Douglas Partners
Geotechnics / Environment / Groundwater

Douglas Partners Pty Ltd
ABN 75 053 980 117
www.douglaspartners.com.au
96 Hermitage Road
West Ryde NSW 2114
PO Box 472
West Ryde NSW 1685
Phone (02) 9809 0666
Fax (02) 9809 4095

Project 71920
13 October 2010
SCP:jlb

Holdmark Constructions Pty Ltd
c/- Robertson & Marks Architects Pty Ltd
Ground Floor, 11-17 Buckingham Street
SURRY HILLS NSW 2010

Attention: Mr Brian Mann
Mr Lesley Jacob

Email: brian.mann@rmarks.com.au
lesley.jacob@marks.net.au

Dear Sirs

Shepherds Bay Urban Renewal
Meadowbank

We understand that the concept design for the proposed Shepherds Bay Urban Renewal has been updated since the "Terrace Concept" and "Harbour View Concept" referred to within our reports.

The current concept design is understood to be referenced as the "Preferred Master Plan". It is understood that the preferred master plan still mainly consists of medium to high density residential development, but differs from the previous concept plans with regards to the precise building layout and building heights across the site, and that the proposed jetty is no longer under consideration. Details such as basement or excavation locations and depths are still not available.

We do not consider that the revisions to the proposed above-ground building layout significantly alter the comments in our Preliminary Geotechnical and Groundwater Assessment (Report 71920, dated 12 October 2010) or Preliminary Contamination Screening Assessment (Report 71920-1, dated 13 October 2010). Comments regarding the proposed jetty are, however, no longer relevant.

Please contact either Kurt Plambeck or Sally Peacock if you have any queries on the above.

Yours faithfully
Douglas Partners Pty Ltd

Kurt Plambeck
Environmental Scientist

Reviewed by

R.W.Lumsdaine
Principal

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REPORT ON PRELIMINARY GEOTECHNICAL AND GROUNDWATER ASSESSMENT

PROPOSED SHEPHERDS BAY URBAN RENEWAL
CONSTITUTION ROAD
MEADOWBANK

Prepared for
HOLDMARK PROPERTY GROUP

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October 2010

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96 Hermitage Road
West Ryde NSW 2114
Australia

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West Ryde NSW 1685

Phone (02) 9809 0666
Fax (02) 9809 4095
sydney@douglaspartners.com.au

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TABLE OF CONTENTS

SCP:lll
Project 71920
12 October 2010

**REPORT ON PRELIMINARY GEOTECHNICAL AND GROUNDWATER ASSESSMENT
PROPOSED SHEPHERDS BAY URBAN RENEWAL
CONSTITUTION ROAD, MEADOWBANK**

1. INTRODUCTION

This report provides the results of a preliminary geotechnical and groundwater assessment by Douglas Partners Pty Ltd (DP Pty Ltd) for the proposed Shepherds Bay Urban Renewal at Constitution Road, Meadowbank. The work was requested by Robertson + Marks Architects Pty Ltd (R+M) on behalf of Holdmark Property Group.

The redevelopment of the existing, largely industrial area into a residential site is proposed. The works will include the construction of apartments and/or terraces, together with construction or renovation of associated infrastructure including roads and stormwater drainage. Some additional works are also proposed at the Shepherds Bay foreshore south of the site, including landscaping and a new jetty structure.

This preliminary geotechnical and groundwater assessment was required as part of the response to the Director General Requirements (DGRs) prior to approval of the proposed development. In particular, this report considers potential geotechnical and related groundwater risks and impacts in relation to the proposed project. This assessment has been prepared in conjunction with a Report on Preliminary Screening Contamination Assessment for the site (Report 71920-1, dated 13 October 2010) in which issues related to subsurface contamination and chemistry, including salinity and acid sulphate soils risks, are assessed. References to the Preliminary Screening Contamination Assessment are included within this report, where appropriate.

The assessment is based on a walkover of accessible areas of the site, and a desk top study.

2. INFORMATION PROVIDED BY CLIENT

The assessment is based on concept information provided by the client's agent, including the following documentation:

- Proposed development concepts for "Terrace Concept" and "View Concept", by R+M;
- Preliminary Environmental Assessment by Place Design Group, dated December 2009;
- A list of DGRs and responses from various interested parties;
- A table of existing land uses and site information, by R+M; and,
- A CAD survey plan of the site.
- Preliminary basement plans for the Stage 1 works by Robertson + Marks (Drawings A101-A103, dated 6/7/10 to 13/7/10)
- Report text only of a contamination assessment that includes part of the Stage 1 site (Report on Contamination Assessment, Hoover Manufacturing Facility, Meadowbank, NSW, May 2000) by Egis Consulting Pty Ltd

Of the above documents, it is noted that a response to the draft DGRs by the City of Ryde Council (letter dated 23 April 2010) included comment on the existing potential risk of collapse of the Constitution Road embankment under flood conditions. The letter outlines the management strategy adopted by Council that includes components such as reconstruction of the embankment, together with upgraded stormwater drainage provisions.

3. SITE DESCRIPTION

3.1 Site areas

The greater site, subject to the current assessment, consists of two areas within the existing Meadowbank Employment Area. For the purpose of this report, the two areas are referred to as the "Constitution Road site" and "Parsonage Street site", whereas the "greater site" refers to both areas. These sites are shown in Drawing 1 in Appendix A.

The Constitution Road site has an area of approximately 77200 m^2. This site is located immediately south-west of Constitution Road, and is bounded by Bowden Street, Belmore Street and Rothesay Avenue. Hamilton Crescent, Hamilton Crescent West and Nancarrow Avenue are within the area of the proposed development. This site includes the area of proposed "Stage 1" works, which is located at the south-eastern corner of the Constitution Road site, as shown in Drawing 3.

The Parsonage Street site has an area of approximately 3950 m^2. This site is bounded by Parsonage Street to the north-west, Well Street to the north-east, Church Street to the south-east and Loop Road to the south-west.

Both sites consist of numerous existing DP lots. For simplicity, subdivision of the greater site area for the purpose of more detailed descriptions, has followed the property numbering scheme established in the table of existing land uses and site information provided by R+M. The property numbers (which do not always correspond to individual lots) are shown in Drawing 2, in Appendix A. The Stage 1 site is understood to include Property 31 and part of Property 32.

3.2 General Site Description

At the time of this assessment, the majority of the greater site area was occupied by existing commercial/industrial properties. The buildings within the greater site were generally one to two storeys high and typically of brick or tilt-up concrete panel construction, although buildings up to four storeys high were present on the Constitution Road site. Partial or single level basements

were visible at a number of the existing properties on the Constitution Road site. Outside of the buildings, the ground surfaces were generally paved with concrete or asphalt. Vegetated and grassed areas were typically limited to landscaped strips adjacent to individual property boundaries and to the nature strip.

The Stage 1 area of the Constitution Road site is largely occupied by existing industrial buildings of 3 to 4 storeys and associated pavement areas.

The current land use on properties adjacent to the Constitution Road site is predominantly residential, with houses and apartments occupying the majority of properties on the far sides of Bowden Street, Constitution Road and Belmore Street. Industrial properties are present opposite the site at the north-eastern ends of Belmore and Bowden Streets. Existing parkland is located on the opposite side of Rothesay Avenue (along part of the south-western side of the site) including opposite the Stage 1 works area. At the western corner of the site, an existing vacant lot is present immediately south-west of the site at 146 Bowden Street. It is understood that this vacant lot is to be developed as a residential property.

The Constitution Road embankment is located adjacent to the Constitution Road site, starting near the northern corner of the site and extending approximately 170 m along Constitution Road, as shown in Drawing 1 in Appendix A. The embankment height is up to 4.5 m high, and supports the main part of Constitution Road. Filling is visible on the batters of the embankment. The subject site is separated from the toe of the embankment by the single lane access road (also part of Constitution Road).

At the Parsonage Street site, the land use of nearby properties is similarly residential and industrial. Parks and landscaped areas are present on the far side of Loop Road.

The foreshore area adjacent to the Constitution Road site, in the area of proposed landscaping, is generally either supported by retaining walls and/or slopes to the bay in the form of a mulched batter. Tidal land with some mangrove vegetation is present at the edge of the bay immediately beyond the shoreline. This area connects up with a sandstone sea wall located adjacent to the 146 Bowden Street site, and existing landscaped foreshore areas at Anderson Park.

Additional information relating to site description is also provided in Section 6 of this report, on the site walkover.

3.3 Ground Levels

The ground levels at the Constitution Road site generally fall from the eastern corner of the site (at approximately RL 21), towards Shepherds Bay along the south-western side of the site (to RL 2 to RL 4). Ground levels are typically high around Hamilton Crescent West (approximately RL 19 to RL 21) and low in the area south-west of the Constitution Road embankment (approximately RL 4 to RL 8). The ground levels fall variously over gently to moderately sloping ground, retaining walls, existing cuts and sandstone cliffs.

Ground levels adjacent to the Constitution Road site are generally also gently sloping, except for the Constitution Road embankment and a moderately steep batter down to Shepards Bay, south-west of the site.

The ground levels at the Parsonage Street site generally slope gently down from the eastern corner of the site towards the western corner, from RL 13 to RL 10. Surrounding ground levels are generally gently sloping, although south-west of the site the ground levels slope gently down the existing strip of parkland, then very steeply down to Loop Road.

Regional topographic contours are shown in Drawing 4 in Appendix A, attached.

4. REGIONAL MAPPING, GROUNDWATER BORES

Reference was made to regional mapping for geology, soil landscape groupings and acid sulphate soil risk. The site is outside of the area of salinity risk mapping. The regional mapping for the greater site area is summarised in Drawing 4, in Appendix A.

Reference was also made to historic aerial photographs of the site, for assessment of changes to the site over time.

4.1 Geology

Reference to the Sydney 1:100 000 Geological Series Sheet indicates that the greater site area is largely underlain by Hawkesbury Sandstone. Ashfield Shale is mapped at the eastern corner of the Constitution Road site, which is often underlain by a transitional unit, the Mittagong Formation, which is in turn underlain by Hawkesbury sandstone.

Ashfield Shale typically comprises black to dark grey shale and laminate, whereas Hawkesbury Sandstone typically comprises medium to coarse-grained quartz sandstone with very minor shale and laminate lenses. The Mittagong Formation typically comprises interbedded and laminated quartz sandstone and black siltstone.

Observations on site were generally consistent with the Hawkesbury Sandstone mapping, however the Mittagong Formation may be present at the eastern corner of the site.

4.2 Soil Landscape

Reference to the Sydney 1:100 000 Soil Landscape Grouping sheet indicates that the greater site is largely underlain by soils of the Gymea Soil Landscape Group. Small areas at the eastern and northern corners of the Constitution Road site are mapped as being underlain by the Glenorie and Lucas Heights Soil Landscape Groupings, respectively.

These soils are generally associated with clay, clayey sand and sand soils, which often, but not always, are of relatively shallow depth (less than approximately 2 m).

4.3 Acid Sulfate Soil (ASS) Risk

Reference to the 1:25 000 Acid Sulfate Soil (ASS) risk data indicates that the Parsonage Road site is located in an area of no known acid sulphate soil risk. Parts of the Constitution Road site, however, are located in areas of unknown risk, in disturbed terrain. These areas are located downslope of the Constitution Road embankment.

The sediments within Shepherds Bay are mapped as at high risk for acid sulphate soils.

Further comment on the risk of acid sulphate soils is provided within our Preliminary Contamination Assessment.

4.4 Registered Groundwater Bores

A search of the Office of Water in DECCW groundwater bore database was conducted on 20 July 2010. The location of the three registered groundwater bores located within 1km of the site are shown in Drawing 5, in Appendix A. No registered bores were found within the subject site area. The three bores shown were ~ 3 m and relatively distant from the subject site. It is considered that the results of groundwater monitoring at these bores are not relevant to the current site.

5. AERIAL PHOTOGRAPHS

Selected aerial photographs are included in Appendix B of this report, and observations on these photographs are included below, in Table 1. The included aerial photographs have been selected on the basis of interesting features. Additional photographs, (which may provide a better indication of the time frame of various site conditions) are included within our Preliminary Contamination Assessment, together with further observations including changes in land uses, etc.

Table 1 – Selected Observations of Aerial Photographs

Year	Observations
1930 (Plate B1)	Constitution Road embankment is not visible, and a line of trees extends from the embankment area down to Shepherds Bay (within Properties 8 and 9), suggestive of a waterway. The shoreline differs from that of the existing Shepherds Bay. The property immediately south-west of the Constitution Bay site (i.e. 146 Bowden Street) is apparently located within the bay, and part of the western "arm" of Property 8 may also be within the bay. The shoreline in this area is bordered by vegetation, which extends partly into the Constitution Bay site. The Parsonage Street site is intersected by Parsonage Street itself.
1943 (Plate B2)	A dark line is visible along part of Constitution Road, possibly a shadow from the road embankment. The line of trees that extended to the south-west of the embankment (in Properties 9 and 9) is no longer present, however the ground colour appears darker, possibly due to any or a combination of lower ground levels, different vegetation or higher moisture contents. The shoreline in the area of 146 Bowden Street is similar to that of the 1930 photograph, although the visible area of water extends closer to the subject site (and Property 8) than in the previous photograph. Ryde Bridge has by now been constructed, and while the Parsonage Street site is still intersected by Parsonage Street itself, its eastern boundary is now defined by Church Street.
1951 (Plate B3)	Constitution Road Embankment is visible. The shoreline in the area of 146 Bowden Street is similar to that of the earlier photographs, however significant earthworks are visible in the immediate area, with a wide trench excavation extending into Property 8. Excavation also appears to have been undertaken at Property 32 in the southern corner of the Constitution Road site, possibly for building platforms, which appear to step down towards Rothesay Avenue
1961 (Plate B4)	The shoreline in the area of 146 Bowden Street is similar to that of the earlier photographs, however the earthworks previously visible within Property 8 now appear to be of smaller scale.

Year	Observations
1970 (Plate B5)	The adjacent site at 146 Bowden Street has apparently been reclaimed, with a straight line (presumably the sea wall) separating the new land from Shepherds Bay. No vegetation is present within this area and no excavation is visible within property 8.
1996 (Plate B6)	The greater site appears substantially similar to its existing state. Vegetation has now extended along most of the foreshore of the Constitution Road site. The Parsonage Street site now apparently includes that part of Parsonage Street that previously intersected the site.

6. SITE WALKOVER

A geotechnical site walkover was undertaken as part of the preliminary geotechnical assessment, and involved viewing the properties that constitute the site from publicly accessible areas. Within selected properties owned by the client, closer inspection was undertaken of areas of interest (typically existing cuts).

Selected photographs from the geotechnical site walkover are included in Appendix C, together with Drawing 6, which indicates selected features observed on the site. Additional site photographs are included in the Preliminary Contamination Assessment.

Generally speaking, the existing buildings and retaining walls on the site were in reasonable condition for their age, with only minor cracking present in most structures. No significant seepage was observed at the base of retaining walls on the site, although few retaining walls appeared to include drainage provisions.

Sandstone outcrops were observed at numerous locations within and adjacent to the site. The locations of outcrops are indicated in Drawing 6 in Appendix C, together with further comments on observations regarding the outcrops and photographic plates. The following general comments are made:

- Sandstone outcrops were generally of medium and high strength, however variably weathered sandstone was also present, including extremely low and very low strength materials.
- No significant seepage was observed through the rock faces at outcrops, although some surficial seepage was note locally, apparently originating from surface flows, or from the base of the soil layer.
- A thrust fault was observed within the north-eastern cut located in Property 32 (in the Stage 1 part of the Constitution Road area). The fault was associated with significant shearing of the immediately overlying rock. The fault discontinued at a bedding plane. (refer to Photo C of Plate D4)
- Some areas of sandstone were densely vegetated, and close inspection was not possible

Filling was observed generally at ground level within most of the nature strips around the greater site area, and included sandstone gravel and possible sandstone boulders in some areas (see, for example Photo D in Photographic Plate C8, in Appendix C). The depth of filling is, however, unknown.

Filling was also observed within the sideslopes of the Constitution Road embankment which apparently also including sandstone cobbles and boulders. It is not clear whether this filling material extends throughout the embankment. No seepage was observed at the embankment face (see also Photographic Plate C9).

The foreshore area, where proposed raised walkways are to be constructed at the edge of the existing shoreline, was typically supported by existing retaining walls and/or a mulched batter slope. Some surficial movement of mulch on the batter slopes was visible. A possible sandstone boulder (or possibly a sandstone outcrop) was observed at the base of the batter in one area (beyond Property 34 – see Photo D of Photographic Plate C10).

7. COMMENTS

7.1 Proposed Development

7.1.1 Greater Site Area

The proposal for the greater site is redevelopment as a new residential area. Two different development concepts were available at the time of writing of this report – the "Terrace Concept" and "Harbour View Concept". These concepts include the construction of residential buildings of between 3 and 18 storeys at the Constitution Road site (though mostly 4 to 11 storeys), and a building of up to 33 storeys at Parsonage Street site. The building layout and building heights vary between the two concept plans, although both include a tower of 33 storeys at part of the Parsonage Street site. The Terrace concept layout is included in Drawing 4, in Appendix A, as an example of the proposed works.

It is understood that both concepts will include a range of associated works including:

- construction of new roads and/or renovation of existing roads
- upgrade of stormwater drainage
- extensive foreshore landscaping, including the construction of a raised walkway along part of the existing Shepherds Bay foreshore and extending over the existing water and/or tidal areas
- Construction of a new jetty within Shepherd's Bay

The precise geotechnical impacts of the above concepts are not defined at this stage, however it is expected that the following works will be required:

- Excavation for basement car parking areas with associated excavation support and possible dewatering;
- Construction of retaining walls and excavation for building platforms and for landscaping purposes;
- Localised excavation for services, stormwater upgrade;

- Construction of foundations for buildings, retaining structures, offshore piles for the proposed jetty and raised walkway; and,
- Construction and renovation of roads.

The precise location and depth of features such as the basement car parking over the greater site area are unknown at this stage, and are likely to vary depending on the adopted development proposal. Similarly, foundation locations and requirements are unknown at this stage. Relatively deep excavation, and high foundation loads are nonetheless expected at the Parsonage Street site, given the proposed height of the building and smaller site footprint.

7.1.2 Stage 1 Works

The proposed works at the Stage 1 part of the site are better defined. Here, the proposed development is understood to include the construction of a 7 to 8 storey residential building over much of the site. Basement carparking is proposed under the full building footprint, consisting of one to three levels, with a lowermost floor level at RL 1.7. Excavation will be required at the site, with the deepest excavation (of up to approximately 8 m) at the north-eastern end of the site, in an area of existing higher ground levels. As surrounding ground levels fall towards the south-west, excavation requirements will reduce to less than 1.5 m towards Rothesay Avenue.

The excavation will require associated retaining walls, excavation support and groundwater management, and new foundations will be required for the proposed building.

7.2 Previous Investigations

DP Pty Ltd has undertaken numerous investigations and site inspections both within the site boundaries, and on adjacent sites. This information has been used, together with the regional mapping and results of the site walkover, in the development of the geological and groundwater model for the site.

It is noted that all investigations are undertaken in order to provide specific information to meet the needs and requirements of the particular site geology, the proposed works and the client, and that subsequent works on a site may alter the actual ground conditions on a site. It is

therefore not considered appropriate to include specific borehole log information, etc. as part of this preliminary assessment.

7.3 Geological and Groundwater Model

The following geological and hydrogeological model has been developed on the basis of the site walkover, regional mapping and DP Pty Ltd's previous investigation at the site. Geotechnical investigation will be required to assess the accuracy of the model, which can then be revised based on the additional information.

7.3.1 Soil

Existing soils on the site are expected to generally comprise filling, underlain by natural residual soils including sandy clay, clayey sand and clay.

The nature of the filling material would depend on the source of the material and placement treatment, and could exhibit significant variability across the site. In the absence of specific test data, however, all filling on the site should be assumed to be uncontrolled. The depth of filling could be quite deep in some areas on the site, particularly behind retaining walls and in areas south-west of the Constitution Road embankment. Deep filling is particularly likely within Properties 8 and 9, where earlier watercourses were noted in aerial photographs. The depth of filling at Property 8 will also be influenced by the earthworks noted from the aerial photographs, while the south-western edges of this property site may have been influenced by previous natural variations or man-made alterations to the shoreline.

The thickness of the natural residual soil layer is not generally expected to exceed approximately 2 m, based on the regional mapping. This, however, should be confirmed by testing. Greater depths are, however, expected south-west of the Constitution Road embankment, where a natural watercourse is considered likely (on the basis of aerial photographs) to have been present.

7.3.2 Rock

Based on the results of DP's previous experience, the depth to rock is likely to be relatively shallow across the greater site area, including the Stage 1 site. However an increased depth to

rock is expected within Property 8 and Property 9, where depths of up to 4 m to 7 m to rock may be anticipated. These estimates will require confirmation by investigation.

Hawkesbury Sandstone is expected across much of the greater site area, although Ashfield shale is mapped at the eastern corner of the Constitution Road site. DP has previously encountered shale in investigations near this eastern corner of the site and it is considered possible that Ashfield Shale, and possibly Mittagong Formation materials are locally present within this area.

When encountered, the upper layers of bedrock are likely to be variably weathered, with some local areas of sandstone potentially weathered to extremely low strength rock to significant depth. The weaker rock is likely to be underlain by medium and high strength sandstone, although significant seams of extremely low strength rock and clays may still be present within these materials.

The thrust fault identified by the site walkover in the Stage 1 area, is consistent with DP experience at least one other property in the general area of the subject site. It is considered likely that additional thrust faulting may be present across the greater site, and at variable depth, including other areas and depths of the Stage 1 site. Such faults may alternately shear through rock beds then through bedding planes, and so may “step” across the site. As a result, these faults may not be identified at all test locations, and may appear to be discontinuous. The shear zones associated with such faulting will comprise weaker rock than the surrounding rock material, and would generally be associated with higher permeability materials. Some shear movement may also extend into the surrounding rock, resulting in thick layers of extremely low strength rock or clay within otherwise high strength rock. DPs experience in the vicinity of the site is that such layers are often up to 50 mm thick and can be thicker. Such weak bands have been identified to depths of more than 9 m at some locations.

As such, conditions at the site are expected to be highly variable, and more investigation would be required to confirm the geological model.

7.3.3 Groundwater

The groundwater in the greater site area is likely to be governed by two, interacting systems; the groundwater that originates on land, and continues to travel through subsurface stratum, and the water originating from Parramatta river that infiltrates into the adjoining soils and rock.

The absence of seepage from the sandstone cut faces suggests that groundwater levels are many metres below ground level in the higher areas of the site. Permanent groundwater levels within the sandstone bedrock are therefore expected across much of the site, except in the areas south-west of the Constitution Road embankment (and particularly Properties 8 and 9) where deeper soils are expected. The behaviour of groundwater flows within the sandstone is generally governed by defects within the rock mass, such as joints, bedding planes and shear zones, and as such is likely to be highly specific to the particular location of any proposed excavations.

It would be expected that groundwater levels within the soil and rock towards Shepherds Bay are likely to be influenced by the water level at Parramatta River.

Temporary groundwater flows at the base of filling layers, and at the base of natural soils (along the top of the sandstone) would also be expected to occur following periods of rainfall. Such temporary flows are consistent with the apparent localised surface dampness observed at some cut faces.

A specific regional groundwater monitoring program will be required to provide more information on the depth of groundwater, and direction of groundwater flow.

7.4 Site Preparation

Site preparation will be required at the site for the purpose of landscaping, construction of building platforms and roads. In the absence of information on the existing filling, it must be assumed to be uncontrolled.

Controlled filling would generally be required for building and pavement areas, which would require:

- Removal of topsoil, existing filling and unsuitable material, followed by proof rolling of the exposed natural soil surface;
- Excavation of any loose or compressible zones identified by the proof roll;
- Compaction of filling, with suitable testing and compaction. The precise testing and compaction requirements generally depend on the role of the filling, and an acceptable level of risk.

The material used for controlled filling could potentially include the existing filling and soils on the site, provided that they are considered suitable for re-use. The presence of significant organic material, contamination or large cobbles, among other things, may render the material unsuitable for re-use on the site. Reference should also be made to the Preliminary Contamination Assessment regarding this matter.

Waste classification would be required for any material to be disposed of off site, which is discussed in greater detail in the Preliminary Contamination Report.

Changes in level on the site could be accommodated by the appropriate use of batter slopes. Such slopes would vary depending on the consistency of the material and soil encountered on site, however generally a maximum slope of 3(H):1(V) would be recommended for permanent slopes to allow for maintenance of vegetation etc. Steeper batters could be adopted if the slope is to be protected by shotcrete or similar, or if the batter slopes are temporary.

7.5 Basement Construction

The construction of basement car parking will be required at the site. This will require excavation below existing ground levels, together with provision of adequate support for the adjacent soil and rock, and any adjacent structures that could be influenced by the excavation.

Specific locations and depths of basement excavations across the greater site area are not known at this time. Excavation for the Stage 1 works, however, is expected to require up to 8 m

of cut and is expected to include excavation into soils then sandstone. The strength of the sandstone is expected to vary from extremely low strength to high strength, possibly with some very high strength rock. Given that thrust faulting is present in the area, the site is considered more likely to encounter thick bands of weaker rock below higher strength rock. Such conditions could reduce bearing capacities for foundation design and require additional support measures during excavation.

The following comments are given with regard to excavation.

- Excavation into filling, soils and extremely to very low strength rock is expected to be readily achievable using conventional earthmoving equipment such as excavators. Excavation of low strength and stronger rock (including thick bands within otherwise extremely low or very low strength rock) is likely to require rock hammers, rock saws or milling heads attached to excavators. Excavation of low strength strong rock may cause significant vibrations, which is discussed in further detail in Section 7.10.
- Appropriate excavation support will be required, which will depend on the material and/or structures to be retained, specific soil, rock and groundwater conditions and details such as the depth of the basement. In some areas, battered excavations may be appropriate, while in others stabilised rock walls, or retaining walls may need to be constructed. Retaining structures and rock stabilisation are discussed in further detail in Section 7.7.
- Some movement of adjacent ground towards the basement excavation will occur, either due to relaxation of the retaining wall or stress relief of the adjacent rock.

Careful consideration will also need to be given to the presence of structures adjacent to any basements during excavation. The following cases serve as examples.

- Excavation near the Ryde bridge abutment for the Parsonage Street site may influence the stability or bearing capacity of the abutment foundation. Assessment of the existing foundation conditions and requirements would therefore be required prior to any adjacent basement excavation.
- Excavation near the toe of the Constitution Road embankment, may reduce the stability of the embankment in the short term. The influence of such an excavation is likely to depend on the factors influencing the embankment stability, including the particular geometry of the excavation and subsurface conditions.

- Excavation adjacent to existing structures, including buildings, roads, and services on the site may require retaining structures to be subject to tight deflection limits to prevent excessive movements.

7.6 Groundwater Management

Additional investigation will be required to assess the groundwater impacts on the site, in order to assess appropriate methods for managing those impacts. However the following serve as a general overview of possible management methods.

7.6.1 Dewatering

Where excavation is undertaken below the groundwater table, but inflows are relatively minor (such as in relatively intact rock, with relatively low pressure head change), or where groundwater inflow is limited to temporary flows the use of a dewatered excavation may be considered appropriate. In these cases, the inflows into the basement will be governed by the defects within the rock mass. Dewatering can potentially be undertaken with little influence on the surrounding groundwater level, however additional investigation would be required, specific to the proposed excavation depth and site, in order to assess the potential groundwater inflows, and influence of a dewatering scheme.

The use of management techniques, such as the use of monitoring wells outside the excavation, and reinjection points, can be used to monitor and, if necessary, mitigate the impacts of dewatering activities. Where groundwater inflows into the excavation are governed by significant defects within the rock mass such as shear zones, the use of grout cut-off walls or tanking may be appropriate to reduce groundwater inflows to more manageable levels.

Given that the lowermost basement floor level for the Stage 1 works is at RL 1.7 m, it is considered likely that groundwater infiltration into the excavation will be governed by defects in the rock mass, and that long term control with sump and pump methods could be appropriate. However, it should be noted that relatively high groundwater flows could be associated with defects such as the thrust faulting observed at the site (particularly in the short term), and that grouting of selected defects may be required to reduce long-term flows to a manageable level.

Further investigation to identify groundwater levels would be recommended, and further advice is likely to be required through the course of construction.

7.6.2 Tanking

Where high groundwater flows may be anticipated, or where dewatering is undesirable, tanking may be used. With this method of construction the basement is constructed as a relatively water resistant structure, and the structure is designed to resist the uplift pressures of the groundwater.

7.6.3 Impact on Groundwater Resources

The impact on groundwater resources of any proposed basement excavation cannot be reliably estimated at this time, as such impacts would depend on the particular location, depth and extent of the excavation, subsurface environment at that location and proposed basement design. Further investigation would be required. As such, it is likely that a water licence will be required under Part 5 of the Water Act 1912.

It is nonetheless expected that no substantial long term impact on groundwater resources would be anticipated at this site, provided that an appropriate method of groundwater management is adopted during the construction and life of the basements.

7.7 Retaining Structures and Rock Stabilisation

The design of any retaining structures should take into consideration the presence of surcharge loads behind the retaining wall, potential hydrostatic loads (such as from groundwater, including temporary flows), and acceptable wall movements. Retaining structures would generally be required for any vertical excavations in soils, or rock of very low or weaker strength. Low strength and greater strength rock can generally stand vertically, provided that no adverse jointing is present. Particular caution will be required in this regard at this site, due to the presence of thrust faulting and associated defects within the rock mass.

Where adverse defects are present within the rock mass, rock anchors, or similar can be installed to provide restraint to the rock. The use of shotcrete and dowels may also be required

where deeply weathered or sheared zones of rock exist within the rock mass, to prevent further weakening and spalling of the material following exposure.

For the Stage 1 works, retaining structures are likely to be required for the expected near-surface soils, with additional rock support likely to be required for the cut rock faces, particularly given that thrust faults and associated defects are expected at the site.

Should any existing rock cliffs, rock slopes or retaining structures be retained as part of the new developments, including existing sea walls, it is recommended that a stability assessment be undertaken in order to assess the risk of failure over the life of the proposed residences, with due consideration of the consequences of failure. The use of a slope stability risk assessment method such as that recommended by the Australian Geomechanics Society (AGS), as outlined in the 2007 journal, would be considered appropriate. These may indicate that additional rectification works are required in order to reduce risks to an acceptable level.

7.8 Foundations

The existing structures are generally in reasonable condition, and it is considered likely that they are largely founded on rock. It is recommended that the majority of the new buildings also be constructed with foundations bearing in the Hawkesbury Sandstone.

The allowable bearing capacity of the rock is likely to be governed by the presence of defects within the rock mass, and additional investigation will be required, including at the Stage 1 site. Where higher bearing capacities are required (generally where higher buildings are proposed), a higher density of testing should be undertaken. All foundations should be inspected by a geotechnical professional in order to confirm that foundation conditions are consistent with the required bearing capacities.

DP Pty Ltd's experience in offshore investigation in the area indicates that offshore structures are also likely to require foundations taken down to sandstone due to the presence of weak, overlying sediments. This would need to be verified at the particular location of the proposed jetty by investigation.

7.9 Working Platforms

The use of working platforms may be required where weak soil exists. Based on expected conditions, it is considered likely that requirements for working platforms would be limited to the areas of deeper soil anticipated at Properties 8 and 9. Working platform requirements, however, could also be dictated by poor backfilling of existing trenches etc. Additional testing would be required to further assess existing ground conditions.

7.10 Vibrations

Management of vibrations during construction activities on site will be required to reduce the impact to neighbouring residences and properties. The main source of vibrations at this site is likely to be excavation in rock, although relatively high vibrations levels can also occur during use of vibratory or impact rolling equipment, such as could be used during earthworks compaction.

Ground vibration can be strongly perceptible to humans at levels above 2.5 mm/s vector sum peak particle velocity (VSPPV) and can be disturbing at levels above 5 mm/s VSPPV. Complaints from building occupants are sometimes received when levels are as low as 1 mm/s VSPPV. The Australian Standard AS2670.2-1990 “Evaluation of human exposure to whole-body vibrations – continuous and shock induced vibrations in buildings (1-80 Hz)” indicates an acceptable day time limit of 8 mm/s peak velocity of vertical particle motion (PPVz) for human comfort.

From DIN 4150-2 (1999), a maximum limit of 15 mm/s PPVi (peak velocity of particle motion for any directional component) is recommended to prevent structural damage to residential-type structures. However, some architectural damage such as cracks through rendering, cornices and skirtings may occur below this limit, particularly when the buildings have been poorly constructed.

At this preliminary stage, a vibration level of 8 mm/s PPVi would therefore generally be suggested at adjacent, occupied residential buildings. Higher vibration levels may be

acceptable if the nearest adjacent buildings are unoccupied, or are of industrial construction, which may allow some operations, such as rock excavation, to be more rapidly completed and reduce construction costs. Review of the above, preliminary vibration level would therefore be considered appropriate when the staging of development works at the site are known.

Vibration trials and vibration monitoring would be recommended to ensure that vibrations are within acceptable levels. Vibration trials would generally be recommended at the commencement of rock excavation with particular equipment, and for a particular basement area. The trial would measure the vibrations at different distances from the proposed excavation equipment so that minimum clearance distances can be determined from the neighbouring buildings. The trial may indicate that smaller or different types of excavation equipment have to be used. Where the trial indicates that the adopted vibration limits may be exceeded, ongoing vibration monitoring during rock excavation would be recommended. Precise vibration trial and monitoring requirements are likely to depend on the proposed excavations, and construction sequence on the site.

7.11 Further Investigation

While it is anticipated that the geotechnical and groundwater risks at the site may be readily managed by appropriate deign and construction procedures, further geotechnical and groundwater investigation will be required, including for the Stage 1 works. The additional investigation would provide further information for the hydrogeological model, and to provide information relevant to design and construction at the site. Particular investigation requirements will depend on the details of the proposed development at the site, such as particular foundation requirements, or proposed excavation levels, but will include groundwater monitoring at the site to confirm the depth to groundwater. Additional monitoring and tests, such as water pressure or pump out tests may be appropriate where significant dewatering is proposed, to provide information on the impact of dewatering.

A phased approach to the investigation is considered to be appropriate given the scale of the site, and to provide flexibility in design.

8. LIMITATIONS

Douglas Partners (DP) has prepared this report for this project at Constitution Road, Meadowbank in accordance with DP's proposal dated 15 June 2010 and acceptance received from Robertson + Marks Architects, on behalf of Holdmark Constructions Pty Ltd dated 9 July 2010. The work was carried out under DP Conditions of Engagement. This report is provided for the exclusive use of Holdmark Constructions Pty Ltd for the specific project and purpose as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party.

The results discussed in the report are considered to be indicative of the sub-surface conditions on the site only to the depths investigated at the specific sampling and/or testing locations, and only at the time the work was carried out. DP's advice may be based on observations, measurements, tests or derived interpretations. The accuracy of the advice provided by DP in this report is limited by unobserved features and variations in ground conditions across the site in areas between test locations and beyond the site boundaries or by variations with time. The advice is limited by restrictions in the sampling and testing which was able to be carried out, as well as by the amount of data that could be collected given the project and site constraints. Actual ground conditions and materials behaviour observed or inferred at the test locations may differ from those which may be encountered elsewhere on the site. Should variations in subsurface conditions be encountered, then additional advice should be sought from DP and, if required, amendments made.

This report must be read in conjunction with the attached "Notes Relating to This Report" and any other attached explanatory notes and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions from review by others of this report or test data, which are not otherwise supported by an expressed statement, interpretation, outcome or conclusion stated in this report. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

DOUGLAS PARTNERS PTY LTD

Reviewed by

Sally Peacock
Associate

R W Lumsdaine
Principal