DEPARTMENT OF TRANSPORT AND WORKS

TR 36/94.

HUDSON CREEK TRADE WASTE TREATMENT PLANT

GEOTECHNICAL REPORT

REF 431/19055/00

7 July 1994

GUTTERIDGE HASKINS AND DAVEY PTY LTD
1.0 INTRODUCTION

This report presents the results of site investigation work carried out on the site of the proposed Trade Waste Treatment Plant at Hudson Creek for the purpose of assessing the likely ground conditions prevailing on the site as an aid to the selection of an appropriate plant location and pond floor levels and to assess the quantity and quality of materials likely to be available for the construction of ponds and embankments.

The investigation comprised the excavation of six test pits over the area expected to be occupied by the new Trade Waste Treatment Plant, the logging of materials found and obtaining samples of typical material types.

A previous report carried out by Coffey and Partners on behalf of Kinhill Engineers Pty Ltd for the Power and Water Authority and include in the report "East Arm Sewerage Ponds - Preliminary Environmental Report" - Kinhill Engineers Pty Ltd April 1989, covers the area immediately to the east of the proposed pond site and is attached as Appendix B. It can reasonably be assumed that detailed analysis of various typical materials can be applied to similar materials identified in test pits and finding of this investigation should be read in conjunction with the results of the previous report.

2.0 TEST PITS

The test pits were excavated with Caterpillar 428 Series II backhoe with 600 wide bucket. Pits were generally 2m-4m long and one bucket width. Pits were excavated to a maximum depth of 3.00m or to refusal.

The approximate location of test pits is shown in Figure 1.

Logs of each pit are attached.
Photos of each pit are shown in Fig 2-7

3.0 DISCUSSION

There appears to be a general trend to shallow rock towards the North East of the site with this being continued across the northern boundary as indicated by the previous investigation. The rock presence is however fairly erratic. A suitable site for the ponds can be found adjacent to the western boundary provided the pond floor level is set at a level at or above the apparent rock level.

The rock is generally of rippable strength and some minor rock removal should be possible without difficulty.

The material obtained from the excavation is generally a red/grey sandy to gravelly clay material of medium plasticity. Previous laboratory tests indicated an Emerson class of 6 for similar material. It is of low permeability and was previously deemed suitable for the construction of pond embankments.
**CLIENT:** JAMPA

**PROJECT:** HUDSON CREEK STP PONDS

**LOCATION:** OFF WISHART RD, EAST ARM.

<table>
<thead>
<tr>
<th>TEST PIT NO.</th>
<th>EQUIPMENT TYPE</th>
<th>GHD JOB NO</th>
<th>YOUR REFERENCE</th>
<th>DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CAT 428 SERIES II BACKHOE - 660MM GUTTER</td>
<td>431-019055</td>
<td>LAYOUT PLAN</td>
<td>6/7/94</td>
</tr>
</tbody>
</table>

**PIT LOCATION:** WESTERN CORNER

**SURFACE RL:** 7.0m

<table>
<thead>
<tr>
<th>DESCRIPTION OF STRATA</th>
<th>DEPTH (m)</th>
<th>SAMPLES</th>
<th>PENETROMETER TESTS</th>
<th>SOIL TESTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grey Topsoil</td>
<td>0.2</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td>0.4</td>
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<td>0.8</td>
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<td></td>
<td>3.0</td>
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</tr>
</tbody>
</table>

- excavation terminated at a depth of 3.0m.

**LOGGED BY:** LKB  
**DATE:** 6/7/94
**CLIENT:** PAWA

**PROJECT:** HUDSON CREEK STD PONDS

**LOCATION:** OFF WISHART RD, EAST ARM.

<table>
<thead>
<tr>
<th>TEST PIT NO.</th>
<th>EQUIPMENT TYPE</th>
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<th>YOUR REFERENCE</th>
<th>DATE</th>
</tr>
</thead>
<tbody>
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<td>2</td>
<td>CAT 428 SERIES II BACKHOE - 600mm BUCKET</td>
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<td>LAYOUT PLAN</td>
<td>6/7/94</td>
</tr>
</tbody>
</table>

**PIT LOCATION:** CENTRE OF SITE - WESTERN SIDE

**SURFACE RL:** 5.0m

**DESCRIPTION OF STRATA**

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>SAMPLES</th>
<th>PENETROMETER TESTS</th>
<th>SOIL TESTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.4</td>
<td></td>
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<tr>
<td>3.0</td>
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</tr>
</tbody>
</table>

*Excavation terminated at 3.0m depth*

**LOGGED BY:** JMB

**DATE:** 6/7/94
**CLIENT:** PAWA  
**PROJECT:** HUDSON CREEK STP PONDS  
**LOCATION:** OFF WISHART RD, EAST ARM.

<table>
<thead>
<tr>
<th>TEST PIT NO.</th>
<th>EQUIPMENT TYPE</th>
<th>GHD JOB NO</th>
<th>YOUR REFERENCE</th>
<th>DATE</th>
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</thead>
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<td>3</td>
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<td>431-015055</td>
<td>LAYOUT PLAN</td>
<td>6/7/94</td>
</tr>
</tbody>
</table>

**SURFACE RL:** 4.0m

**PIT LOCATION:** SOUTHERN CORNER

<table>
<thead>
<tr>
<th>DESCRIPTION OF STRATA</th>
<th>DEPTH (m)</th>
<th>SAMPLES</th>
<th>PENETROMETER TESTS</th>
<th>SOIL TESTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black, peaty top soil</td>
<td>0.2</td>
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<td></td>
<td>0.4</td>
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<td></td>
<td>0.6</td>
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<tr>
<td>Empty clay with some gravel</td>
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<td>3</td>
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<tr>
<td>Very soft</td>
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<td></td>
</tr>
<tr>
<td>Moist</td>
<td>1.2</td>
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<tr>
<td></td>
<td>1.4</td>
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<tr>
<td></td>
<td>1.8</td>
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<td></td>
<td></td>
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<tr>
<td>Red clay</td>
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<tr>
<td>Very soft</td>
<td>2.2</td>
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<td></td>
</tr>
<tr>
<td>moist</td>
<td>2.4</td>
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<td></td>
</tr>
<tr>
<td>Water table</td>
<td>2.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Fine sand to medium)</td>
<td>2.8</td>
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<tr>
<td>Angular gravel present</td>
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</table>

Excavation terminated at depth of 3.0m

**LOGGED BY:** IKB  
**DATE:** 6/7/94
### Test Pit No. 4

**Equipment Type:** CAT 428 SERIES II BACKHOE - 600mm GLOBET

**GHD Job No.:** 421-019055

**Your Reference:** LAYOUT PLAN

**Date:** 6/7/94

**Location:** Northern Corner

**Surface RL:** 7.0 m

### Description of Strata

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<th>Depth (m)</th>
<th>Samples</th>
<th>Penetrometer Tests</th>
<th>Soil Tests</th>
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<td></td>
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</tr>
<tr>
<td>1.0</td>
<td>4</td>
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<tr>
<td>1.2</td>
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<td>1.4</td>
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<td>3.0</td>
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**Logged By:** H.G.  
**Date:** 6/7/94
**CLIENT:** PAVWA

**PROJECT:** HUDSON CREEK STP PONDS

**LOCATION:** OFF WISHART RD, EAST ARM.

<table>
<thead>
<tr>
<th>TEST PIT NO.</th>
<th>EQUIPMENT TYPE</th>
<th>GHD JOB NO</th>
<th>YOUR REFERENCE</th>
<th>DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>CAT 428 SERIES II BACKHOE - 600mm BUCKET</td>
<td>431-013055</td>
<td>LAYOUT PLAN</td>
<td>6/7/94</td>
</tr>
</tbody>
</table>

**PIT LOCATION:** CENTRE OF SITE - EASTERN SIDE

**SURFACE RL:** 5.0m

**DESCRIPTION OF STRATA**

- Sandy, grey topsoil

- Sandy, clay
- Red, dry

- Rock (rippable)

* Rock refusal at 0.8m depth

<table>
<thead>
<tr>
<th>DEPTH (m)</th>
<th>SAMPLES</th>
<th>PENETROMETER TESTS</th>
<th>SOIL TESTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>0.4</td>
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<td>0.6</td>
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<td>0.8</td>
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**LOGGED BY:** TKB  
**DATE:** 6/7/94
<table>
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<tr>
<th>TEST PIT NO.</th>
<th>EQUIPMENT TYPE</th>
<th>GHD JOB NO</th>
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<th>DATE</th>
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<tbody>
<tr>
<td>6</td>
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<td>491-015055</td>
<td>LAYOUT PLAN</td>
<td>6/7/94</td>
</tr>
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</table>

**PIT LOCATION:** EASTERN CORNER  
**SURFACE RL:** 4.0m

<table>
<thead>
<tr>
<th>DESCRIPTION OF STRATA</th>
<th>DEPTH (m)</th>
<th>SAMPLES</th>
<th>PENETROMETER TESTS</th>
<th>SOIL TESTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sandy, grey topsoil</td>
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<td></td>
<td>0.4</td>
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**LOGGED BY:** IKS  
**DATE:** 6/7/94
APPENDIX A

PREVIOUS INVESTIGATION REPORT

(COFFEY AND PARTNERS 1989)

FROM KINHILL ENGINEERS PTY LTD REPORT
"East Arm Sewerage Ponds - Preliminary Environmental Report"
KINHILL ENGINEERS PTY LTD

HUDSON CREEK SEWERAGE TREATMENT PLANT

Proposed Geotechnical Study

Report No. D81/1       June, 1988
ATTENTION: Mr. John Thorpe

Dear Sir,

RE: Hudson Creek Sewerage Treatment Plant (Proposed
Geotechnical Study).

Please find enclosed our report on the above geotechnical study.

Summary of results: Field study was conducted on the site and on representative samples laboratory tests were carried out. Based on field observations and laboratory results the site of the proposed development is divided into zones with respect to the near surface soil conditions. The suitability of the site materials for the purpose of the proposed development is assessed. It is suggested that the CLAYEY SANDY GRAVEL available on site may be used as embankment material and low permeability floor lining in treatment ponds.

Should you require further information on this geotechnical study, please do not hesitate to contact the undersigned.

Yours faithfully,

COFFEY AND PARTNERS PTY LTD

Mr Kris Fabian
Senior Engineer, Darwin

Attachment: "Important Information about your your Geotechnical Engineering Report."
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4.0 SITE CONDITIONS 3

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ATTACHMENT: "Important Information about your Geotechnical Engineering Report."

LIST OF DRAWINGS

D81/1-1

APPENDICES

APPENDIX A: Results of Field Investigation

APPENDIX B: Results of Laboratory Tests
1.0 INTRODUCTION

The work described in this report was carried out at the request of Kinhill Engineers (Mr. John Thorpe) dated 17th June, 1988. This report was prepared for a Preliminary Feasibility Report for the establishment of sewerage treatment ponds in the Hudson Creek area on the East Arm.

The findings of this report should be used for Feasibility Report and preliminary design only and should not be used for detailed design or construction.

2.0 FIELD STUDY

Field work for the geotechnical study was undertaken on 24th June, 1988. Prior to the field work it was necessary to prepare a track into and around the area of the proposed sewerage plant to provide access for the backhoe which was used to excavate the testpits.

In all twelve testpits were excavated on the area of the future development. The testpits were excavated to rock refusal (TP 5, 6, 7R, 7, 8, 9, 9R) or to the ground water table (TP1, 2, 3, 4, 10). The testpits were excavated above the high water mark with the exception of TP10 which was excavated below the high tide water mark. In some other areas where access was not possible for the backhoe Dynamic Penetrometer (Scalaprobe) soundings were taken.

The selection of location of testpits, sampling and logging of the excavations was undertaken by Mr. K. Fabian, Senior Engineer.

The approximate locations of the testpits and Dynamic Penetrometer soundings are shown on Drawing No. D81/l-1. The engineering borelogs of the testpits together with explanatory sheets describing the terms and symbols used in the preparation of the borelogs are collected in Appendix A.

3.0 LABORATORY TESTS

On selected representative samples laboratory tests were carried out for the classification of the soil layers encountered and for the preliminary assessment of the site materials in the construction of the proposed development as embankment material. Atterberg limits (together with linear shrinkage), gradings and dispersivity tests using Emerson classification methods were carried out. Test results are summarised in Appendix B.

4.0 SITE CONDITIONS

4.1 Surface Conditions

The area of the proposed development is approximately 70 hectares, having about 40 hectares below the high water mark and about 30 hectares above the high water mark. The high water mark runs about 300m across the area of the proposed development from SW to NE then turning towards almost Northerly direction for about 600m then returning into the SW to NE direction for another 300m.
The area below the high water mark is flat and densely vegetated with mangrove trees.

An area, which is about 100m wide and runs parallel with the high water mark, is flat and vegetated with a medium dense forest of eucalyptus and pandanas. The surface in this area is densely overgrown by tall grass and shrubs.

A smaller area towards the NW boundary of the site is the base of a small hill which lies to the NW. The NW section of the site of the proposed development is gently sloping and vegetated sparsely with eucalyptus and the surface is covered with low, thin grass located amongst visible rock outcrops.

4.2 Subsurface Conditions

Based on the engineering borelogs (refer to Appendix A) the site may be divided into three zones. The three zones are indicated on Drawing No. D81/1-1. The generalised subsurface profiles of these zones may be summarised as follows.

TABLE 1: Generalised Subsurface Profile in Zone 1
(TP 1, 2, 3, 4, 5, 6)

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>COMMENTS</th>
<th>DEPTH RANGE TO BASE OF LAYER (metre)</th>
<th>THICKNESS ENCOUNTERED (metre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOPSOIL</td>
<td>brown, organic</td>
<td>0.2 - 0.3</td>
<td>0.2 - 0.3</td>
</tr>
<tr>
<td>CLAYEY SANDY</td>
<td>cemented FERRICRETE</td>
<td>1.2 to 1.8</td>
<td>1.0 to 2.0</td>
</tr>
<tr>
<td>GRAVEL</td>
<td></td>
<td>2.3 (TP6)</td>
<td></td>
</tr>
</tbody>
</table>

Excavations terminated at ground water table with the exception of TP5 and TP6 which were terminated on rock refusal on SANDSTONE/PHYLLITE.

TABLE 2: Generalised Subsurface Profile on Zone II
(TP 7, 7R, 8, 9, 9R)

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>COMMENTS</th>
<th>DEPTH RANGE TO BASE OF LAYER (metre)</th>
<th>THICKNESS ENCOUNTERED (metre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOPSOIL</td>
<td>grey</td>
<td>0 - 0.2</td>
<td>0 - 0.2</td>
</tr>
<tr>
<td>CLAYEY SANDY</td>
<td>cemented FERRICRETE</td>
<td>0 - 2.3</td>
<td>0 - 2.3</td>
</tr>
<tr>
<td>GRAVEL</td>
<td>dense to very dense</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PHYLLITE/</td>
<td>weathered (highly)</td>
<td>0 - 2.3</td>
<td>N/A</td>
</tr>
<tr>
<td>SANDSTONE</td>
<td>often mixed with quartz boulders.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Observing the borelogs and the surface features of the site it is plausible to assume that the extent of the three geotechnically different zones described and characterised above is as shown on Drawing No. D81/1-1.

Based on the laboratory test results it may be seen that the CLAYEY SANDY GRAVEL soil covering Zone I and II is of medium plasticity and relatively high Emerson Dispersivity Class Number. The fine content of the material is about 20%.

This material is often cemented (FERRICRETE). In Zone I the cementation is weaker. In Zone II the cementation is stronger and the material is sometimes mixed with quartz lumps. In Zone III the cementation is very weak or often missing. In this zone the consistency of the material is soft.

5.0 DISCUSSION AND RECOMMENDATIONS

5.1 Site Preparation

For the preparation of those areas of the site where buildings and sewerage treatment ponds are to be located all topsoil and vegetation should be removed to a minimum thickness of 300mm. The stripped topsoil should be stockpiled for later use. It is envisaged that the stripping can be carried out using a dozer. Attention is drawn to the possible difficulties when carrying out site preparation in areas where rock is close to or on the surface.

5.2 Suitability of Site Materials for Embankment Construction

Based on the soil properties described earlier such as Atterberg Limits and relatively high fine content and also relatively high Emerson Dispersivity Class Number it can be concluded that the CLAYEY SANDY GRAVEL (GC) soil can be used as material for the low permeability core of embankments and floor lining of the sewerage treatment ponds. According to the US Bureau of Reclamation's Earth Manual GC soils when compacted show low permeability, good to fair shearing strength, low compressibility and good workability. This statement is subject to further more detailed investigations at a later stage of the planning of the proposed development.
In Zones I and II the insitu conditions and consistency of the materials is suitable for consideration to place buildings and sewerage treatment installations. In Zone III the insitu consistency of the materials is unfavourable to support buildings and sewerage treatment installations.

5.3 Preliminary Recommendation on Embankment Geometry

It is suggested to build the embankments required around the sewerage treatment ponds with a side batter of 1 (Vertical) in 2 (Horizontal).

From the materials available on site the CLAYEY SANDY GRAVEL should be used as embankment material. The material should be compacted to a dry density ratio of 98% (Standard compaction) at a moisture content which is 0 to 2% higher than the Optimum Moisture Content determined for the material in Standard compaction tests.

Where the depth of the insitu CLAYEY SANDY GRAVEL is more than 0.6 - 0.8m -after site preparation- it can be used as low permeability floor lining in the sewerage treatment ponds. Some on site reworking of the insitu material may be necessary to ensure homogeneity of the core.

Where the thickness of the CLAYEY SANDY GRAVEL is less than 0.6m after site preparation the floor lining may be formed using the insitu and imported CLAYEY SANDY GRAVEL by compacting it to 98% dry density ratio (Standard compaction) at a moisture content, which is 0 to 2% higher than the Optimum Moisture Content determined for the material in Standard compaction tests. The compaction should be carried out in minimum two layers.

If excavation on the site is necessary in the CLAYEY SANDY GRAVEL it is suggested that 1V in 1H temporary and 1V in 2H permanent battered slopes be used. Attention is drawn to the possible difficulties when excavating SANDSTONE, PHYLLITE.

5.4 Recommendation for Further Investigation

It is understood that this report is used for the preparation of a Preliminary Environmental Report. Should the proposed development proceed we suggest that further geotechnical studies with respect to the following research areas be carried out.

1. allowable pressure for footings
2. permeability of insitu and remoulded soils in areas to be occupied by sewerage ponds
3. compaction characteristics of the soils for detailed specification
4. subgrade evaluation for access roads

If your request further information regarding this report please do not hesitate to contact the undersigned.

COFFEY AND PARTNERS PTY LTD

K Fabian Manager, Darwin
IMPORTANT INFORMATION
ABOUT YOUR
GEOTECHNICAL ENGINEERING REPORT

More construction problems are caused by site subsurface conditions than any other factor. As troublesome as subsurface problems can be, their frequency and extent have been lessened considerably in recent years, thanks to the Association of Soil and Foundation Engineers (ASFE).

When ASFE was founded in 1969, subsurface problems were frequently being resolved through lawsuits. In fact, the situation had grown to such alarming proportions that consulting geotechnical engineers had the worst professional liability record of all design professionals. By 1980, ASFE-member consulting soil and foundation engineers had the best professional liability record. This dramatic turn-about can be attributed directly to client acceptance of problem-solving programs and materials developed by ASFE for its members’ application. This acceptance was gained because clients perceived the ASFE approach to be in their own best interest. Disputes benefit only those who earn their living from others’ disagreements.

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

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

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

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

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

A geotechnical engineer cannot accept responsibility for problems which may develop if he is not consulted after factors considered in his reports development have changed.

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MOST GEOTECHNICAL “FINDINGS” ARE PROFESSIONAL ESTIMATES

Site exploration identifies actual subsurface conditions only at those points where samples are taken, when they are taken. Data derived through sampling and subsequent laboratory testing are extrapolated by the geotechnical engineer who then renders an opinion about overall subsurface conditions, their likely reaction to proposed construction activity, and appropriate foundation design. Even under optimal circumstances actual conditions may differ from those opined to exist, because no geotechnical engineer, no matter how qualified, and no subsurface exploration program, no matter how comprehensive, can reveal what is hidden by earth, rock, and time. For example, the actual interface between materials may be far more gradual or abrupt than the report indicates, and actual conditions in areas not sampled may differ from predictions. Nothing can be done to prevent the unanticipated, but steps can be taken to help minimize their impact. For this reason, most experienced owners retain their geotechnical consultants through the construction stage, to identify variances, conduct additional tests which may be needed, and to recommend solutions to problems encountered on site.

SUBSURFACE CONDITIONS CAN CHANGE

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

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

A GEOTECHNICAL ENGINEERING REPORT IS SUBJECT TO MISINTERPRETATION

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

BORING LOGS SHOULD NOT BE SEPARATED FROM THE ENGINEERING REPORT *

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

To minimize the likelihood of boring log misinterpretation, contractors must have access to the complete geotechnical engineering report. Those who do not provide such access may proceed under the mistaken impression that simply disclaiming responsibility for the accuracy of subsurface information always insulates them from attendant liability. Providing the best available information to contractors helps prevent costly construction problems and the adversarial attitudes which aggravate them to disproportionate scale.

READ RESPONSIBILITY CLAUSES CLOSELY

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

OTHER STEPS YOU CAN TAKE TO REDUCE RISK

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

*Note this clause may not be directly applicable to Australian practice depending upon the nature of latent condition clauses in the contract and other matters. SAA and Institution of Engineers Australia have this and related matters under consideration (June 1986).
APPENDIX A

results of field investigation
SOIL DESCRIPTIONS

Classification of Material based on Unified Classification System, refer SAA Site Investigation Code AS1726-1975 Add. No. 1 Table D1.

Moisture Condition based on appearance of soil
- dry: Looks and feels dry; cohesive soils usually hard, powdery or friable, granular soils run freely through hands.
- moist: Soil feels cool, darkened in colour; cohesive soils usually weakened by moisture, granular soils tend to cohesion, but one gets no free water on hands on remoulding.
- wet: Soil feels cool, darkened in colour; cohesive soils weakened, granular soils tend to cohesion, free water collects on hands when remoulding.

Consistency based on unconfined compressive strength (Qu) (generally estimated or measured by hand penetrometer).

<table>
<thead>
<tr>
<th>term</th>
<th>very soft</th>
<th>soft</th>
<th>firm</th>
<th>stiff</th>
<th>very stiff</th>
<th>hard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Qu kPa</td>
<td>0</td>
<td>25</td>
<td>50</td>
<td>100</td>
<td>200</td>
<td>400</td>
</tr>
</tbody>
</table>

If soil crumbles on test without meaningful result, it is described as friable.

Density Index: (generally estimated or based on penetrometer results).

<table>
<thead>
<tr>
<th>term</th>
<th>very loose</th>
<th>loose</th>
<th>medium dense</th>
<th>dense</th>
<th>very dense</th>
</tr>
</thead>
<tbody>
<tr>
<td>density index %</td>
<td>15</td>
<td>35</td>
<td>65</td>
<td>85</td>
<td></td>
</tr>
</tbody>
</table>

ROCK DESCRIPTIONS

Weathering based on visual assessment

- Fresh: Rock substance unaffected by weathering.
- Slightly Weathered: Rock substance affected by weathering to the extent that partial staining or partial discolouration of the rock substance usually by limonite has taken place. The colour and texture of the fresh rock is recognisable; strength properties are essentially those of the fresh rock substance.
- Moderately Weathered: Rock substance affected by weathering to the extent that staining extends throughout whole of the rock substance and the original colour of the fresh rock is no longer recognisable.
- Highly Weathered: Rock substance affected by weathering to the extent that limonite staining or bleaching affects the whole of the rock substance and signs of chemical or physical decomposition of individual minerals are usually evident. Porosity and strength may be increased or decreased when compared to the fresh rock substance, usually as a result of the leaching or deposition of iron. The colour and strength of the original fresh rock substance is no longer recognisable.
- Extremely Weathered: Rock substance affected by weathering to the extent that the rock exhibits soil properties, i.e. it can be remoulded and can be classified according to the Unified Classification System, but the texture of the original rock is still evident.

Strength based on point load strength index, corrected to 50 mm diameter: Is(50) (refer IS.R.M., Commission on Standardisation of Laboratory and Field Tests, Suggested Methods for Determining the Uniaxial Compressive Strength of Rock Materials and the Point Load Strength Index, Committee on Laboratory Tests Document No. 11. Generally estimated: * indicates test result).

<table>
<thead>
<tr>
<th>classification</th>
<th>Is (50) MPa</th>
</tr>
</thead>
<tbody>
<tr>
<td>extremely low</td>
<td>0.03</td>
</tr>
<tr>
<td>low</td>
<td>0.1</td>
</tr>
<tr>
<td>medium</td>
<td>0.3</td>
</tr>
<tr>
<td>high</td>
<td>1</td>
</tr>
<tr>
<td>very high</td>
<td>3</td>
</tr>
<tr>
<td>extremely high</td>
<td>10</td>
</tr>
</tbody>
</table>

The unconfined compressive strength is typically about 20 x Is(50) but the multiplier may range, for different rock types, from as low as 4 to as high as 30.

Defect Spacing

<table>
<thead>
<tr>
<th>classification</th>
<th>spacing m</th>
</tr>
</thead>
<tbody>
<tr>
<td>extremely close</td>
<td>0.03</td>
</tr>
<tr>
<td>very close</td>
<td>0.1</td>
</tr>
<tr>
<td>close</td>
<td>0.2</td>
</tr>
<tr>
<td>medium</td>
<td>1</td>
</tr>
<tr>
<td>wide</td>
<td>2</td>
</tr>
<tr>
<td>very wide</td>
<td>3</td>
</tr>
<tr>
<td>extremely wide</td>
<td>10</td>
</tr>
</tbody>
</table>

Defect description uses terms contained on AS1726 Table D2 to describe nature of defect (fault, joint, crushed zone, clay seam etc.) and character (roughness, extent, coating etc.).
graphic symbols
soil and rock

SOIL
- Asphalitic Concrete or Hotmix
- Concrete
- Topsoil
- Fill
- Peat, Organic Clays and Silts (Pt, CL, OH)
- Clay (CL, CH)
- Silt (ML, MH)
- Sandy Clay (CL, CH)
- Silty Clay (CL, CH)
- Gravelly Clay (CL, CH)
- Sandy Silt (ML)
- Clayey Sand (SC)
- Silty Sand (SM)
- Sand (SP, SW)
- Clayey Gravel (GC)
- Silty Gravel (GM)
- Gravel (GP, GW)

ROCK
- Claystone (massive)
- Siltstone (massive)
- Shale (laminated)
- Sandstone (undifferentiated)
- Sandstone, fine grained
- Sandstone, coarse grained
- Conglomerate
- Limestone
- Coal
- Dolerite, Basalt
- Tuff
- Porphyry
- Granite
- Schist
- Gneiss
- Quartzite
- Talus
- Alluvium

SEAMS
- Seam >0.1 m thick
  (on a scale 1:50)
- Seam 0.01 m to 0.1 m thick
  (on a scale 1:50)

INCLUSIONS (Special purposes only)
- Rock Fragments
- Swamp
- Ironstone Gravel, Laterite
- Shale Breccia in Sandstone

Water Level
- Surfaces
- Known Boundary
- Probable Boundary
- Possible Boundary
# Engineering Log - Excavation

**Client:** KINHILL ENGINEERS  
**Project:** HUDSON CREEK SEWERAGE TREATMENT PLANT  
**Pit Location:** DRAWING NO. D81/1-1  
**Equipment Type and Model:** BACKHOE  
**Excavation Dimensions:** 2.5 m long, 0.6 m wide

<table>
<thead>
<tr>
<th>Method</th>
<th>Support Water</th>
<th>Notes/Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>BACKHOE</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Graphic Log</th>
<th>Classification Symbol</th>
<th>Material Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2</td>
<td></td>
<td>GC</td>
<td>Brown, Topsoil</td>
</tr>
<tr>
<td>0.5</td>
<td></td>
<td>CL</td>
<td>GRAVELLY CLAY, medium plastic, yellow-grey, subrounded coarse.</td>
</tr>
<tr>
<td>1.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.5</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Consistency Index:** M  
- **Hand Sampling:** VS  
- **P.P.:** 80-100 KPa  
- **C.U.:** 40-50 KPa

**Notes:**  
- Groundwater flowing freely, caving after 10 min.  
- Terminated @ 1.8m at GWT

**Key:**  
- N: Natural Exposure  
- E: Excavation  
- BH: Backhoe Bucket  
- B: Bulldozer Blade  
- R: Ripper  

**Consistency/Density Index:**  
- VS: Very Soft  
- S: Soft  
- F: Fat  
- SI: Silty  
- VF: Very Fat  
- H: Hard  
- VH: Very Hard  
- VL: Very Loose  
- CL: Clayey  
- MD: Medium Dense  
- D: Dense  
- VD: Very Dense
### Engineering Log

**Excavation**

**Client:** KINHILL ENGINEERS  
**Project:** HUDSON CREEK SEWERAGE TREATMENT PLANT  
**Pit Location:** AS PER DRAWING D81/1-1

**Equipment Type and Model:** BACKHOE  
**Excavation Dimensions:** 3.0 m long, 0.6 m wide

<table>
<thead>
<tr>
<th>Method</th>
<th>Penetration</th>
<th>Support</th>
<th>Notes</th>
<th>Depth (metres)</th>
<th>Classification Symbol</th>
<th>Material</th>
<th>Moisture Condition</th>
<th>Consistency Index</th>
<th>Hand Consistency</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>123</td>
<td></td>
<td></td>
<td></td>
<td>0.5</td>
<td>GC</td>
<td>SANDY GRAVELLY CLAY, medium plasticity, yellow coarse.</td>
<td>M</td>
<td>D</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.0</td>
<td>GC</td>
<td>GRAVELLY CLAY, medium plastic, red-brown, sub-rounded coarse gravel.</td>
<td>W</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.5</td>
<td>SC</td>
<td>SANDY CLAY, medium plasticity.</td>
<td>W</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>GC</td>
<td>GRAVELLY CLAY, cemented with interbedded SANDY CLAY, red-brown, coarse.</td>
<td>W</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Terminated @ 1.8m at GWT

---

**Key**

- **N**: Natural exposure
- **E**: Existing excavation
- **BH**: Backhoe bucket
- **R**: Ripper

**Support**

- **

---

**Additional Observations**

- **Hand Consistency Index:**
  - **p. p = 120 KPa**
  - **Perricrete cemented**

- **Columb:**
  - **p. p = 70 KPa**
  - **cu = 35 KPa**

  **Perricrete**

---

**Classification System**

- **VS**: Very stiff
- **S**: Soft
- **SS**: Stiff
- **VSS**: Very stiff
- **H**: Hard
- **Vh**: Very hard
- **CL**: Coarse
- **FL**: Fine
- **ML**: Medium

**Density Index**

- **VS**: Very stiff
- **S**: Soft
- **SS**: Stiff
- **VSS**: Very stiff
- **H**: Hard
- **Vh**: Very hard
- **CL**: Coarse
- **FL**: Fine
- **ML**: Medium
- **MV**: Medium very
- **VD**: Very dense
**Engineering Log**

**Excavation**

---

**Client:** KINHILL ENGINEERS  
**Project:** HUDSON CREEK SEWERAGE TREATMENT PLANT  
**Pit Location:** AS PER DRAWING NO. D81/1-1

**Equipment Type and Model:** BACKHOE  
**Excavation Dimensions:** 3.0 m long, 0.6 m wide

<table>
<thead>
<tr>
<th>Method</th>
<th>Penetration</th>
<th>Support</th>
<th>Water</th>
<th>Notes</th>
<th>Depth (metres)</th>
<th>Material</th>
<th>Soil Type: Plasticity or Particle Characteristics</th>
<th>Colour, Secondary and Minor Components</th>
<th>Moisture Condition</th>
<th>Consistency/Density Index</th>
<th>Hand Compressometer</th>
<th>Structure and Additional Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>123</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>DL</td>
<td>Dark grey, TOPSOIL</td>
<td>D</td>
<td>p.p = 500 KPa</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CL</td>
<td>SANDY CLAY, medium, red-brown, plasticity coarse sand/indurated</td>
<td>M</td>
<td>p.p = 150 KPa</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CL</td>
<td>CLAY, medium plastic grey-yellow.</td>
<td>W S</td>
<td>p.p = 20 KPa</td>
<td>greasy feel</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SC</td>
<td>CLAYEY SAND/GRAVEL, coarse subangular, red-brown (dark), plastic fines.</td>
<td>W SAT</td>
<td>p.p = 150 KPa</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Terminated @ 1.8m at GWT</td>
<td></td>
<td></td>
<td>FERRIGRETE</td>
<td>slightly cemented</td>
<td></td>
</tr>
</tbody>
</table>

---

**Terminated:**

- **Structure and Additional Observations:**
  - FERRIGRETE
  - slightly cemented

---

**Key:**

- **N:** Natural exposure
- **E:** Existing excavation
- **BH:** Backhoe bucket
- **B:** Bulldozer blade
- **S:** Roper

---

**Notes:**

- **Samples and Tests:**
  - Undisturbed sample 50 mm diameter
  - Disturbed sample
  - Standard penetration test - N = result
  - SPT + sample
  - Cone penetrometer

---

**Classification Symbols:**

- **Soil Type:**
  - D: Dry
  - M: Medium
  - W: Wet

---

**Consistency/Density Index:**

- **Soil Type:**
  - VS: Very soft
  - S: Soft
  - St: Stiff
  - SS: Very stiff
  - H: Hard
  - PL: Plastic
  - CL: Very loose
  - ML: Medium dense
  - D: Dense
  - VD: Very dense
Excavation Log

Client: Kinhill Engineers

Excavation performed by:

Client: Kinhill Engineers

Location: As per drawing no. D81-1-1

Project: Hudson Creek Sewage Treatment Plant

Client: Kinhill Engineers

Equipment Type and Model: BACKHOE

Additional Observations:

Material: TOPSOIL

Depth: 0.5 - 2.0 m

Sample: monitoring borehole

Notes: monitoring borehole

Datum: 0.0

Surface: 0.0

Equipment: F-1

Client: Kinhill Engineers

Office and Job no. 081/1
# Engineering Log: Excavation

**Client:** KINHILL ENGINEERS  
**Project:** HUDSON CREEK SEWERAGE TREATMENT PLANT  
**Pit Location:** AS PER DRAWING NO. D81/1-1

**Equipment Type and Model:** BACKHOE  
**Excavation Dimensions:** 2.3 m long, 0.6 m wide

**Notes:**
- Material type: Plasticity or particle characteristics, colour, secondary and minor components
- Structure and additional observations

**Graphical Log:**
- Water level 10. Jan. 75 ft above datum

<table>
<thead>
<tr>
<th>Layer</th>
<th>Classification Symbol</th>
<th>Material Description</th>
<th>Colour, Plasticity</th>
<th>Depth</th>
<th>Notes</th>
<th>Additional Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>DL</td>
<td>TOPSOIL, grey.</td>
<td>D S</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.5</td>
<td></td>
<td>p.p = 30, 20 KPa</td>
</tr>
<tr>
<td></td>
<td>CLAYEY SAND, subrounded yellow-grey, plastic fines</td>
<td>M F</td>
<td></td>
<td>1.0</td>
<td></td>
<td>Cemented FERRICRETE</td>
</tr>
<tr>
<td></td>
<td>SANDY CLAY, medium/high plasticity, grey (light) subrounded sand.</td>
<td>M VS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SANDY GRAVELLY CLAY, medium plasticity, brown-grey, angular gravel.</td>
<td>H</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Terminated @ 1.3m on refusal**

---

**Key:**
- **N** Natural exposure
- **E** Excavating excavation
- **B** Backhoe bucket
- **G** Bulldozer blade
- **R** Ripper

---

**Diagram:**
- Water level 10. Jan. 75 ft above datum

---

**Table:**
- **Consistency/Drainage Index:**
  - VS: Very slow
  - S: Slow
  - F: Fairly
  - SL: Slightly
  - VS: Very stiff
  - H: Hard
  - Fb: Freeable
  - VL: Very loose
  - LS: Loose
  - MC: Medium dense
  - DO: Dense
  - VD: Very dense
**Engineering Log: Excavation**

**Client:** KINHILL ENGINEERS  
**Project:** HUDSON CREEK SEWAGE TREATMENT PLANT  
**Pit Location:** AS PER DRAWING NO. D81/1

**Pit Dimensions:** 3.2 m long, 0.6 m wide

<table>
<thead>
<tr>
<th>Method</th>
<th>Support</th>
<th>Notes</th>
<th>Depth (m)</th>
<th>Classification</th>
<th>Material Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>D13</td>
<td></td>
<td>water samples,</td>
<td>0.5</td>
<td>D</td>
<td>TOPSOIL, Black</td>
</tr>
<tr>
<td></td>
<td></td>
<td>tests, etc.</td>
<td></td>
<td></td>
<td>P.P = 200 KPa</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>1.0</td>
<td>M</td>
<td>GRAVELLY / SANDY CLAY, medium plasticity, red-brown, subangular coarse gravel.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>VSt</td>
<td>p.P = 20-30 KPa</td>
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<td></td>
<td></td>
<td>1.5</td>
<td>M</td>
<td>SANDY CLAY, medium/high plasticity, grey-yellow, very soft in grey soft/firm in yellow.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2.0</td>
<td>W</td>
<td>BEDROCK SILSTONE, saturated on surface.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Terminated @ 2:3m on rock refusal.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Horizontal bedding 10-20KPa.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Cracks 1-2mm see-page in cracks.</td>
</tr>
</tbody>
</table>

**Key:**
- **N:** Natural exposure
- **E:** Excavation
- **BH:** Backhoe bucket
- **B:** Bulldozer blade
- **R:** Ripper

**Notes:**
- **USG:** Undisturbed sample 50 mm diameter
- **D:** Disturbed sample
- **N:** Standard penetration test
- **Nc:** SPT + cone penetrometer

**Classification Symbols:**
- **VS:** Very soft
- **S:** Soft
- **F:** Firm
- **SL:** Stiff
- **SDF:** Very stiff
- **H:** Hard
- **Fb:** Fibrile
- **VL:** Very loose
- **L:** Loose
- **MD:** Medium dense
- **WO:** Very dense

**Samples and Tests:**
- **V**: 10 Jan 76, water level on data shown
- **N**: Water stable
- **W**: Water soluble

**Bedrock:** Siltstone, saturated on surface.

**Supervision:**
- **K.F.**

**Checked by:**
- **K.F.**

**Pit Commenced:** 24.6.88

**Datum:**
- M

**Pit No.:** TP 6

**Sheet of:** [Diagram not shown]
# Engineering Log

## Excavation

**Client:** KINHILL ENGINEERS

**Project:** HUDSON CREEK SEWAGE TREATMENT PLANT

**Location:** AS PER DRAWING NO. D81/1-1

**Equipment Type and Model:** BACKHOE

**Excavation Dimensions:** 2.0 m long, 0.6 m wide

**Notes:**

- Phyllite with interbedded quartz lumps, weathered.
- TP 7R Terminated @ 0.3m on rock refusal.

**Additional Observations:**

- Very hard, spark on quartz.

---

### Table

<table>
<thead>
<tr>
<th>Method</th>
<th>Support</th>
<th>Water</th>
<th>Notes</th>
<th>Log</th>
<th>Material</th>
<th>Moisture Condition</th>
<th>Consistency/Density Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2-3</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Key**

- **N:** Natural expose
- **E:** Earth excavation
- **B:** Backhoe bucket
- **R:** Bulldozer blade
- **D:** Disturbed sample
- **W:** Wet
- **O:** Loose
- **V:** Very loose
- **D:** Dense
- **V:** Very dense

**Sample Tests:**

- **USC:** Undisturbed sample
- **D:** Disturbed sample
- **N:** Standard penetration test
- **C:** Cone penetrometer
- **Moisture:**
  - **O:** Dry
  - **W:** Wet
  - **M:** Moist
- **Consistency/Density Index:**
  - **VS:** Very soft
  - **S:** Soft
  - **SL:** Silt
  - **WS:** Very stiff
  - **H:** Hard
  - **F:** Firm
  - **VF:** Very firm
  - **V:** Vibrate
  - **D:** Dense
  - **VD:** Very dense

**Penetration Test:**

- **1 D:** 1 D
- **2 D:** 2 D
- **3 D:** 3 D

**Datum:**

- **R.L.:** Relative level
- **Surface:**
  - **m:** Meter
- **Datum:**
  - **m:** Meter

**Drawings:**

- **Number:** D81/1-1

**Supervision:**

- **R.L.:** Required level
- **K.F.:** Checked by K.F.

**Date:**

- **Commenced:** 24.6.88
- **Completed:**

---

**Office and Job No:**

- **D81/1**
**Engineering Log: Excavation**

**Client:** KINHILL ENGINEERS  
**Project:** HUDSON CREEK SEWERAGE TREATMENT PLANT  
**Pit Location:** AS PER DRAWING NO. D81/1-1

**Equipment Type and Model:** BACKHOE  
**Excavation Dimensions:** 3.2 m long, 0.6 m wide  
**R.L. Surface:** m  
**Datum:**

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Soil Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.9</td>
<td>TOPSOIL, dark grey.</td>
</tr>
<tr>
<td>1.5</td>
<td>CLAYEY SANDY GRAVEL, mixed with QUARTZ, subangular particles fines of medium to high plasticity.</td>
</tr>
<tr>
<td>2.0</td>
<td>Terminated 2 m on rock refusal.</td>
</tr>
</tbody>
</table>

**Key:**
- T: Immersing penetration 1 2 3  
- N: Natural exposure  
- E: Existing excavation  
- BH: Backhoe bucket  
- B: Bulldozer blade  
- R: Ripper

**Classification Symbols:**
- US: Undisturbed sample 50 mm diameter  
- N: Disturbed sample  
- N°: Standard penetration test, N = result  
- SPT + sample  
- M: Mohs  
- W: Wet

**Tests:**
- USO: Undisturbed sample 50 mm diameter  
- SPT: Standard penetration test  
- M: Mohs  
- W: Wet

**Additional Observations:**
- FERRICRETE cemented slightly.  
- Very hard limestone pockets of white quartz.
## Engineering Log: Excavation

**Client:** KINHILL ENGINEERS  
**Project:** HUDSON CREEK SEWERAGE TREATMENT PLANT  
**Pit Location:** AS PER DRAWING NO. DB1/1-1

### Excavation Details

- **Equipment Type and Model:** BACKHOE
- **Excavation Dimensions:** 1.5 m long, 0.6 m wide
- **R.L. Surface:** m
- **Supervision:**
  - **Commenced:** 1600/24.6.88
  - **Completed:**
  - **Supervised by:** K.F
  - **Checked by:** K.F

### Notes

- **Soil Type:**
  - **Topsoil:** grey (dark)  
  - **Gravelly Clay:** mixed with Sandstone with very hard quartz pieces, gravelly content angular.

- **Terminated at 0.8m at rock refusal.**

### Key

- **Method:**
  - N: Natural Exposure
  - E: Existing Excavation
  - BH: Backhoe Bucket
  - B: Bulldozer Blade
  - R: Ropes

- **Support:**
  - Backhoe excavation

- **Notes:**
  - USO: Undisturbed Sample (50 mm)
  - DS: Disturbed Sample
  - SPT: Standard Penetration Test
  - NC: Cone Penetrometer

### Consistency

- **VS:** Very Soft
- **S:** Soft
- **S:** Stiff
- **VS:** Very Stiff
- **H:** Hard
- **F:** Fissile
- **VL:** Very Loose
- **L:** Loose
- **MD:** Medium Dense
- **D:** Dense
- **VD:** Very Dense
### Engineering Log

**Excavation**

**Client:** KINHILL ENGINEERS  
**Project:** HUDSON CREEK SEWERAGE TREATMENT PLANT  
**Pit Location:** AS PER DRAWING NO. D81/1-1

**Equipment Type and Model:** BACKHOE

**Excavation Dimensions:**
- Long: m
- Wide: m

**RL Surface:** m

**Notes:**
- Samples, tests, etc.
- Color, secondary and minor components
- Structure and additional observations

**Material:**
- TOPSOIL grey (hard)
- SAND, subrounded, yellow,
- SANDY GRAVELLY CLAY, medium plasticity, red-brown, angular gravel.
- SILTSTONE, moderately weathered.

**Terminated @ 0.3m on rock refusal.**

---

**Key:**
- N: Natural exposure
- E: Existing excavation
- SH: Backhoe bucket
- B: Bulldozer blade
- R: Rod

**Notes:**
- US0: Undisturbed sample 50 mm diameter
- D: Disturbed sample
- N: Standard penetration test
- N': SPT + sample
- NC: Cone Penetrometer

**Classification Symbols:**
- VS: Very soft
- S: Soft
- SH: stiff
- VSH: very stiff
- H: Hard
- Fb: fragile
- VL: Very loose
- L: Loose
- MD: Medium dense
- D: Dense
- VD: Very dense

---

**Structure and Additional Observations:**
- Cemented FERRICRETE
## Engineering Log

### Excavation

**Client:** KINHILL ENGINEERS  
**Project:** HUDSON CREEK SEWERAGE TREATMENT PLANT  
**Pit Location:** AS PER DRAWING NO. D81/1-1

**Equipment Type and Model:**  
**Excavation Dimensions:** 2.0 m long, 0.6 m wide

### Notes

<table>
<thead>
<tr>
<th>Sample, tests, etc.</th>
<th>Graphic log</th>
<th>Classification symbol</th>
<th>Material</th>
<th>Moisture condition</th>
<th>Consistency index</th>
<th>Hand</th>
<th>Hammer</th>
<th>Density (kg/m^3)</th>
<th>Hand</th>
<th>Hand</th>
<th>Hammer</th>
<th>Hand</th>
<th>Density (kg/m^3)</th>
<th>Hand</th>
<th>Hand</th>
<th>Hammer</th>
<th>Hand</th>
<th>Density (kg/m^3)</th>
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<tbody>
<tr>
<td>0.3</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Material:** PHYLITTE/SANDSTONE, moderately weathered.

**Additional Observations:** Terminated @ 0.3m on rock refusal.

**Notes:**

- Some quartz lumps
- Some quartz lumps

### Key

- **Method**
  - N: Natural exposure
  - E: Excavating excavation
  - B: Backhoe bucket
  - R: Bulldozer blade

- **Support**
  - T: Timbering
  - P: Penetration 1, 2, J

- **Notes**
  - L50: Undescribed sample 50 mm diameter
  - O: Disturbed sample
  - N: Standard penetration test
  - NC: Core penetrator

**Classification Symbols and soil description** based on unified classification system

- **Moisture**
  - D: Dry
  - M: Moist
  - W: Wet

- **Consistency/Density Index**
  - VS: Very soft
  - S: Soft
  - F: Firm
  - Si: Silt
  - VSt: Very stiff
  - H: Hard
  - Fp: Fines
  - VL: Very loose
  - LG: Loose
  - MO: Medium dense
  - DG: Dense
  - VD: Very dense
# Engineering Log: Excavation

**Client:** KINHILL ENGINEERS  
**Project:** HUDSON CREEK SEWAGE TREATMENT PLANT  
**Pit Location:** AS PER DRAWING NO. D81/1-1

## Pit Dimensions
- **Equipment Type and Model:** BACKHOE
- **Excavation Dimensions:** 1.5 m long, 0.6 m wide

<table>
<thead>
<tr>
<th>Method</th>
<th>Notes</th>
<th>Support</th>
<th>Depth (m)</th>
<th>Material</th>
<th>Moisture Condition</th>
<th>Consistency Index</th>
<th>Hand Penetration kPa</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.5</td>
<td>SC, SILTY SAND, grey, low liquidity</td>
<td>D</td>
<td>L</td>
<td>p.p = 20 - 30 KPa</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1.0</td>
<td>CL, CLAY, medium plasticity</td>
<td>W</td>
<td>VS</td>
<td>p.p = 20 KPa</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1.0</td>
<td>GC, GRAVELLY CLAY, medium to high plasticity, red-brown, subrounded coarse</td>
<td>W</td>
<td>LL</td>
<td>p.p = 20 - 40 KPa</td>
</tr>
</tbody>
</table>

**Terminated @ 1.2m.**

*FERRICRETE, very slightly cemented breakable by hand.*
dynamic cone penetrometer test

client: KINHILL ENGINEERS
project: HUDSON CREEK SEWERAGE TREATMENT PLANT
location: DB1/1-1

data:
test location and level:
cumulative blows

start of test

penetration mm

profile

no.
of blows

hammer mass: 9.06 kg (20 lb)
hammer drop: 508 mm (20 in)
dynamic cone penetrometer test

client: KINHILL ENGINEERS
principal:
project: HUDSON CREEK SEWERAGE TREATMENT PLANT
location: D81/1-1

job no: S2
test location and level:

Cumulative blows

<table>
<thead>
<tr>
<th>Start of Test</th>
<th>0</th>
<th>5</th>
<th>10</th>
<th>15</th>
<th>20</th>
<th>25</th>
<th>30</th>
<th>35</th>
<th>40</th>
<th>45</th>
<th>50</th>
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<tr>
<td>Penetration mm</td>
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<td>1.5</td>
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<tr>
<td>112 mm</td>
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</table>

Profile

<table>
<thead>
<tr>
<th>No. of Blows</th>
</tr>
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<tbody>
<tr>
<td>1</td>
</tr>
<tr>
<td>1.5</td>
</tr>
<tr>
<td>1.5</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>112 mm blow</td>
</tr>
</tbody>
</table>
dynamic cone penetrometer test

client: KINHILL ENGINEERS
principal: DARWIN
project: HUDSON CREEK SEWERAGE TREATMENT PLANT
location: D81/1-1

date:
tested by:
hammer mass: 9.06 kg (20 lb)
hammer drop: 508 mm (20 in)

job no: D81/1

Profile No. of Blows

cumulative blows

test location and level:

profile

start of test

0 6 10 15 20 25 30 35 40 45 50

100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600

penetration mm
### Particle Size Distribution

**Client:** KINHILL ENGINEERS  
**Principal:** HUDSON CREEK  
**Location:** DARWIN, NT  
**Sample Identification:** S930 TP 4  
**Test Procedure:** AS1289, C1.1, C2.1, C3.1, C4.1  
**Date:** 4/7/88  
**Tested by:** A.L  
**Checked by:** A.L  
**Depth:** 2.2 - 2.4 m

#### AS sieve size distribution

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<th>AS sieve size</th>
<th>0.150mm</th>
<th>0.125mm</th>
<th>0.100mm</th>
<th>0.075mm</th>
<th>0.063mm</th>
<th>0.042mm</th>
<th>0.035mm</th>
<th>0.025mm</th>
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</thead>
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<tr>
<td></td>
<td>75%</td>
<td>50%</td>
<td>25%</td>
<td>10%</td>
<td>7%</td>
<td>4%</td>
<td>2%</td>
<td>1%</td>
</tr>
<tr>
<td></td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

#### Particle Size - Millimetres

- **Clay:** fine, medium, coarse  
- **Silt:** fine, medium, coarse  
- **Sand:** fine, medium, coarse  
- **Gravel:** fine, medium, coarse  
- **Cobbles:**

#### Liquid Limit

- **%:** 45

#### Plastic Limit

- **%:** 19

#### Plasticity Index

- **%:** 26

#### Linear Shrinkage

- **%:** 8.0

#### Particle Density (dry)

- **g/cm³:**

#### Natural Moisture %

- **%:**

**Classification:**

CL SANDY GRAVELLY CLAY, medium plasticity fines, white, fine to coarse sand, fine to coarse angular gravel.

---

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Authorised Signature: [Signature]

Date: 6/7/88
particle size distribution

client  KINHILL ENGINEERS
principal
project  HUDSON CREEK
location  DARWIN, NT
sample identification  S919 TP1 0.6 - 0.7m
test procedure  AS1289.C1.1, C2.1, C3.1, C4.1.

<table>
<thead>
<tr>
<th>particle size - millimetres</th>
<th>0.002</th>
<th>0.06</th>
<th>2.0</th>
<th>60</th>
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<tr>
<td>clay</td>
<td>fine</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>silt</td>
<td>medium</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sand</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>gravel</td>
<td></td>
<td>fine</td>
<td></td>
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</tr>
<tr>
<td>cobbles</td>
<td></td>
<td></td>
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</tbody>
</table>

AS-1289

liquid limit %  37
plastic limit %  14
plasticity index %  23
linear shrinkage %  7.0
particle density cm³  -
natural moisture %  -

classification
CL GRAVELLY SANDY CLAY, medium plasticity fines, grey, fine to coarse sand, fine to coarse angular gravel.

C

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Authorized Signature

10/7/88
particle size distribution

client
KINHILL ENGINEERS

principal

project
HUDSON CREEK

location
DARWIN, NT

test procedure
AS1289.C1.1, C2.1, C3.1, C4.1, C5.1, C6.1

percentage finer than size

AS sieve size

75µm
150µm
300µm
425µm
600µm
1.18mm
2.36mm
4.75mm
6.7mm
9.5mm
13.2mm
20mm
25.4mm
31.5mm
40mm
50mm
75mm
150mm

width

depth 1.8m E

Further information:

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classification

GC  SANDY CLAYEY GRAVEL, fine to coarse subangular gravel, brown, fine to coarse sand, medium plasticity fines.
<table>
<thead>
<tr>
<th>Soil Core</th>
<th>Slaking</th>
<th>Remoulded at Plastic Limit</th>
<th>Condition</th>
<th>Time</th>
<th>Hour</th>
<th>Condition</th>
<th>Time</th>
<th>Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>S918</td>
<td>Slaking</td>
<td>No change</td>
<td>Clear Water; Class 6</td>
<td>10</td>
<td>min</td>
<td>No change</td>
<td>10</td>
<td>min</td>
</tr>
<tr>
<td>S919</td>
<td>Slaking</td>
<td>No change</td>
<td>Clear Water; Class 6</td>
<td>10</td>
<td>min</td>
<td>No change</td>
<td>10</td>
<td>min</td>
</tr>
<tr>
<td>S920</td>
<td>Slaking</td>
<td>No change</td>
<td>Clear Water; Class 6</td>
<td>10</td>
<td>min</td>
<td>No change</td>
<td>10</td>
<td>min</td>
</tr>
</tbody>
</table>
APPENDIX A-2
SUPPLEMENTARY INVESTIGATION
22nd November, 1988

Kinhill Enigneers
37 McMinn Street
DARWIN NT 0800

ATTENTION: Mr. J. Thorpe

Dear Sir,

RE: East Arm Sewerage Treatment Ponds

Site investigation work regarding the above project was carried out on 18th November, 1988. For the excavation of test pits a KATO - HD 1220-SE 30t excavator was used, with a 1,200mm bucket.

The test pits were excavated in those areas of the site of proposed development, where our previous backhoe investigation encountered rock refusal at shallow depth. The layers encountered in the excavator are summarised in Table 1.

Further comments to Table 1:

EP 1: excavation of SILSTONE is very hard, slow 0.5m³ excavated in approximately 10 minutes. Applicable, very slow.

EP 2: refusal, not rippable with excavator, partly due to very soft topsoil.

EP 5.7: excavation of FERRICRETE is slow, but no refusal.

EP 6: excavation of SILSTONE is very hard barely rippable, excavator had refusal.

The above observations can be summarised as follows:-
1). Excavation of GRAVELLY CLAY (Ferricrete) and SANDY CLAY (mudstone) can be carried out with sufficiently large excavator.

2). Excavation of SILTSTONE/PHYLLITE is very hard using an excavator. It might be expected that using a dozer of D7 size (or similar), the SILTSTONE could be more efficiently ripped.

Please advise us if you require further information on this matter. I shall be happy to assist you promptly.

Yours faithfully,

COFFEY AND PARTNERS PTY LTD

Kris Fabian

Attach: "Important Information about your Geotechnical Engineering Report".
ATTENTION: Mr. J. Thorpe

Dear Sir,

RE: East Arm Sewerage Treatment Ponds

Site investigation work regarding the above project was carried out on 18th November, 1988. For the excavation of test pits a KATO - HD 1220-SE, 30t excavator was used, with a 1,200mm bucket.

The test pits were excavated in those areas of the site of proposed development, where our previous backhoe investigation encountered rock refusal at shallow depth. The layers encountered in the excavator are summarised in Table 1.

Further comments to Table 1:

- **EP 1**: excavation of SILSTONE is very hard, slow 0.5m³ excavated in approximately 10 minutes. Ripppable, very slow.
- **EP 3**: refusal, not ripppable with excavator, partly due to very soft topsoil.
- **EP 5**: excavation of PERRICRETE is slow, but no refusal.
- **EP 6**: excavation of SILSTONE is very hard barely ripppable, excavator had refusal.

The above observations can be summarised as follows:
<table>
<thead>
<tr>
<th>EXCAVATION PIT</th>
<th>LOCATION</th>
<th>LAYERS ENCOUNTERED</th>
</tr>
</thead>
<tbody>
<tr>
<td>EP 1</td>
<td>Near TP 6</td>
<td>0 - 0.3 Topsoil</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.3 - 1.3m CLAYEY GRAVEL (ferricrete)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.3 - 2.8m SANDY CLAY</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.8m Refusal on SILTSTONE</td>
</tr>
<tr>
<td>EP 2</td>
<td>50m North of TP 6</td>
<td>0 - 0.3 Topsoil</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.3 - 1.8m CLAYEY GRAVEL (ferricrete)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.8 - 2.3m SANDY CLAY</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.3m Refusal on SILTSTONE</td>
</tr>
<tr>
<td>EP 3</td>
<td>At TP 5</td>
<td>0 - 0.2m Topsoil</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.2 - 1.3m SANDY CLAY</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.2m Refusal on SILTSTONE</td>
</tr>
<tr>
<td>EP 4</td>
<td>50m East of TP 7</td>
<td>0 - 0.2m Topsoil</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.2 - 1.5m CLAYEY GRAVEL (ferricrete)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.5 - 2.0m SANDY CLAY (porcellanite/mudstone)</td>
</tr>
<tr>
<td>EP 5</td>
<td>Near TP 7 R</td>
<td>0 - 0.2m Topsoil</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.2 - 1.8m GRAVELLY CLAY (ferricrete)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.8 - 3.3m SANDY CLAY (porcellanite/mudstone)</td>
</tr>
<tr>
<td>EP 6</td>
<td>Near TP 8</td>
<td>0 - 0.3m Topsoil</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.3 - 0.6m GRAVELLY CLAY</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.6 - 1.2m GRAVELLY CLAY (ferricrete)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.2m Refusal on PHYLLITE/SILTSTONE</td>
</tr>
<tr>
<td>EP 7</td>
<td>30m East of TP 9</td>
<td>0 - 0.2m Topsoil</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.2 - 2.6m GRAVELLY CLAY (ferricrete)</td>
</tr>
</tbody>
</table>

NOTES: 1) n/e - not encountered
2) approximate TP locations given in Report no. DB1/1.
1). Excavation of GRAVELLY CLAY (Ferricrete) and SANDY CLAY (mudstone) can be carried out with sufficiently large excavator.

2). Excavation of SILTSTONE/PHYLLITE is very hard using an excavator. It might be expected, that using a dozer of D7 size (or similar), the SILTSTONE could be more efficiently ripped.

Please advise us if you require further information on this matter. I shall be happy to assist you promptly.

Yours faithfully,
COFFEY AND PARTNERS PTY LTD

Kris Fabian

Attach: "Important Information about your Geotechnical Engineering Report".
<table>
<thead>
<tr>
<th>EXCAVATION PIT LOCATION</th>
<th>LAYERS ENCOUNTERED</th>
</tr>
</thead>
<tbody>
<tr>
<td>EP 1 Near TP 6</td>
<td>0 - 0.3 Topsoil</td>
</tr>
<tr>
<td></td>
<td>0.3 - 1.3m CLAYEY GRAVEL (ferricrete)</td>
</tr>
<tr>
<td></td>
<td>1.3 - 2.0m SANDY CLAY</td>
</tr>
<tr>
<td></td>
<td>2.8m Refusal on SILTSTONE 2m</td>
</tr>
<tr>
<td>EP 2 50m North of TP 6</td>
<td>0 - 0.3 Topsoil</td>
</tr>
<tr>
<td></td>
<td>0.3 - 1.8m CLAYEY GRAVEL (ferricrete)</td>
</tr>
<tr>
<td></td>
<td>1.8 - 2.3m SANDY CLAY</td>
</tr>
<tr>
<td></td>
<td>2.3m Refusal on SILTSTONE 2m</td>
</tr>
<tr>
<td>EP 3 At TP 5</td>
<td>0 - 0.2m Topsoil</td>
</tr>
<tr>
<td></td>
<td>0.2 - 1.3m SANDY CLAY</td>
</tr>
<tr>
<td></td>
<td>1.2m refusal on SILTSTONE n/e</td>
</tr>
<tr>
<td>EP 4 50m East of TP 7</td>
<td>0 - 0.2m Topsoil</td>
</tr>
<tr>
<td></td>
<td>0.2 - 1.5m CLAYEY GRAVEL (ferricrete)</td>
</tr>
<tr>
<td></td>
<td>1.5 - 2.0m SANDY CLAY (porcellanite/mudstone) n/e</td>
</tr>
<tr>
<td>EP 5 Near TP 7 R</td>
<td>0 - 0.2m Topsoil</td>
</tr>
<tr>
<td></td>
<td>0.2 - 1.8m GRAVELLY CLAY (ferricrete)</td>
</tr>
<tr>
<td></td>
<td>1.8 - 3.3m SANDY CLAY (porcellanite/mudstone) n/e</td>
</tr>
<tr>
<td>EP 6 Near TP 8</td>
<td>0 - 0.3m Topsoil</td>
</tr>
<tr>
<td></td>
<td>0.3 - 0.6m GRAVELLY CLAY</td>
</tr>
<tr>
<td></td>
<td>0.6 - 1.2m GRAVELLY CLAY (ferricrete)</td>
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<tr>
<td></td>
<td>1.2m refusal on PHYLLITE/SILTSTONE n/e</td>
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<tr>
<td>EP 7 30m East of TP 9</td>
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<td>0.2 - 2.6m GRAVELLY CLAY (ferricrete) n/e</td>
</tr>
</tbody>
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NOTES: 1) n/e - not encountered
2) approximate TP locations given in Report no. D81/1.