Pells Sullivan Meynink
Engineering Consultants
Rock-Soil-Water

G3 56 Delhi Road
North Ryde NSW 2113
P: 61-2 9812 5000
F: 61-2 9812 5001
mailbox@psm.com.au
www.psm.com.au

Our Ref: PSM2426-001L

21 March 2014

Richard Green
Taylor Thomson Whiting (NSW) Pty Ltd
Level 3, Chandos Street
ST LEONARDS NSW 2065

ATTENTION: RICHARD GREEN
By email to: Richard.Green@ttw.com.au

Dear Sir,

RE: EDUCATION AND LANDS DEPARTMENT BUILDING – DESKTOP STUDY

1 SUMMARY

The proposed site is underlain by Hawkesbury Sandstone with the majority of the site lying within the inferred G.P.O Fault Zone. The Pittman LIV Dyke is inferred to lie just to the north but is unlikely to impact the site itself. The G.P.O Fault Zone is characterised by closely spaced, sub-vertical joints and a weaker rock mass associated with deeper weathering than the surrounding rock mass. The presence of this poorer material beneath site will have the following implications:

1. Deeper or larger foundations may be required or in the worst case, relocation of footings and/or transfer structures may be required.
2. Higher occurrence of jointing may cause rock wedges which would reduce allowable footing bearing capacity compared to rock with no jointing. These rock wedges are also likely to require support in the form of rock bolts or anchors in any excavated faces.
3. Lower stiffness rock mass associated with larger vertical and horizontal deformation of cut faces.
4. Relatively high water inflows to excavations.

2 INTRODUCTION

2.1 Background

This letter responds to the 4 March 2014 request from Richard Green of TTW for Pells Sullivan Meynink (PSM) to provide a desktop study of the likely geotechnical conditions of the above site. PSM's proposal of 5 March was accepted by TTW on 12 March 2014.

2.2 Project Understanding

The proposed site occupies two blocks that have addresses 23-33 and 35-39 Bridge Street, Sydney. 23-33 Bridge Street is bounded by Bridge Street, Gresham Street, Bent Street and Loftus Street (the Lands Department). The site at 35-39 Bridge Street is bounded by Bridge Street, Loftus Street, Bent Street, Farrer Place and Young Street (the Education Department). Loftus Street and Farrer Place are part of the project area. The surrounding ground generally falls toward the Tank Stream which lies approx. 100 m to the west.

PSM has not considered specific details of the existing building or the proposal for redevelopment. This study provides preliminary geotechnical advice and site investigation recommendations, for redevelopment options with and without additional basement excavation.

3 EXPECTED GEOTECHNICAL CONDITIONS

3.1 Preamble

PSM has completed a desktop study to assess the expected geotechnical conditions in the vicinity of the site. PSM has been involved in the investigation, design and construction of numerous projects in the Sydney CBD area. Data from PSM's archives, project experience of staff members, and publically available geotechnical and historic information form the basis of this study. The main projects considered in this study are:

- City East Cable Tunnel (CECT) which runs beneath the site at 23-35 Bridge Street.
- CBD Metro Desktop Study.

In addition, we considered information from projects more remote from the site.

3.2 Bedrock

The rock unit underlying the site is Hawkesbury Sandstone[1]. The geotechnical behaviour of this rock unit is relatively well understood, and significant tunnel and basement excavations have been constructed throughout the Sydney CBD within this rock unit.

[1] NSW Department of Mineral Resources, 1983. Sydney 1:100,000 Geological map (Geological Series Sheet 9130 Edition 1).

For the purposes of foundation design, the Hawkesbury Sandstone is classified into five classes, ranging from Class I (highest quality) to Class V (lowest quality, essentially a soil)[2]. These classes are often used for general description and communication, as well as foundation design.

3.3 Overburden

The near-surface layers of the Hawkesbury Sandstone typically weather to a thin veneer of clayey, residual soil, with a relatively thin transition zone (in the order of metres) from soil to rock.

The site lies to the east of the Tank Stream with rock contour levels showing that the rock level is relatively shallow and rises eastward toward the top of a ridgeline around Macquarie Street. This information is supported by two boreholes near the boundaries of the site for the CECT geotechnical investigation. Depth to rock in these holes ranged from 0.5 m to 2.5 m with the overburden comprising fill and/or clayey, residual soil.

3.4 Major geological structures

Information on known major geological structures is presented in a publically available map[3]. This map indicates that the G.P.O Fault Zone is inferred to directly underlie the site while the Pittman LIV Dyke has been inferred to pass near the northern boundary of the site. We note that these are based on inferences from observations including some situated near the site and are thus likely to be reasonably accurate (see Figure 1).

3.4.1 G.P.O Fault Zone

The G.P.O fault zone comprises sub-vertical joints within the central part of the zone with zones of closely spaced joints running parallel to the faulting. Faults are typically infilled with sandy clays and rock fragments. The faults and joints are open and may contribute seepage.

Rock between the faults and joints is typically intact although weathering is deeper than away from the fault zone and 'sugary' sandstone may be encountered down to about 25 m.

Above 25 m depth, the fault zones tend to be significantly more weathered and of extremely low to low strength (colloquially described as 'sugary sandstone'). Some zones up to about 1 m of soil-like strength (stiff to very stiff) may also be encountered within the weak rock matrix. Joints typically become more closely spaced, sometimes between 0.05 m and 0.3 m and dip over a wider range of angles from sub-vertical to about 50° to the horizontal. Joints/faults are more likely to be clay filled.

---

[2] Pells, P.J.N., Mostyn, G. and Walker, R.F. (1998) "Foundations on sandstone and shale in the Sydney region". *Australian Geomechanics*, Vol 33, No 3, pp. 17 - 20

[3] Pells, P.J.N., Braybrooke, J.C., & Och, D., 2004. Map and selected details of near vertical structural features in the Sydney CBD. Hema Maps Pty Ltd.

As shown in Figure 1, two boreholes in PSM's database near to the site are situated within the G.P.O Fault Zone. Borehole CECT4 encountered weathered sandstone to a depth of approx. 20 m which contrasts with 9.4 m for CECT3. Within this weathered zone, joint spacing was much closer than for the corresponding depths in CECT 3. Borehole SYDM55_BH4 experienced very poor core recovery within the upper 14 m, close joint spacing and weathering throughout the entire length of the hole (16.5 m).

3.4.2 Dykes

Dykes in the Sydney CBD area typically consist of near vertical basalt (igneous rock) intrusions into the sedimentary Hawkesbury Sandstone, striking ENE to WSW. Dykes in the area known to PSM are shown on Figure 1.

Although the central core of these dykes at depth can comprise relatively good quality rock, previous experience[4] has shown that at the margins of the dyke, the igneous rock is more weathered and of weaker strength, and the adjacent sandstone is also of relatively poorer quality. This is of significance as while the inferred alignment does not pass through the site, it does pass within approx. 40 to 60 m of the site. Near surface, the dykes often comprise soil strength material due to advanced weathering. Further, the dykes are often either local barriers or conduits for sub-surface groundwater flow.

3.4.3 Implications

Publically available information indicates that there is the likely occurrence of two major geological structures underlying or adjacent to the site. These two features, and potentially other related features, are expected to have the following adverse effects on basement excavation or footing design:

- Relatively deeper and more variable weathering (depth to rock) compared to typical conditions outside of major geological structures. This may require deeper/larger foundations and/or heavier shoring (excavation support). In the worst case, it can require relocating footings and/or the use of transfer structures.
- Joints causing loose rock wedges within excavated faces, and/or lower ultimate and allowable footing bearing pressures compared to rock with no joints. Joints in excavated faces may require support e.g. by rock bolts or rock anchors, which would extend beyond the site boundary if the excavation was to the site perimeter and thus can require the agreement of road authorities.
- Lower stiffness rock mass associated with larger vertical and horizontal deformation of cut faces.
- Relatively high water inflows to excavations, with water flowing primarily along joints and dyke/sandstone interfaces. This would require a robust and well-maintained drainage system.

---

[4] Bertuzzi, R., & Justice, T.R., 1999. The geology of the Eastern Distributor tunnel. Tenth Australian Tunnelling Conference, Melbourne.

3.5 Groundwater

Piezometers were installed in a number of boreholes for the CECT project including borehole CECT 3 which returned a groundwater level of RL -0.24 m. Based on this borehole's proximity to the site, groundwater can be expected to have been at a similar level at the time the measurements were made. It is likely the groundwater level is higher during prolonged wet periods. Localised 'perched' groundwater may be present above this level.

The presence of the G.P.O Fault Zone is likely to coincide with zones of significantly higher permeability than the surrounding rock mass. Packer testing for the CECT project included tests in boreholes CECT 3 & 4. One test within CECT 4 returned a permeability value in the order of 40 times higher than those encountered in CECT 3 where no fault zone was observed.

A basement excavation design would need to consider groundwater inflows, an appropriate drainage system, and effects of potential dewatering around the site.

4 FOUNDATION INVESTIGATION AND DESIGN

4.1 General

PSM has not considered details of existing or proposed footing types and footing loads. As such, this study provides general guidance on allowable bearing pressures, for preliminary structural design.

4.2 Footings on rock

For concept design of footings on rock, we recommend an allowable bearing pressure for centric vertical loadings of 3.5 MPa be adopted. This is the lower end of allowable bearing pressures for Class III sandstone[2], and assumes that over much of the site, joints will be encountered at less than 0.6 m spacing but greater than 0.2 m spacing. This allowable bearing pressure is associated with expected settlements of up to 1% of the maximum foundation plan dimension. It is likely that over the north and west portion of the Lands department site, higher bearing pressures could be available.

Site investigation and/or construction inspection is required to confirm the depth to rock and the recommended allowable bearing pressure. Given the expected variable adverse geotechnical conditions over much of the site, we expect that it would be preferable for the owner to undertake a site investigation to confirm foundation design assumptions during the design phase.

4.3 Footings on soil or soil strength materials

We do not expect footings on soil at this site and for any probable development.

5 EXCAVATION INVESTIGATION AND DESIGN

5.1 General

This section of the study has been prepared should a basement excavation be undertaken as part of future redevelopment.

Previous experience on excavations projects in similar conditions has demonstrated that such excavations are achievable with satisfactory outcomes, but such an undertaking involves several geotechnical hazards requiring risk management. It is likely that a high level of temporary and permanent support will be required for excavated faces.

5.2 Expected geotechnical hazards

Table 1 presents a summary of the potential geotechnical hazards and possible risk management measures.

TABLE 1
SUMMARY OF POTENTIAL GEOTECHNICAL HAZARDS AND RISK MANAGEMENT

GEOTECHNICAL HAZARD	PROVENANCE OF HAZARD	RISK MANAGEMENT ACTIONS
Water inflow	• Presence of major geological structures.	• Temporary and permanent drainage of excavated faces. • Permanent pumping system. • Robust maintenance system including drainage inspection and flushing points.
Instability of overburden	• Presence of soil strength material overlying bedrock. • Deep soil strength material within dyke.	• Design of a robust shoring system to support overburden.
Unstable rock wedges within excavation faces	• Closely spaced joints within G.P.O Fault Zone. • Sub vertical jointing and horizontal bedding typical in Hawkesbury Sandstone. • Disturbed rock mass adjacent to dyke. • Weaker rock mass within weathered zone.	• High level of geotechnical inspections during construction. • Rock anchors/bolts installed in excavated faces. • Shotcrete / mesh installed over excavated faces. • Deeper shoring piles.
Ground movement causing damage to adjacent roads, buildings, tunnels	• Movement of soil strength materials retained by shoring. • Stress relaxation in rock mass.	• Robust shoring design. • Appropriate construction sequencing. • Condition surveys of adjacent infrastructure. • Geotechnical inspections and monitoring.

6 SUMMARY AND INVESTIGATION RECOMMENDATIONS

The information reported above indicates that this site is not typical of those in the CBD. Due to the range of likely unfavourable and variable geotechnical conditions underlying the site, the owner should expect a relatively high level of geotechnical input during the investigation, design and construction phases.

PSM's recommended site investigation scope will depend on the existing and proposed foundation system and basement excavations (including locations, loading, foundation type and excavation depth). Potential outcomes of the site investigation may include:

- Depth to rock and variability in depth to rock across the site.
- Location and character of the Pittman LIV Dyke, if encountered.
- Location and character of the G.P.O Fault Zone, if encountered.

We recommend a relatively extensive site investigation due to the multiple causes of potentially unfavourable subsurface conditions. The following boreholes would be recommended:

1. At least one inclined hole on the northern boundary of the site drilled to confirm that the Pittman LIV Dyke does not intersect the proposed site. If the dyke is intersected, an additional hole should be drilled to provide information on dyke extent and nature as it pertains to shoring, foundation, and excavation design.
2. At least four inclined holes drilled to intersect the inferred location of the G.P.O Fault Zone, to provide information on its extent and nature as it pertains to shoring, foundation, and excavation design.
3. At least four additional vertical holes near the perimeter of the proposed excavation and within the site, to provide input to shoring design and foundation including depth to rock, nature of soil to be retained, and rock condition at foundation levels.

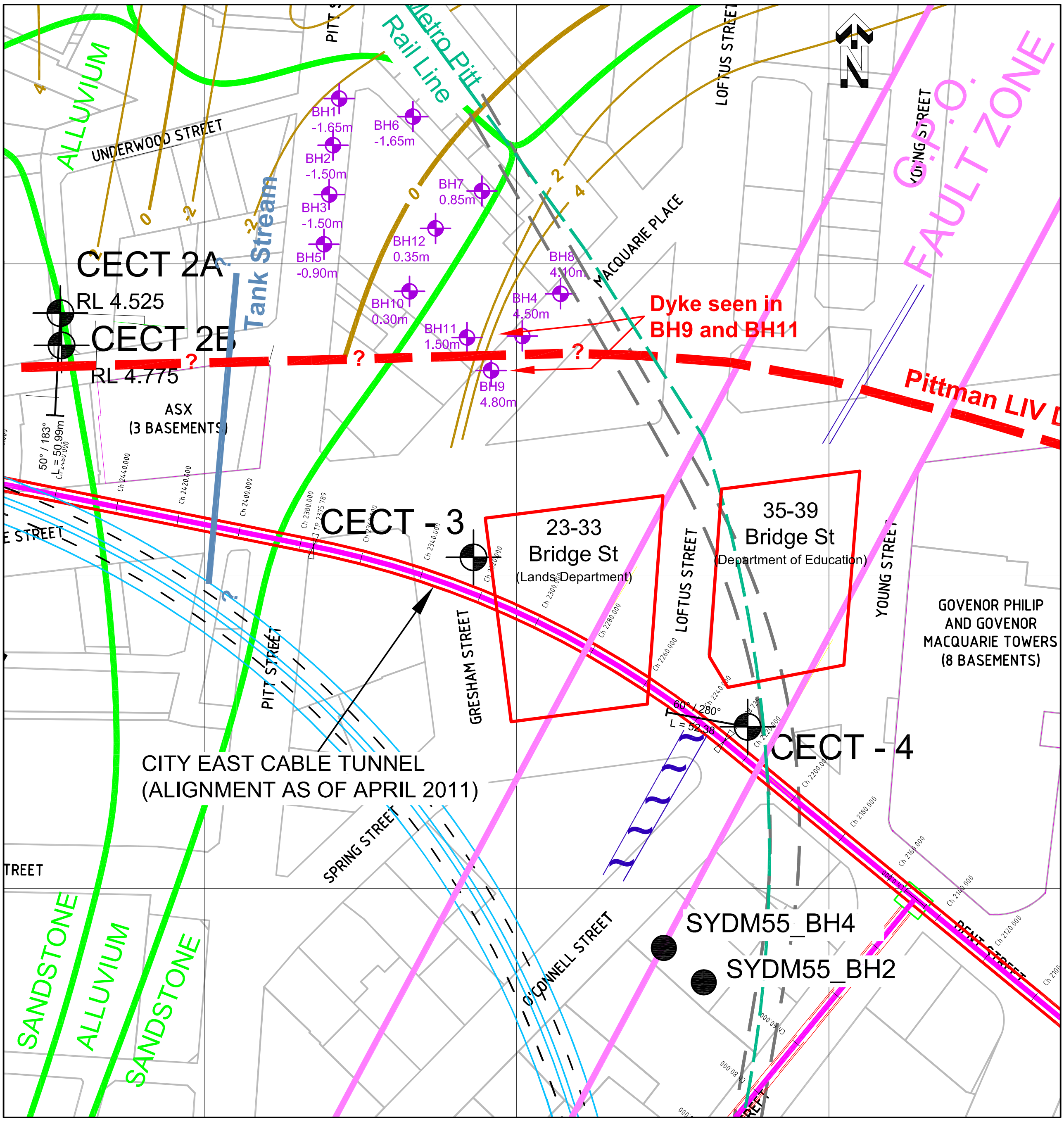
Please do not hesitate to contact the undersigned or Jeremy Toh should you have any queries.

For and on behalf of
PELLS SULLIVAN MEYNINK

GARRY MOSTYN
Principal

JEREMY TOH
Associate

Encl. Figure 1 Location Plan



LEGEND

- Borehole from CECT Geotechnical Investigation
- Borehole from CBD Metro Geotechnical Desktop Study
- Borehole Location & Rock Level (from PSM Archive)
- G.P.O Fault Zone Observed

Notes:
1. Coordinates to MGA Zone 56
2. Levels to AHD
3. GPO Fault zone & dyke taken from Pells et al (2004)
4. Contours shown are top of rock level

0 50 100
Scale (m)

PSM
Pells Sullivan Meynink

Taylor Thomson Whiting (NSW) Pty Ltd
Education and Lands Department
Geotechnical Desktop Study

LOCATION PLAN

PSM2426-001L	Figure 1