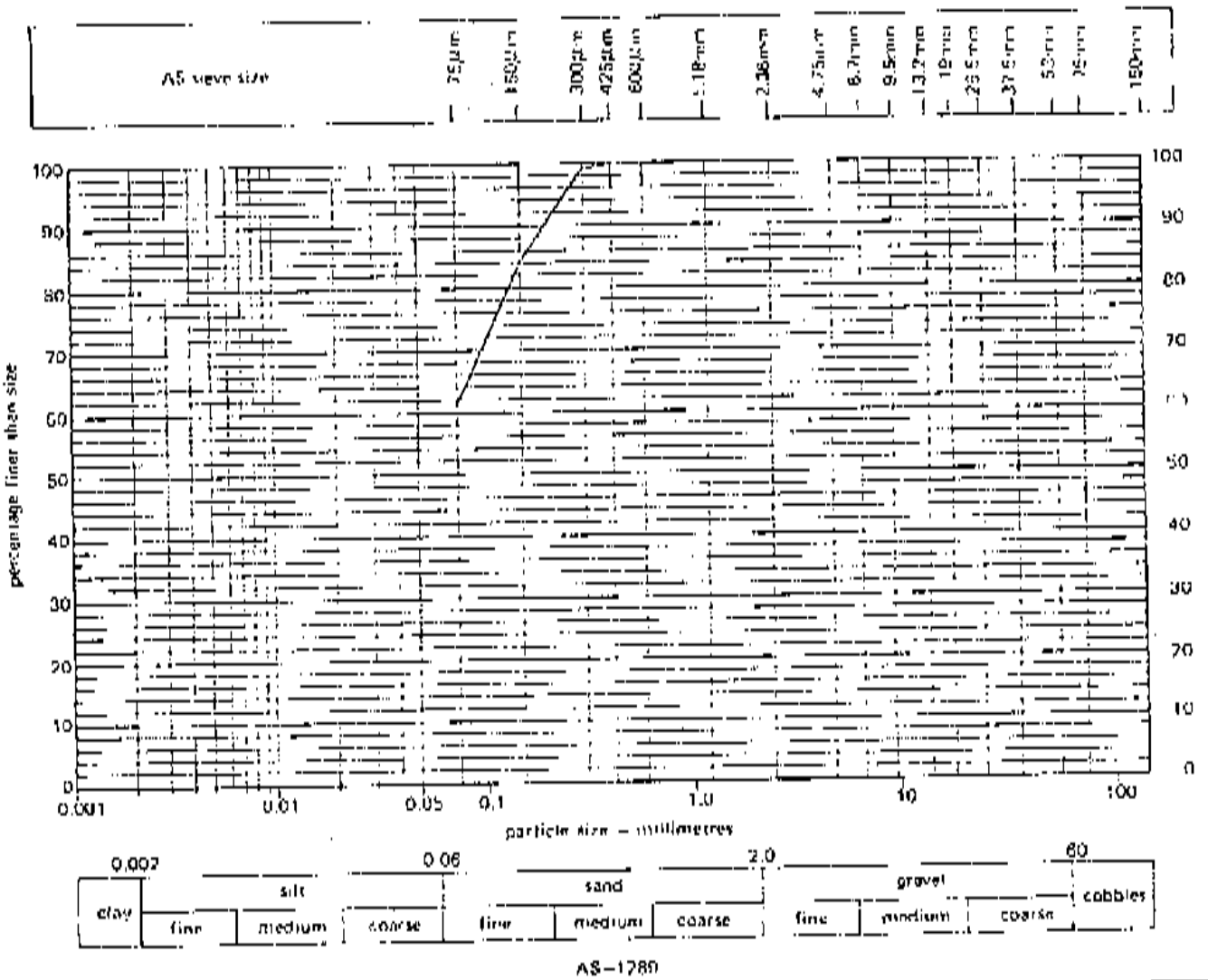
office Sydney

client Clarence River County Council
principal
project
location Grafton

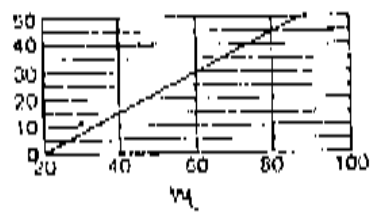
job no S6568
date 11th July 1981
tested by AC
checked by KB

sample identification B116
test procedure

depth 4.0 - 4.5 m



liquid limit	%	29
plastic limit	%	17
plasticity index	%	12
linear shrinkage	%	7.0
particle density	t/m³	
natural moisture	%	



classification
(CL) Sandy silty clay, low plasticity, brown, fine to medium grained sand.

This laboratory is registered by the National Association of Testing Authorities, Australia. The tests reported herein have been performed in accordance with the terms of registration. This document shall not be reproduced except in full without the prior approval of the laboratory.

Authorised Signature

Coffey & Partners Pty. Ltd.

particle size distribution

COFFEY

borehole no

sheet of

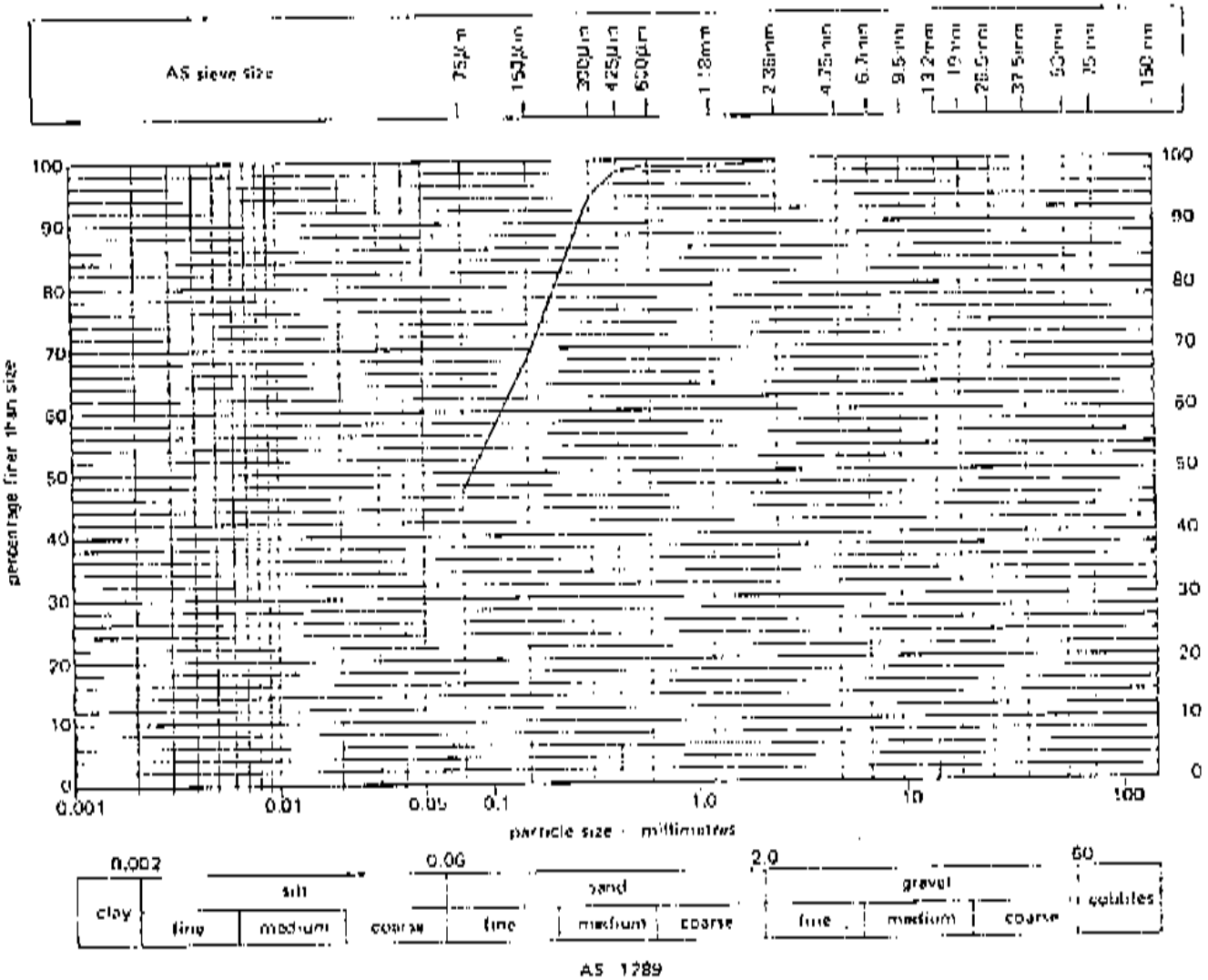
office Sydney

client Clarence River County Council
principal
project
location Grafton

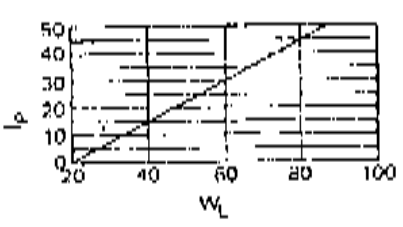
job no S6568
date 11th July 1981
tested by JR
checked by KB

sample identification BH7
test procedure

depth 6.0 - 6.5 m



liquid limit	%	29
plastic limit	%	16
plasticity index	%	13
linear shrinkage	%	5.5
particle density	t/m³	
natural moisture	%	



classification

(SM/SC) Clayey silty sand, fine to medium grained, brown, fines of low plasticity.

Authorised Signature

Coffey & Partners Pty. Ltd.

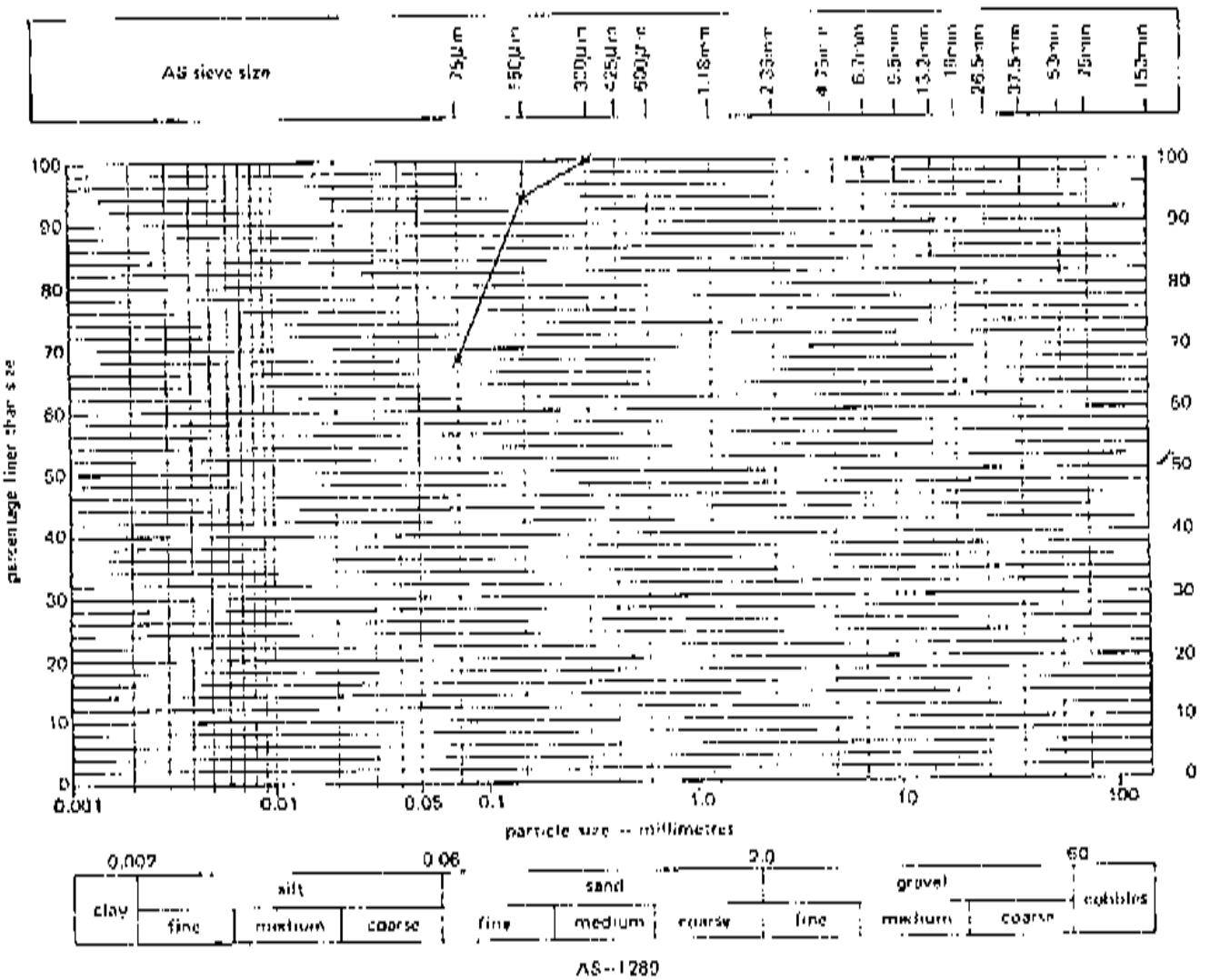
particle size distribution

borehole no 8
1.0 m.
sheet 1 of 1

office Sydney

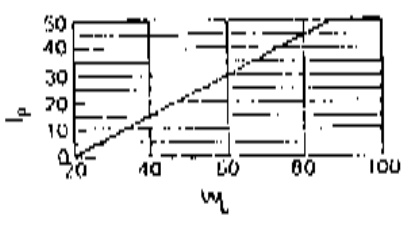
client	CLARENCE RIVER COUNTY COUNCIL	job no	S6568
principal		date	18 August 1981
project	CLARENCE RIVER FLOOD MITIGATION	tested by	JB
location	GRAFTON	checked by	PKW

sample identification BH8 depth 1.0 metres
test procedure



AS-1289

liquid limit %	
plastic limit %	
plasticity index %	
linear shrinkage %	
particle density t/m³	
natural moisture %	



classification

(CL) SANDY SILTY CLAY, low to medium plasticity, brown, fine grained sand.

Authorised Signature

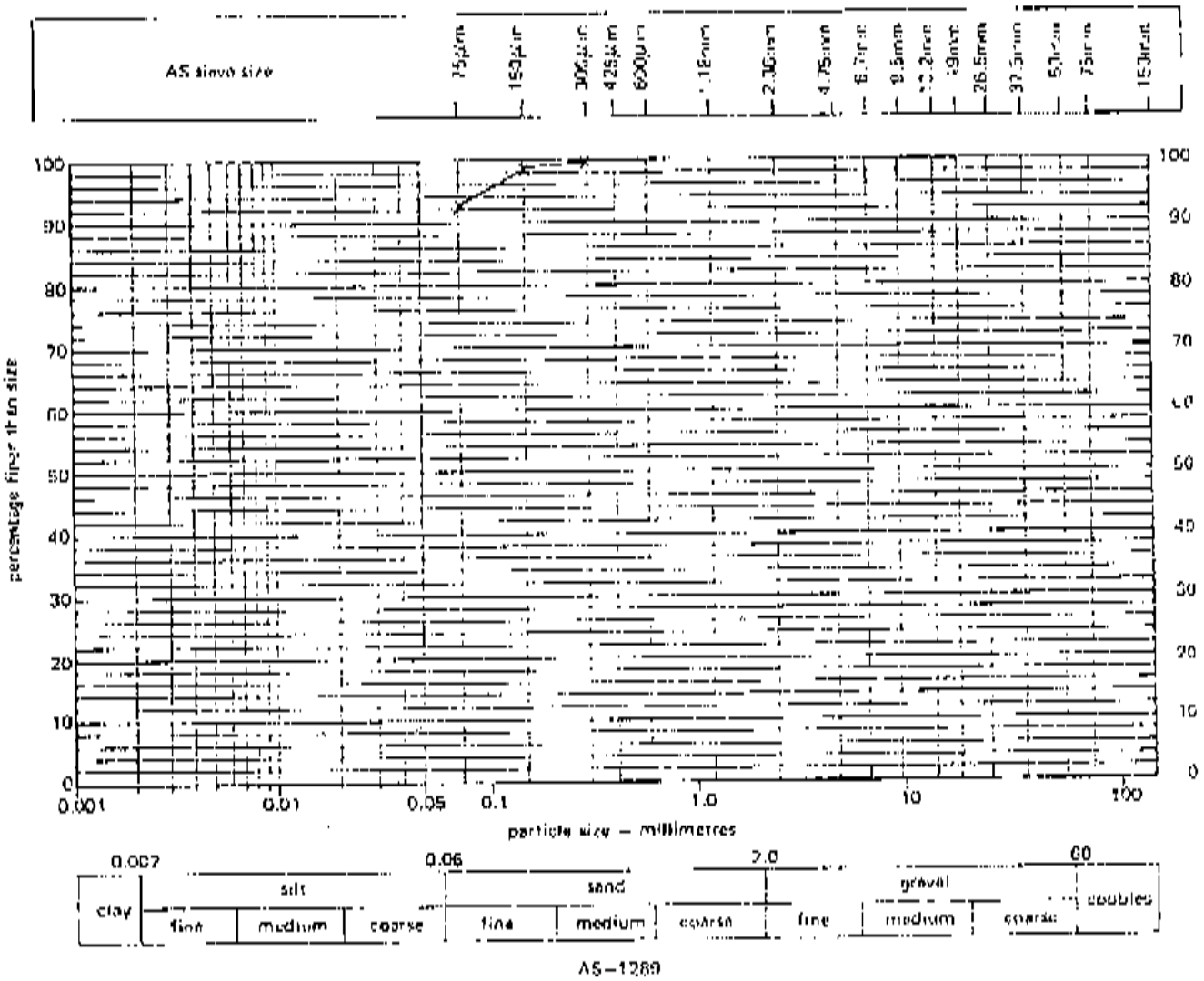
Coffey & Partners Pty. Ltd.

particle size distribution

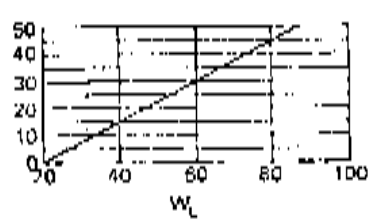
borehole no 8
3.0 m.
sheet 1 of 1

office Sydney

client	CLARENCE RIVER COUNTY COUNCIL	job no	S6568
principal		date	18 August 1981
project	CLARENCE RIVER FLOOD MITIGATION	tested by	JB
location	GRAFTON	checked by	PKW
sample identification	BH8	depth	3.0 metres
test procedure			



liquid limit	%
plastic limit	%
plasticity index	%
linear shrinkage	%
particle density	t/m³
natural moisture	%



classification
(CL) SILTY CLAY, low to medium plasticity, brown.

Authorised Signature

Coffey & Partners Pty. Ltd.

particle size distribution

COFFEY

borehole no TP1

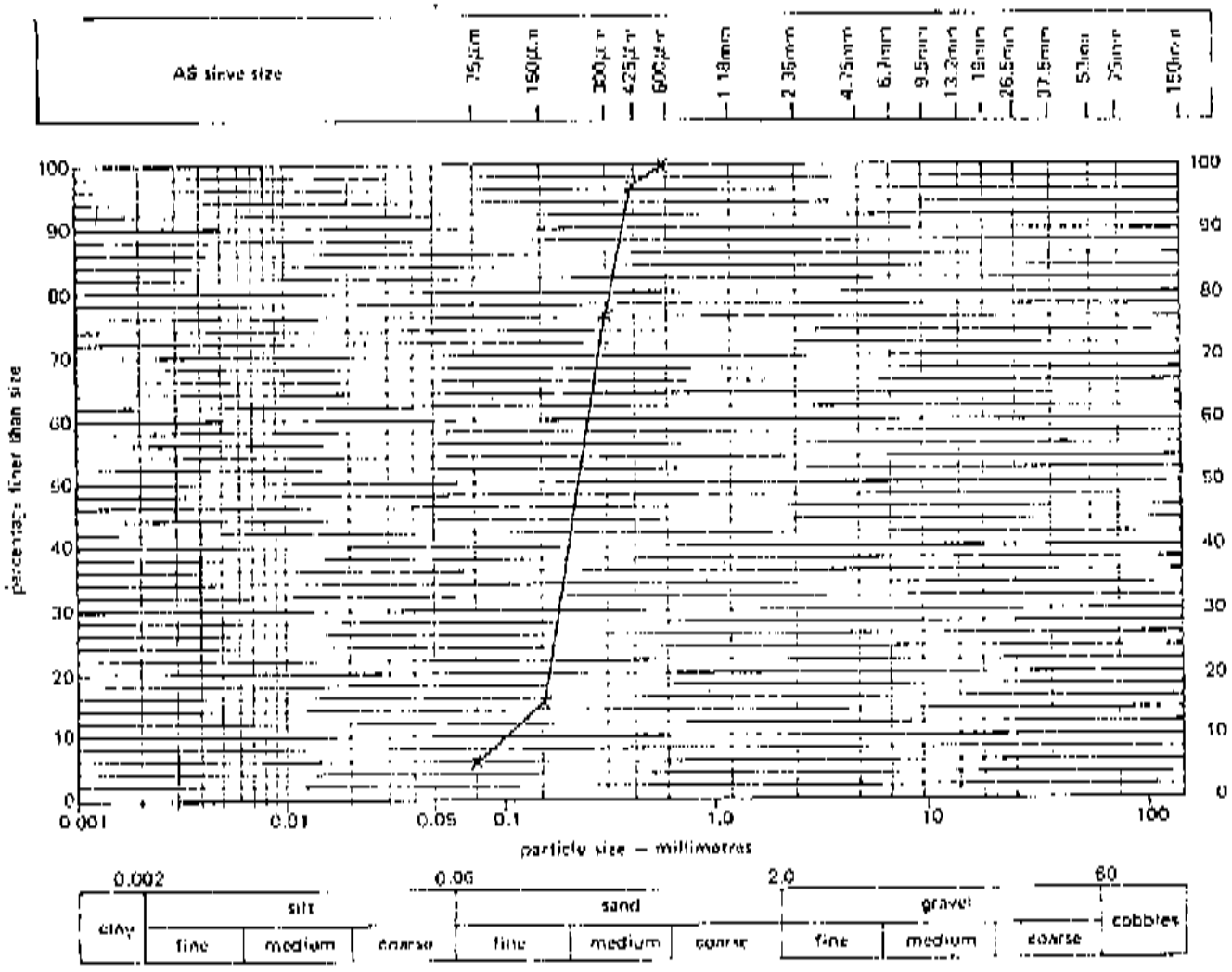
sheet 1 of 1

office Sydney

client	CLARENCE RIVER COUNTY COUNCIL	job no	S6568
principal		date	17 August 1981
project	CLARENCE RIVER FLOOD MITIGATION	tested by	KB
location	GRAFTON	checked by	PKW

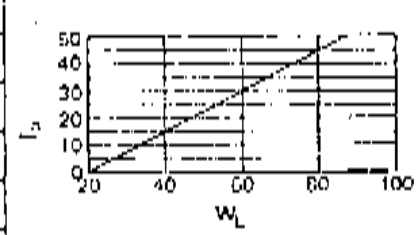
sample identification Test Pit 1 depth 1.0 metres

test procedure



AS-1289

liquid limit %	
plastic limit %	
plasticity index %	
linear shrinkage %	
particle density t/m³	
natural moisture %	



classification

(SP) SAND, medium to fine grained, brown.

Authorised Signature

Attachment B

Ground Investigation Data Report, Arup 2012

Roads and Maritime Services

Main Road 83 Summerland Way - Additional Crossing of the Clarence River at Grafton

Ground Investigation Data Report

July 2012

Job number 220422/00

Arup
Arup Pty Ltd ABN 18 000 966 165

Arup
Level 10 201 Kent Street
PO Box 76 Millers Point
Sydney 2000
Australia
www.arup.com

Transport Roads & Maritime Services

ARUP

Contents

Appendices

1 Introduction

This report contains the factual data from the ground investigations undertaken for the Arup Geotechnical Investigation for the Route Options report.

1.1 Project background

Roads and Maritime Services (RMS) are currently undertaking a route selection investigation of an additional crossing of the Clarence River at Grafton. Six route options are currently being considered as discussed in Section 1 of Arup's Geotechnical Investigations for Route Options report. The objective of the ground investigation is to provide a geotechnical assessment of the foundation conditions associated with the six route options so they can be reasonably compared.

This report presents the factual results of the ground investigation for the project. Results included in this report comprise all site works completed and all results of laboratory testing

1.2 Scope of ground investigation

Prior to this route options investigation, there was existing geotechnical information as follows:

- In the vicinity of the existing Grafton Bridge;
- For the flood plain area on the south side of the river, downstream of the existing Grafton Bridge and this can be extrapolated, to an extent, to interpret ground conditions along the three route options that cross the flood plain (Options 11 and 14/15).

There was no existing geotechnical borehole data for the Grafton side of the river and the area north to Great Marlow.

Therefore, to supplement the existing information, the supplementary investigation concentrated on the northern bank with five boreholes located at route options E, 11, 14 and 15. One borehole was located on the floodplain on the southern river bank in close proximity to route Options 14/15 to provide information on the anticipated rock level in this area.

A land based gravity survey was carried out on the south side of the Clarence River for route options 11 and 14/15. The aim of the gravity survey was to profile the top of the bedrock to the south east of the river up to the Pacific Highway and correlate the findings to the nearest boreholes. This will enable a more accurate estimation of the depth of piles along the floodplain covered by these options.

The borehole locations and gravity survey undertaken for this investigation is presented in Appendix A. Table 1 provides a list of the investigations undertaken and their relevance to the route options.

Table 1 Summary of investigation purpose

Location	Route option	Primary purpose
BH101	E	Investigation of bridge abutment founding materials and depth
BH102	11	Investigation of bridge abutment founding materials and depth
BH103	14/15	Investigation of bridge abutment founding materials and depth
BH104	14/15	Investigation of embankment founding materials and depth
BH105	15	Investigation of embankment founding materials and depth surrounding Lawrence Road
BH106	14/15	Investigation of founding materials and depth for bridge abutment and floodplain crossing
Gravity Survey along McLaers Lane and adjacent road	11	Correlation of bedrock depth across the floodplain crossing
Gravity Survey along Meona Lane and Eggins Lane	14/15	Correlation of bedrock depth across the floodplain crossing

1.3 Project execution

The ground investigation was carried out between the 5th and 23rd of March 2012. All works were conducted in accordance with the following documents:

- Summerland Way Geotechnical Investigation, Review of Environmental Factors, Revision 2;
- Main Road No. 83 Summerland Way Additional Clarence River Crossing, Geotechnical Investigation Environmental Management Plan, Issue 2;
- Main Road No. 83 Summerland Way Additional Crossing of the Clarence River at Grafton, Geotechnical Investigation Health and Safety Management Plan, Issue 3.

1.4 Boreholes

All boreholes were carried out by Terratest Pty Ltd, using a Hydropower 5000 truck mounted rig. Site supervision and logging was carried out by an Arup Engineer. Boreholes were advanced using washbore with standard penetration tests at 2m intervals. Undisturbed samples were taken of soft cohesive soils. Where rock was encountered the boreholes were advanced with NMLC core recovery (52mm core).

The boreholes were carried out in the locations presented in Table 2. Borehole locations were surveyed by GPS accurate to ±3 m.

Boreholes located at abutment foundations were progressed 3 metres into rock. Due to difficulties in advancing casing through gravels, poor core recovery was

obtained from BH101. BH105 was terminated within the gravels on approval from RMS.

Borehole logs and explanatory notes are presented in Appendix B. The core boxes were stored at the RMS Laboratory in Grafton.

Table 2 Summary of borehole locations

Borehole	Easting	Northing	Elevation (mAHD)	Total Depth
BH101	493755	6714983	2.49	35.5
BH102	495161	6715352	3.4	27.24
BH103	495438	6716883	3.77	27
BH104	494995	6717473	1.75	16.7
BH105	494720	6718301	6.7	27.5
BH106	495904	6716405	4.79	28.8

1.5 Laboratory testing

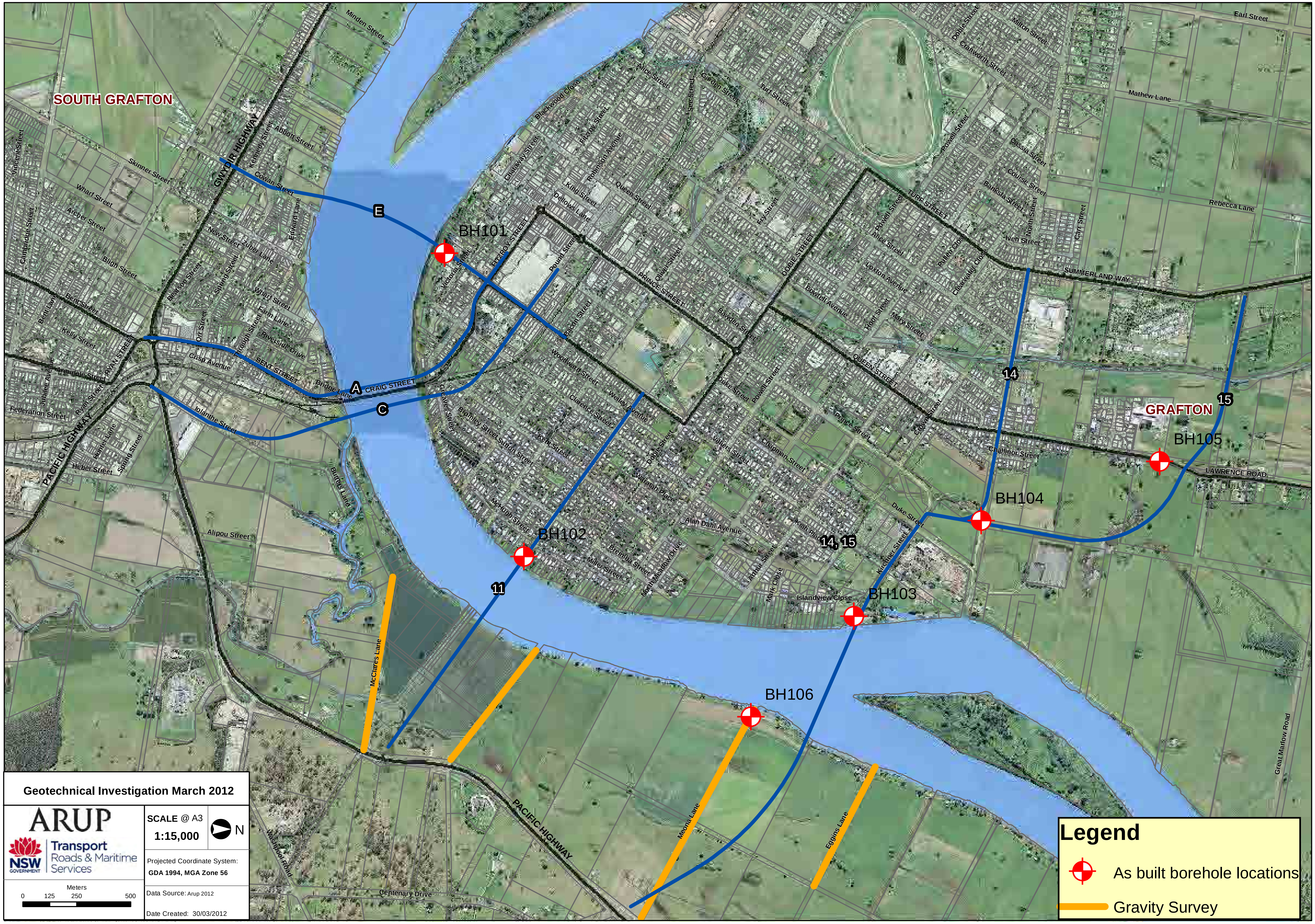
Laboratory testing of soil samples was undertaken by Trilab Pty Ltd, Brisbane, which included six atterberg limit, six particle size distribution, two oedometer, and one undrained triaxial tests. Laboratory testing of rock core samples was undertaken by SGS Australia Pty Ltd, Alexandria, NSW, which included twelve point load tests, six diametral and six axial. All laboratory testing results are presented in Appendix C.

1.6 Gravity survey

A gravity survey was undertaken for route options 11 and 14/15 to the east of the Clarence River. The survey was conducted along existing tracks between the river and the Pacific Highway. The survey was used to correlate bedrock elevation below the flood plain with borehole BH106 and previous investigation data. The results are presented in Appendix D.

Appendix A

Site Layout



Geotechnical Investigation March 2012
ARUP
NSW GOVERNMENT Transport Roads & Maritime Services
SCALE @ A3
1:15,000
N
Meters
0 125 250 500
Projected Coordinate System:
GDA 1994, MGA Zone 56
Data Source: Arup 2012
Date Created: 30/03/2012
Legend
As built borehole locations
Gravity Survey
SOUTH GRAFTON
GRAFTON
BH101
BH102
BH103
BH104
BH105
BH106
A
C
E
11
14
15
14, 15
GWYDIR HIGHWAY
PACIFIC HIGHWAY
SUMMERLAND WAY
LAWRENCE ROAD
PRINCE STREET
QUEEN STREET
TURF STREET
DOBIE STREET
FITZROY STREET
CRAIG STREET
BENT STREET
RYAN STREET
Minden Street
Skinner Street
Wharf Street
Archer Street
Bligh Street
Cambridge Street
Vincent Street
Kelly Street
Federation Street
Heber Street
Alipou Street
McClares Lane
Moona Lane
Eggins Lane
Centenary Drive
Great Marlow Road
Earl Street
Mathew Lane
Rebecca Lane
Duke Street
Kirchner Street
Islandview Close
Alan Dahl Avenue
Challinor Street
Pound Street
Victoria Street
Crisp Avenue
Iolanthe Street
Bridge Lane
Abbott Street
Cowan Street
Kennedy Street
Edward Lane
Riverside Drive

Appendix B

Borehole Logs

Geotechnical Explanatory Notes

ARUP

DESCRIPTION AND CLASSIFICATION METHODS

Soil and rock descriptions are generally in accordance with the recommendations of Australian Standards AS 1726-1993 and cover the following properties:

SOIL	Classification Group	**ROCK**	Name
	Soil Name		Grain Size
	Plasticity		Texture and Fabric
	Grain Size		Colour
	Colour		Strength
	Texture and Fabric		Weathering
	Secondary Components		Structure
	Minor Components		Defects
	Moisture		Weathering of Rock Mass
	Consistency		
	Structure		
	Origin		
	Other Relevant Information		

Field tests have been used extensively to assess soil consistency, rock strength and grain size. Unless specifically stated otherwise, these assessments have been transferred directly to the record sheets and not modified to coincide with laboratory test results. Field descriptions may therefore be used as an independent estimate of material properties which can be correlated with other data.

SOIL CLASSIFICATION SYMBOLS

The appropriate group symbol is given as shown on Sheet 2. This is based on the Unified Classification procedure - Visual Method for field identification in accordance with ASTM D 2487 - 83 and D 2488 - 84.

COMPOSITE SOIL TYPE

As most natural soils are a mixture of basic soil types, the primary soil is described and modified by secondary constituents as follows:

Coarse Grained Soils		Fine Grained Soils	
% Fines	**Terms**	**% Fines**	**Terms**
≤5	omit, or use 'trace'	≤15	omit, or use 'trace'
>5 ≤12	describe as 'with clay/silt' as applicable	>15 ≤30	describe as 'with sand/gravel' as applicable
>12	'silty/clayey' preceding primary soil	>30	'sandy/gravelly' preceding primary soil

GRAIN SIZE

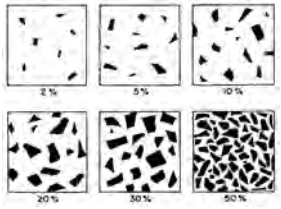
FIELD TEST	i Not visible with x10 lens ii Does not dilate on shaking iii Adheres to fingers when dry	i Particles >10µm visible with x10 lens ii Dilates on shaking iii Does not adhere to fingers when dry iv Feels gritty on teeth	i Particles >75µm visible to naked eye ii Fine sand feels gritty in fingers	Visible identification

DESIGNATION	CLAY	SILT	SAND			GRAVEL			COBBLES	BOULDERS
			Fine (f)	Medium (m)	Coarse (c)	Fine (f)	Medium (m)	Coarse (c)		
GRAIN SIZE	2	75	200	600	2.36	6	20	63	200	
	microns				millimetres					

			GROUP SYMBOL	GENERAL DESCRIPTION
COARSE GRAINED SOILS (MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE)	GRAVEL AND GRAVELLY SOILS	CLEAN GRAVELS (LITTLE OR NO FINES)	GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
			GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
	MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)	GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
			GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
	SAND AND SANDY SOILS	CLEAN SANDS (LITTLE OR NO FINES)	SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
			SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES
	MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)	SM	SILTY SANDS, SAND - SILT MIXTURES
			SC	CLAYEY SANDS, SAND - CLAY MIXTURES

			GROUP SYMBOL	GENERAL DESCRIPTIONS
FINE GRAINED SOILS (MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE)	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50	ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
			CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
			OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50	MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
			CH	INORGANIC CLAYS OF HIGH PLASTICITY
			OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
	HIGHLY ORGANIC SOILS		PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS
	FILL			FILL

PERCENTAGE AND SHAPE CLASSIFICATION



Essentially two-dimensional particles with the third dimension small by comparison may be described as 'flaky' or 'platy'.

Essentially one-dimensional particles with the other two dimensions small by comparison may be described as 'elongated'.

COLOUR

Individual assessment of colour has been made at field moisture condition, or as received using simple terms like **black**, **white**, **grey**, **red**, **brown**, **orange**, **yellow**, **green** or **blue**. No reference has been made to standard colour charts unless specifically stated. These may be modified where necessary using '**pale**', or '**dark**' or '**mottled**'. Borderline colours shall be described as a combination of colours e.g. **red-brown** etc.

Mottling shall be described as '(Primary colour) mottled (secondary colour)'. Where a soil consists of two colours present in roughly equal proportions the colour description should be 'Mottled (first colour) and (second colour)'

SOIL MOISTURE CONDITION

Condition	Cohesive	Granular
DRY (D)	Hard and friable or powdery, well dry of plastic limit	Cohesionless and free-running
MOIST (M)	Cool, darkened in colour, can be moulded	Cool, darkened in colour, tends to cohere
WET (W)	Weakened. Free water forms on hands when handling	Tends to cohere

Moisture content (mc) may be compared to the plastic limit (PL), eg mc>PL means moisture content greater than the plastic limit. The presence of any water seepage may be noted on the borehole records.

CONSISTENCY Cohesive Soils

FIELD TEST	Exudes between fingers when squeezed	Moulded by light finger pressure	Moulded by strong finger pressure	Indented by thumb, cannot be moulded by fingers	Indented by thumbnail	Indented with difficulty by thumbnail
DESIGNATION	Very Soft (VS)	Soft (S)	Firm (F)	Stiff (ST)	Very Stiff (VST)	Hard (H)
UNDRAINED SHEAR STRENGTH kPa	12	25	50	100	200	

CONSISTENCY Non-Cohesive Soils

FIELD TEST	Easily excavated with a spade	Some resistance to a spade or penetration with a hand bar	Considerable resistance to spade or penetration with a hand bar	No penetration with a hand bar; requires pick for excavation	High resistance to a pick
SPT 'N' VALUE (blows / 300 mm)	4	10	30	50	
DESIGNATION	Very loose (VL)	Loose (L)	Medium Dense (MD)	Dense (D)	Very Dense (VD)
DENSITY INDEX %	15	35	65	85	

DILATANCY Cohesive Soils

A positive reaction consists of the appearance of water on the surface of the pat which changes to livery consistency and becomes glossy. When the sample is squeezed the water and gloss disappear from the surface, the pat stiffens and finally cracks or crumbles.

The rapidity of appearance of water during shaking and its disappearance during squeezing assist in identifying the character of the fines in a soil.

Very fine clean sands give the quickest and most distinct reaction whereas a plastic clay has no reaction. Inorganic silts, such as a typical rock flour, show a moderately quick reaction.

SOIL STRUCTURE

Zoning: May consist of separate zone differing in colour, grain size or other properties. These should be describe d with the following descriptions:

a. **"Layer"** i.e. zone is continuous across exposure or sample
b. **"Lens"** i.e. a discontinuous layer of different material, with lenticular shape
c. **"Pocket"** i.e. an irregular inclusion

(the thickness , orientation an distinguishing features of the zones should be described).

Defects: described dimensions, orientation and spacing. Defects may include fissures, cracks, root-holes etc.

Cementing: Coarse grained soils may be cemented together by various agents. If the cementing agent allows the particle aggregations to be easily fractured by hand when the soil is saturated it is described as **"weakly"** cemented. If the cementing agent prevents fracturing by hand of the particle aggregations when saturated, it is described as **"strongly"** cemented.

ORGANICS

The presence of organic material shall be described using proportion terms such as 'with' or 'trace' using the following terms: **fibrous peat; charcoal; wood fragments; roots** (greater than 2 mm diameter); or **root fibres** (less than 2 mm diameter).

TYPICAL REPRESENTATION AND TERMS USED FOR CARBONATE ROCK

Classification of calcareous materials (modified from Clark and Walker)

Soil Consistency and Rock Strength	Increasing grain size of particulate deposits → 0.002 mm / 0.06 mm / 2 mm / 60 mm				Total Carbonate Content (%)
Soil Density/Consistency used as per AS1726-1993	CARBONATE CLAY	CARBONATE SILT	CARBONATE SAND	CARBONATE GRAVEL	90-100
		Siliceous CARBONATE SILT	Siliceous CARBONATE SAND	Mixed carbonate and non-carbonate GRAVEL	50-90
	Calcareous CLAY	Calcareous SILT	Calcareous silica SAND		10-50
	CLAY	SILT	Silica SAND	GRAVEL	0-10
Extremely Low to Medium Strength I_s50<1MPa UCS<12.5MPa	CALCILUTITE	CALCISILTITE	CALCARENITE	CALCIRUDITE	90-100
	Clayey CALCILUTITE	Siliceous CALCISILTITE	Siliceous CALCARENITE	Conglomeratic CALCIRUDITE	50-90
	Calcareous CLAYSTONE	Calcareous SILTSTONE	Calcareous SANDSTONE	Calcareous CONGLOMERATE	10-50
	CLAYSTONE	SILTSTONE	SANDSTONE	CONGLOMERATE	0-10
High to Very High Strength. I_s50>1MPa UCS >12.5 MPa	Fine-grained LIMESTONE		Detrital LIMESTONE	CONGLOMERATE LIMESTONE	90-100
	Fine-grained Argillaceous LIMESTONE	Fine-grained Siliceous LIMESTONE	Siliceous detrital LIMESTONE	Conglomeratic LIMESTONE	50-90
	Calcareous CLAYSTONE	Calcareous SILTSTONE	Calcareous SANDSTONE	Calcareous LIMESTONE	10-50
	CLAYSTONE	SILTSTONE	SANDSTONE	CONGLOMERATE	0-10
	CRYSTALLINE LIMESTONE [2]				

1. The strength of rock was determined in the field based on visual identification in accordance with page 3 of the Arup Explanatory Notes and was subsequently confirmed by laboratory testing.
2. Classification based upon rock displaying a crystalline fabric.

The term 'siliceous' replaces the term 'silica' when a secondary descriptor are used to indicate the presence of clay or silt fractions. These terms are as follows:
- Calcareous Siliceous Silty Sand
- Calcareous Siliceous Clayey Sand
- Siliceous Silty Sand
- Siliceous Clayey Sand

ROCK STRENGTH **Based on visual identification**

FIELD TEST	Easily remoulded by hand to a material with soil properties	Material crumbles under firm blows with sharp end of pick. Pieces up to 3cm thick can be broken by finger pressure	Easily scored with knife. A piece of core 150mm long and 50mm diameter may be broken by hand.	Readily scored by knife; a piece of core 150mm long by 50mm diameter can be broken by hand with difficulty	A piece of core 150mm long by 50mm diameter cannot be broken by hand but can be broken by a pick with single firm blow	Hand specimen breaks with pick after more than one blow; rock rings under hammer	Specimen requires many blows with geological pick to break through intact material; rock rings under hammer
POINT LOAD STRENGTH INDEX Is(50) MPa	0.03	0.1	0.3	1	3	10	
DESIGNATION	Extremely Low (EL)	Very Low (VL)	Low (L)	Medium (M)	High (H)	Very High (VH)	Extremely High (EH)
UNCONFINED COMPRESSIVE STRENGTH (q_u) MPa	The unconfined compressive strength is typically about 20 x Is(50). The ratio may vary widely for different rock types.						

ROCK WEATHERING **Based on visual identification**

FIELD APPEARANCE	Soil developed on extremely weathered rock; the mass structure and substance fabric are no longer evident; there is a large change in volume but the soil has not been significantly transported	Rock is weathered to an extent that it has 'soil' properties, ie it either disintegrates or can be remoulded, in water	Rock strength usually changed by weathering. The rock may be highly discoloured, usually by iron staining. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores.	Rock is slightly discoloured but shows little or no change of strength from fresh rock.	Rock shows no sign of decomposition or staining
DESIGNATION	Residual Soil (RS)	Extremely weathered rock (XW)	Distinctly weathered rock (DW)	Slightly weathered rock (SW)	Fresh rock (FR)

BEDDING STRATIFICATION

Term		Description	Separation of Stratification Planes
Stratification not recognisable		Massive	-
Stratification more than 20 mm apart	Bedded	Very thickly bedded	>2 m
		Thickly bedded	0.6 - 2 m
		Medium bedded	0.2 - 0.6 m
		Thinly bedded	60 mm-0.2 m
		Very thinly bedded	20 – 60 mm
Stratification planes less than 20 mm apart	Laminated	Thickly laminated	6 – 20 mm
		Thinly laminated	<6 mm

Table based on Geological Society Engineering Group Working Party report on *The Logging of Rock Cores for Engineering Purposes* - Q Jl Eng Geol Vol 3, 1970, pp1-24.

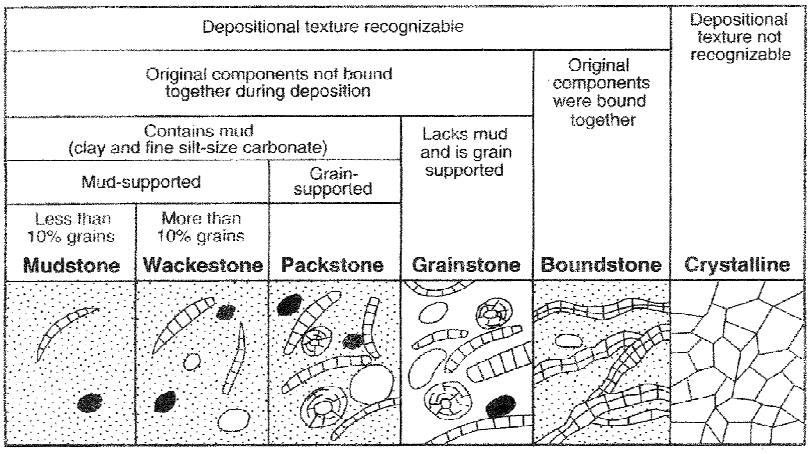
DEVELOPMENT OF STRATIFICATION

Term	Description
Poorly Developed	Bedding is barely obvious as faint mineralogical layering or grain size banding, but bedding planes are poorly defined
Well Developed	Bedding is apparent as distinct layers or lines marked by mineralogical or grain size layering
Very Well Developed	Bedding is often marked by a discrete colour banding as well as by mineralogical or grain size layering

ROCK TEXTURE AND FABRIC

Texture of rock refers to individual grains. Terms used frequently are: Crystalline, porphyritic, granular, cryptocrystalline, amorphous, glassy.

The arrangement of the grains (fabric) should be described as massive or layered (bedded, foliated, cleaved) Calcareous rocks should be described using the table below.



Carbonate rock fabric descriptive terminology based on Dunham 1962.

ROCK STRUCTURE

Sedimentary rocks – Bedded, laminated (<20 mm)

Metamorphic – Foliated, banded or cleaved

Igneous – massive, flow banded

DEFECT DESCRIPTION

Order of description: type, angle, thickness, planarity, roughness, coating, infill.

Defect Type

Symbol	Description
Sh	Sheared Zone - zone of multiple closely spaced fracture planes with roughly parallel planar boundaries, usually forming blocks of lenticular or wedge-shaped intact material. Fractures are typically smooth, polished or slickensided; and curved.
Be	Bedding plane parting - arrangement in layers of mineral grains of similar sizes, near parallel to surface of deposition along which a continuous observable parting occurs. Generally no microfractures.
Fo	Foliation Parting – As for bedding plane parting except discontinuous microfractures may be present near parallel to the layering.
Jo	Joint - a fracture across which rock has little or no tensile strength and is not obviously related to rock fabric.
Cr	Crushed Seam - zone with roughly parallel, planar boundaries (commonly slickensided) containing disoriented usually angular rock fragments of variable size often in a soil matrix.
Cl	Dyke – Igneous intrusion - often weathered and altered to a clay-like substance.
We	Weathered/Decomposed Zone - zone of any shape but commonly with parallel planar boundaries containing moderately to gradational boundaries into fresher rock.
SC	Solution cavity

Inclination

For specific defects, the orientation of each individual defect is noted in degrees from core normal. If the orientation cannot be measured, a dash (-) is used.

SPT SAMPLE DESCRIPTIONS

Where SPT tests are carried out in regions of core loss, a separate description of the SPT sample is provided. A separate description of the SPT sample is not however provided when core loss has not been recovered.

SHAPE

Symbol	Description
PL	Planar - forms a continuous plane without variation in orientation
IR	Irregular - has no clear orientation
CU	Curved - has a gradual change in orientation
UN	Undulating - has a wavy surface shape
ST	Stepped - has one or more well-defined steps

ROUGHNESS

Symbol	Description
Ro1	Slickensided or polished - very smooth, reflects light
Ro2	Smooth - roughness not detected with finger
Ro3	Defined ridges - Sandpaper feel (fine to medium sandpaper)
Ro4	Small steps - sandpaper feel (medium to coarse sandpaper)
Ro5	Very rough - very well defined ridges and/or steps.

INFILL TYPE

Symbol	Description
CL	Clean
CA	Calcite
CB	Carbonaceous material
CH	Chlorite
CT	Carbonate
FE	Iron oxide
LM	Limonite
QZ	Quartz
SU	Sulphides
RF	Rock fragments
g	gravelly
s	sandy
m	silty
c	clayey
G	Gravel
S	Sand
M	Silt
C	Clay

Note: lower case letters are used as prefix

INFILL THICKNESS

Where infilling is present, the thickness of infill is recorded using the following convention:

- ST Iron oxide staining less than 1mm
- VN Veneer coating less than 1mm

If the infilling is greater than 1mm, the actual thickness of infill is recorded in millimetres. If infill is not present, a dash (-) is recorded.

SAMPLE CODES

Symbol	Description
C	Core sample
SB	Small bulk disturbed
AMAL	Amalgamated sample
B	Bulk disturbed
BLK	Block
CBR	CBR mould
CD	Plastic tub for chemical analysis
D	Small disturbed
DEN	Denison Sampler
DENm	Denison Sampler (modified)
E	Environmental
G	Gas
J	Jar
K	Amber chemical jar
LB	Large bulk disturbed
LDS	Large disturbed
M	Mazier type
P	Piston
TW	Thin walled push-in
U	Undisturbed – open drive
U100	100mm diameter undisturbed
U63	63mm diameter undisturbed
U76	76mm diameter undisturbed
W	Water

STANDARD PENETRATION TEST REPORTING

The results of SPT's are reported on both borehole and cored borehole logs.

Typically the test is reported as the number of blows for the seating drive ; and the number of blows of the two increments of the main drive e.g. N 5;10,15

For a test which is terminated during the main drive, the blows for the seating drive are reported followed by a semi-colon (;) and then the total number of blows and the total distance driven (mm) is reported e.g. N 15;50/250

For a test which is terminated during the seating drive, the total number of blows and the distance driven (mm) is reported and the result is suffixed with an "s" to designate the test was terminated during the seating drive e.g. N 50/75s.

For a test that is terminated within the seating drive the N values is determined by extrapolation of the penetration and number of blows recorded and is denoted with "**".

For a test that is terminated before achieving the full main drive penetration, the N values is determined by extrapolation of the penetration and number of blows recorded and is denoted with "*".

HB – Hammer double bouncing

POINT LOAD TESTING

$I_{s(50)}$ Diametral test results to be recorded on log as: **2.05 DI**
$I_{s(50)}$ Axial test results to be recorded on log as: **2.05 AX**
$I_{s(50)}$ Irregular test results to be recorded on log as: **2.05 IR**

SYMBOLS & ABBREVIATIONS

Drilling

Method	
AD	Auger drilling (drilled depths shown (m))
V bit	Steel 'V' bit
TC	Tungsten carbide bit
RR	Tricone (rock roller) bit
W	Washboring
NMLC, BMLC	Triple tube rotary core drilling (52mm, 35mm diameter)
NH, HQ	Wireline core drilling
D	Diatube coring

Support	
W	Water
M	Mud
C	Casing
T	Timbering
U	Unsupported

Sample and Field Testing

D	Disturbed sample
U(x)	Undisturbed sample x mm diameter
U(x)+	U(x) attempted, little or no recovery
PT	Pressuremeter test
PL	Point load test (AX - axial, DI - diametral test)
Is(50)	Point load strength index (MPa)
q_c	Cone resistance (from CPT)
q_p, PP	Unconfined compressive strength estimated from pocket penetrometer (kPa)
RQD	Rock quality designation expressed as: sum of lengths of sound core pieces >100mm total length of core section considered
SCR	Solid core recovery
TCR	Total core recovery
D/DD	Dip/dip direction of rock discontinuity (degrees)
CPT	Cone penetration test
SPT	Standard penetration test
N	SPT blow count (blows/300 mm)
R	SPT refusal
V	In situ vane test (showing peak/residual value (kPa))
W	Water sample
B	Bulk sample

Water – Moisture

W	Wet
M	Moist
D	Dry
S	Standpipe installed to depth shown
P	Piezometer installed at depth shown
----▶-----	Inflow
----◀-----	Outflow (loss)
----▼-----	Level (date)
----◁-----	Partial loss

Soil Properties

CBR	California Bearing Ratio
c'	Effective shear strength
c_c	Compressed index
c_u	Undrained shear strength
c_v	Coefficient of consolidation
c_α	Coefficient of secondary compression
DD	Dry density
D_r	Dry density expressed
E	Elastic modulus
e	Void ratio
G	Shear modules
G_s	Specific gravity
k	Coefficient of permeability
MDD	Maximum dry density obtained in compaction test
m_v	Coefficient of volume compressibility
NDD	Natural dry density
NMC	Natural moisture content
OMC	Optimum moisture content obtained in compaction test
LI	Liquidity index
LL	Liquidity limit
LS	Linear shrinkage
PI	Plasticity index
PL	Plastic limit
q_u, UCS	Unconfined compressive strength
w	Moisture content (% of dry weight)
γ_b	Bulk density
γ_d	Dry density
γ_w	Density of water
υ	Poisson's ratio
ϕ_u	Apparent angle of friction from quick undrained triaxial test
$\phi_u\phi_u'$	Effective angles of friction in drained and undrained conditions

Design Parameters

Ab	Footing or pile base area
B	Footing or pile width or diameter
D	Footing or pile depth
d	Diameter of pile (m)
K	Coefficient of earth pressure
Ka	Coefficient of active pressure
Ko	Coefficient earth pressure at rest
Kp	Coefficient of passive pressure
L	Footing length
N_c, N_q, N_γ	Bearing capacity factors
NSF	Negative skin friction
P	Load
P_a	Total active force
P_b	Pile base load
P_p	Total passive force
P_s	Pile shaft load
P_a	Active earth pressure
P_b	Pile base pressure
P_p	Passive earth pressure
P_s	Pile shaft adhesion
S	Settlement
T_v	Dimensionless time factor
t	Time
U	Degree of consolidation
u	Pore water pressure
α	Shaft adhesion factor
δ	Angle of friction between soil and structure
σ	Total normal stress
σ'	Effective normal stress
τ	Shear stress
Subscript all	Allowable or working
Subscript h	Horizontal
Subscript r	Residual
Subscript ult	Ultimate
Subscript v	Vertical

ARUP

BOREHOLE RECORD

BH101
HOLE

SHEET 1
OF 5

CLIENT	RMS	LOGGED BY	RG
PROJECT	Summerland Way Additional Clarence River Crossing	CHECKED BY	AB
		DRILLED DATE	06-Mar-12 to 09-Mar-12
CONTRACTOR	Terratest Pty Ltd	ANGLE	Vertical
DRILL MODEL	Hydropower 5000	BEARING	-
DRILLER	Terratest (DC)	HOLE DIAMETER	100mm ()
		GROUND LEVEL	RL 2.49m
		LOCATION	493755 E 6714983 N
		ELEVATION DATUM	Australian Height Datum
		COORDINATE SYSTEM	AMG84 Zone 56

DRILLING		STRATA				MATERIAL DESCRIPTION	CONDITION		OBSERVATION
SAMPLE, TEST, BIT, SUPPORT, ETC.		R.L.	DEPTH	GROUP SYMBOL	LEGEND	SOIL TYPE Plasticity / Grain Size, Colour, Minor Components	WATER / MOISTURE	CONSISTENCY: COHESIVE (VS, S, F, ST, VST, H) / NON COHESIVE (VL, L, MD, D, VD)	SOIL ORIGIN, STRUCTURE, ETC.
		mAHD	m						
D	N=25 4;5,20	1.74	0.75	CL		Gravelly CLAY, (CL) low plasticity, brown, gravel is medium to coarse grained, angular (sandstone and siltstone), with sand, trace root fibres. (inferred Probable FILL).	D		**FILL**
			1	SM		Silty SAND, (SM) fine to medium grained, sub-angular to rounded, brown-pale brown, trace clay.	M		**Alluvium**
	▼1						W		
			2						
D	N=8 4;3,5								
			3						
			4						
D	N=16 6;8,8	-2.01	4.50	SM		Silty SAND, (SM) fine to coarse grained, poorly graded, sub-angular, grey-pale brown.	W		**Alluvium**
			5			.... 5.00m - 8.00m thin layers of Clayey SAND, fine to coarse grained, sub-angular, pale brown			
			6						
D	N=11 4;4,7								
			7						
			8			.... 8.00m - 10.90m higher proportion of coarse grained sand, trace fine to medium gravels, sub-angular (fine grained sandstone/ siltstone), dark grey			
D	N=10 4;5,5								
			9						

NOTES Hole Diameter 100mm to 2.50m depth. (Auger, then 100mm to 20.5m depth, washbore, then 75mm to 22.5m depth, washbore, then 52mm to 35.5m depth, NMLC)
End of borehole at 35.50m as agreed with the RMS

JOB 220422

ARUP BOREHOLE RECORD

BH101 HOLE

SHEET 2 OF 5

CLIENT	RMS	LOGGED BY	RG
PROJECT	Summerland Way Additional Clarence River Crossing	CHECKED BY	AB
		DRILLED DATE	06-Mar-12 to 09-Mar-12
CONTRACTOR	Terratest Pty Ltd	ANGLE	Vertical
DRILL MODEL	Hydropower 5000	BEARING	-
DRILLER	Terratest (DC)	HOLE DIAMETER	100mm ()
		GROUND LEVEL	RL 2.49m
		LOCATION	493755 E 6714983 N
		ELEVATION DATUM	Australian Height Datum
		COORDINATE SYSTEM	AMG84 Zone 56

DRILLING		STRATA				MATERIAL DESCRIPTION	CONDITION			OBSERVATION
SAMPLE, TEST, BIT, SUPPORT, ETC.		R.L. mAHD	DEPTH m	GROUP SYMBOL	LEGEND	SOIL TYPE Plasticity / Grain Size, Colour, Minor Components	WATER / MOISTURE	CONSISTENCY: COHESIVE VS S F ST VST H; NON COHESIVE VL L MD D VD		SOIL ORIGIN, STRUCTURE, ETC.
				SM		Silty SAND, (SM) fine to coarse grained, poorly graded, sub-angular, grey-pale brown. *(continued)*				**Alluvium**
D	N=12 7;6,6									
			11			.... 10.90m clay layer, 7mm thick, high plasticity, dark grey, organic odour				
			12			.... 12.30m becoming trace silt				
D	N=13 5;6,7									
			13							
			14			.... 14.00m gravel layers, probably fine grained (some resistance to boring)				
D	N=17 8;8,9									
			15							
			16			.... 16.00m gravel layers				
D	N=26 9;12,14					.... 16.50m SPT sample had fall in from above. Gravel layer over silty sand, fine to coarse grained, sub-angular, grey				
			17							
		-15.51	18 18.00	GP		GRAVEL, (GP) fine to coarse grained, poorly graded, sub-angular to sub-rounded, dark grey mottled brown-white.	W			**Alluvium**
D	N=26 18;10,16					.... 18.50m large amount of fall in for SPT sample				
			19							

NOTES Hole Diameter 100mm to 2.50m depth. (Auger, then 100mm to 20.5m depth, washbore, then 75mm to 22.5m depth, washbore, then 52mm to 35.5m depth, NMLC)
End of borehole at 35.50m as agreed with the RMS

JOB 220422

ARUP BOREHOLE RECORD

BH101 HOLE

SHEET 3 OF 5

CLIENT	RMS	LOGGED BY	RG
PROJECT	Summerland Way Additional Clarence River Crossing	CHECKED BY	AB
		DRILLED DATE	06-Mar-12 to 09-Mar-12
CONTRACTOR	Terratest Pty Ltd	ANGLE	Vertical
DRILL MODEL	Hydropower 5000	BEARING	-
DRILLER	Terratest (DC)	HOLE DIAMETER	100mm ()
		GROUND LEVEL	RL 2.49m
		LOCATION	493755 E 6714983 N
		ELEVATION DATUM	Australian Height Datum
		COORDINATE SYSTEM	AMG84 Zone 56

DRILLING	STRATA				MATERIAL DESCRIPTION	CONDITION		OBSERVATION
SAMPLE, TEST, BIT, SUPPORT, ETC.	R.L. mAHD	DEPTH m	GROUP SYMBOL	LEGEND	SOIL TYPE Plasticity / Grain Size, Colour, Minor Components	WATER / MOISTURE	CONSISTENCY: COHESIVE VS S F ST VST H; NON COHESIVE VL L MD D VD	SOIL ORIGIN, STRUCTURE, ETC.
D N=38 19;18,20		21	GP		GRAVEL, (GP) fine to coarse grained, poorly graded, sub-angular to sub-rounded, dark grey mottled brown-white. *(continued)*			**Alluvium**
					.... 20.50m becoming Clayey, medium plasticity, brown	W		
		22						
					Borehole continued as a Cored Drillhole	W		
		23						
		24						
		25						
		26						
		27						
		28						
		29						

NOTES Hole Diameter 100mm to 2.50m depth. (Auger, then 100mm to 20.5m depth, washbore, then 75mm to 22.5m depth, washbore, then 52mm to 35.5m depth, NMLC)
End of borehole at 35.50m as agreed with the RMS

JOB 220422

ARUP — CORED BOREHOLE RECORD

BH101 HOLE — SHEET 4 OF 5

CLIENT	RMS	LOGGED BY	RG
PROJECT	Summerland Way Additional Clarence River Crossing	CHECKED BY	AB
		DRILLED DATE	06-Mar-12 to 09-Mar-12
CONTRACTOR	Terratest Pty Ltd	ANGLE	Vertical
DRILL MODEL	Hydropower 5000	BEARING	-
DRILLER	Terratest (DC)	HOLE DIAMETER	100mm ()
		GROUND LEVEL	RL 2.49m
		LOCATION	493755 E 6714983 N
		ELEVATION DATUM	Australian Height Datum
		COORDINATE SYSTEM	AMG84 Zone 56

DRILLING | STRATA | MATERIAL DESCRIPTION | DISCONTINUITIES

TCR % (Drill rate)	SCR / (RQD)	FLUSH RETURN % (TYPE)	SAMPLES ($CaCO_3$, SPT, UCS, etc)	R.L. mAHD	DEPTH m	GRAPHIC LOG	ROCK TYPE Grain Size, Texture/Fabric, Colour, Minor Components	WEATHERING	ESTIMATED ROCK STRENGTH	Is 50 (MPa)	FREQUENCY (per m)	SPECIFIC TYPE	SPECIFIC ANGLE	SPECIFIC THICKNESS (mm)	GENERAL DESCRIPTION Planarity, Roughness, Coating, Infill
(100)	0/(0)								EL VL L M H VH EH		30 10 3 1				
87()	0/(0)														
25()	0/(0)	70 %													
50()	0/(0)														
		(Washbore) 70 %													
		(Washbore) 60 %													

R.L. mAHD	DEPTH m	Description
	21	
	22	
-20.11	22.60	Continued from Borehole
-20.26	22.75	GRAVEL, (GP) coarse grained, sub-rounded, very dense, with cobbles.
-20.36	22.85	CORE LOSS.
	23	Gravelly SAND, (SP) medium to coarse grained, poorly graded, sub-angular, pale brown, very dense, gravel is fine to coarse grained, sub-rounded, trace clay.
-21.01	23.50	.... 23.15m - 23.40m without gravel, sand becoming fine to medium grained
		CORE LOSS (probable wash out of fines around gravels).
	24	
-21.76	24.25	Gravelly SAND, (SP) medium to coarse grained, poorly graded, sub-angular, pale brown, very dense, gravel is fine to coarse grained, sub-rounded, trace clay.
-22.01	24.50	CORE LOSS (probably Gravelly SAND).
-22.16	24.65	Gravelly SAND, (SP) medium to coarse grained, poorly graded, sub-angular, pale brown, very dense, gravel is fine to coarse grained, sub-rounded, trace clay.
	25	
	26	
		.... 26.50m with gravel, fine to medium grained, sub-rounded, mixed lithologies
	27	
-25.51	28 28.00	Clayey GRAVEL, (GC) fine to coarse grained, poorly graded, sub-rounded to sub-angular, mottled grey-brown.
	29	

N 30/55s N 30/60s N 30/135s N 30/100s

NOTES

Hole Diameter 100mm to 2.50m depth. (Auger, then 100mm to 20.5m depth, washbore, then 75mm to 22.5m depth, washbore, then 52mm to 35.5m depth, NMLC)
End of borehole at 35.50m as agreed with the RMS

See explanatory notes for details of abbreviations and basis of descriptions

JOB 220422

ARUP — CORED BOREHOLE RECORD

BH101 HOLE — SHEET 5 OF 5

CLIENT	RMS	LOGGED BY	RG
PROJECT	Summerland Way Additional Clarence River Crossing	CHECKED BY	AB
		DRILLED DATE	06-Mar-12 to 09-Mar-12
CONTRACTOR	Terratest Pty Ltd	ANGLE	Vertical
DRILL MODEL	Hydropower 5000	BEARING	-
DRILLER	Terratest (DC)	HOLE DIAMETER	100mm ()
		GROUND LEVEL	RL 2.49m
		LOCATION	493755 E 6714983 N
		ELEVATION DATUM	Australian Height Datum
		COORDINATE SYSTEM	AMG84 Zone 56

DRILLING | STRATA | MATERIAL DESCRIPTION | DISCONTINUITIES

TCR % (Drill rate)	SCR / (RQD)	FLUSH RETURN % (TYPE)	SAMPLES ($CaCO_3$, SPT, UCS, etc)	R.L. mAHD	DEPTH m	GRAPHIC LOG	ROCK TYPE Grain Size, Texture/Fabric, Colour, Minor Components	WEATHERING	ESTIMATED ROCK STRENGTH	Is 50 (MPa)	FREQUENCY (per m)	SPECIFIC TYPE	SPECIFIC ANGLE	SPECIFIC THICKNESS (mm)	GENERAL DESCRIPTION Planarity, Roughness, Coating, Infill
			N 30/110s				Clayey GRAVEL, (GC) fine to coarse grained, poorly graded, sub-rounded to sub-angular, mottled grey-brown. *(continued)*		EL VL L M H VH EH		30 10 3 1				
		(Washbore) 60 %			31										
				-29.51	32 32.00		CLAYSTONE, recovered on the end of the roller and barrel as clay, high plasticity, grey, stiff to very stiff.								
8() 20()	0/(0) 0/(0)	60 %		-30.01 -30.09 -30.11 -30.34 -30.36	32.50 32.58 32.60 32.83 32.85		CORE LOSS. CLAYSTONE, recovered as clay, high plasticity, grey, stiff to very stiff. CORE LOSS (fall in of gravel from above caused washout of claystone). Casing could not be advanced further. .... 32.80m short runs due to gravel fall in blocking core barrel								
					33		CLAYSTONE, recovered as clay, high plasticity, grey, stiff to very stiff. CORE LOSS (fall in of gravel from above caused washout of claystone). .... 34.00m cleaned hole with tricone roller, returned clay, grey, stiff to very stiff								
0()	0/(0)	60 %			34										
2()	0/(0)	70 %		-32.49 -32.51	34.98 35 35.00		CLAYSTONE, recovered as clay, high plasticity, grey, stiff to very stiff. CORE LOSS (fall in of gravel from above caused washout of claystone).								
0()	0/(0)	70 %		-33.01	35.50		.... 35.50m end of borehole as agreed with RMS End of Borehole at 35.50m								
					36										
					37										
					38										
					39										

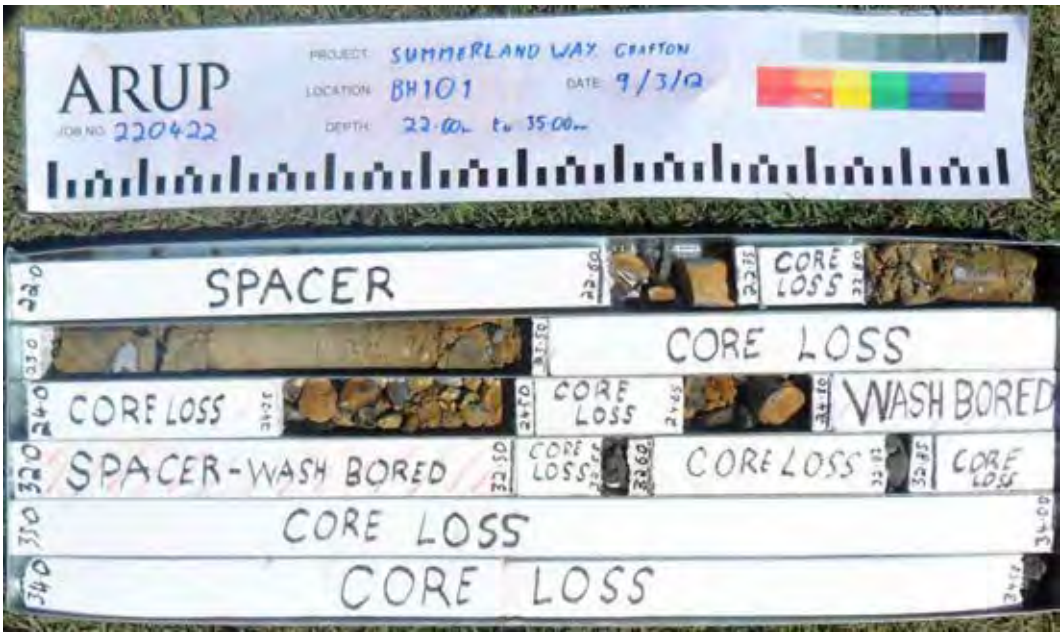
NOTES

Hole Diameter 100mm to 2.50m depth. (Auger, then 100mm to 20.5m depth, washbore, then 75mm to 22.5m depth, washbore, then 52mm to 35.5m depth, NMLC)
End of borehole at 35.50m as agreed with the RMS

See explanatory notes for details of abbreviations and basis of descriptions

JOB 220422

ARUP	Core Photographs	BH101



22.60m to 35.00m

ARUP

BOREHOLE RECORD

BH102
HOLE

SHEET 1
OF 4

CLIENT	RMS	LOGGED BY	RG
PROJECT	Summerland Way Additional Clarence River Crossing	CHECKED BY	JV
		DRILLED DATE	13-Mar-12 to 15-Mar-12
CONTRACTOR	Terratest Pty Ltd	ANGLE	Vertical
DRILL MODEL	Hydropower 5000	BEARING	-
DRILLER	Terratest (DC)	HOLE DIAMETER	100mm ()
		GROUND LEVEL	RL 3.40m
		LOCATION	495161 E 6715352 N
		ELEVATION DATUM	Australian Height Datum
		COORDINATE SYSTEM	AMG84 Zone 56

DRILLING		STRATA				MATERIAL DESCRIPTION	CONDITION		OBSERVATION
SAMPLE, TEST, BIT, SUPPORT, ETC.		R.L. mAHD	DEPTH m	GROUP SYMBOL	LEGEND	SOIL TYPE Plasticity / Grain Size, Colour, Minor Components	WATER / MOISTURE	CONSISTENCY: COHESIVE VS S F ST VST H; NON COHESIVE VL L MD D VD	SOIL ORIGIN, STRUCTURE, ETC.
D	N=4 1;2,2			SM		Sandy CLAY, (SM) medium plasticity, dark brown, sand is fine grained, trace root fibres.	M		**Alluvium**
D		2.20	1.20	SM		SAND, trace Silt, (SM) fine to medium grained, trace coarse grained, poorly graded, sub-angular to sub-rounded, brown to pale brown.	M		**Alluvium**
D	N=4 2;2,2								
		0.20	3.20	SM		Silty Clayey SAND, (SM) fine to medium grained, poorly graded, dark brown, clay is low plasticity, layered, black.	W		**Alluvium**
D	N=4 0;0,4								
		-2.10	5.50	SM		Silty SAND, (SM) fine to medium grained, poorly graded, sub-angular to sub-rounded, grey-brown.			**Alluvium**
D	N=11 4;5,6						W		
D	N=10 3;4,6						W		

NOTES Hole Diameter 100mm to 4.50m depth. (Auger, then 100mm to 23m depth, washbore, then 75mm to 24.24m depth, washbore, then 52mm to 27.24m depth, NMLC)

JOB 220422

ARUP

BOREHOLE RECORD

BH102
HOLE

SHEET 2
OF 4

CLIENT	RMS	LOGGED BY	RG
PROJECT	Summerland Way Additional Clarence River Crossing	CHECKED BY	JV
		DRILLED DATE	13-Mar-12 to 15-Mar-12
CONTRACTOR	Terratest Pty Ltd	ANGLE	Vertical
DRILL MODEL	Hydropower 5000	BEARING	-
DRILLER	Terratest (DC)	HOLE DIAMETER	100mm ()
		GROUND LEVEL	RL 3.40m
		LOCATION	495161 E 6715352 N
		ELEVATION DATUM	Australian Height Datum
		COORDINATE SYSTEM	AMG84 Zone 56

DRILLING	STRATA				MATERIAL DESCRIPTION	CONDITION			OBSERVATION
SAMPLE, TEST, BIT, SUPPORT, ETC.	R.L.	DEPTH	GROUP SYMBOL	LEGEND	SOIL TYPE Plasticity / Grain Size, Colour, Minor Components	WATER / MOISTURE	CONSISTENCY: COHESIVE (VS, S, F, ST, VST, H)	CONSISTENCY: NON COHESIVE (VL, L, MD, D, VD)	SOIL ORIGIN, STRUCTURE, ETC.
	mAHD	m							
			SM		Silty SAND, (SM) fine to medium grained, poorly graded, sub-angular to sub-rounded, grey-brown. *(continued)*				**Alluvium**
D N=15 6;6,9						W			
		11			.... 11.50m becoming fine to coarse grained.				
		12							
D N=13 4;5,8									
		13							
		14							
D N=14 6;7,7					.... 14.40m GRAVEL layer, 50mm thick, likely fine grained.				
		15			.... 15.00m becoming Gravelly.				
		16							
D N=26 17;13,13	-13.10	16.50	GC		Clayey GRAVEL, (GC) fine to coarse grained, poorly graded, sub-angular to sub-rounded, mixed lithologies, clay is high plasticity, brown.				**Alluvium**
		17							
		18							
D N=17 10;6,11					.... 18.50m becoming Sandy, sand is fine to medium grained, sub-angular, brown.				
		19							

NOTES Hole Diameter 100mm to 4.50m depth. (Auger, then 100mm to 23m depth, washbore, then 75mm to 24.24m depth, washbore, then 52mm to 27.24m depth, NMLC)

JOB 220422

ARUP

BOREHOLE RECORD

BH102
HOLE

SHEET 3
OF 4

CLIENT	RMS	LOGGED BY	RG
PROJECT	Summerland Way Additional Clarence River Crossing	CHECKED BY	JV
		DRILLED DATE	13-Mar-12 to 15-Mar-12
CONTRACTOR	Terratest Pty Ltd	ANGLE	Vertical
DRILL MODEL	Hydropower 5000	BEARING	-
DRILLER	Terratest (DC)	HOLE DIAMETER	100mm ()
		GROUND LEVEL	RL 3.40m
		LOCATION	495161 E 6715352 N
		ELEVATION DATUM	Australian Height Datum
		COORDINATE SYSTEM	AMG84 Zone 56

DRILLING	STRATA				MATERIAL DESCRIPTION	CONDITION			OBSERVATION
SAMPLE, TEST, BIT, SUPPORT, ETC.	R.L. mAHD	DEPTH m	GROUP SYMBOL	LEGEND	SOIL TYPE Plasticity / Grain Size, Colour, Minor Components	WATER / MOISTURE	CONSISTENCY: COHESIVE (VS, S, F, ST, VST, H)	CONSISTENCY: NON COHESIVE (VL, L, MD, D, VD)	SOIL ORIGIN, STRUCTURE, ETC.
			GC		Clayey GRAVEL, (GC) fine to coarse grained, poorly graded, sub-angular to sub-rounded, mixed lithologies, clay is high plasticity, brown. *(continued)*				**Alluvium**
N=75** 30/120s		21			.... 20.50m medium grained gravel blocked SPT tube, sub-rounded.	W			
D N=40 27;22,18		22			.... 22.50m large amount of gravel fall-in top of SPT. 100mm at base of sample shows Sandy Clayey GRAVEL.	W			
	-20.10	23			CLAYSTONE, recovered as Gravelly CLAY, high plasticity, dark grey, gravel is fine to medium grained, tabular.	M-W			**Bedrock**
N=100** 30/90s		24			Borehole continued as a Cored Drillhole	D			
		25							
		26							
		27							
		28							
		29							

NOTES Hole Diameter 100mm to 4.50m depth. (Auger, then 100mm to 23m depth, washbore, then 75mm to 24.24m depth, washbore, then 52mm to 27.24m depth, NMLC)

JOB 220422

ARUP

CORED BOREHOLE RECORD

BH102 HOLE

SHEET 4 OF 4

CLIENT	RMS	LOGGED BY	RG
PROJECT	Summerland Way Additional Clarence River Crossing	CHECKED BY	JV
		DRILLED DATE	13-Mar-12 to 15-Mar-12
CONTRACTOR	Terratest Pty Ltd	ANGLE	Vertical
DRILL MODEL	Hydropower 5000	BEARING	-
DRILLER	Terratest (DC)	HOLE DIAMETER	100mm ()
		GROUND LEVEL	RL 3.40m
		LOCATION	495161 E 6715352 N
		ELEVATION DATUM	Australian Height Datum
		COORDINATE SYSTEM	AMG84 Zone 56

DRILLING | STRATA | MATERIAL DESCRIPTION | DISCONTINUITIES

TCR % (Drill rate)	SCR / (RQD)	FLUSH RETURN % (TYPE)	SAMPLES ($CaCO_3$, SPT, UCS, etc)	R.L. mAHD	DEPTH m	GRAPHIC LOG	ROCK TYPE Grain Size, Texture/Fabric, Colour, Minor Components	WEATHERING	ESTIMATED ROCK STRENGTH EL VL L M H VH EH	Is 50 (MPa)	FREQUENCY (per m) 30 10 3 1	SPECIFIC TYPE	SPECIFIC ANGLE	SPECIFIC THICKNESS (mm)	GENERAL DESCRIPTION Planarity, Roughness, Coating, Infill
100()	100/(100)			-20.84	24.24		Continued from Borehole								
				-20.95	24.35		INTERBEDDED SANDSTONE / CLAYSTONE, thinly laminated at 5 to 10 degrees. sandstone is fine grained, grey, claystone is dark brown. trace inclusions of organic matter and coal on bedding planes.	SW/DW							
				-21.02	24.42		CORE LOSS.	SW/DW							
							INTERBEDDED SANDSTONE / CLAYSTONE, thinly laminated at 5 to 10 degrees. sandstone is fine grained, grey, claystone is dark brown. trace inclusions of organic matter and coal on bedding planes.			D0.41 A0.49		Jo Be Jo Jo Jo Jo Jo Jo Jo Jo Jo Jo Jo Jo	45 10 20 25 30 10 20 20 25 70 10 80 80 75	0 0 1 1 1 1 0 0 0 0 0 1 1 1	PL Ro3 CL PL Ro3 CL PL Ro4 CL PL Ro4 C PL Ro4 CL PL Ro3 C PL Ro2 CL PL Ro2 CL PL Ro2 CL PL Ro2 CL PL Ro4 C PL Ro2 M UN Ro2 M PL Ro2 M
			C				.... 25.81m - 24.30m sandstone laminations are less frequent, higher proportion of claystone.								
96()	89/(86)			-22.90	26.30		CORE LOSS.								
				-23.10	26.50		INTERBEDDED SANDSTONE / CLAYSTONE, thinly laminated at 5 to 10 degrees. sandstone is fine grained, grey, claystone is dark brown. trace inclusions of organic matter and coal on bedding planes.	SW/DW							
79()	69/(69)			-23.84	27.24		.... 26.50m - 26.70m drilling induced core diameter reduction.								
							End of Borehole at 27.24m								

NOTES

Hole Diameter 100mm to 4.50m depth. (Auger, then 100mm to 23m depth, washbore, then 75mm to 24.24m depth, washbore, then 52mm to 27.24m depth, NMLC)

See explanatory notes for details of abbreviations and basis of descriptions

JOB 220422

ARUP	Core Photographs	BH102

24.24m to 27.24m

ARUP

BOREHOLE RECORD

BH103
HOLE

SHEET 1
OF 4

CLIENT	RMS	LOGGED BY	RG
PROJECT	Summerland Way Additional Clarence River Crossing	CHECKED BY	JV
		DRILLED DATE	12-Mar-12 to 13-Mar-12
CONTRACTOR	Terratest Pty Ltd	ANGLE	Vertical
DRILL MODEL	Hydropower 5000	BEARING	-
DRILLER	Terratest (DC)	HOLE DIAMETER	100mm ()
		GROUND LEVEL	RL 3.77m
		LOCATION	495438 E 6716883 N
		ELEVATION DATUM	Australian Height Datum
		COORDINATE SYSTEM	AMG84 Zone 56

DRILLING		STRATA				MATERIAL DESCRIPTION	CONDITION			OBSERVATION
SAMPLE, TEST, BIT, SUPPORT, ETC.		R.L.	DEPTH	GROUP SYMBOL	LEGEND	SOIL TYPE Plasticity / Grain Size, Colour, Minor Components	WATER / MOISTURE	CONSISTENCY COHESIVE VS S F ST VST H	CONSISTENCY NON COHESIVE VL L MD D VD	SOIL ORIGIN, STRUCTURE, ETC.
		mAHD	m							
D	N=5 1;2,3			CL		Silty CLAY, (CL) medium plasticity, grey, silt is brown, thinly layered, with sand, fine grained, trace root fibres.	M			**Alluvium**
						.... 1.25m sand lense at base of U50 sample.				
		1.97	1.80	SM		Silty Clayey SAND, (SM) fine to medium grained, poorly graded, sub-angular, brown, clay is medium plasticity, trace gravel, medium grained, sub-angular.	M			**Alluvium**
D	N=3 2;2,1									
		0.37	3.40	CH		Silty CLAY, (CH) medium to high plasticity, brown, trace sand, fine grained.	M			**Alluvium**
		-0.23	4.00	SM		Silty SAND, (SM) fine to medium grained, poorly graded, sub-rounded to sub-angular, brown to pale brown, trace clay.	W			**Alluvium**
D	N=5 2;2,3									
						.... 5.50m becoming dark grey.				
D	N=2 0;1,1						W			
D	N=18 7;8,10	-4.73	8.50	SM		Silty SAND, (SM) fine to coarse grained, poorly graded, sub-angular, grey.	W			**Alluvium**
						.... 9.10m - 10.00m with gravel, likely fine to medium grained.				

NOTES Hole Diameter 100mm to 4.50m depth. (Auger, then 100mm to 21m depth, washbore, then 75mm to 23.9m depth, washbore, then 52mm to 27m depth, NMLC)

JOB 220422

ARUP BOREHOLE RECORD

BH103 HOLE

SHEET 2 OF 4

CLIENT	RMS	LOGGED BY	RG
PROJECT	Summerland Way Additional Clarence River Crossing	CHECKED BY	JV
		DRILLED DATE	12-Mar-12 to 13-Mar-12
CONTRACTOR	Terratest Pty Ltd	ANGLE	Vertical
DRILL MODEL	Hydropower 5000	BEARING	-
DRILLER	Terratest (DC)	HOLE DIAMETER	100mm ()
		GROUND LEVEL	RL 3.77m
		LOCATION	495438 E 6716883 N
		ELEVATION DATUM	Australian Height Datum
		COORDINATE SYSTEM	AMG84 Zone 56

DRILLING		STRATA				MATERIAL DESCRIPTION	CONDITION										OBSERVATION
SAMPLE, TEST, BIT, SUPPORT, ETC.		R.L.	DEPTH	GROUP SYMBOL	LEGEND	SOIL TYPE Plasticity / Grain Size, Colour, Minor Components	WATER / MOISTURE	CONSISTENCY									SOIL ORIGIN, STRUCTURE, ETC.
								COHESIVE					NON COHESIVE				
								VS	S	F	ST	VST	H	VL	L	MD	D	VD	
		mAHD	m														
				SM		Silty SAND, (SM) fine to coarse grained, poorly graded, sub-angular, grey. *(continued)*												**Alluvium**
D	N=32 10;13,19		11				W											
			12															
D	N=20 6;9,11		13			.... 12.50m becoming with gravel, fine grained, sub-rounded.	W											
			14															
D	N=16 10;10,6		15															
			16															
D	N=14 9;7,7		17			.... 16.35m GRAVEL layer 100mm thick, likely fine grained.												
			18			.... 17.50m - 18.00m Gravelly, likely fine to medium grained.												
		-14.43	18.20	GC		Sandy GRAVEL, (GC) fine to medium grained, poorly graded, sub-rounded to sub-angular, brown, sand is fine to coarse grained, sub-angular, with clay.	M-W											**Alluvium**
D	N=75* 29;30/120		19															

NOTES Hole Diameter 100mm to 4.50m depth. (Auger, then 100mm to 21m depth, washbore, then 75mm to 23.9m depth, washbore, then 52mm to 27m depth, NMLC)

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ARUP

BOREHOLE RECORD

BH103
HOLE

SHEET 3
OF 4

CLIENT	RMS	LOGGED BY	RG
PROJECT	Summerland Way Additional Clarence River Crossing	CHECKED BY	JV
		DRILLED DATE	12-Mar-12 to 13-Mar-12
CONTRACTOR	Terratest Pty Ltd	ANGLE	Vertical
DRILL MODEL	Hydropower 5000	BEARING	-
DRILLER	Terratest (DC)	HOLE DIAMETER	100mm ()
		GROUND LEVEL	RL 3.77m
		LOCATION	495438 E 6716883 N
		ELEVATION DATUM	Australian Height Datum
		COORDINATE SYSTEM	AMG84 Zone 56

DRILLING	STRATA				MATERIAL DESCRIPTION	CONDITION										OBSERVATION
SAMPLE, TEST, BIT, SUPPORT, ETC.	R.L.	DEPTH	GROUP SYMBOL	LEGEND	SOIL TYPE Plasticity / Grain Size, Colour, Minor Components	WATER / MOISTURE	CONSISTENCY									SOIL ORIGIN, STRUCTURE, ETC.
							COHESIVE					NON COHESIVE				
	mAHD	m					VS	S	F	ST	VST	H	VL	L	MD	D	VD	
			GC		Sandy GRAVEL, (GC) fine to medium grained, poorly graded, sub-rounded to sub-angular, brown, sand is fine to coarse grained, sub-angular, with clay. *(continued)*													**Alluvium**
N=60* 25;58/290		21			.... 20.50m medium grained gravel blocked SPT tube.													
		22																
D N=69* 29;30/130		23			.... 22.50m becoming Clayey, high plasticity, brown.													
	-19.83	23.60			CLAYSTONE, dark grey, extremely low strength, recovered as CLAY, high plasticity, with gravel, fine to medium grained, tabular.	D-M												**Bedrock**
N=129** D 30/70s		24			Borehole continued as a Cored Drillhole													
		25																
		26																
		27																
		28																
		29																

NOTES Hole Diameter 100mm to 4.50m depth. (Auger, then 100mm to 21m depth, washbore, then 75mm to 23.9m depth, washbore, then 52mm to 27m depth, NMLC)

JOB 220422

ARUP

CORED BOREHOLE RECORD

BH103
HOLE

SHEET 4
OF 4

CLIENT	RMS	LOGGED BY	RG
PROJECT	Summerland Way Additional Clarence River Crossing	CHECKED BY	JV
		DRILLED DATE	12-Mar-12 to 13-Mar-12
CONTRACTOR	Terratest Pty Ltd	ANGLE	Vertical
DRILL MODEL	Hydropower 5000	BEARING	-
DRILLER	Terratest (DC)	HOLE DIAMETER	100mm ()
		GROUND LEVEL	RL 3.77m
		LOCATION	495438 E 6716883 N
		ELEVATION DATUM	Australian Height Datum
		COORDINATE SYSTEM	AMG84 Zone 56

DRILLING | STRATA | MATERIAL DESCRIPTION | DISCONTINUITIES

TCR % (Drill rate)	SCR / (RQD)	FLUSH RETURN % (TYPE)	SAMPLES ($CaCO_3$, SPT, UCS, etc)	R.L. mAHD	DEPTH m	GRAPHIC LOG	ROCK TYPE Grain Size, Texture/Fabric, Colour, Minor Components	WEATHERING	ESTIMATED ROCK STRENGTH	Is 50 (MPa)	FREQUENCY (per m)	SPECIFIC TYPE	SPECIFIC ANGLE	SPECIFIC THICKNESS (mm)	GENERAL DESCRIPTION Planarity, Roughness, Coating, Infill
83()	63/(38)	70 % (clay)		-20.13	23.90		Continued from Borehole								
				-20.23	24.00		CORE LOSS.								
				-20.33	24.10		CLAYSTONE, thinly laminated, well developed bedding dipping at 5 to 10 degrees, dark grey-brown.	DW/XW							
				-20.35	24.12		CORE LOSS (due to core rotating inside barrel).	DW/XW							
				-20.73	24.50		CLAYSTONE, thinly laminated, well developed bedding dipping at 5 to 10 degrees, dark grey-brown.					Jo	40	1	PL Ro2 C
74()	74/(60)	100 % (clay)		-20.86	24.63		CORE LOSS.	DW				Jo	45	1	PL Ro4 CL
							INTERBEDDED CLAYSTONE/SANDSTONE, Claystone, is dark grey, organic, Sandstone is fine grained, thinly laminated, very well developed bedding, dark grey.					Jo	40	1	PL Ro3 C
			C	-21.23	25.00		CORE LOSS.			D0.51					
				-21.32	25.09		.... 25.00m organic fragments on bedding plane.	DW		A0.90					
93()	81/(73)	(mud) 90 %					INTERBEDDED CLAYSTONE/SANDSTONE, Claystone, is dark grey, organic, Sandstone is fine grained, thinly laminated, with very well developed bedding, dark grey.					Jo	45	1	PL Ro4 c, G
							.... 25.90m - 26.00m recovered as Clayey GRAVEL, fine grained, angular.					Jo	20	0	PL Ro3 CL
				-22.53	26.30		.... 26.10m slickenslides on joint plane dipping at 70 degrees.					Jo	80	1	UN Ro1 CL
				-22.55	26.32		.... 26.15m - 26.30m dark grey-brown, increasing clay content.	SW				Jo	45	0	PL Ro1 CL
97()	94/(73)	(mud) 90 %	C				CORE LOSS.					Jo	40	1	PL Ro2 CL
				-23.23	27.00		INTERBEDDED CLAYSTONE/SANDSTONE, Claystone, is dark grey, organic, Sandstone is fine grained, thinly laminated, with very well developed bedding, dark grey.			D0.84		Jo	10	1	PL Ro3 CL
							End of Borehole at 27.00m			A2.01		Jo	30	1	PL Ro2 CL

NOTES

Hole Diameter 100mm to 4.50m depth. (Auger, then 100mm to 21m depth, washbore, then 75mm to 23.9m depth, washbore, then 52mm to 27m depth, NMLC)

See explanatory notes for details of abbreviations and basis of descriptions

JOB 220422

ARUP	Core Photographs	BH103

23.90m to 27.00m

ARUP

BOREHOLE RECORD

BH104
HOLE

SHEET 1
OF 2

CLIENT	RMS	LOGGED BY	RG
PROJECT	Summerland Way Additional Clarence River Crossing	CHECKED BY	JV
		DRILLED DATE	10-Mar-12
CONTRACTOR	Terratest Pty Ltd	ANGLE	Vertical
DRILL MODEL	Hydropower 5000	BEARING	-
DRILLER	Terratest (DC)	HOLE DIAMETER	100mm ()
		GROUND LEVEL	RL 1.75m
		LOCATION	494995 E 6717473 N
		ELEVATION DATUM	Australian Height Datum
		COORDINATE SYSTEM	AMG84 Zone 56

DRILLING	STRATA				MATERIAL DESCRIPTION	CONDITION		OBSERVATION
SAMPLE, TEST, BIT, SUPPORT, ETC.	R.L. mAHD	DEPTH m	GROUP SYMBOL	LEGEND	SOIL TYPE Plasticity / Grain Size, Colour, Minor Components	WATER / MOISTURE	CONSISTENCY: COHESIVE VS S F ST VST H; NON COHESIVE VL L MD D VD	SOIL ORIGIN, STRUCTURE, ETC.
D N=9 3;4,5			CH		CLAY, (CH) medium to high plasticity, dark grey mottled brown, with silt, trace sand, fine to medium grained, trace root fibres.	M		**Alluvium**
U50		1						
						M		
		2						
D N=8 4;3,5								
	-1.15	2.90	SM		Silty SAND, (SM) fine to medium grained, poorly graded, sub-angular to sub-rounded, grey, trace clay.	M-W		**Alluvium**
	-1.45	3.20	CL		Silty CLAY, (CL) medium to high plasticity, grey, with sand, fine to medium grained, sub-angular.	M		**Alluvium**
		4						
U50								
	-3.05	4.80	SM		Silty SAND, (SM) fine to medium grained, poorly graded, sub-rounded to sub-angular, grey, with clay.	W		**Alluvium**
D N=7 1;2,5		5						
		6			.... 6.00m becoming trace clay.			
						W		
D N=5 3;3,2		7						
		8						
D N=4 1;2,2					.... 8.50m trace clay lenses, high plasticity, dark grey.			
		9						

NOTES Hole Diameter 100mm to 2.00m depth. (Auger, then 100mm to 16.7m depth, washbore)
End of borehole at 16.70m as instructed by the RMS

JOB 220422

ARUP

BOREHOLE RECORD

BH104
HOLE

SHEET 2
OF 2

CLIENT	RMS	LOGGED BY	RG
PROJECT	Summerland Way Additional Clarence River Crossing	CHECKED BY	JV
		DRILLED DATE	10-Mar-12
CONTRACTOR	Terratest Pty Ltd	ANGLE	Vertical
DRILL MODEL	Hydropower 5000	BEARING	-
DRILLER	Terratest (DC)	HOLE DIAMETER	100mm ()
		GROUND LEVEL	RL 1.75m
		LOCATION	494995 E 6717473 N
		ELEVATION DATUM	Australian Height Datum
		COORDINATE SYSTEM	AMG84 Zone 56

DRILLING	STRATA				MATERIAL DESCRIPTION	CONDITION			OBSERVATION
SAMPLE, TEST, BIT, SUPPORT, ETC.	R.L. mAHD	DEPTH m	GROUP SYMBOL	LEGEND	SOIL TYPE Plasticity / Grain Size, Colour, Minor Components	WATER / MOISTURE	CONSISTENCY: COHESIVE VS S F ST VST H	CONSISTENCY: NON COHESIVE VL L MD D VD	SOIL ORIGIN, STRUCTURE, ETC.
			SM		Silty SAND, (SM) fine to medium grained, poorly graded, sub-rounded to sub-angular, grey, with clay. *(continued)* .... 10.20m becoming dark grey-brown.				**Alluvium**
D N=8 5;4,4		11				W			
	-9.75	11.50	SM		SAND (SM) fine to coarse grained, poorly graded, sub-rounded to sub-angular, grey, with silt.				**Alluvium**
		12			.... 12.00m GRAVEL layer, 50mm thick, likely fine to medium grained.				
D N=13 6;7,6		13				W			
		14			.... 14.20m GRAVEL layer, 100mm thick, likely fine to medium grained.				
D N=40 13;22,18	-12.95	14.70	GP		Sandy GRAVEL, (GP) fine to coarse grained, poorly graded, sub-rounded, of mixed lithologies, grey, sand is medium to coarse grained, poorly graded, sub-angular. .... 15.00m high resistance to tri-cone roller.	W			**Alluvium**
		15							
		16			.... 16.00m large amount of gravel fall in and slow drilling progress.				
D N=180* 27;30/50	-14.95	16.70				W			
		17			*Borehole completed at 16.7m depth*				
		18							
		19							

NOTES
Hole Diameter 100mm to 2.00m depth. (Auger, then 100mm to 16.7m depth, washbore)
End of borehole at 16.70m as instructed by the RMS

JOB
220422

ARUP

BOREHOLE RECORD

BH105
HOLE

SHEET 1
OF 3

CLIENT	RMS	LOGGED BY	JV
PROJECT	Summerland Way Additional Clarence River Crossing	CHECKED BY	AB
		DRILLED DATE	19-Mar-12 to 21-Mar-12
CONTRACTOR	Terratest Pty Ltd	ANGLE	Vertical
DRILL MODEL	Hydropower 5000	BEARING	-
DRILLER	Terratest (DC)	HOLE DIAMETER	100mm ()
		GROUND LEVEL	RL 6.70m
		LOCATION	494720 E 6718301 N
		ELEVATION DATUM	Australian Height Datum
		COORDINATE SYSTEM	AMG84 Zone 56

DRILLING	STRATA				MATERIAL DESCRIPTION	CONDITION		OBSERVATION
SAMPLE, TEST, BIT, SUPPORT, ETC.	R.L. mAHD	DEPTH m	GROUP SYMBOL	LEGEND	SOIL TYPE Plasticity / Grain Size, Colour, Minor Components	WATER / MOISTURE	CONSISTENCY: COHESIVE VS S F ST VST H; NON COHESIVE VL L MD D VD	SOIL ORIGIN, STRUCTURE, ETC.
			CL		Silty CLAY, (CL) low to medium plasticity, dark brown, trace sand, fine grained, trace root fibres.	D		**Alluvium**
	5.80	0.90	SP		Silty SAND, (SP) fine to medium grained, sub-angular, poorly graded, yellow-pale brown, with silt.	D		**Alluvium**
D	N=5 2;2,3	1				M		
		2						
		3						
D	N=5 2;2,3	4						
					.... 4.50m becoming Clayey, brown.			
		5				M-W		
	1.20	5.50	CH		CLAY, (CH) high plasticity, grey mottled brown, trace organic lenses.	M-W		**Alluvium**
D	N=5 0;3,2	6						
U50					.... 6.50m becoming dark brown mottled brown.			
		7			.... 7.20m becoming brown.			
	-0.80	7.50	SP		Silty SAND, (SP) fine grained, poorly graded, grey.	M-W		**Alluvium**
D	N=5 2;1,4	8						
	-1.40	8.10	CH		CLAY, (CH) high plasticity, brown.	M-W		**Alluvium**
	-2.00	8.70	SP		Silty SAND, (SP) fine to medium grained, poorly graded, grey-dark grey.	M-W		**Alluvium**
		9						
D	N=8 4;5,3							

NOTES Hole Diameter 100mm to 5.50m depth. (Auger, then 100mm to 27.5m depth, washbore)
End of borehole at 27.50m as agreed with the RMS

JOB 220422

ARUP BOREHOLE RECORD

BH105 HOLE

SHEET 2 OF 3

CLIENT	RMS	LOGGED BY	JV
PROJECT	Summerland Way Additional Clarence River Crossing	CHECKED BY	AB
		DRILLED DATE	19-Mar-12 to 21-Mar-12
CONTRACTOR	Terratest Pty Ltd	ANGLE	Vertical
DRILL MODEL	Hydropower 5000	BEARING	-
DRILLER	Terratest (DC)	HOLE DIAMETER	100mm ()
		GROUND LEVEL	RL 6.70m
		LOCATION	494720 E 6718301 N
		ELEVATION DATUM	Australian Height Datum
		COORDINATE SYSTEM	AMG84 Zone 56

DRILLING	STRATA				MATERIAL DESCRIPTION	CONDITION		OBSERVATION
SAMPLE, TEST, BIT, SUPPORT, ETC.	R.L. (mAHD)	DEPTH (m)	GROUP SYMBOL	LEGEND	SOIL TYPE Plasticity / Grain Size, Colour, Minor Components	WATER / MOISTURE	CONSISTENCY (COHESIVE: VS S F ST VST H; NON COHESIVE: VL L MD D VD)	SOIL ORIGIN, STRUCTURE, ETC.
			SP		Silty SAND, (SP) fine to medium grained, poorly graded, grey-dark grey. *(continued)*			**Alluvium**
		11						
D N=7 4;4,3		12						
		13						
D N=11 6;4,7					.... 13.50m with clay.			
		14			.... 14.50m trace shell fragments.			
		15						
D N=3 0;0,3	-8.80	15.50	CH		CLAY, (CH) high plasticity, grey-dark grey.	M-W		**Alluvium**
	-9.10	15.80	SC		Clayey Silty SAND, (SC) fine grained, poorly graded, grey.	M-W		**Alluvium**
		16						
		17			.... 17.00m trace organics.			
D N=7 5;3,4	-10.80	17.50	SP		Silty SAND, (SP) fine grained, poorly graded, grey.	M		**Alluvium**
		18						
	-12.10	18.80	GM		Silty Sandy GRAVEL, (GM) fine to coarse grained, sub-rounded to sub-angular, well graded, grey, sand is fine to medium grained.	W		**Alluvium**
		19						
D N=67* 20;60/270								

NOTES Hole Diameter 100mm to 5.50m depth. (Auger, then 100mm to 27.5m depth, washbore)
End of borehole at 27.50m as agreed with the RMS

JOB 220422

ARUP

BOREHOLE RECORD

BH105
HOLE

SHEET 3
OF 3

CLIENT	RMS	LOGGED BY	JV
PROJECT	Summerland Way Additional Clarence River Crossing	CHECKED BY	AB
		DRILLED DATE	19-Mar-12 to 21-Mar-12
CONTRACTOR	Terratest Pty Ltd	ANGLE	Vertical
DRILL MODEL	Hydropower 5000	BEARING	-
DRILLER	Terratest (DC)	HOLE DIAMETER	100mm ()
		GROUND LEVEL	RL 6.70m
		LOCATION	494720 E 6718301 N
		ELEVATION DATUM	Australian Height Datum
		COORDINATE SYSTEM	AMG84 Zone 56

DRILLING	STRATA				MATERIAL DESCRIPTION	CONDITION										OBSERVATION
SAMPLE, TEST, BIT, SUPPORT, ETC.	R.L.	DEPTH	GROUP SYMBOL	LEGEND	SOIL TYPE Plasticity / Grain Size, Colour, Minor Components	WATER / MOISTURE	CONSISTENCY									SOIL ORIGIN, STRUCTURE, ETC.
							COHESIVE					NON COHESIVE				
	mAHD	m					VS	S	F	ST	VST	H	VL	L	MD	D	VD	
			GM		Silty Sandy GRAVEL, (GM) fine to coarse grained, sub-rounded to sub-angular, well graded, grey, sand is fine to medium grained. *(continued)*													**Alluvium**
D N=100** 30/90s	-14.80	21.50	GW		Sandy GRAVEL (GW) fine to coarse grained, sub-angular to angular, well graded, grey, brown, white, sand is medium to coarse grained, sub-rounded, brown, white, with silt.													**Alluvium**
D N=64* 29;30/140	-16.80	23.50	GP		GRAVEL (GP) fine to medium grained, angular, poorly graded, dark grey, brown, white, with sand, fine to medium grained, brown, white, black.													**Alluvium**
N=78** 30/115s					.... 25.00m large amount of water loss into gravels.													
					.... 26.60m reduction in cutting return.													
	-20.80	27.50			*Borehole completed at 27.5m depth*													

NOTES Hole Diameter 100mm to 5.50m depth. (Auger, then 100mm to 27.5m depth, washbore)
End of borehole at 27.50m as agreed with the RMS

JOB 220422

ARUP

BOREHOLE RECORD

BH106
HOLE

SHEET 1
OF 4

CLIENT	RMS	LOGGED BY	JV
PROJECT	Summerland Way Additional Clarence River Crossing	CHECKED BY	AB
		DRILLED DATE	21-Mar-12 to 23-Mar-12
CONTRACTOR	Terratest Pty Ltd	ANGLE	Vertical
DRILL MODEL	Hydropower 5000	BEARING	-
DRILLER	Terratest (DC)	HOLE DIAMETER	100mm ()
		GROUND LEVEL	RL 4.79m
		LOCATION	495904 E 6716405 N
		ELEVATION DATUM	Australian Height Datum
		COORDINATE SYSTEM	AMG84 Zone 56

DRILLING		STRATA				MATERIAL DESCRIPTION	CONDITION		OBSERVATION
SAMPLE, TEST, BIT, SUPPORT, ETC.		R.L.	DEPTH	GROUP SYMBOL	LEGEND	SOIL TYPE Plasticity / Grain Size, Colour, Minor Components	WATER / MOISTURE	CONSISTENCY COHESIVE: VS S F ST VST H NON COHESIVE: VL L MD D VD	SOIL ORIGIN, STRUCTURE, ETC.
		mAHD	m						
				ML		Sandy Clayey SILT, (ML) medium plasticity, dark brown, trace gravel, trace organics.	D		**Alluvium**
						.... 0.60m increasing clay proportion, decreasing sand proportion.			
		3.79	1 1.00	CH		Silty CLAY, (CH) medium plasticity, brown-dark brown, trace sand, fine grained.	D-M		**Alluvium**
D	N=11 3;5,6		2						
			3			.... 3.50m without sand.			
D	N=8 4;4,4		4			.... 4.50m becoming pale grey mottled orange.			
			5				M		
						.... 5.50m - 6.50m becoming dark grey, organic odour.	M		
D	N=4 2;2,2		6			.... 6.50m trace yellow-brown clay pockets.			
			7						
			8						
D	N=9 4;4,5		9				M		

NOTES Hole Diameter 100mm to 8.50m depth. (Auger, then 100mm to 25.6m depth, washbore, then 52mm to 28.8m depth, NMLC)

JOB 220422

ARUP

BOREHOLE RECORD

BH106 HOLE

SHEET 2 OF 4

CLIENT	RMS	LOGGED BY	JV
PROJECT	Summerland Way Additional Clarence River Crossing	CHECKED BY	AB
		DRILLED DATE	21-Mar-12 to 23-Mar-12
CONTRACTOR	Terratest Pty Ltd	ANGLE	Vertical
DRILL MODEL	Hydropower 5000	BEARING	-
DRILLER	Terratest (DC)	HOLE DIAMETER	100mm ()
		GROUND LEVEL	RL 4.79m
		LOCATION	495904 E 6716405 N
		ELEVATION DATUM	Australian Height Datum
		COORDINATE SYSTEM	AMG84 Zone 56

DRILLING		STRATA				MATERIAL DESCRIPTION	CONDITION		OBSERVATION
SAMPLE, TEST, BIT, SUPPORT, ETC.		R.L. mAHD	DEPTH m	GROUP SYMBOL	LEGEND	SOIL TYPE Plasticity / Grain Size, Colour, Minor Components	WATER / MOISTURE	CONSISTENCY: COHESIVE VS S F ST VST H; NON COHESIVE VL L MD D VD	SOIL ORIGIN, STRUCTURE, ETC.
				CH		Silty CLAY, (CH) medium plasticity, brown-dark brown, trace sand, fine grained. *(continued)*			**Alluvium**
D	N=3 1;1,2	-5.71	10.50	SC		Silty SAND, (SC) fine grained, poorly graded, sub-rounded to angular, pale brown-yellow, with clay, non-plastic.	M		**Alluvium**
			11			.... 11.50m increasing clay component.			
			12						
D	N=8 1;4,4						M		
			13						
			14						
D	N=11 2;4,7					.... 14.60m - 14.70m Sand CLAY, medium to high plasticity, dark brown mottled pale grey, sand, fine grained.	M M		
			15						
			16						
D	N=14 0;7,7					.... 16.50m - 16.60m trace organics.			
		-12.01	16.80	SP		.... 16.70m - 16.80m Sand CLAY, medium to high plasticity, dark brown mottled pale grey, sand, fine grained.	M M		**Alluvium**
			17			Silty SAND, (SP) fine grained, poorly graded, brown-yellow, trace clay, trace organics.			
						.... 17.50m trace mica grains.			
			18						
D	N=19 7;8,11	-13.71	18.50	SP		SAND, (SP) fine grained, poorly graded, brown.			**Alluvium**
			19			.... 19.60m trace gravel.			

NOTES Hole Diameter 100mm to 8.50m depth. (Auger, then 100mm to 25.6m depth, washbore, then 52mm to 28.8m depth, NMLC)

JOB 220422

ARUP

BOREHOLE RECORD

BH106
HOLE

SHEET 3
OF 4

CLIENT	RMS	LOGGED BY	JV
PROJECT	Summerland Way Additional Clarence River Crossing	CHECKED BY	AB
		DRILLED DATE	21-Mar-12 to 23-Mar-12
CONTRACTOR	Terratest Pty Ltd	ANGLE	Vertical
DRILL MODEL	Hydropower 5000	BEARING	-
DRILLER	Terratest (DC)	HOLE DIAMETER	100mm ()
		GROUND LEVEL	RL 4.79m
		LOCATION	495904 E 6716405 N
		ELEVATION DATUM	Australian Height Datum
		COORDINATE SYSTEM	AMG84 Zone 56

DRILLING		STRATA				MATERIAL DESCRIPTION	CONDITION										OBSERVATION
SAMPLE, TEST, BIT, SUPPORT, ETC.		R.L.	DEPTH	GROUP SYMBOL	LEGEND	SOIL TYPE Plasticity / Grain Size, Colour, Minor Components	WATER / MOISTURE	CONSISTENCY									SOIL ORIGIN, STRUCTURE, ETC.
								COHESIVE					NON COHESIVE				
								VS	S	F	ST	VST	H	VL	L	MD	D	VD	
		mAHD	m														
		-15.21	20.00	GW		Sandy GRAVEL, (GW) fine to coarse grained, sub-angular to angular, black, white, sand is fine to coarse grained, sub-rounded to angular, brown, black, white, with clay, brown.	M-W											**Alluvium**
D	N=55 29;25,30																	
			21			.... 21.50m decreasing clay proportion.												
			22															
D	N=90** 30/100s	-17.71	22.50	GW		GRAVEL, (GW) fine to medium grained, sub-angular to angular, black, brown, white, red, with sand, medium to coarse grained, sub-rounded to angular, black, brown.	M-W											**Alluvium**
			23															
D	N=50 27;24,26					.... 23.70m becoming fine to coarse grained, trace clay.												
			24															
			25															
D	N=113** 30/80s	-20.71	25.50			CLAYSTONE fine grained, thinly laminated at 5 degrees, grey.												**Bedrock**
						Borehole continued as a Cored Drillhole												
			26															
			27															
			28															
			29															

NOTES Hole Diameter 100mm to 8.50m depth. (Auger, then 100mm to 25.6m depth, washbore, then 52mm to 28.8m depth, NMLC)

JOB 220422

ARUP

CORED BOREHOLE RECORD

BH106 HOLE

SHEET 4 OF 4

CLIENT	RMS
PROJECT	Summerland Way Additional Clarence River Crossing
CONTRACTOR	Terratest Pty Ltd
DRILL MODEL	Hydropower 5000
DRILLER	Terratest (DC)
ANGLE	Vertical
BEARING	-
HOLE DIAMETER	100mm ()
LOGGED BY	JV
CHECKED BY	AB
DRILLED DATE	21-Mar-12 to 23-Mar-12
GROUND LEVEL	RL 4.79m
LOCATION	495904 E 6716405 N
ELEVATION DATUM	Australian Height Datum
COORDINATE SYSTEM	AMG84 Zone 56

DRILLING | STRATA | MATERIAL DESCRIPTION | DISCONTINUITIES

TCR % (Dril rate)	SCR / (RQD)	FLUSH RETURN % (TYPE)	SAMPLES ($CaCO_3$, SPT, UCS, etc)	R.L. mAHD	DEPTH m	GRAPHIC LOG	ROCK TYPE Grain Size, Texture/Fabric, Colour, Minor Components	WEATHERING	ESTIMATED ROCK STRENGTH EL VL L M H VH EH	Is 50 (MPa)	FREQUENCY (per m) 30 10 3 1	SPECIFIC TYPE	SPECIFIC ANGLE	SPECIFIC THICKNESS (mm)	GENERAL DESCRIPTION Planarity, Roughness, Coating, Infill
					21										
					22										
					23										
					24										
					25										
				-20.81	25.60		Continued from Borehole								
				-20.96	25.75		CORE LOSS.								
70()	70/(40)			-21.31	26 26.10		SILTSTONE, fine grained, poorly developed bedding, grey.	FR/SW				Jo Jo	80 15	0 0	ST Ro3 C PL Ro2 C
				-21.41	26.20		CORE LOSS.								
			C				INTERBEDDED SILTSTONE/SANDSTONE, sandstone, fine grained, pale grey, siltstone, fine grained, grey, thinly laminated.	FR		D0.56 A0.85		Jo Jo Jo Jo Jo	5 60 20 0 5	5 2 0 2 0	PL Ro4 G PL Ro2 c, G PL Ro2 c, G PL Ro4 c, G PL Ro1 C
96()	93/(93)		C		27					D0.32 A0.65		Jo Jo Jo Jo Jo Jo Jo Jo Jo Jo Cr Jo	90 0 0 0 5 90 30 5 5 0	0 0 2 0 0 0 0 0 0 70 0	PL Ro3 G PL Ro2 CL PL Ro2 Cl PL Ro4 CL PL Ro3 Pyrite PL Ro3 CL PL Ro3 Pyrite PL Ro2 CL PL Ro3 G PL Ro3 G IR Ro5 G PL Ro2 G
					28										
			C	-24.01	28.80		End of Borehole at 28.80m			D0.40 A0.48					
					29										

NOTES

Hole Diameter 100mm to 8.50m depth. (Auger, then 100mm to 25.6m depth, washbore, then 52mm to 28.8m depth, NMLC)

See explanatory notes for details of abbreviations and basis of descriptions

JOB 220422

ARUP	Core Photographs	BH106

25.60m to 28.80m

Appendix C

Laboratory Tests

TEST CERTIFICATE

SGS Australia Pty Ltd
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Alexandria NSW 2015
Australia

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POINT LOAD STRENGTH INDEX

CLIENT: **Arup**
PO Box 76 Millers Point NSW 2000

PROJECT: **Summerland Way, Grafton (220422)**

LAB. NO.	SAMPLE SOURCE	LITHOLOGY	PLATEN SEPARATION DIAM (mm)	PLATEN SEPARATION HEIGHT (mm)	TEST ORIENTATION	POINT LOAD STRENGTH Is (MPa)	POINT LOAD STRENGTH $Is_{(50)}$ (MPa)	Type OF FAILURE
71494	BH102 25.41-25.53m	Siltstone	50.3	28.5	Diametral Axial	0.41 0.53	0.41 0.49	FB FOB
71495	BH103 24.88-25.00m	Siltstone / Sandstone	51.5	28.9	Diametral Axial	0.51 0.96	0.51 0.90	FB FOB
71496	BH103 26.70-26.87m	Siltstone	51.6	31.7	Diametral Axial	0.83 2.09	0.84 2.01	FB FOB
71497	BH106 26.57-26.60m	Siltstone	51.2	34.5	Diametral Axial	0.55 0.87	0.56 0.85	FB FOB
71498	BH106 28.68-28.80m	Siltstone	51.6	30.6	Diametral Axial	0.40 0.51	0.40 0.48	FB FOB
71499	BH106 27.44-27.51m	Siltstone	51.6	30.8	Diametral Axial	0.32 0.68	0.32 0.65	FB FOB

NOTES TO TESTING

Testing Device	ELE Point Load Tester
Sample History	Unsoaked
Sampled By:	Client
Job Number:	007-272
Date Tested:	28.03.12
Test Method:	AS 4133.4.1 2007

Failure Type

FOB	Fracture through fabric of specimen oblique to bedding not influenced by weak planes
FB	Fracture along bedding
FIP	Fracture influenced by pre-existing plane, microfracture, vein, chemical alteration
CPF	Chip or partial fracture

Approved Signatory: Chris Lloyd **Date:** 28.03.12

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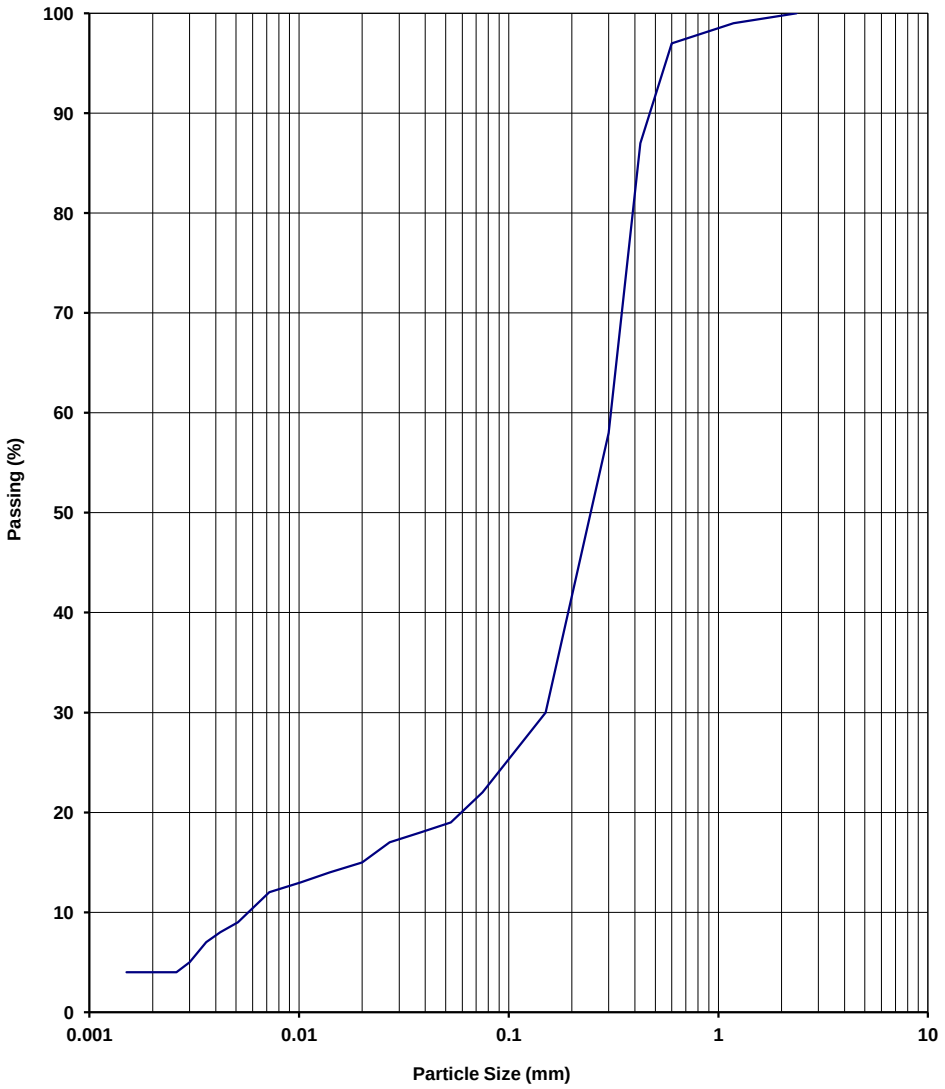
PARTICLE SIZE DISTRIBUTION TEST REPORT

Test Method: AS 1289 3.6.3, 3.5.1

Client	Arup Geotechnics Pty Ltd	**Report No.**	12031187-G
Project	Summerland Way, Grafton GI	**Test Date**	11-13/04/2012
		Report Date	4/5/2012
Client ID	BH101	**Depth (m)**	2.50-2.95

Sieve Size (mm)	Passing %
150.0	
75.0	
53.0	
37.5	
26.5	
19.0	
9.5	
4.75	
2.36	100
1.18	99
0.600	97
0.425	87
0.300	58
0.150	30
0.075	22
0.075	22
0.053	19
0.038	18
0.027	17
0.02	15
0.014	14
0.0102	13
0.0072	12
0.0051	9
0.0042	8
0.0036	7
0.003	5
0.0026	4
0.0015	4



NOTES/REMARKS: -

Moisture Content 25.6% -2.36mm Soil Particle Density(t/m^3) 2.60

Sample/s supplied by the client

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Authorised Signatory
J. Russell

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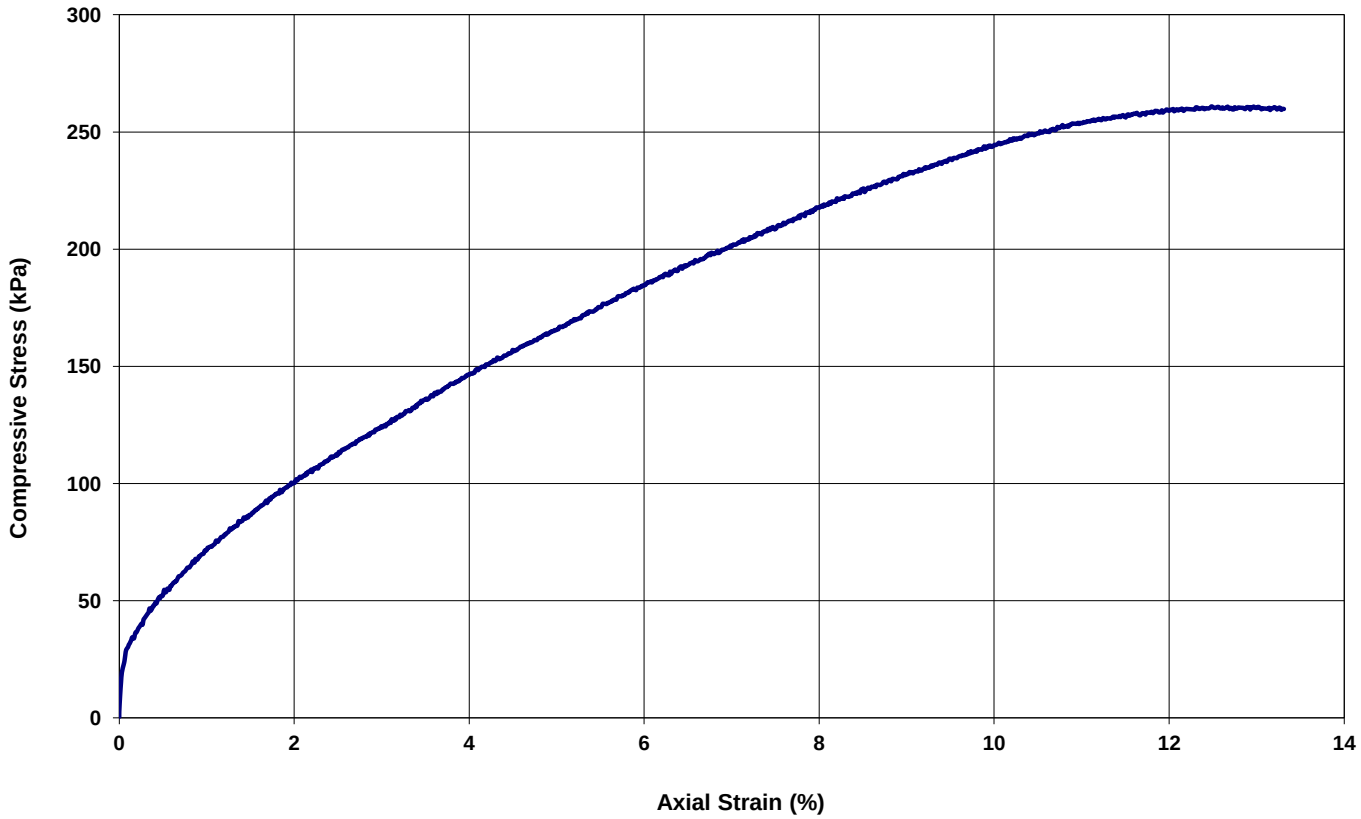
COMPRESSIVE STRENGTH OF A SOIL TEST REPORT

Test Method: AS 1289.6.4.1 - 1998

Client	Arup Geotechnics Pty Ltd	**Sample No.**	12031188-QU
Project	Summerland Way, Grafton GI	**Test Date**	12/04/2012
		Report Date	20/04/2012
Client ID	BH104	**Depth (m)**	1.00-1.30
Description	Silty Sandy Clay - Mottled Brown/Orange/Grey		



Average Sample Diameter (mm)	48.6	Maximum Principal Stress (kPa)	261
Average Sample Height (mm)	101.2	Strain at Failure (%)	13.3
Height to Diameter Ratio	2.1	Average rate of Strain (%/min)	1.5
Wet Density (t/m^3)	1.83	Moisture Content (%)	21.6
Dry Density (t/m^3)	1.50		
Mode of Failure of Specimen	Shear		

Notes/Remarks: -

Sample/s supplied by the client

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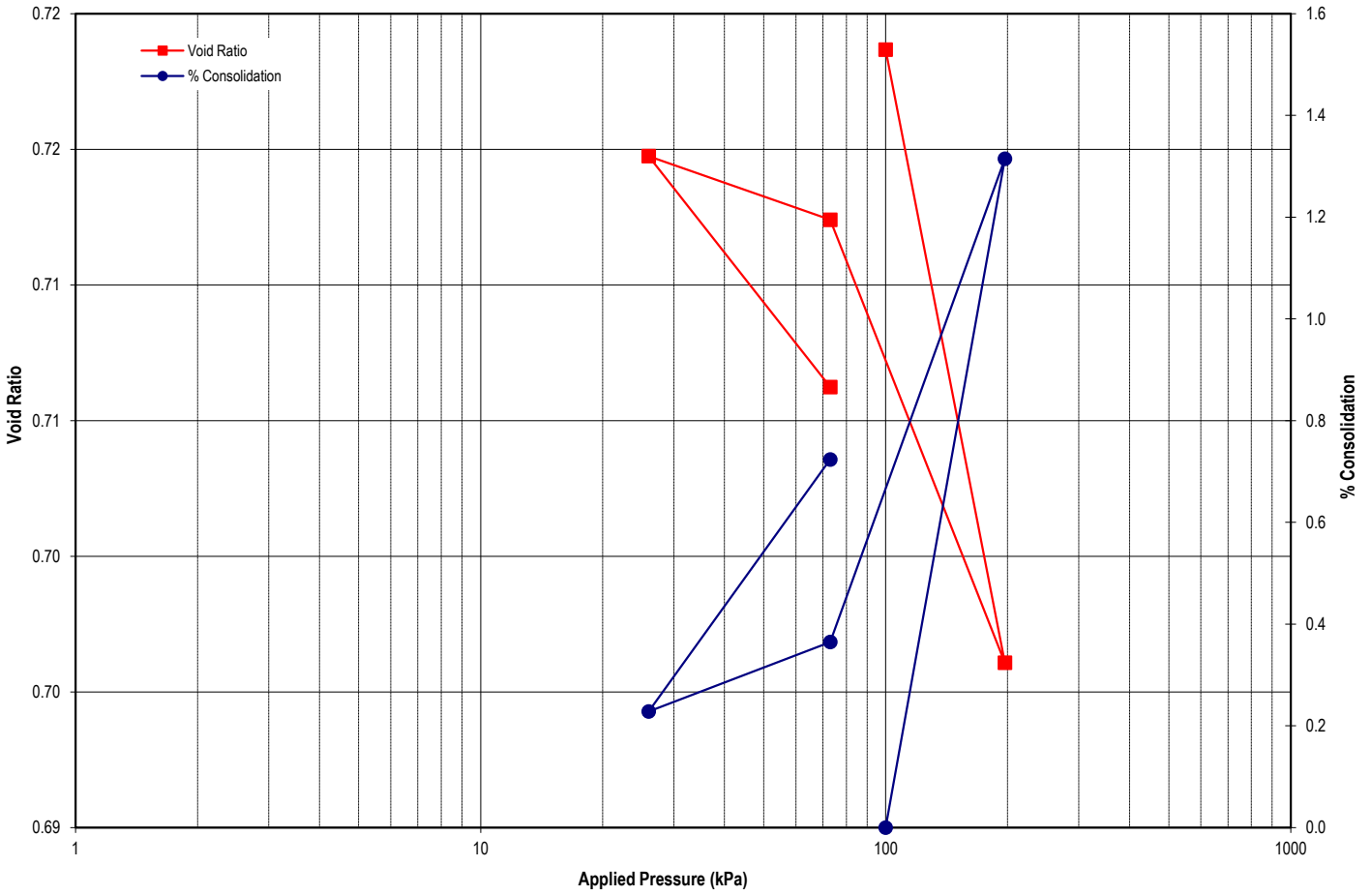
OEDOMETER TEST REPORT

Test Method: AS1289.6.6.1, 3.5.1

Client:	Arup Geotechnics Pty Ltd	**Report No.:**	12031188-OED
Project:	Summerland Way, Grafton GI	**Test Date:**	12/04/2012
		Report Date:	24/04/2012
Client Id.:	BH104	**Depth (m):**	1.00-1.30

Description: SANDY CLAY - mottled yellow red brown grey



Wet Density (t/m^3):	1.94	Initial Moisture (%):	25.3	Test Condition:	Inundated on load
Particle Density (t/m^3):	2.62	Initial Voids Ratio:	0.691	Initial Degree of Saturation (%):	96.7
Undisturbed sample supplied by the client		Remarks:	Tested as Received		Page 1 of 2

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OEDOMETER TEST REPORT

Test Method: AS1289.6.6.1, 3.5.1

Client:	Arup Geotechnics Pty Ltd	**Report No.:**	12031188-OED
Project:	Summerland Way, Grafton GI	**Test Date:**	12/04/2012
		Report Date:	24/04/2012
Client Id.:	BH104	**Depth (m):**	1.00-1.30
Description:	SANDY CLAY - mottled yellow red brown grey		

TEST RESULTS

Stage	Load (kPa)	Cc	Cv (m^2/yr) t_{50}	Cv (m^2/yr) t_{90}	Mv ($kPa^{-1}x10^{-3}$)	C_a x 10^{-3}	% Consolidation
1	100-197	0.077	2.62	211.29	0.136	1.00	1.3
2	197-73	0.038	2.65	2.08	0.078	0.55	0.4
3	73-26	0.005	0.95	70.33	0.029	1.78	0.2
4	26-73	0.019	3.53	29.11	0.106	0.29	0.7

Remarks: Tested as Received

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ATTERBERG LIMITS TEST REPORT

Test Method: AS 1289 2.1.1, 3.1.1, 3.1.2, 3.2.1, 3.3.1, 3.4.1

Client	Arup Geotechnics Pty Ltd	**Report No.**	12031189-AL
Project	Summerland Way, Grafton GI	**Test Date**	19/04/2012
		Report Date	20/04/2012

Sample No.	12031189	12031190	12031194	12031195	-	-
Client ID	BH103	BH102	BH106	BH106	-	-
Depth (m)	0.50-0.95	4.50-4.95	2.50-2.95	12.50-12.95	-	-
Liquid Limit (%)	39	30	39	24	-	-
Plastic Limit (%)	19	24	17	21	-	-
Plasticity Index (%)	20	6	22	3	-	-
Linear Shrinkage (%)	6.5+	2.5*	9.5	0.5	-	-
Moisture Content (%)	29.1	47.4	24.5	32.2	-	-

Sample No.	-	-	-	-	-	-
Client ID	-	-	-	-	-	-
Depth (m)	-	-	-	-	-	-
Liquid Limit (%)	-	-	-	-	-	-
Plastic Limit (%)	-	-	-	-	-	-
Plasticity Index (%)	-	-	-	-	-	-
Linear Shrinkage (%)	-	-	-	-	-	-
Moisture Content (%)	-	-	-	-	-	-

NOTES/REMARKS: The samples were tested oven dried, dry sieved and in a 125-250mm mould.

Sample/s supplied by the client * Crumbling occurred + Curling occurred

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PARTICLE SIZE DISTRIBUTION TEST REPORT

Test Method: AS 1289 3.6.1, 2.1.1

Client	Arup Geotechnics Pty Ltd	**Report No.**	12031190-G
Project	Summerland Way, Grafton GI	**Test Date**	19/04/2012
		Report Date	20/04/2012

Sample No.	12031190	-	-	-	-	-	-
Client ID	BH102	-	-	-	-	-	-
Depth (m)	4.50-4.95	-	-	-	-	-	-
Moisture (%)	47.4	-	-	-	-	-	-
AS SIEVE SIZE (mm)	**PERCENT PASSING**						
150		-	-	-	-	-	-
75		-	-	-	-	-	-
53		-	-	-	-	-	-
37.5		-	-	-	-	-	-
26.5		-	-	-	-	-	-
19		-	-	-	-	-	-
9.5		-	-	-	-	-	-
4.75		-	-	-	-	-	-
2.36		-	-	-	-	-	-
1.18	100	-	-	-	-	-	-
0.600	98	-	-	-	-	-	-
0.425	97	-	-	-	-	-	-
0.300	91	-	-	-	-	-	-
0.150	68	-	-	-	-	-	-
0.075	53	-	-	-	-	-	-

NOTES/REMARKS:

Sample/s supplied by the client

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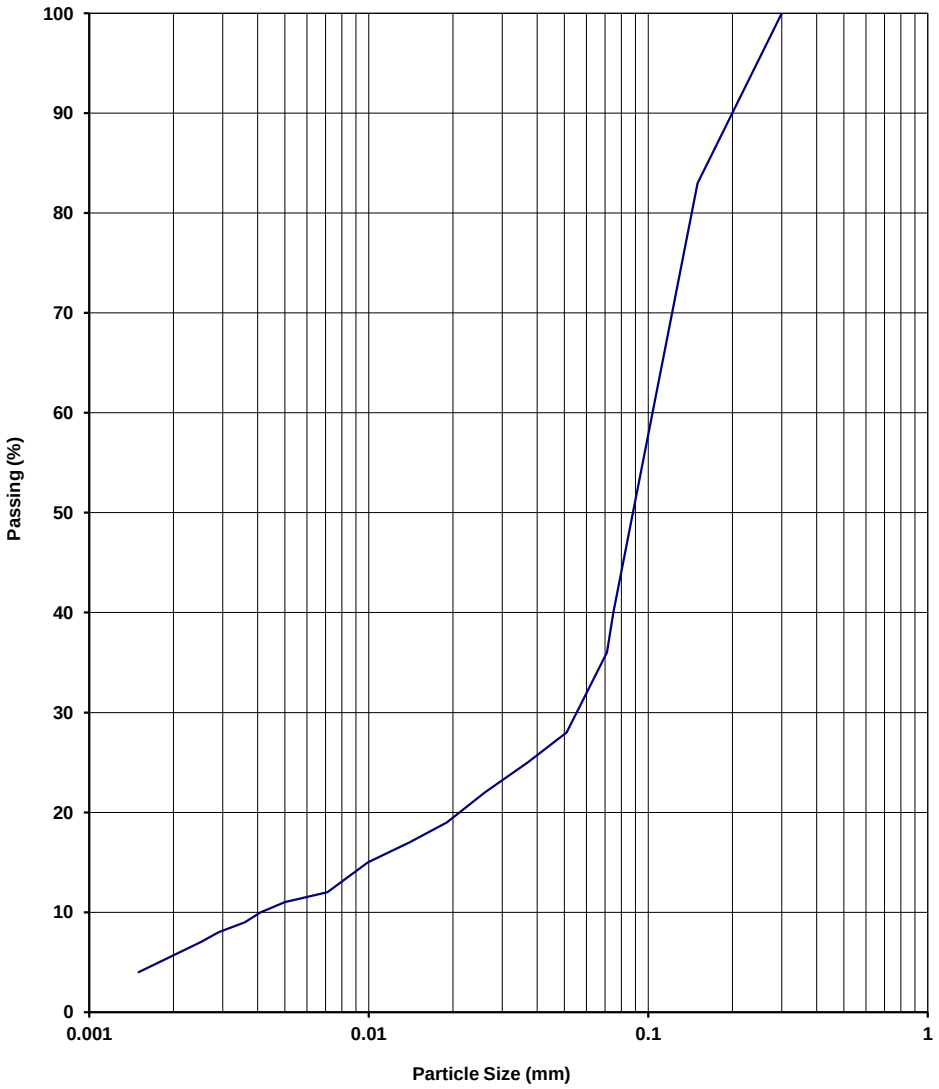
PARTICLE SIZE DISTRIBUTION TEST REPORT

Test Method: AS 1289 3.6.3, 3.5.1

Client	Arup Geotechnics Pty Ltd	**Report No.**	12031191-G
Project	Summerland Way, Grafton GI	**Test Date**	11-13/04/2012
		Report Date	17/4/2012
Client ID	BH105	**Depth (m)**	3.50-3.95

Sieve Size (mm)	Passing %
150.0	
75.0	
53.0	
37.5	
26.5	
19.0	
9.5	
4.75	
2.36	
1.18	
0.600	
0.425	
0.300	100
0.150	83
0.075	40
0.071	36
0.051	28
0.037	25
0.026	22
0.019	19
0.014	17
0.0099	15
0.0071	12
0.005	11
0.0041	10
0.0036	9
0.0029	8
0.0025	7
0.0015	4



NOTES/REMARKS: -

Moisture Content 16.2% -2.36mm Soil Particle Density(t/m^3) 2.66

Sample/s supplied by the client

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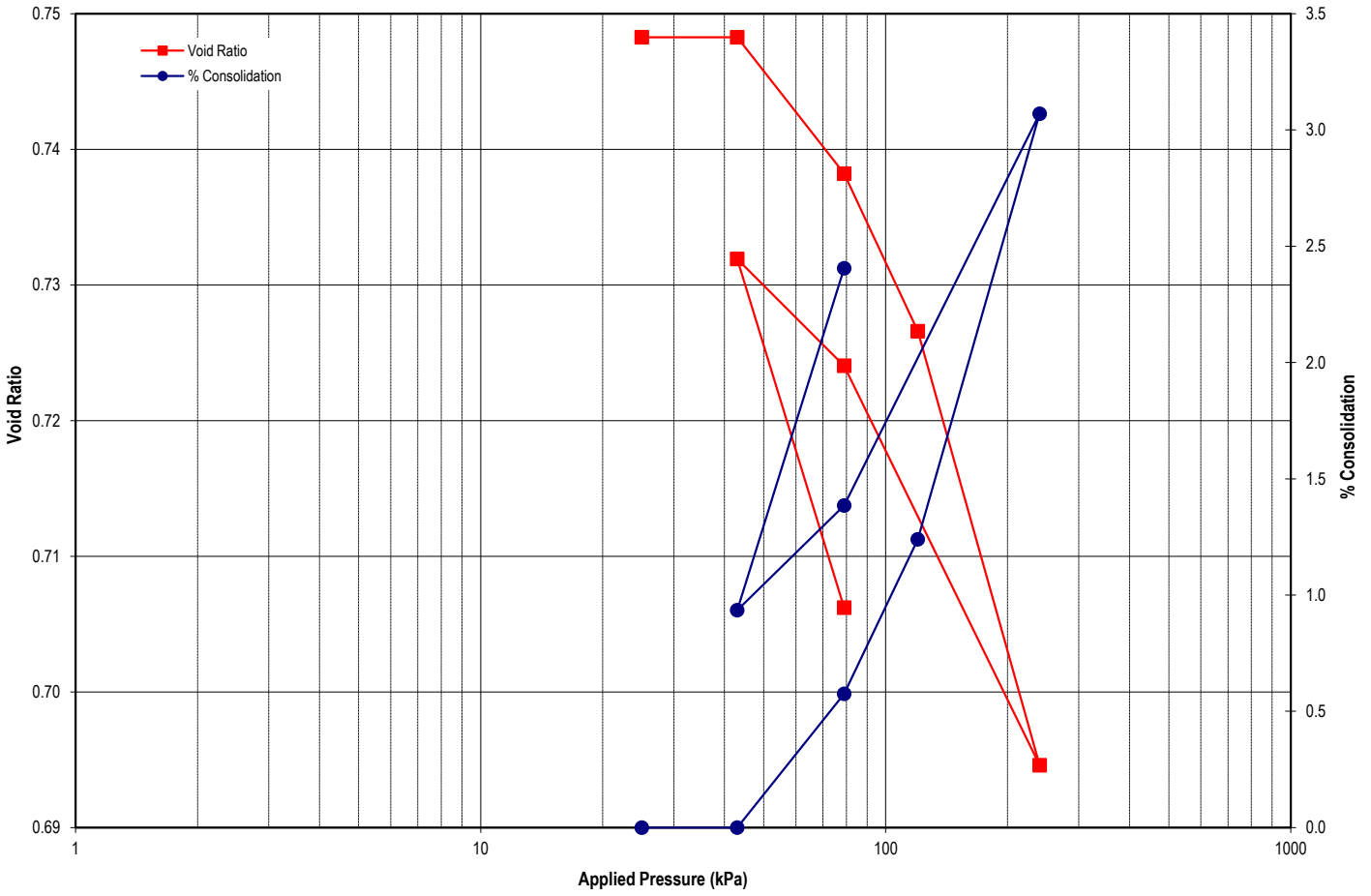
OEDOMETER TEST REPORT

Test Method: AS1289.6.6.1, 3.5.1

Client:	Arup Geotechnics Pty Ltd	**Report No.:**	12031192-OED
Project:	Summerland Way, Grafton GI	**Test Date:**	13/04/2012
		Report Date:	24/04/2012
Client Id.:	BH105	**Depth (m):**	6.00-6.45

Description: SILTY CLAY - mottled yellow red brown grey



Wet Density (t/m^3):	1.90	Initial Moisture (%):	28.1	Test Condition:	Inundated on load
Particle Density (t/m^3):	2.57	Initial Voids Ratio:	0.731	Initial Degree of Saturation (%):	99.3
Undisturbed sample supplied by the client		Remarks:	Tested as Received		Page 1 of 2

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OEDOMETER TEST REPORT

Test Method: AS1289.6.6.1, 3.5.1

Client:	Arup Geotechnics Pty Ltd	**Report No.:**	12031192-OED
Project:	Summerland Way, Grafton GI	**Test Date:**	13/04/2012
		Report Date:	24/04/2012
Client Id.:	BH105	**Depth (m):**	6.00-6.45
Description:	SILTY CLAY - mottled yellow red brown grey		

TEST RESULTS

Stage	Load (kPa)	Cc	Cv (m^2/yr) t_{50}	Cv (m^2/yr) t_{90}	Mv ($kPa^{-1}x10^{-3}$)	C_a x 10^{-3}	% Consolidation
1	25-43	0.000	50.44	47.91	0.000	0.00	0.0
2	43-79	0.038	5.06	175.78	0.160	1.21	0.6
3	79-120	0.064	3.02	303.36	0.163	1.32	1.2
4	120-240	0.106	5.27	84.52	0.154	1.50	3.1
5	240-79	0.061	5.22	15.12	0.108	0.40	1.4
6	79-43	0.030	1.15	166.33	0.127	0.77	0.9
7	43-79	0.097	6.21	258.24	0.412	0.23	2.4

Remarks: Tested as Received

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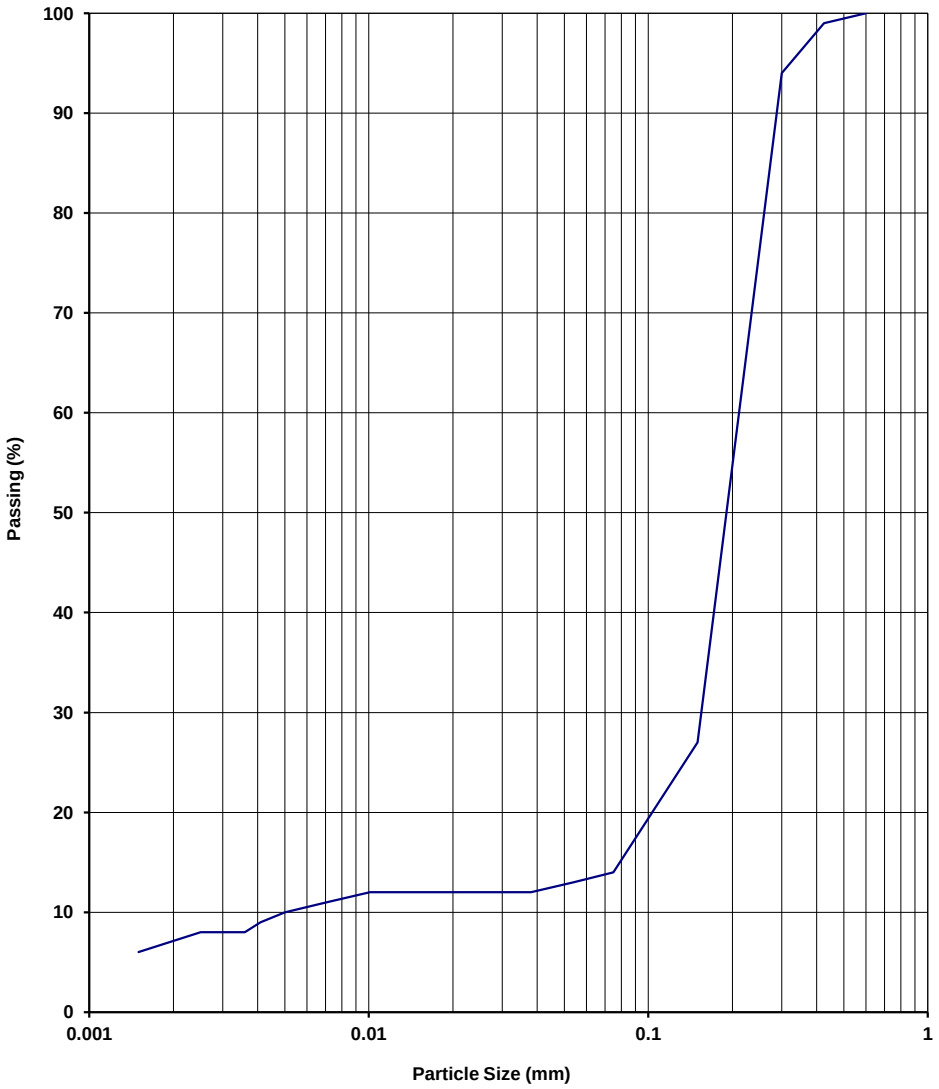
PARTICLE SIZE DISTRIBUTION TEST REPORT

Test Method: AS 1289 3.6.3, 3.5.1

Client	Arup Geotechnics Pty Ltd	**Report No.**	12031193-G
Project	Summerland Way, Grafton GI	**Test Date**	11-12/04/2012
		Report Date	17/4/2012
Client ID	BH105	**Depth (m)**	11.50-11.95

Sieve Size (mm)	Passing %
150.0	
75.0	
53.0	
37.5	
26.5	
19.0	
9.5	
4.75	
2.36	
1.18	
0.600	100
0.425	99
0.300	94
0.150	27
0.075	14
0.075	14
0.054	13
0.038	12
0.027	12
0.02	12
0.014	12
0.0101	12
0.0071	11
0.005	10
0.0041	9
0.0036	8
0.0029	8
0.0025	8
0.0015	6



NOTES/REMARKS: -

Moisture Content 25.6% -2.36mm Soil Particle Density(t/m^3) 2.67

Sample/s supplied by the client

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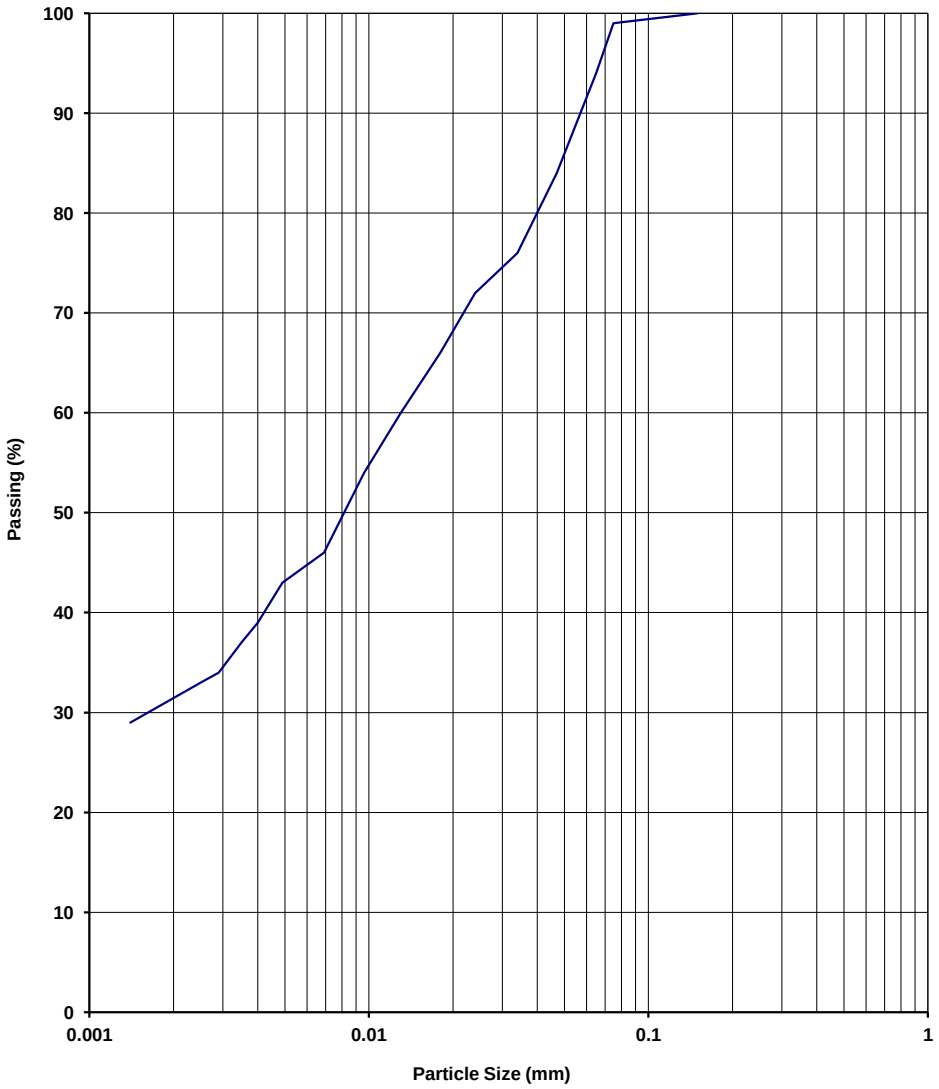
PARTICLE SIZE DISTRIBUTION TEST REPORT

Test Method: AS 1289 3.6.3, 3.5.1

Client	Arup Geotechnics Pty Ltd	**Report No.**	12031194-G
Project	Summerland Way, Grafton GI	**Test Date**	12-19/04/2012
		Report Date	23/4/2012
Client ID	BH106	**Depth (m)**	2.50-2.95

Sieve Size (mm)	Passing %
150.0	
75.0	
53.0	
37.5	
26.5	
19.0	
9.5	
4.75	
2.36	
1.18	
0.600	
0.425	
0.300	
0.150	100
0.075	99
0.065	94
0.047	84
0.034	76
0.024	72
0.018	66
0.013	60
0.0096	54
0.0069	46
0.0049	43
0.004	39
0.0035	37
0.0029	34
0.0025	33
0.0014	29



NOTES/REMARKS: -

Moisture Content 24.5% -2.36mm Soil Particle Density(t/m^3) 2.56

Sample/s supplied by the client

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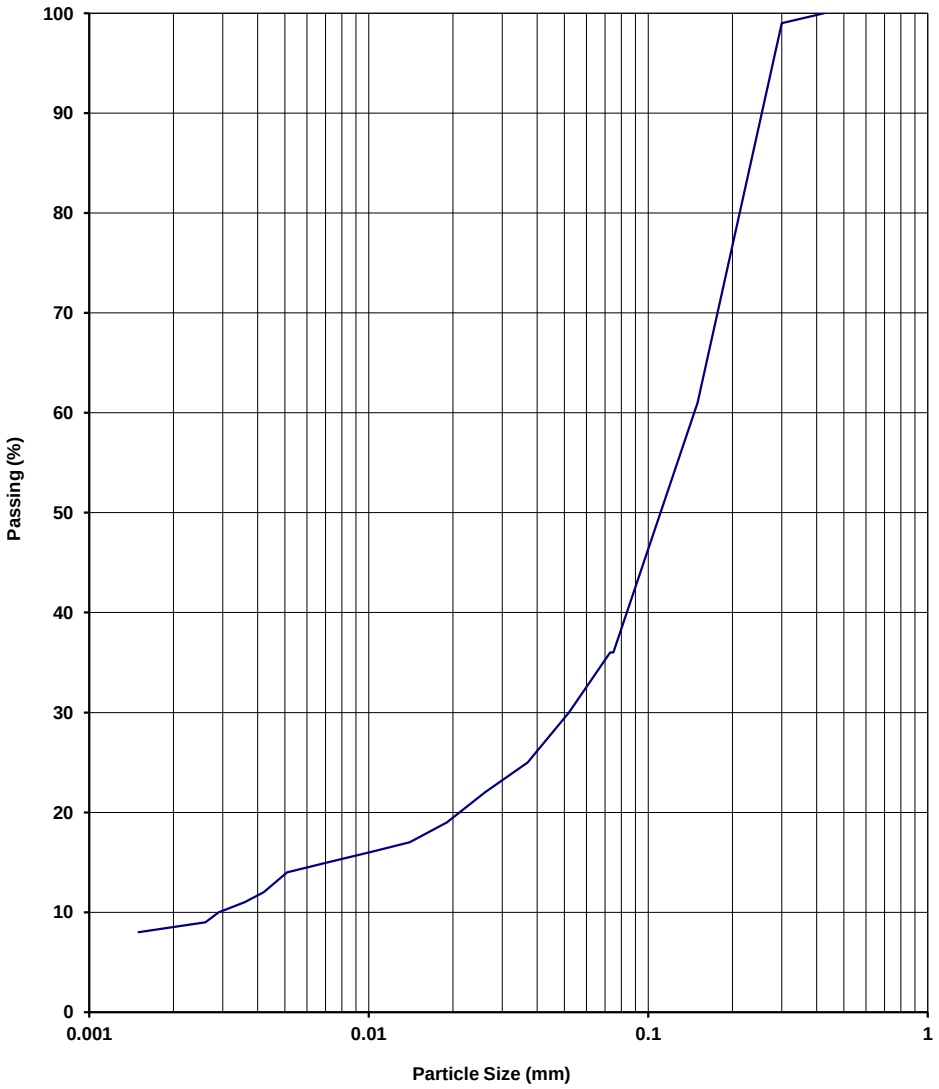
PARTICLE SIZE DISTRIBUTION TEST REPORT

Test Method: AS 1289 3.6.3, 3.5.1

Client	Arup Geotechnics Pty Ltd	**Report No.**	12031195-G
Project	Summerland Way, Grafton GI	**Test Date**	13-19/04/2012
		Report Date	23/4/2012
Client ID	BH106	**Depth (m)**	12.50-12.95

Sieve Size (mm)	Passing %
150.0	
75.0	
53.0	
37.5	
26.5	
19.0	
9.5	
4.75	
2.36	
1.18	
0.600	
0.425	100
0.300	99
0.150	61
0.075	36
0.073	36
0.052	30
0.037	25
0.026	22
0.019	19
0.014	17
0.0101	16
0.0071	15
0.0051	14
0.0042	12
0.0036	11
0.0029	10
0.0026	9
0.0015	8



NOTES/REMARKS: -

Moisture Content 32.2% -2.36mm Soil Particle Density(t/m^3) 2.62

Sample/s supplied by the client

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ATTERBERG LIMITS TEST REPORT

Test Method: AS 1289 2.1.1, 3.1.1, 3.1.2, 3.2.1, 3.3.1, 3.4.1

Client	Arup Geotechnics Pty Ltd	**Report No.**	12031188-AL
Project	Summerland Way, Grafton GI	**Test Date**	19-30/4/2012
		Report Date	11/05/2012

Sample No.	12031188	12031189	12031190	12031192	12031194	12031195
Client ID	BH104	BH103	BH102	BH105	BH106	BH106
Depth (m)	1.00-1.30	0.50-0.95	4.50-4.95	6.00-6.45	2.50-2.95	12.50-12.95
Liquid Limit (%)	54	39	30	65	39	24
Plastic Limit (%)	28	19	24	29	17	21
Plasticity Index (%)	26	20	6	36	22	3
Linear Shrinkage (%)	13.0+	6.5	2.5	16.5	9.5	0.5
Moisture Content (%)	25.3	29.1	47.4	28.1	24.5	32.2

Sample No.	-	-	-	-	-	-
Client ID	-	-	-	-	-	-
Depth (m)	-	-	-	-	-	-
Liquid Limit (%)	-	-	-	-	-	-
Plastic Limit (%)	-	-	-	-	-	-
Plasticity Index (%)	-	-	-	-	-	-
Linear Shrinkage (%)	-	-	-	-	-	-
Moisture Content (%)	-	-	-	-	-	-

NOTES/REMARKS: The samples were tested oven dried, dry sieved and in a 125-250mm mould.

Sample/s supplied by the client * Crumbling occurred + Curling occurred

This document is issued in accordance with NATA's accreditation requirements. Accredited for compliance with ISO/IES 17025. The results of the tests, calibrations, and/or measurements included in this document are traceable to Australian/National Standards.

Authorised Signatory
J. Russell

NATA
ACCREDITED FOR TECHNICAL COMPETENCE

Laboratory No. 9926

Appendix D

Gravity Field Survey

ET403.01

Report
prepared for

ARUP

On behalf of

Roads and Maritime Services of NSW

GRAFTON SUMMERLAND WAY
GRAVITY SURVEY

April 2012 ETS Job No. ET403

Report Prepared By:
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1.0 INTRODUCTION

Earth Technology Solutions Pty Ltd (ETS) was commissioned by ARUP on behalf of the Roads & Maritime Services of NSW (RMS) to carry out a gravity survey adjacent to the Clarence River at Grafton for the proposed Summerland Way road project.

The gravity profiling was undertaken as part of a preliminary level study to provide interpreted bedrock profiles in the region of two potential road alignments to aid the assessment of foundation conditions for a proposed bridge and elevated roadway.

Borehole results from a number of previous investigations in the area had indicated a palaeochannel in the region of the current river however access to land for a drilling investigation was limited.

The gravity method was recommended as the most effective non-invasive method to delineate the general rock profile and provide information on the bedrock depths given the site conditions.

The fieldwork was carried out from 13th and 14th March 2012 in accordance with standard practice as detailed below.

2.0 SCOPE OF WORK

Four (4) individual gravity lines were completed, totalling approximately 3500m in length. The locations of the gravity lines are shown on the general site plan Figure 1. This site plan has been generated from an aerial photo plan provided by ARUP showing proposed road alignments, previous borehole locations and the proposed location of the gravity stations.

Line 1 extended from the Pacific Highway along Eggins and Moana Lanes. Line 2 was positioned along the western and northern extension of Eggins Lane. Line 3 was positioned along a public access laneway further to the south and the southern Line 4 was positioned along McClaers Lane.

3.0 EQUIPMENT

A Lacoste & Romberg G-Model gravimeter was used to acquire the gravity data. This instrument measures the Earth's gravitational field very accurately by balancing or "nulling" the gravitational force on a proof mass, with a restoring force provided by a series of levers activated by turning a high precision screw.

Gravity readings are taken by levelling the instrument on a base plate and manual reading of the "null" position.

Further details of the specifications of the Lacoste & Romberg gravimeter are provided in Appendix A.

4.0 FIELD PROCEDURES

A description of the field procedures is provided below. Some further background information of the micro-gravity method is also provided in Appendix A.

Gravity readings were taken generally at 20m intervals along the survey lines. The position of each station was located using a 100m tape laid along the ground surface and marked with marker paint.

The surface elevations for each gravity station were measured by the geophysical crew, using an ATG-6 Automatic level, whilst undertaking the gravity measurements for each area.

The horizontal position of the start and end of each of the gravity lines was determined with a Differential GPS system.

A number of base station were established in relatively quite locations and repeat readings were taken at these base station and a number of other secondary base points at approximately 30 to 45 minute intervals, to allow determination of the residual drift of the gravity meter, in accordance with accepted practice.

The ground surface was generally very stable comprising gravel roadways over the majority of stations with some of the survey points on grass surface. In general the data was considered of good quality and repeat measurements indicated a survey accuracy of approximately 10 microgals.

A number of outlier gravity points were taken to the south of the Pacific Highway where rock is expected to be very shallow, and at Borehole locations to the South and North of the river with known rock levels, to allow an estimation of the regional gravity gradient across the area of interest.

5.0 INTERPRETATION PROCEDURES

5.1 Survey Co-ordinates

The Relative Levels for each gravity survey point was measured during the gravity survey relative to the start of each line.

Listing of the corrected Easting and Northing coordinates to AMG-56 for each of the gravity stations were provided to ARUP and ground surface levels to AHD were then derived from the LIDAR survey. These levels were used to provide a shift of the ground surface for each gravity line to AHD

datum. It is expected that overall the surface levels would be accurate to within approximately +/-0.1m.

5.2 Gravity Data Processing & Corrections

The **Earth Tide corrections** and the **short-term residual gravity meter drift** were removed using repeat base station readings. Approximately 150 microgals of drift was observed over the course of each day of the survey, which was effectively removed by curve fitting of the base station data.

A **latitude correction** was applied to the data using the surveyed station co-ordinates, assuming a datum point to the south of the site. A Free Air correction was applied using the elevations provided for each station.

Bouguer Corrections were applied to the Free Air gravity data using a range of densities from 1.6 to 2.4 tonne/cubic metre, and plotted against elevation to determine the most appropriate density of the near-surface rocks using Nettleton's Method. A value of 2.2 t/cu.m was chosen as the most appropriate density for the near surface to derive a final Bouguer Gravity Data.

Terrain corrections were not applied as the ground surface was relatively flat and there were no obvious areas where irregularities in the surface elevations would have resulted in errors in assumption, which would cause a reduction in gravity due to upward pull. The river and subsequent drop in river bed surface may have an effect on the data within approximately 50m of the river's edge.

5.3 Regional Gravity Gradient

The regional gravity gradient is a longer wavelength gravity anomaly due to large and deeper structures such as the sedimentary basin structure or other large scale changes in bedrock density. Typically this gradient would be sub-planar over a survey area of this size and may be identified by taking gravity readings at locations where rock outcrops ie the contribution of the alluvium is nil. However rock outcrops in the vicinity of the site were limited.

A number of spatially diverse locations where the rock level was relatively shallow as provided by the borehole data, were used in conjunction with 2D modelling of the gravity response for these known depths to rock, to best approximate the region gravity gradient. This is shown in Figure 2 where the contoured Bouguer gravity data and estimated regional gradient is shown as a 3D perspective view.

5.4 Gravity Modelling

This Regional Corrected Bouguer gravity data was used as the input data to

2-Dimensional modelling, using Grav2D Gravity Interpretation package. The gravity modelling is based on a simplified earth-model with the following assumed densities for the soil and rock units.

Alluvium	1.8 t/cu. m wet
Rock	2.35 t/cu. m wet

As the water table and moisture levels would be considered relatively shallow and sub-parallel with the ground surface, separate regions of density variations due to moisture content were not included in the gravity model. It was assumed that the water table was fairly shallow and the shallow soils were generally moist.

Gravity modelling was undertaken assuming a soil layer, of generally uniform density contrast of -0.55 t/cu.m compared to the underlying bedrock. The depth to rock indicated at the boreholes nearest the gravity lines were used to calibrate the gravity modelling.

Sections of the gravity lines with varying depths to rock were modelled to obtain a “best approximation” between the corrected Bouguer gravity data and known depths to rock. An approximate correlation factor of 0.038 milligals per meter depth to rock was determined. This was used then used to calculate an interpreted depth below ground surface which when subtracted from the measured ground surface provided an interpreted rock level to AHD datum.

Further details of the gravity data corrections and interpretation are provided in Appendix A.

6.0 RESULTS

A contour plan of interpreted rock RL (AHD) has been provided on Figure 3. The Interpreted Rock Contour Plan is interpreted to represent the bedrock mass as defined by the assumed two layer model. The gravity station locations, interpreted rock RL’s and contours of the interpreted rock levels from the gravity data labelled at 5m depth intervals are shown. The location and RL of the bedrock from the nearby boreholes provided are also shown.

These same interpreted rock contour levels derived from the gravity survey are shown overlain on the aerial photo base map provided by ARUP in Figure 4.

The interpreted rock profile is observed to vary from approximately RL 0m depth to RL-22m over the regions tested.

There may be some significant variation in densities along the lines due to variable thickness of gravels or dense sediments. Such density variations

may affect the interpreted levels. If the sediments contain an increased percentage of gravel, then the density contrast used in the modelling (-0.55 t/cu.m) may have been overestimated resulting in an underestimation of the depth to rock. Similarly if some areas contain relatively less dense sediments then the depth to rock may be overestimated.

Density variations within the bedrock are also possible. Due to variations in the weathering profile across site the interface of the relatively “dense” rock surface on which the gravity interpretation is based may vary slightly.

It was not possible to account for these variations systematically based on the limited spatial information available and the single gravity profiles.

Listings of the gravity station coordinates and interpreted rock levels along the gravity profiles from which the contour plans have been derived will be provided in electronic format.

7.0 CONCLUSIONS

Gravity survey was successfully completed along the designated profiles. The gravity data acquired was considered to be generally of good quality.

The gravity testing has allowed modelling of an interpreted rock profile along each of the surveyed lines based on a relatively simplistic subsurface model of uniform sediment density overlying a uniform rock mass.

This interpreted rock profile is observed to vary from approximately RL 0m to RL-22m depth over the regions tested.

Whilst the actual rock level may vary from the interpreted rock level for a number of reasons as detailed in this report it is considered that the interpretation included is a good approximation of the overall bedrock topography and trends given the scope and objectives of the survey.

Appendix A – Gravity Method, Instrumentation & General Assumptions of Interpretation, is provided to offer some general information on the gravity method including the precision and accuracy of results and the possible effect of variations to the assumptions on which the method and interpretation procedure is based.

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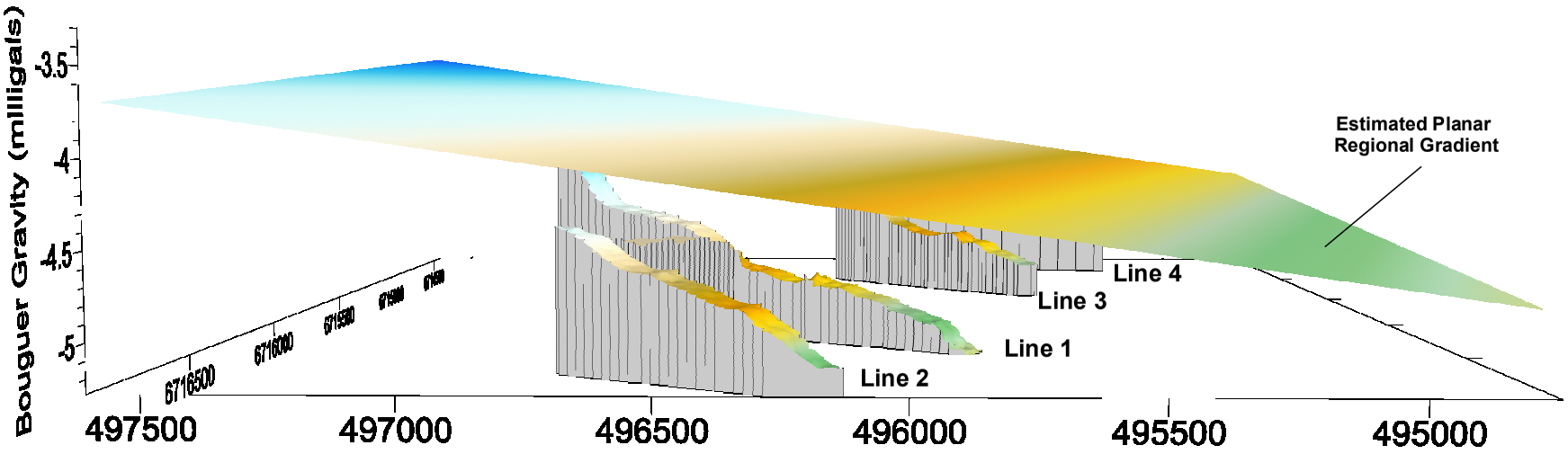
ARUP / ROADS & MARITIME SERVICES
SUMMERLAND
GRAVITY SU
S PLAN
Location of Gravity Lines

ETS

Figure 1

Bouguer Gravity Data
& estimated Regional Gravity Gradient



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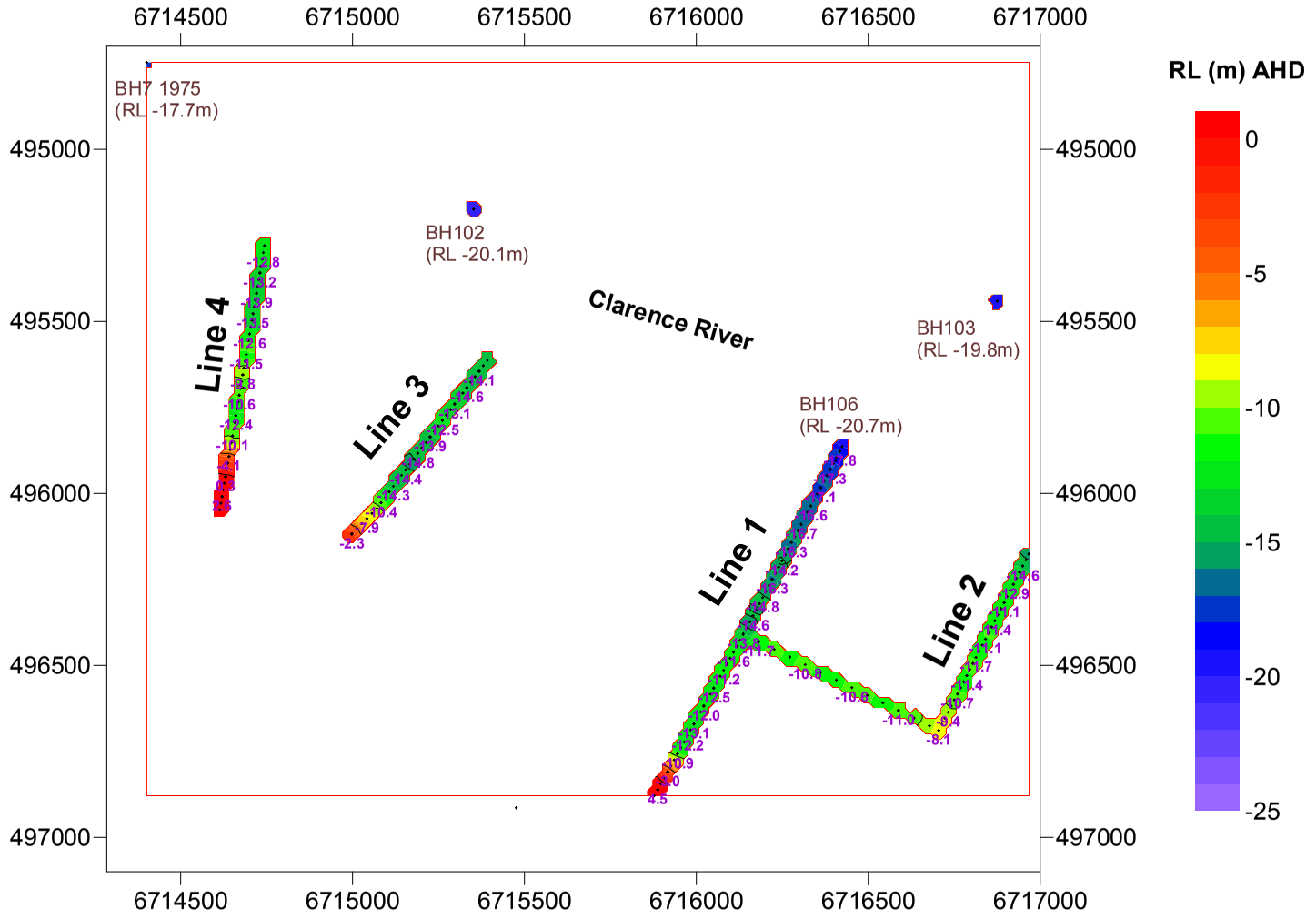
ARUP / ROADS & MARITIME SERVICES
SUMMERLAND
GRAVITY SU
3D VIEW - BOUGUER GRAVITY DATA &
ESTIMATED REGIONAL GRADIENT

ETS

Figure 2

Interpreted Rock Levels - RL (m) AHD



Scale 1:2000

+ 5.4 Interp Rock RL (m) AHD @ Gravity Stations

-17.7m BH Rock RL (m) AHD

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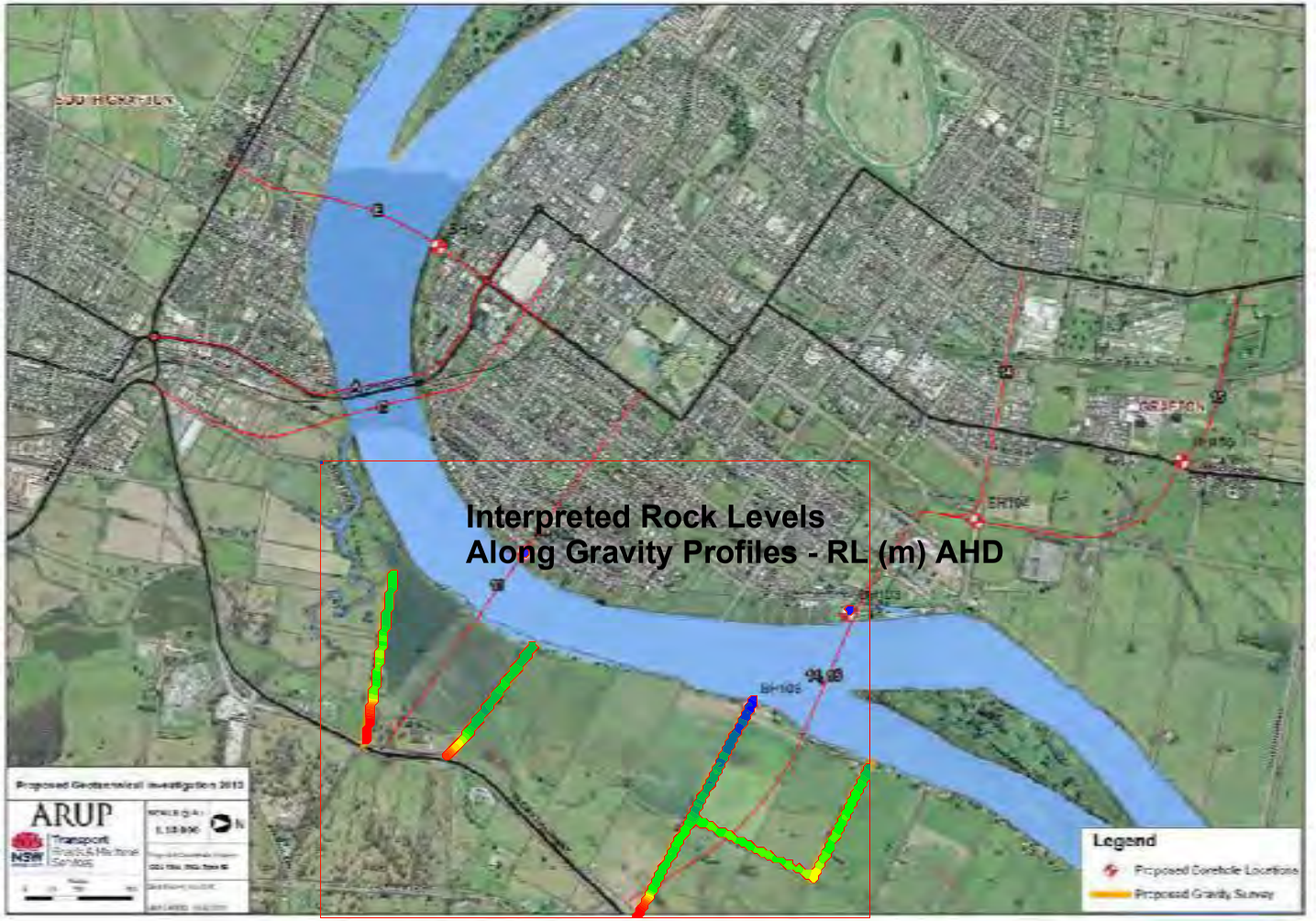
ARUP / ROADS & MARITIME SERVICES
SUMMERLAND [redacted]
GRAVITY SU[redacted]
INTERPRETED ROCK LEVELS
CONTOUR P[redacted]

ETS

Figure 3



RL (m) AHD

0
-5
-10
-15
-20
-25

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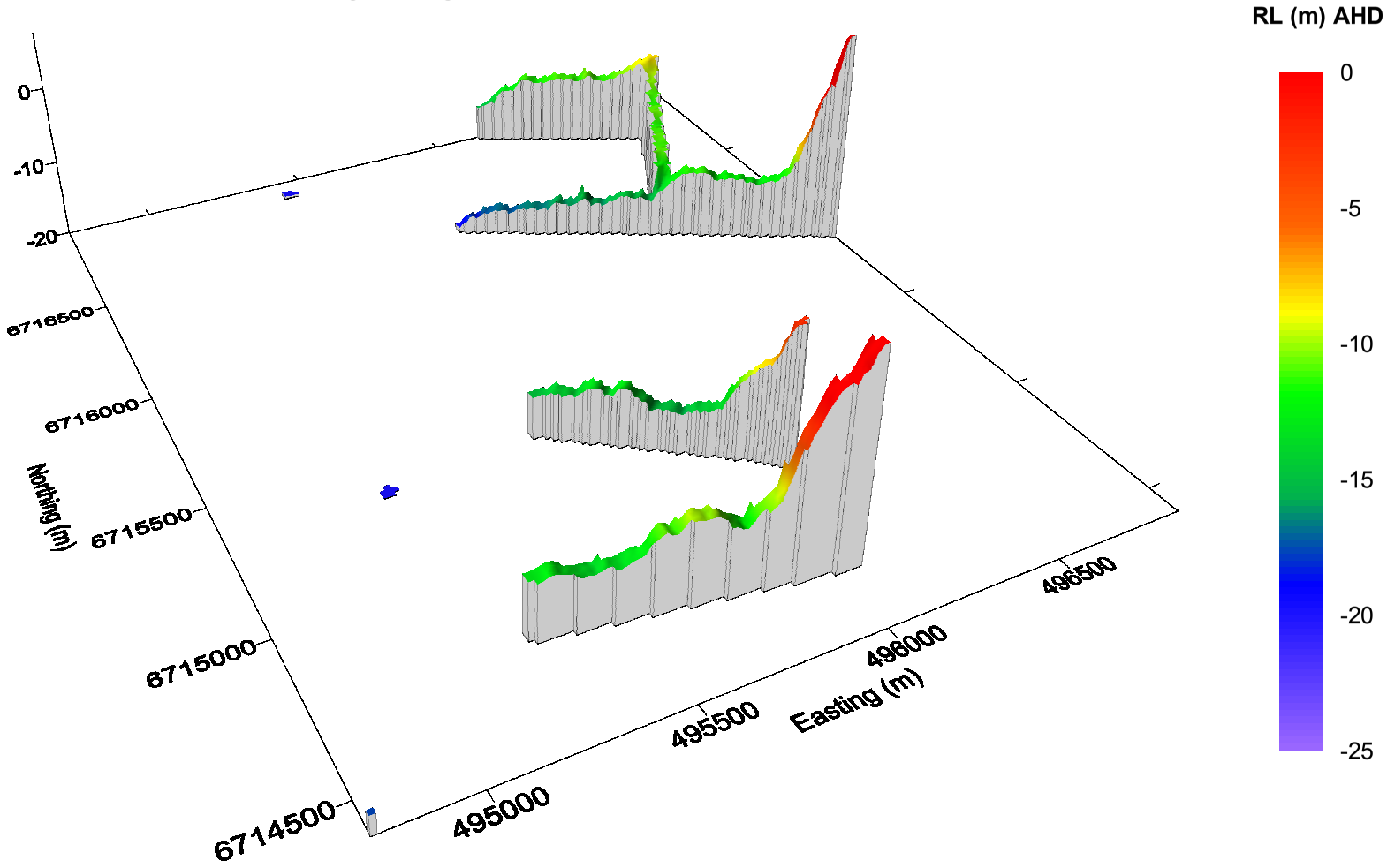
ARUP / ROADS & MARITIME SERVICES
SUMMERLAND
GRAVITY SU
INTERPRETED ROCK LEVELS
(AERIAL PHOTO SITE PLAN)

ETS

Figure 4

Interpreted Rock Levels - RL (m) AHD
3D View



Earth Technology Solutions Pty Ltd ABN 12 078 325 658 Report No: ET403.01 Date: 04/4/12

ARUP / ROADS & MARITIME SERVICES
SUMMERLAND [redacted]
GRAVITY SU[redacted]
3D VIEW - INTERPRETED ROCK LEVELS

ETS

Figure 5

APPENDIX A

GRAVITY METHOD, INSTRUMENTATION & GENERAL ASSUMPTIONS OF INTERPRETATION

The results of gravity surveys are presented as interpreted rock profiles beneath the line of traverse. These outputs are a two-dimensional model, which have been interpreted from corrected gravity data obtained in the field.

The following background information is intended to assist in the understanding of the gravity instrumentation and method, and the interpreted gravity sections provided.

A1 The Earth's Gravitational Field and its Variations

The Earth is essentially a spheroid, with slight flattening at the poles. The mean value of gravity reduces at the equator and increases at the poles. Due to lateral variation in density the Earths gravitational field (**g**) is not a simple spheroid.

A **Latitude Correction** is applied using an equation, which approximates the Earth spheroid and includes the Newtonian attraction of the Earth as a spheroid and the centrifugal force caused by rotation about its axis.

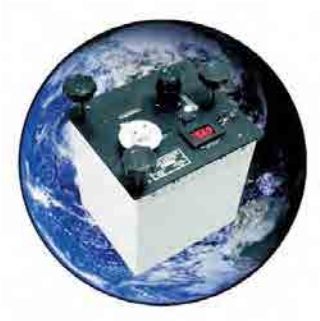
The Free-Air Effect is the mean vertical gradient of **g** above the surface of the Earth. As one increases in elevation above sea level, the gravitational attraction will decrease as the inverse square of the distance to the centre of the Earth. A **Free-Air Correction** is applied using the measured elevation for each gravity station.

When one increases elevation on the Earth, it usually implies that there is an additional mass, which will exert a positive gravitational attraction, which acts to reduce the Free-Air gravity change. The **Bouguer** gravity effect is calculated on the basis of the gravitational attraction of a horizontal slab, of infinite extent and of thickness equal to the elevation difference assuming a mean density of the slab. Nettleton's Method for determining the density of near-surface rocks is based on applying the Bouguer correction to the Free-Air gravity data over a broad topographic feature using a range of assumed densities. The correct density is indicated by the profile which least correlates with the topography.

Local irregularities in the topography around a gravity station may give rise to significant **Terrain Effects**. Embankments or dense structures rising above a station will cause a reduction in gravity, due to upward pull. Road cuttings or embankments falling below the station will also cause a reduction in gravity due to the deficit of mass that would be included in the Bouguer assumption of an infinite slab. As the ground surface surrounding the areas tested was relatively flat and the distance to the river was approximately constant, no terrain corrections were attempted for this data.

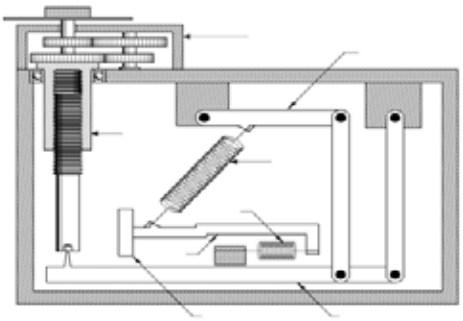
The final correction to the gravity data is the removal of the **Regional Gradient,** which are longer wavelength anomalies due to large and deeper structures such as the sedimentary basin structure. These are typically observed as sub-planar gradients over a relatively short profile, and are defined by comparing the corrected gravity values at a number of regions around the site of constant depth to rock. Ideally we would take gravity readings at a number of points around the site where rock outcropped (ie the contribution of sediments/alluvium nil) to determine the regional gradient. However as rock was not outcropping at this site a number of locations of relatively shallow rock were used to attempt to best define this gradient.

A2 Gravity Instrumentation – Lacoste & Romberg G Meter



The Lacoste & Romberg is a gravimeter which measures the Earth's gravitational field very accurately by measuring the gravitational force on a proof mass. The beam is supported from a point just behind the mass by a " zero length" spring. The spring is at an angle of approximately 45 degrees from horizontal.

The meter is read by nulling the mass position, that is, adding or subtracting a small amount of force to the mass to restore it to the same " reading" position. This is accomplished by lifting up on the top end of the zero length spring. This must be done with great accuracy and is accomplished with a series of levers. In turn, the levers are moved by a high-precision screw which in turn is rotated by a gear box with considerable reduction.



The instrument is placed on a tripod base plate, which contains levelling screws and tilt meters to allow very accurate levelling of the meter in the vertical plane.

A3 Assumptions Of Interpretation

Two-dimensional modelling of the corrected gravity profile data (Bouguer Profile) enables an interpretation of the rock profile assuming a density distribution of the shallow subsurface.

The gravity interpretation provides a simplified model of the subsurface densities and is based on a number of assumptions about its nature. The major assumptions are:

i) the subsurface essentially consists of two layers of uniform density ie alluvium overlying rock,

ii) the cross section of the density model is assumed to be constant in the direction orthogonal to the direction of the gravity profile.

There is no unique interpretation to any observed gravity data as the densities or density contrasts of the subsurface materials must be assumed. Thus the depth to the source of a specific gravity anomaly cannot be precisely determined.

The interpreted rock levels provided in this report are based on 2-dimensional modelling of the gravity data assuming a uniform density contrast of -0.55t/cu.m between the sediments and underlying bedrock.

If the assumed density contrast varies along the gravity lines the interpreted depth to rock will be in error. If the actual density of the shallow subsurface is 10% higher than the assumed density, this will result in an interpreted bedrock model which is approximately 10% shallower than the actual depth to rock.