Dear Sir

re: Proposed Two Billboards  
M7 Motorway (Dean Park and Eastern Creek)  
Geotechnical Investigation

This report provides the results of a geotechnical investigation at the above locations. The investigation was commissioned by Mr S Audet of Complete Urban Pty Ltd in an email dated 15 October 2010, and was carried out in general accordance with Geotechnique Pty Ltd proposal Q5160, dated 15 October 2010.

Proposed Development
It is understood that two billboards would be constructed for the Western Sydney Parklands, along the M7 Motorway at the following sites:

- Near Symonds Road, Dean Park
- Near Church Street, Eastern Creek

A geotechnical investigation was required to assess foundation conditions at the locations of the proposed billboards.

Field Work
Field work for the investigation was carried out on 26 and 27 October 2010 and consisted of the following:

- A walk over survey to assess existing site conditions.
- Scanning borehole locations for underground services. A specialist services locator was engaged for this purpose.
- Drilling one borehole at each site (BH1 at Eastern Creek and BH2 at Dean Park) using a truck mounted drilling rig fully equipped for geotechnical investigation. Boreholes were terminated at depths of about 9m. Boreholes were initially drilled using V and TC bits to refusal, and then cored to recover rock cores. Approximate borehole locations are indicated on the attached Drawings 12360/1-AA1 and 12360/1-AA2. Engineering borehole logs and core photographs are also attached.
- Conducting Standard Penetration Tests (SPT) at regular depth intervals to assess strength and compressibility characteristics of sub-surface soils.
- Recovering soil samples for visual assessment and laboratory testing.

Field work was supervised by a Geotechnical Engineer from this company, responsible for nominating the borehole locations, sampling and preparation of field logs.
Regional Geology

Eastern Creek
Reference to the Geological Map of Penrith (1:100,000) indicates that the site is underlain by the following:

- Quaternary Deposits comprising fine grained sand, silt and clay and silt or;
- Bringelly Shale, belonging to the Wianamatta Group of shales and comprising shale, carbonaceous claystone, laminitie, fine to medium grained lithic sandstone, rare coal.

Reference to the Soil Landscape Map (1:100,000) of Penrith indicates that the landscape of the site is likely to belong to the South Creek Group, which comprises flood plains, valleys, flats and drainage depressions of channels on the Cumberland plains, usually flat with incised channels. Soils in this landscape are often very deep layers of sediments over bedrock or relict soils. This landscape is subject to frequent flooding and erosion hazards.

Dean Park
Reference to the Geological Map of Penrith (1:100,000) indicates that the site is underlain by Quaternary Deposits comprising fine grained sand, silt and clay and silt.

Reference to the Soil Landscape Map (1:100,000) of Penrith indicates that the landscape of the site is likely to belong to the South Creek Group.

Site Conditions

Eastern Creek
The proposed billboard site is located on the eastern side of the M7 Motorway (Western Sydney Parklands) near Church Street, Eastern Creek. The ground surface near the site is generally flat and covered with grass. There is a boundary fence on the western side of the site.

Dean Park
The proposed billboard site is located on the southern side of the M7 Motorway (Western Sydney Parklands) near Symonds Street, Dean Park. The ground surface is covered with grass. There is a drainage trench, boundary fence and bicycle path on the northern side of the site. There are some shrub mounds on the eastern side.

Sub-surface Conditions
Sub-surface conditions encountered at the site are detailed in the attached borehole logs and summarised below in Table 1.

<table>
<thead>
<tr>
<th>Site Location</th>
<th>BH</th>
<th>Termination Depth (m)</th>
<th>Topsoil (m)</th>
<th>Natural (m)</th>
<th>Bedrock (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eastern Creek</td>
<td>1</td>
<td>9.0</td>
<td>0.0 – 0.4</td>
<td>0.4 – 5.4</td>
<td>5.4 -&gt; 9.0</td>
</tr>
<tr>
<td>Dean Park</td>
<td>2</td>
<td>8.9</td>
<td>0.0 – 0.3</td>
<td>0.3 – 5.4</td>
<td>5.4 -&gt; 8.9</td>
</tr>
</tbody>
</table>
BH1 - Eastern Creek

Topsoil
Clayey Silt, low plasticity, pale brown, roots and root fibres

Natural (Alluvial & Residual)
Silty Clay, medium plasticity, yellow-brown
Sandy Clayey Gravel, fine grained, yellow, red-brown, with rounded ironstone pebbles and gravel
Silty Clay, high plasticity, pale grey-yellow with ironstone gravel layers
Shaley Clay, medium plasticity, yellow-brown

Bedrock
Shale, yellow-grey-brown, extremely low to very low strength, extremely weathered
Shale/Siltstone, grey, distinctly to slightly weathered, low to medium strength
Shale, with minor Sandstone intercalated, grey, light grey, distinctly to slightly weathered medium strength

BH2 - Dean Park

Topsoil
Clayey Silt, low plasticity, pale brown, roots and root fibres

Natural (Alluvium)
Silty Clay, medium to high plasticity, mottled yellow-orange-grey
Silty Sandy Clay, low plasticity, pale yellow brown, with clayey sand layers
Clayey Sand, fine grained, yellow-brown, grey with sandy clay layers
Clayey Sandy Gravel, fine grained, with ironstone gravels and pebbles

Bedrock
Shale and Ironstone interbedded, grey-red-brown, extremely low strength, extremely weathered
Shale, grey, slightly weathered to fresh with depth, medium to high strength.
Sandstone, fine grained, light grey, with minor shale laminae

Groundwater Conditions
BH1 (Eastern Creek) encountered minor seepage at about 3m, and BH2 (Dean Park) encountered groundwater at about 3.3m. It should be noted that seepage and groundwater levels might vary due to changes in rainfall, temperature and other factors not evident during drilling.

Laboratory Testing
Point Load Strength Index Tests
Rock cores recovered from the boreholes were photographed and tested for determination of point load strength index ($f_{pk}$). The point load strength indices for the rock cores and the assessed rock strength classes for axially loaded samples, in accordance with Australian Standards (Reference 1), are summarised in the following Table 2.
**TABLE 2**

<table>
<thead>
<tr>
<th>BH</th>
<th>Depth (m)</th>
<th>Diametral Point Load Strength Index (MPa)</th>
<th>Axial Point Load Strength Index (MPa)</th>
<th>Estimated Axial Strength (Reference 1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6.3</td>
<td>-</td>
<td>0.02</td>
<td>Extremely Low</td>
</tr>
<tr>
<td>1</td>
<td>6.95</td>
<td>-</td>
<td>0.04</td>
<td>Very Low</td>
</tr>
<tr>
<td>1</td>
<td>7.4</td>
<td>0.13</td>
<td>0.14</td>
<td>Low</td>
</tr>
<tr>
<td>1</td>
<td>8.6</td>
<td>0.08</td>
<td>0.31</td>
<td>Low/Medium</td>
</tr>
<tr>
<td>2</td>
<td>6.3</td>
<td>0.04</td>
<td>0.43</td>
<td>Medium</td>
</tr>
<tr>
<td>2</td>
<td>6.65</td>
<td>0.07</td>
<td>1.11</td>
<td>High</td>
</tr>
<tr>
<td>2</td>
<td>7.3</td>
<td>1.33</td>
<td>2.19</td>
<td>High</td>
</tr>
<tr>
<td>2</td>
<td>7.8</td>
<td>2.75</td>
<td>3.56</td>
<td>Very High</td>
</tr>
<tr>
<td>2</td>
<td>8.65</td>
<td>1.91</td>
<td>4.42</td>
<td>Very High</td>
</tr>
</tbody>
</table>

**Bedrock Classification**

Based on rock strengths (Table 2) and rock discontinuities shown in the borehole logs, bedrock at the site is classified for foundation design in accordance with Pells et al (Reference 2) and shown in Table 3 below.

**TABLE 3**

<table>
<thead>
<tr>
<th>Location</th>
<th>BH</th>
<th>Top Depth to Class V Rock (m)</th>
<th>Top Depth to Class IV (m)</th>
<th>Top Depth to Class III or Better (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eastern Creek</td>
<td>1</td>
<td>5.4</td>
<td>6.8</td>
<td>7.4</td>
</tr>
<tr>
<td>Dean Park</td>
<td>2</td>
<td>5.4</td>
<td>-</td>
<td>6.5</td>
</tr>
</tbody>
</table>

**Discussion and Recommendations**

**Excavation Conditions**

We anticipate that excavation for construction of footings for the proposed billboards will be about 1m to 2m. Sub-surface materials to the anticipated excavation depths are anticipated to be topsoil and natural soils. These materials can be readily excavated using conventional earthmoving equipment, such as excavators and dozers.

BH1 encountered minor seepage at about 3m and BH2 encountered groundwater at about 3.3m. We do not expect footing excavations to reach these depths, hence we do not anticipate groundwater related problems during footing excavations. However, due to variations in rainfall and/or other factors, groundwater level or seepage might be encountered during excavation. If minor groundwater/seepage is encountered in footing excavations it could be removed by conventional pump and sump system.

Trafficability problems might arise locally during wet weather or if water is allowed to pond at the site.

**Footings**

**BH1 - Eastern Creek**

The proposed billboard at this site could either be supported on shallow footings (pad type) founded in natural soils or deep footings (bored piers) founded in bedrock. Footings should be designed for the following bearing pressure values.
TABLE 5A

<table>
<thead>
<tr>
<th>Founding Material</th>
<th>Serviceability End Bearing Pressures (kPa)</th>
<th>Allowable Shaft Adhesion (kPa)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Soils (Stiff Clays or Medium Dense Sands)</td>
<td>150</td>
<td>-</td>
</tr>
<tr>
<td>Class V Rock</td>
<td>700</td>
<td>50</td>
</tr>
<tr>
<td>Class IV Rock</td>
<td>1000</td>
<td>75</td>
</tr>
<tr>
<td>Class III Rock</td>
<td>3000</td>
<td>300</td>
</tr>
</tbody>
</table>

* Clean Socket of roughness category R2 or better as per Pells et al (Reference 2)

BH2 - Dean Park

BH2 encountered topsoil, overlying alluvium comprising firm to soft clays and loose to medium dense sands/gravels, overlying shale bedrock.

Considering that soft clays are encountered between depths of 1.2m and 2.8m, followed by loose sands to a depth of about 4.4m, shallow footings founded on these materials may undergo large settlements which may be detrimental to the proposed structure. Hence it will be prudent to support the proposed billboard at this location on deep footings (board piers or continuous flight augers).

TABLE 5B

<table>
<thead>
<tr>
<th>Founding Material</th>
<th>Serviceability End Bearing Pressures (kPa)</th>
<th>Allowable Shaft Adhesion (kPa)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class V Rock</td>
<td>700</td>
<td>50</td>
</tr>
<tr>
<td>Class III/II Rock</td>
<td>4000</td>
<td>400</td>
</tr>
</tbody>
</table>

* Clean Socket of roughness category R2 or better as per Pells et al (Reference 2)

Total settlements of footings for the proposed billboards bearing in stiff natural clays or medium dense sands, under the recommended allowable bearing pressure, are anticipated to be about 20mm to 25mm. Total settlements of footings bearing in the bedrock, under the recommended allowable bearing pressures, are estimated to be about 1% of the minimum dimension of footings or pier. Differential settlements are estimated to be about half the estimated total settlements.

It is recommended that footings are not placed on any loose/soft soil/rock or clay bands. If such materials are encountered they should be removed and replaced with controlled fill/mass concrete. All footing excavations should be inspected and tested, as deemed necessary by a qualified geotechnical engineer, prior to placement of concrete.

As founding materials are likely to vary, it is important that an experienced geotechnical engineer/engineering geologist inspect the footing excavations prior to pouring concrete, to ensure that all footings are founded on competent bearing stratum.

Deep Footings Construction

BH1 (Eastern Creek) encountered seepage at about 3m depth. Due to seepage, it is possible that the sides of the pier holes, especially in the gravelly layer, may collapse.

BH2 (Dean Park) encountered groundwater at about 3.3m. Considering that soft clays and loose and medium dense sandy and gravelly soils were encountered, there will be considerable seepage into the pier holes. Due to the groundwater seepage, the sides of the pier holes might collapse.
Therefore, temporary casings are made available to support the sides during drilling. Also, dewatering of the pier holes will be required prior to placement of concrete, which should be placed using the tremie method.

Alternatively, Continuous Flight Auger (CFA) piles could be used to support the proposed billboards. Integrity testing using a Pile Driving Analyzer (PDA) should be conducted to ensure that constructed CFA piles are not defective.

**Uplift and Lateral Capacities**

In calculating uplift capacity of footings, the weight of the footing and soil above it, as well as perimeter resistance along the failure surface shall be considered. In calculating perimeter resistance, an allowable adhesion value of 20kPa can be considered for stiff clays. For sandy soils, beta value can be taken as 0.2 (i.e. coefficient of friction x coefficient of earth pressure).

In calculating uplift capacity of bored piers socketed in bedrock, 50% of the recommended shaft adhesion values (Table 5a and 5b) should be used.

For estimating lateral capacity of shallow footings, a coefficient of friction between the concrete and underlying soils (stiff clays or medium dense sand) can be taken as 0.35. The coefficient of passive and active pressure values can be taken as 3.0 and 0.3. The coefficient of passive pressure for Class V/IV bedrock can be taken as 300kPa and Class III as 1500kPa.

Appropriate safety factors (1.5 to 2) should be applied in calculating allowable uplift and lateral capacities.

**General**

As the recommendations presented in this report are based on information from one borehole drilled at each site, actual sub-surface conditions within the site/footing area might differ from those expected (interpreted). If such differences appear to exist or are encountered during construction, we recommend that this office is contacted for further advice. This can also occur with groundwater conditions, especially after climatic changes.

If you have any questions regarding this report, please do not hesitate to contact the undersigned.

Yours faithfully

GEOTECHNIQUE PTY LTD

Reviewed by

ZIAUDDIN AHMED
Senior Geotechnical Engineer

EMGED RIZKALLA
Director

Attached
Drawing No 12360/1-AA1 & 12360/1-AA2 - Borehole Location Plan
Borehole Logs
Core Photographs
Explanatory Notes

**References**

NOTES

1. Site features are indicative and are not to scale.
2. This drawing has been produced using a base plan provided by others to which additional information e.g. test pits, borehole locations or notes have been added. Some or all of the plan may not be relevant at the time of producing this drawing.

LEGEND

- Borehole

Complete Urban Pty Ltd
Proposed Billboards
Site 2, M7 Motorway
Near Church Street, Eastern Creek

Borehole Location Plan

Drawing No: 12360/1-AA1
Job No: 12360/1
Drawn By: MH
Date: 28 October 2010
Checked By: ZA

File No: Drawing 12360-1
Layers: 0, AA1
NOTES

1. Site features are indicative and are not to scale.

2. This drawing has been produced using a base plan provided by others to which additional information e.g. test pits, borehole locations or notes have been added. Some or all of the plan may not be relevant at the time of producing this drawing.
### MATERIAL DESCRIPTION

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Plasticity or Particle Characteristic, Colour, Secondary and Minor Components</th>
<th>Moisture Condition</th>
<th>Consistency Index</th>
<th>Hand Penetrometer kPa</th>
<th>Remarks and Additional Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topsoil; Clayey Silt, low plasticity, pale brown, roots and root fibres</td>
<td>M&gt;PL</td>
<td>CI</td>
<td>Silty Clay, medium plasticity, yellow-brown</td>
<td>M&gt;PL</td>
<td>F-St</td>
</tr>
<tr>
<td>Sandy Clayey Gravel, fine grained, yellow, red-brown, with rounded ironstone pebbles and gravel</td>
<td>M&lt;PL</td>
<td>CH</td>
<td>Silty Clay, high plasticity, pale grey-yellow, with ironstone gravel layers</td>
<td>M&lt;PL</td>
<td>St-VSt</td>
</tr>
<tr>
<td>Shaley Clay, medium plasticity, yellow-grey-brown</td>
<td>M&lt;PL</td>
<td>CI</td>
<td>SHALE, yellow-grey-brown, extremely low strength, extremely weathered</td>
<td>M&lt;PL</td>
<td>H</td>
</tr>
</tbody>
</table>

**Engineering Log - Borehole**

Client: Complete Urban Pty Ltd  
Job No.: 12360/1  
Project: Proposed Two Billboards  
Location: M7 Motorway  
Date: 26/10/2010  
Borehole No.: 1 (Eastern Creek)  
Logged/Checked by: ZM/ZA  

**Drill Model and Mounting:** Explorer 200  
**Slope:** 90° deg.  
**R.L. Surface:**

**Hole Diameter:** 125 mm  
**Bearing:**

**Methods:**
- Groundwater samples
- Field tests
- Depth or R.L.
- Graphic log
- Classification symbol
- Moisture condition
- Consistency index
- Hand penetrometer kPa
- Remarks and additional observations

**Groundwater samples and Field Tests:**

<table>
<thead>
<tr>
<th>Depth or R.L.</th>
<th>Soil Type</th>
<th>Plasticity or Particle Characteristic, Colour, Secondary and Minor Components</th>
<th>Moisture Condition</th>
<th>Consistency Index</th>
<th>Hand Penetrometer kPa</th>
<th>Remarks and Additional Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Topsoil; Clayey Silt, low plasticity, pale brown, roots and root fibres</td>
<td>M&gt;PL</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Silty Clay, medium plasticity, yellow-brown</td>
<td>M&lt;PL</td>
<td>F-St</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Sandy Clayey Gravel, fine grained, yellow, red-brown, with rounded ironstone pebbles and gravel</td>
<td>M&lt;PL</td>
<td>St-VSt</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Shaley Clay, medium plasticity, yellow-grey-brown</td>
<td>M&lt;PL</td>
<td>H</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>SHALE, yellow-grey-brown, extremely low strength, extremely weathered</td>
<td>M&lt;PL</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Groundwater and Geotechnical Field Tests:**

- Moisture condition
- Consistency index
- Hand penetrometer kPa
- Remarks and additional observations

**Groundwater and Geotechnical Field Tests:**

- **Moisture condition:** M>PL, M<PL, M
- **Consistency index:** F-St, St-VSt, H
- **Hand penetrometer kPa:**

**Groundwater and Geotechnical Field Tests:**

- **Remarks and additional observations:**
  - Aluvium
  - Minor seepage encountered at 3.0m
  - Residual
  - Bedrock

**Drill diameter:** 125 mm  
**Bearing:**

**Borehole No. 1 starting coring at 6.0m**
**Coring** started at 6.0m

**SHALE, grey, yellow-brown**

**SHALE, Siltstone, grey**

**SHALE, with minor Sandstone intercalated, grey, light grey**

**Borehole No 1 terminated at 9.0m**

---

### CORE DESCRIPTION

- **rock type, grain characteristics, colour, structure, minor components.**
- **weathering**
- **point load index strength $S_{(50)}$**
- **defect spacing (mm)**

<table>
<thead>
<tr>
<th>core size</th>
<th>bearing</th>
<th>EW</th>
<th>EL-VL</th>
<th>L-M</th>
<th>V-L</th>
<th>L-M</th>
<th>V-H</th>
<th>defect spacing (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NMLC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6.0 - 6.2m</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6.75 - 6.82m</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8.5 - 8.55M</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8.86 - 8.88m</td>
</tr>
</tbody>
</table>

---

### DEFECT DETAILS

**type, inclination, thickness, planarity, roughness, coating.**

<table>
<thead>
<tr>
<th>defect</th>
<th>spacing (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2000</td>
</tr>
<tr>
<td></td>
<td>1000</td>
</tr>
<tr>
<td></td>
<td>500</td>
</tr>
<tr>
<td></td>
<td>300</td>
</tr>
<tr>
<td></td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>50</td>
</tr>
</tbody>
</table>

**Specific**

**General**
Job No 12360/1  BH1 Started Coring at 6.0m

BH1 terminated at 9.0m
**MATERIAL DESCRIPTION**

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Plasticity or Particle Characteristic</th>
<th>Colour</th>
<th>Secondary and Minor Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOPSOIL, Clayey Silt, low plasticity, pale brown, roots and root fibres</td>
<td>N=7 2,3,4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Silty CLAY, medium to high plasticity, mottled yellow-orange-grey</td>
<td>N=5 2,2,3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Silty Sandy CLAY, low plasticity, pale yellow-brown, with clayey sand layers</td>
<td>N=7 2,3,4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clayey SAND, fine grained, yellow-brown, grey, with sandy clay layers</td>
<td>N=14 7,7,7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clayey Sandy GRAVEL, fine grained, with ironstone gravels and pebbles</td>
<td>N=14 7,7,7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SHALE &amp; IRONSTONE, interbedded, grey-red-brown, extremely low strength, extremely weathered</td>
<td>N=14 7,7,7</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Remarks and additional observations**

- Borehole No 2 started coring at 6.0m
- Starting water level at 3.3m
- Bedrock
# Geotechnical Engineering Log
## Cored Borehole

<table>
<thead>
<tr>
<th>Client: Complete Urban Pty Ltd</th>
<th>Job No.: 12360/1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project: Proposed Two Billboards</td>
<td>Borehole No.: 2 (Dean Park)</td>
</tr>
<tr>
<td>Location: M7 Motorway</td>
<td>Date: 27/10/2010</td>
</tr>
<tr>
<td>Logged/Checked by: ZM/ZA</td>
<td></td>
</tr>
</tbody>
</table>

**Drill Model and Mounting:**
- Slope: 90° deg.
- Datum: |
- Core Size: NMLC
- Bearing: deg.

### Graphical Log

<table>
<thead>
<tr>
<th>Reading (m)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Coring started at 6.0m</td>
</tr>
<tr>
<td>7</td>
<td>SHALE &amp; IRONSTONE, interbedded</td>
</tr>
<tr>
<td>8</td>
<td>SHALE, grey, dark grey, grey, carbonaceous</td>
</tr>
<tr>
<td>9</td>
<td>SANDSTONE, fine grained, light grey, with minor shale laminae</td>
</tr>
<tr>
<td>10</td>
<td>SHALE, grey, dark grey, with minor sandstone laminae</td>
</tr>
<tr>
<td>12</td>
<td>Borehole No 2 terminated at 8.88m</td>
</tr>
</tbody>
</table>

### Core Description
- **rock type, grain characteristics, colour, structure, minor components.**
- **Sandy, gravelly, silty, clayey, fissured, brecciated, coalitic, carbonaceous, siliceous.**
- **Strength:** EL, VL, L, M, H, VH
- **Point load index (70):** EL, VL, L, M, H

### Defect Details
- **Description:** Type, inclination, thickness, planarity, roughness, coating.
- **Specific** |
- **General** |

### Drill Model and Mounting
- **Slope:** 90° deg.
- **R.L. surface:** deg.
- **Datum:** |
- **Core Size:** NMLC
- **Bearing:** deg.

---

**Form No. 003 version 03 - 09/10**
Job No 12360/1  BH2 Started Coring at 6.0m

6m
7m
8m

BH2 terminated at 8.88m
EXPLANATORY NOTES

Introduction
These notes have been provided to simplify the geotechnical report with regard to investigation procedures, classification methods and certain matters relating to the Discussion and Comments section. Not all notes are necessarily relevant to all reports.

Geotechnical reports are based on information gained from finite sub-surface probing, excavation, boring, sampling or other means of investigation, supplemented by experience and knowledge of local geology. For this reason they must be regarded as interpretative rather than factual documents, limited to some extent by the scope of information on which they rely.

Description and Classification Methods
The methods of description and classification of soils and rocks used in this report are based on AS1726 - 1993 "Geotechnical Site Investigations". In general, descriptions cover the following properties: strength or density, colour, structure, soil or rock type, and inclusions. Identification and classification of soil and rock involves, to a large extent, judgement within the acceptable level commonly adopted by current geotechnical practices.

Soil types are described according to the predominating particle size, qualified by the grading or other particles present (e.g. sandy clay) on the following basis:

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Particle Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clay</td>
<td>Less than 0.002mm</td>
</tr>
<tr>
<td>Silt</td>
<td>0.002 to 0.06mm</td>
</tr>
<tr>
<td>Sand</td>
<td>0.06 to 2.00mm</td>
</tr>
<tr>
<td>Gravel</td>
<td>2.00mm to 60.00mm</td>
</tr>
</tbody>
</table>

Cohesive soils are classified on the basis of strength, either by laboratory testing or engineering examination. The strength terms are defined as follows:

- Very Soft
- Soft
- Firm
- Stiff
- Very Stiff
- Hard

Non-cohesive soils are classified on the basis of relative density, generally from the results of standard penetration tests (SPT) or Dutch cone penetrometer tests (CPT), as below:

<table>
<thead>
<tr>
<th>Relative Density</th>
<th>SPT 'N' Value (blows/300mm)</th>
<th>CPT Cone Value (q,C-MPQ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Loose</td>
<td>Less than 5</td>
<td>Less than 2</td>
</tr>
<tr>
<td>Loose</td>
<td>5 – 10</td>
<td>2 – 5</td>
</tr>
<tr>
<td>Medium Dense</td>
<td>10 – 30</td>
<td>5 – 15</td>
</tr>
<tr>
<td>Dense</td>
<td>30 – 50</td>
<td>15 – 25</td>
</tr>
<tr>
<td>Very Dense</td>
<td>&gt;50</td>
<td>&gt;25</td>
</tr>
</tbody>
</table>

Rock types are classified by their geological names, together with descriptive terms on degrees of weathering, strength, defects and other minor components. Where relevant, further information regarding rock classification is given on the following sheet.

Sampling
Sampling is carried out during drilling to allow engineering examination (and laboratory testing where required) of the soil or rock.

Disturbed samples taken during drilling provide information on plasticity, grain size, colour, type, moisture content, inclusions and depending upon the degree of disturbance, some information on strength and structure.

Undisturbed samples are taken by pushing a thin walled sample tube (normally known as U30) into the soil and withdrawing a sample of the soil in a relatively undisturbed state. Such samples yield information on structure and strength and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils. Details of the type and method of sampling are given in the report.

Field Investigation Methods
The following is a brief summary of investigation methods currently carried out by this Company and comments on their use and application.

Hand Auger Drilling
These are excavated with a tractor-mounted backhoe or a tracked excavator, allowing close examination of the insitu soils if it is safe to descend into the pit. The depth of penetration is limited to about 3.0m for a backhoe and up to 6.0m for an excavator. A potential disadvantage is the disturbance caused by the excavation.

Care must be taken if construction is to be carried out near, or within the test pit locations, to either adequately recompact the backfill during construction, or to design the structure to accommodate the poorly compacted backfill.

Large Diameter Auger (e.g. Pengo)
The hole is advanced by a rotating plate or short spiral auger, generally 300mm or larger in diameter. The cuttings are returned to the surface at intervals (generally of not more than 0.5m) and are disturbed, but usually unchanged in moisture content. Identification of soil strata is generally much more reliable than with continuous spiral flight augers and is usually supplemented by occasional undisturbed tube sampling.

Continuous Spiral Flight Augers
These are advanced by using 90mm-115mm diameter continuous spiral flight augers, which are withdrawn at intervals to allow sampling or insitu testing. This is a relatively economical means of drilling in clays and in sands above the water table. Samples are returned to the surface, or may be collected after withdrawal of the auger flights, but they are very disturbed and may be highly mixed with soil of other stratum.

Information from the drilling (as distinct from specific sampling by SPT or undisturbed samples) is of relatively lower reliability due to remoulding, mixing or softening of samples by groundwater, resulting in uncertainties of the original sample depth.

The spiral augers are usually advanced by using a V-bit through the soil profile to refusal, followed by Tungsten Carbide (TC) bit, to penetrate into bedrock. The quality and continuity of the bedrock may be assessed by examination of recovered rock fragments and through observation of the drilling penetration resistance.

Non-core Rotary Drilling (Wash Boring)
The hole is advanced by a rotary bit, with water being pumped down the drill rod and returned up the annulus carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from the feel and rate of penetration.

Rotary Mud Stabilised Drilling
This is similar to rotary drilling, but uses drilling mud as a circulating fluid, which may consist of a range of products from bentonite to polymers such as Revert or Biogel. The mud tends to mask the cuttings and reliable identification is again only possible from separate intact sampling (e.g. SPT and U<sub>30</sub>) samples.)
Continuous Core Drilling
A continuous core sample is obtained using a diamond tipped core barrel. Providing full core recovery is achieved (which is not always possible in very low strength rocks and granular soils), this technique provides a very reliable (but relatively expensive) method of investigation. In rocks, an NMLC triple tube core barrel, which gives a core of about 50mm diameter, is usually used with water flush.

Portable Proline Drilling
This is manually operated equipment and is only used in sites which require bedrock core sampling and there is restricted site access to truck mounted drill rigs. The boreholes are usually advanced initially using a tricone roller bit and water circulation to penetrate the upper soil profile. In some instances, a hand auger may be used to penetrate the soil profile. Subsequent drilling into bedrock involves the use of NMLC triple tube equipment, using water as a lubricant.

Standard Penetration Tests
Standard penetration tests are used mainly in non-cohesive soils, but occasionally also in cohesive soils, as a means of determining density or strength and of obtaining a relatively undisturbed sample. The test procedure is described in AS1289 6.3.1.

The test is carried out in a borehole by driving a 50mm diameter split sample tube under the impact of a 63kg hammer with a free fall of 769mm. It is normal for the tube to be driven in three successive 150mm increments and the ‘N’ value is taken as the number of blows for the last 300mm. In dense sands, very hard clays or weak rock, the full 450mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form:

- In a case where full penetration is obtained with successive blow counts for each 150mm of, say 4, 6 and 7 blows as;
  \[ N = 13 \]
  4,6,7

- In a case where the test is discontinued short of full penetration, say after 15 blows for the first 150mm and 30 blows for the next 40mm as;
  \[ N = 13 \]
  15, 30/40mm

The results of the tests can be related empirically to the engineering properties of the soil. Occasionally the test method is used to obtain samples in 50mm diameter thin walled sample tubes in clays. In these circumstances, the test results are shown on the bore logs in brackets.

Cone Penetrometer Testing and Interpretation
Cone penetrometer testing (sometimes referred to as Dutch Cone-CPT) described in this report, has been carried out using an electrical friction cone penetrometer and the test is described in AS1289 6.5.1.

In the test, a 35mm diameter rod with cone tipped end is pushed continuously into the soil, the reaction being provided by a specially designed truck or rig, which is fitted with a hydraulic ram system. Measurements are made of the end bearing resistance on the cone and the friction resistance on a separate 130mm long sleeve, immediately behind the cone. Transducers in the tip of the assembly are connected by electrical wires passing through the centre of the push rods to an amplifier and recorder unit mounted on the control truck.

As penetration occurs (at a rate of approximately 20mm per second) the information is output on continuous chart recorders. The plotted results given in this report have been traced from the original records. The information provided on the charts comprises:

- Cone resistance - the actual end bearing force divided by the cross sectional area of the cone, expressed in MPa *
- Sleeve friction - the frictional force on the sleeve divided by the surface area, expressed in kPa

The ratios of the sleeve resistance to cone resistance will vary with the type of soil encountered, with higher relative friction in clays than in sands. Friction ratios of 1% to 2% are commonly encountered in sands and very soft clays, rising to 4% to 10% in stiff clays.

In sands, the relationship between cone resistance and SPT value is commonly in the range:

\[ q_c = (12 to 18)C_u \]

Interpretation of CPT values can also be made to allow estimate of modulus or compressibility values, to allow calculation of foundation settlements. Inferred stratification, as shown on the attached report, is assessed from the cone and friction traces, from experience and information from nearby boreholes etc.

This information is presented for general guidance, but must be regarded as being to some extent interpretative. The test method provides a continuous profile of engineering properties and where precise information or soil classification is required, direct drilling and sampling may be preferable.

Portable Dynamic Cone Penetrometer (DCP)
Portable Dynamic Cone Penetrometer tests are carried out by driving a rod into the ground with a falling weight hammer and measuring the blows per successive 100mm increment of penetration.

There are two similar tests, Cone Penetrometer (commonly known as Scala Penetrometer) AS1289 6.3.2 and the Perth Sand Penetrometer AS1289 6.3.3. Scala Penetrometer is commonly adopted by this company and consists of a 16mm rod with a 20mm diameter cone end, driven with a 9kg hammer, dropping 510mm (AS1289 Test P3.2).

Laboratory Testing
Laboratory testing is carried out in accordance with Australian Standard 1289 "Methods of Testing Soil for Engineering Purposes". Details of the test procedures are given on the individual report forms.

Engineering Logs
The engineering logs presented herein are an engineering and/or geological interpretation of the sub-surface conditions and their reliability will depend to some extent on frequency of sampling and the method of drilling. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, however, this is not always practicable or possible to justify economically. As it is, the boreholes represent only a small sample of the total sub-surface profile. Interpretation of the information and its application to design and construction should take into account the spacing of boreholes, frequency of sampling and the possibility of other than ‘straight line’ variations between the boreholes.

Groundwater
Where groundwater levels are measured in boreholes, there are several potential problems:

- in low permeability soils groundwater, although present, may enter the hole slowly or perhaps not at all during the investigation period
- a localised perched water table may lead to an erroneous indication of the true water table
- water table levels will vary from time to time due to the seasons or recent weather changes. They may not be the same at the time of construction as indicated in the report
- the use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must be washed out of the hole if water observations are to be made
More reliable measurements can be achieved by installing standpipes that are read at intervals over several days, or weeks for low permeability soils. Piezometers sealed in a particular stratum may be advisable in low permeability soils, or where there may be interference from a perched water table or surface water.

Engineering Reports
Engineering reports are prepared by qualified personnel and are based on the information obtained and on current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, perhaps a three-storey building, the information and interpretation may not be relevant if the design proposal is changed, say to a twenty-storey building. If this occurs, the Company will be pleased to review the report and sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of sub-surface conditions, discussions of geotechnical aspects and recommendations or suggestions for design and construction. However, the Company cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions. The potential for this will depend partly on bore spacing and sampling frequency.
- Changes in policy or interpretation of policy by statutory authorities.
- The actions of contractors responding to commercial pressures.

If these occur, the Company will be pleased to assist with investigation or advice to resolve the matter.

Site Anomalies
In the event that conditions encountered on-site during construction appear to vary from those that were expected from the information contained in the report, the Company requests immediate notification. Most problems are much more easily resolved when conditions are exposed rather than at some later stage, well after the event.

Reproduction of Information for Contractual Purposes
Attention is drawn to the document "Guidelines for the Provision of Geotechnical Information in Tender Documents", published by the Institute of Engineers Australia. Where information obtained from this Investigation is provided for tendering purposes; it is recommended that all information, including the written report and discussion, be made available.

In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. The Company would be pleased to assist in this regard and/or make additional copies of the report available for contract purposes, at a nominal charge.

Site Inspection
The Company will always be pleased to provide engineering inspection services for geotechnical aspects of work to which this report is related. This could range from a site visit to confirm that the conditions exposed are as expected, to full time engineering presence on site.

Review of Design
Where major civil or structural developments are proposed, or where only a limited investigation has been completed, or where the geotechnical conditions are complex, it is prudent to have the design reviewed by a Senior Geotechnical Engineer.