Golder Associates

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Margaret Ogston
Asset Management Unit St Vincents and Mater Health
230 Barcom Avenue
DARLINGHURST NSW 2010

ST VINCENTS RESEARCH BIOTECHNOLOGY PRECINCT DEVELOPMENT
GEOTECHNICAL ASSESSMENT OF PROPOSED BASEMENT EXCAVATION

Dear Margaret

1.0 Introduction

This letter report presents geotechnical comments on our feasibility assessment of the proposed deep basement excavations for future development on the east and west side of the Victor Chang Cardiac Research Institute (VCCRI) (Figures 1 to 3). The excavation for the VCCRI forms Stage 1 of the development with Stage 2 to the east West Street side and Stage 3 to the west Victoria Street side. Proposed excavation depths were given on the drawing you provided (SK-2526 Rev.D), viz. about 25 m below Victoria Street and 20 m below West Street.

This work has been completed for the feasibility assessment only of the depth of the proposed basement excavations for Stages 2 and 3 and connections between the two excavations. It was carried out under our Consultancy Agreement for Geotechnical Services for St Vincent's Research Biotechnology Precinct, dated 30 April 2008.

2.0 Available Geotechnical Information

- St Vincent's Research Biotechnology Precinct development, VCCRI building, 2004 – 2006 (Golder Files investigation boreholes and construction inspection records).
- St Vincent's Hospital redevelopment including a 10 m to 15 m deep excavation, 1996 – 1999 (Golder Files, investigation boreholes and construction inspection records and Douglas Partners report 1996).
- Published geological maps from NSW Geological Survey and Australian Geomechanics Society.

3.0 Geology and Topography

The site is located on the eastern side of a broad north-northeast trending ridge and is underlain by soil (fill, residual and possibly some Aeolian sand) and rocks of the Hawkesbury Sandstone formation. The regional geology is presented in Figure 4.

Overlying soils: fill, sand (Aeolian Sands), clayey sand (residual sandstone soil), likely less than 1.5 m thick (indicative depth). Local deeper soils maybe encountered.

Hawkesbury Sandstone – fine to coarse grained sandstone with lenses of shale (siltstone with laminated fine sandstone). Sandstone is quartz-rich, generally 60% to 80% quartz grains with some quartz cement and very abrasive to construction equipment. Strength is mainly medium to high strength. Lower strength rock due to weathering is generally within 3 m of the ground surface. Lower strength zones and fractured zones are also present at depth, probably due to low angle faulting or possibly due to the presence of the Woolloomooloo Fault to the west (Figure 4). These types of zones were indicated in the VCCRI deep excavation and investigation boreholes. Rock jointing is dominated by a north-northeast trending (approximately parallel to the ridge) near vertical joint set, which has a high degree of vertical persistence. There is likely to be a less persistent joint set normal to the north-northeast set. Near horizontal bedding partings, sometime with clay zones are common in this formation. Shale lenses are likely to be more jointed and prone to deterioration and fretting on exposure.

Groundwater will be present in the rock joints and fractures below the level of the VCCRI excavation. This excavation will be draining groundwater in the area. The presence of the Bondi Ocean Outfall Sewer tunnel below Liverpool Street (see below) will also act as a groundwater drain such that high inflows are not expected.

4.0 Adjacent Structures

Buildings - Adjacent buildings, and likely basements, are shown in Figure 2. We are unsure if there are basements below the Telstra building.

Major Services – Bondi Ocean Outfall Sewer (BOOS) below the northern Liverpool Street boundary. The depth of the sewer, which is assumed to have been constructed as a driven rock tunnel through this ridge area, is not known. The location was taken from 1985 UBD Metropolitan Water Sewerage and Drainage Board edition, which contains the Sydney Sewerage System.

5.0 Ground-Induced Movement due to Excavation

Ground movements are induced in the walls of an excavation due to the removal of lateral restraint provided by the rock. In Sydney, this movement is dominated by the release of the high horizontal rock stress present. The regional major *in situ* stress is orientated approximately north-northeast, which in this area is about parallel to the local ridge. This stress typically can cause ground movement at the crest of the excavation of about 0.5 mm to 2 mm per metre of depth of excavation. Behind the excavation, this movement reduces by about 0.5 mm to 2 mm per metre distance from the excavation. We expect that this type of movement, possibly in the order of 20 mm to 30 mm, will occur at the crest of the northern and southern walls of the excavation. The existing VCCRI excavation has likely not reduced the potential for stress movement in the north-south direction. Rock support measures have little influence on the magnitude of stress movement.

Ground movement in the walls of excavations may also occur due to movement of weak ground (soil and upper weathered rock) and due to blocks of rock isolated by jointing and other fracturing. This can be addressed by excavation support measures indicated below.

Rock stress below the excavation may influence footing excavations at the base of the excavation. Stress concentration leading to fracturing of the excavation floor can occur if a low strength bedding seam or layer occurs just below the floor. This can result in the need for over excavation to provide an acceptable foundation for building column footings.

6.0 Support of Deep Excavation

Indicative support systems for the excavation walls are presented below :-

- Soil and upper part of the walls in lower strength weathered rock – retaining measures similar to the VCCRI basement excavation, viz. bored soldier piles with infill shotcrete/concrete between the piles. The spacing and diameter of the piles depend on the lateral load required to take. Temporary tensioned anchors will be required for bracing the wall. These will extend beyond the site boundaries beneath the streets and probably the Medical Centre building. It is likely that a retaining wall of about 6 m high will be required. Permanent support of the wall will need to be provided by the building by bracing from the basement level floor slabs or from a shear wall.
- Rock Walls – Sandstone blocks and weak or fractured zones (including shale lenses) in excavation walls are supported mainly by rockbolts and mesh or steel fibre reinforced shotcrete. For feasibility assessment of quantities, it may be prudent to allow for about 30% of the excavated walls to be supported by pattern bolts (say 1.5 m x 1.5 m) and 75 mm thick shotcrete.

  The above support measures assume that a rock saw is used to excavate the wall to ensure no disturbance of the rock behind the wall. A rock saw cut will also have the benefit of assisting in the reduction of excavation vibrations to adjacent structures.

  Tensioned anchors have also been required in deep excavations for the support of large wedges, which are identified during excavation. These may also be required to provide high capacity restraint for the rock below footings near the excavation crest of adjacent buildings, Medical Centre and Garvan Institute.

7.0 Connection between East and West Basements

You have suggested two options to connect the two basements (Stages 2 & 3). We provide comments on the design and construction of each as follows:-

7.1 High level option

We understand that this may involve a trench-type excavation to about 3 m deep just below the VCCRI basement, about RL27.2. We consider that this will be feasible to construct single lane connections given that careful excavation is carried out to ensure no disturbance of the rock below the VCCRI column footings. The orientation of the connection is favourable to the direction of major jointing, however, if weak or fractured zones are present, then underpinning support below footings is likely to be required. Support may include rock bolts and/or tensioned anchors and replacement of weak zones with concrete.

7.2 Driven tunnel option at basement level

The size of a driven tunnel will be probably be governed by the size of the construction equipment. Mechanical excavation by a roadheader is the most likely means of excavation. Other mechanical excavation methods, e.g. a rockbreaker fitted to an excavator, may not be feasible due to low production rates. Construction vibrations will impact vibration-sensitive equipment in adjacent buildings.

A small roadheader (Mitsui S200) is about 3.6 m wide and 2.5 m high (if the operator is remote from the machine). We envisage a minimum tunnel size of about 5 m wide and 4 m high to allow for construction equipment and services for a single lane tunnel. A dual lane tunnel may require at least 6 m width (assuming about 2.5 m lane width). Height may be governed by the rockbolting equipment required to remotely install rockbolts. Operational phase ventilation and fire safety measures may be required and would be the subject of discussion with the NSW Fire Brigade.

Ground deformations due to the tunnel excavation will affect the foundations of the VCCRI building. These are likely to be less than 5 mm if the depth of the tunnel below the foundations is kept to at least the equivalent of two tunnel spans. Further assessment including detailed design analysis will be required following geotechnical investigation. These deformations can be limited to some extent by design and construction methodology, including short tunnel advances before the installation of construction support comprising rockbolts and shotcrete. Final lining could be rockbolts and shotcrete covering at least the roof area and approximately half the height of the tunnel walls. Equipment would be required to install the support remotely to ensure that no personnel are working below unsupported ground during construction.

8.0 Conclusions

We consider that it would be geotechnically feasible to construct the proposed basement excavations for Stages 2 and 3 of the St Vincent's Research Biotechnology Precinct development to the proposed nine basement levels, or about 30 m depth. This assumes excavation as indicated in this report. The actual basement depth is likely to be governed by:-

- Acceptability of the impact of excavation-induced stress relief movements on adjacent buildings, particularly those which are closest to the excavations on the southern side.
- Depth of the BOOS and the likely impact of the deep excavation on the sewer.

We consider that a deep driven tunnel will be technically feasible to connect the two basements. However, it is unlikely to be economical compared with the high level connection option.

This assessment has been conducted without the knowledge of the ground conditions below the level of the VCCRI basement. The feasibility of the proposed deep basements and tunnel construction should be subject to detailed geotechnical investigation and design.

GOLDER ASSOCIATES PTY LTD

Les McQueen
Principal

LBM/CSC/lbm

CC: Paul Siewert, SCP Consulting Pty Ltd

Attachments: Limitations
Figure 1. Site Locality Plan
Figure 2. Location Plan
Figure 3. Section
Figure 4. Regional Geology

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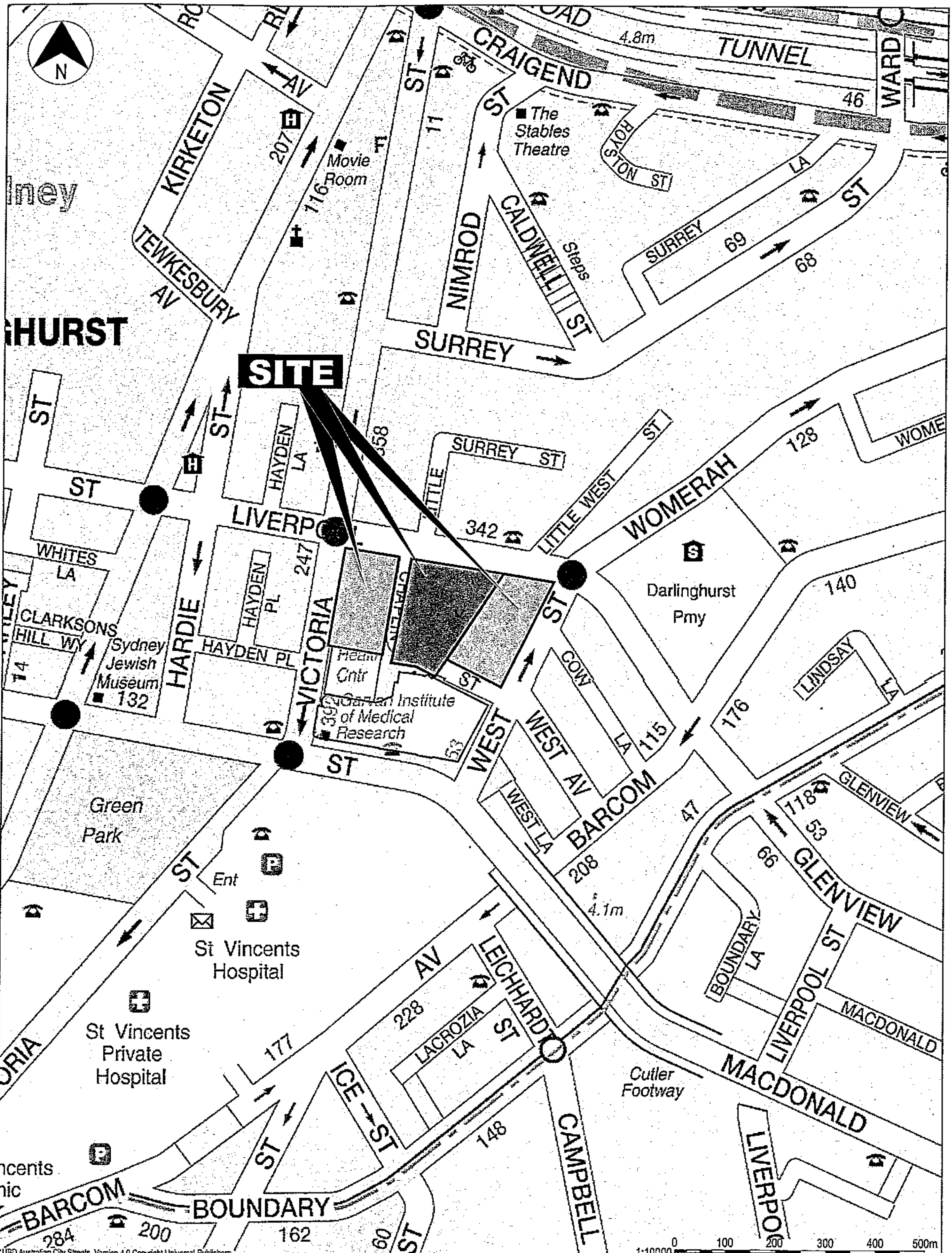

Golder Associates 124 PACIFIC HIGHWAY ST LEONARDS, N.S.W. 2065 Telephone (02) 9478 3900 Facsimile (02) 9478 3901	CLIENT ST VINCENTS & MATER HEALTH		PROJECT ST VINCENTS RESEARCH & BIOTECHNOLOGY PRECINCT, DEVELOPMENT	
	DRAWN HC	20.06.2008	TITLE SITE LOCALITY PLAN	
	CHECKED LBM	20.06.2008		
	SCALE 1:10000	A4	PROJECT No 087622042_004_R	FIGURE F0001 / REVISION 0

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