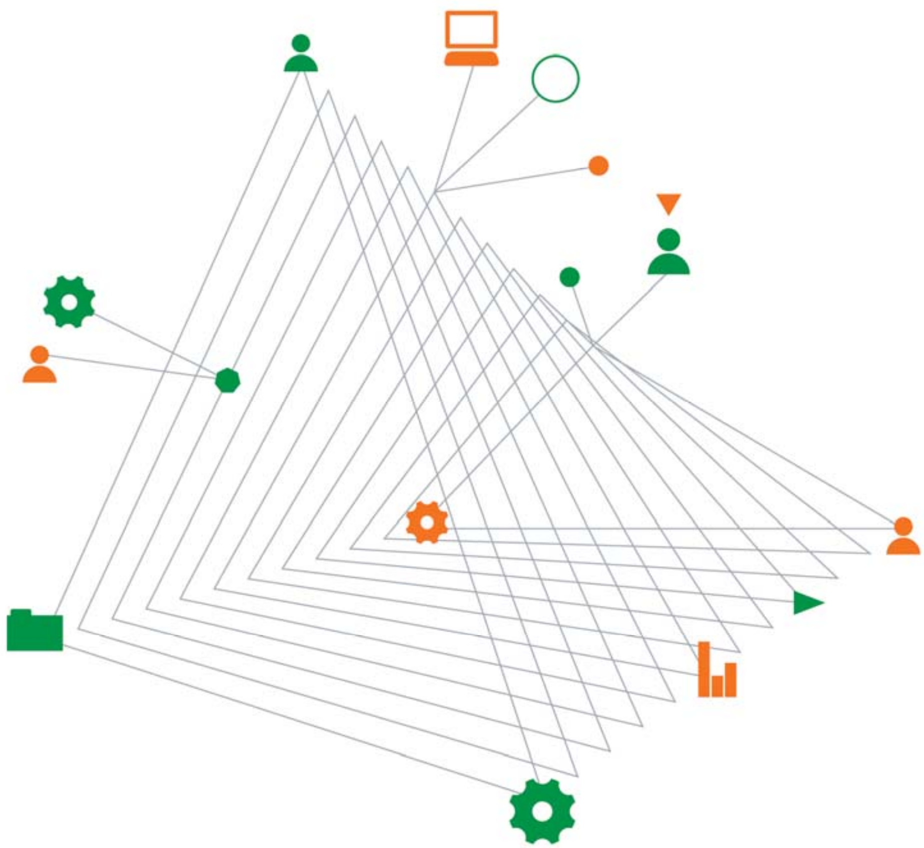
coffey

Sydney International Convention Exhibition and Entertainment Precinct (SICEEP)

**Darling Square
North East Plot**

Geotechnical Assessment for SSDA7

24 October 2014



Experience
comes to life
when it is
powered by
expertise

Sydney International Convention Exhibition and Entertainment Precinct (SICEEP) North East Plot

Prepared for
Lend Lease Development Pty Limited

Prepared by
Coffey Geotechnics Pty Ltd
Level 19, Tower B, 799 Pacific Highway
Chatswood NSW 2067 Australia
t: +61 2 9406 1058 f: +61 2 9406 1002
ABN: 93 056 929 483

24 October 2014

Document authorisation

Our ref: GEOTLCOV24303AG-BZ

For and on behalf of Coffey

Paran Moyes
Associate Geotechnical Engineer

Quality information

Revision history

Revision	Description	Date	Author	Reviewer	Signatory
v1 draft	Draft for client comment	29/10/2014	PKW		
v2 final	Final	02/10/2014	PKW, RC	JT	JT
v3	Minor edits	16/10/2014	RC	PM	PM
v4	Project name change	17/10/2014	RC	PM	PM
v5	Minor Edits	24/10/2014	RC	PM	PM

Distribution

Report Status	No. of copies	Format	Distributed to	Date
v5	1	PDF	Jessica Kelley	24/10/2014

Table of contents

Tables

Figures

Appendices

1. Introduction

This geotechnical report has been prepared by Coffey Geotechnics Pty Ltd (Coffey)to support a detailed Stage 2 State Significant Development (SSD) Development Application (DA) for mixed use development and associated public domain works within the North East Plot of Darling Square (SSDA 7), consistent with the approved Concept Proposal (SSDA 2). The report presents a summary of geotechnical site constraints relating to the future development of the North East Plot based on earlier investigation reports by Coffey.

The application is to be submitted to the Minister for Planning pursuant to Part 4 of the Environmental Planning and Assessment Act 1979 (EP&A Act).The Application (referred to as SSDA 7) follows the approval of a staged SSD DA (SSDA 2) in December 2013. SSDA 2 sets out a Concept Proposal for a new mixed use residential neighbourhood at Haymarket referred to as “Darling Square”, previously known as “The Haymarket”. Darling Square forms part of the Sydney International Convention, Exhibition and Entertainment Precinct (SICEEP) project, which will deliver Australia’s global city with new world class convention, exhibition and entertainment facilities and support the NSW Government’s goal to “make NSW number one again”.

More specifically this subsequent DA seeks approval for mixed use development within the North East development plot of Darling Square and associated public domain works. The DA has been prepared and structured to be consistent with the Concept Proposal DA.

2. Overview of Proposed Development

The proposal relates to a detailed (‘Stage 2’) DA for a mixed use residential development in the North East Plot of Darling Square together with associated public domain works. The Darling Square Site is to be developed for a mix of residential and non-residential uses, including but not limited to residential buildings, commercial, retail, community and open space. The North East Plot is one of six development plots identified within the approved Concept Proposal.

Under the Concept Proposal, the North East Plot is planned to accommodate a mixed use podium and three residential buildings (NE1, NE2, and NE3) above and within the podium structure. More specifically, this SSD DA seeks approval for the following components of the development:

- Demolition of existing site improvements, including the existing Sydney Entertainment Centre (SEC);
- Associated tree removal and planting;
- Construction and use of a predominantly 6 storey mixed use podium, including:
  - retail floor space and residential lobbies on Ground Level;
  - above ground parking;
  - residential apartments; and
  - communal facilities.
- Construction and use of three residential buildings above podium;
- Public domain improvements surrounding the site, including interim works;
- Provision of vehicle access to the development from Harbour Street;
- Landscaping works to the podium roof level; and

- Extension and augmentation of physical infrastructure / utilities as required.

3. Background

The NSW Government considers that a precinct-wide renewal and expansion of the existing convention, exhibition and entertainment centre facilities at Darling Harbour is required, and is committed to Sydney reclaiming its position on centre stage for hosting world-class events with the creation of SICEEP.

Following an extensive and rigorous Expressions of Interest and Request for Proposals process, a consortium comprising AEG Ogden, Lend Lease, Capella Capital and Spotless was announced by the NSW Government in December 2012 as the preferred proponent to transform Darling Harbour and create SICEEP.

Key features of the Preferred Master Plan include:

- Delivering world-class convention, exhibition and entertainment facilities, including:
  - Up to 40,000m^2 exhibition space;
  - Over 8,000m^2 of meeting rooms space, across 40 rooms;
  - Overall convention space capacity for more than 12,000 people;
  - A ballroom capable of accommodating 2,000 people; and
  - A premium, red-carpet entertainment facility with a capacity of 8,000 persons.
- Providing a hotel complex at the northern end of the precinct.
- A vibrant and authentic new neighbourhood at the southern end of the precinct, now called 'Darling Square', including apartments, student accommodation, shops, cafes and restaurants.
- Renewed and upgraded public domain that has been increased by a hectare, including an outdoor event space for up to 27,000 people at an expanded Tumbalong Park; and
- Improved pedestrian connections linking to the proposed Ultimo Pedestrian Network drawing people between Central, Chinatown and Cockle Bay Wharf as well as east-west between Ultimo/Pyrmont and the City.

On 21 March 2013 a critical step in realising the NSW Government's vision for the SICEEP Project was made, with the lodgement of the first two SSD DAs with the (now) Department of Planning and Environment. The key components of these proposals are outlined below.

Public Private Partnership SSD DA (SSD 12_5752)

The Public-Private Partnership (PPP) SSD DA (SSDA 1) includes the core facilities of the SICEEP Project, comprising the new, integrated and world-class convention, exhibition and entertainment facilities along with ancillary commercial premises and public domain upgrades. SSDA1 was approved on 22 August 2013.

Concept Proposal (SSD 13_5878)

The Concept Proposal SSD DA (SSDA 2) establishes the vision and planning and development framework which will be the basis for the consent authority to assess detailed development proposals within the Darling Square Site. SSDA2 was approved on 5 December 2013. The Stage 1 Concept Proposal approved the following key components and development parameters:

- Indicative staging of demolition and development of future development plots;

- Land uses across the site including residential and non-residential uses;
- Street and laneway layouts and pedestrian routes;
- Open spaces and through-site links;
- Six separate development plots, development plot sizes and separation, building envelopes, building separation, building depths, building alignments, and benchmarks for natural ventilation and solar access provisions;
- A maximum total gross floor area of 197,236m^2 (excluding ancillary above ground parking), comprised of:
  - A maximum of 49,545m^2 non-residential GFA; and
  - A maximum of 147,691m^2 residential GFA
- Above ground car parking including public car parking;
- Residential car parking rates;
- Design Guidelines to guide future development and the public domain; and
- A remediation strategy.

In addition to the approval of SSDA1 and SSDA2, the following approvals have been granted for various stages of Darling Square site:

- Darling Drive (part) development plot (SSDA3) for the construction and use of a residential building (student accommodation) and the provision of associated public domain works approved on 7 May 2014;
- North-West development plot (SSDA4) for the construction and use of a mixed use commercial development and public car park building and associated public domain works approved on 7 May 2014; and
- South-West development plot (SSDA5) – construction and use of a mixed use residential development and associated public domain works approved on 21 May 2014.

Approval was also granted on 15 June 2014 for SSDA6 which includes the construction and use of the International Convention Centre (ICC) Hotel and provision of public domain works.

This report has been prepared to support a detailed Stage 2 SSD DA for mixed use development and associated public domain works within Darling Square (SSDA 7), consistent with the approved Concept Proposal (SSDA 2).

4. Site Description

The SICEEP Site is located within Darling Harbour. Darling Harbour is a 60 hectare waterfront precinct on the south-western edge of the Sydney Central Business District that provides a mix of functions including recreational, tourist, entertainment and business.

With an area of approximately 20 hectares, the SICEEP Site is generally bound by the light rail Line to the west, Harbourside shopping centre and Cockle Bay to the north, Darling Quarter, the Chinese Garden and Harbour Street to the east, and Hay Street to the south (refer to **Figure 1**). The Darling Square Site is:

- located in the south of the SICEEP Site, within the northern portion of the suburb of Haymarket;

- bounded by the Powerhouse Museum to the west, the Pier Street overpass and Little Pier Street to the north, Harbour Street to the east, and Hay Street to the south; and
- irregular in shape and occupies an area of approximately 43,807m^2.

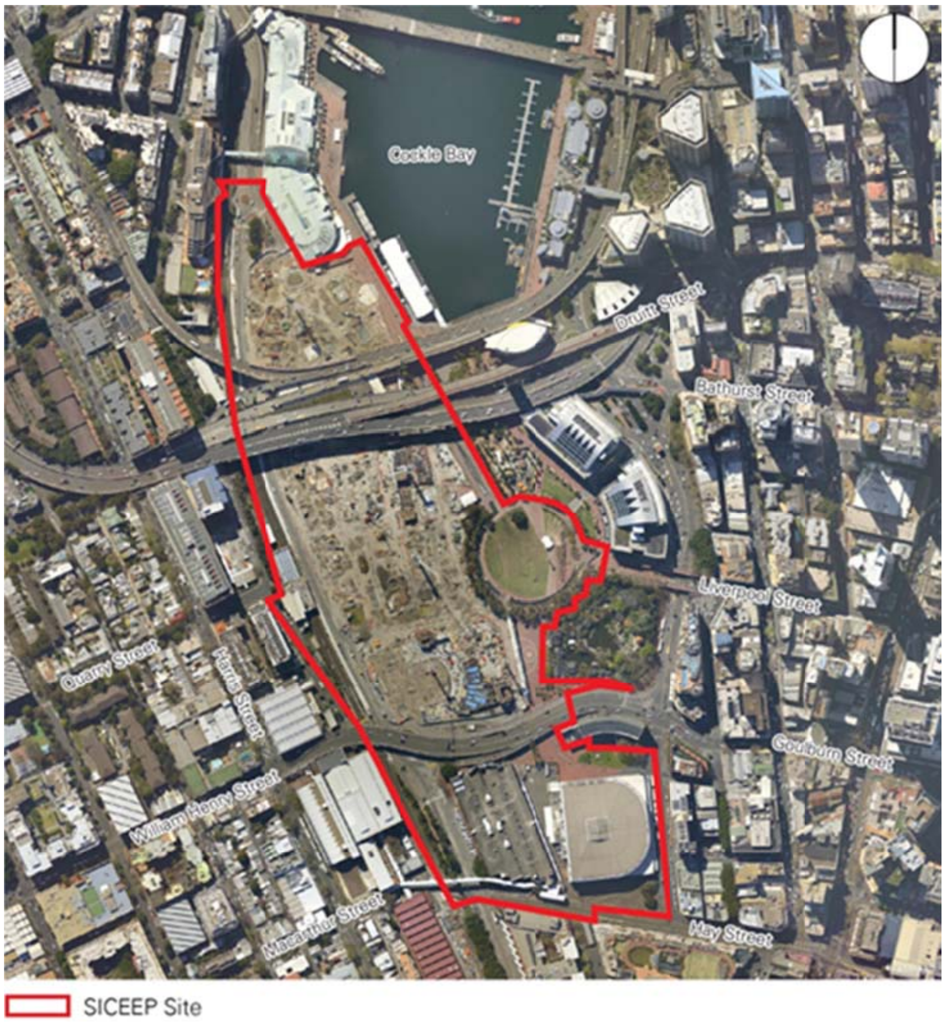


Figure 1 – Aerial Photograph of the SICEEP Site

The North East Plot is included within the Concept Proposal DA which provides for six separate development plots across the Darling Square Site as follows:

1. North Plot;
2. North East Plot;
3. South East Plot;
4. South West Plot;
5. North West Plot; and
6. Western Plot (Darling Drive).

The Application Site area relates to the North East Plot and surrounds as detailed within the architectural and landscape plans submitted in support of the DA (refer to **Figure 2**).

Figure 2 – Concept Proposal Development Plots

5. Planning Approvals Strategy

The SICEEP Project has resulted in the lodgement of numerous SSD DAs for the various components of the redevelopment project. Future applications will continue to be lodged in accordance with the Concept Proposal SSD DA for the remaining development plots of Darling Square Site.

6. Geotechnical Model

Coffey has previously completed a Preliminary Geotechnical Assessment to support a Stage 1 Development Application (SSDA2) for the overall Haymarket (Darling Square) Precinct development (refer report ref: GEOTLCOV24303AG-AD, dated 6 March 2013) which is presented as Appendix A of this report. Additional geotechnical investigations were carried out recently and a geotechnical report has been prepared for the North East Plot (refer report ref: GEOTLCOV24303AG-BM, dated 22 September 2014) which is presented as Appendix B of this report.

Based on the results of our latest geotechnical assessment, the geotechnical constraints for developments within the North East Plot are expected to broadly comprise those associated with the following main subsurface features:

- variable fill in terms of nature and thickness, including a suspected buried dam (discussed below);

- an in-filled palaeochannel, incised into the Sandstone bedrock at the south end of the NE plot and orientated roughly northwest/southeast;
- influence zone of an igneous dyke intrusion through the sandstone bedrock, striking north west/south east located just off the south west corner of the NE plot;
- presence of localised sub-vertical shearing and joint swarms with likely NNE strikes, and
- high groundwater levels.

The material infilling the palaeochannel that has been incised in the Sandstone bedrock comprises man-made fill and alluvium / estuarine deposits. Based on the available borehole information, an overview of the respective subsurface strata is presented in our geotechnical assessment report (refer Appendix B). The North East Plot is located on the eastern side of an in-filled palaeochannel resulting in a variable bedrock profile with depth to bedrock typically increasing towards the western and southern plot boundaries as shown on the inferred top of rock contour plan included as Figure 8 of Appendix B. The inferred location of the igneous dyke to the south west of the site is also shown in Figures 1 and 2 of Appendix B. The foundation conditions at the south-western corner of the western building on the NE Plot may be affected by the presence of the dyke, and our discussion and recommendations on foundation design is presented in our report attached in Appendix B. The site is located between the GPO Fault Zone to the west, and the Martin Place Joint Swarm to the east, and localised shearing and joint swarms may be present within the site.

A buried dam wall is thought to have been built through the NE plot in the early 19th century. Information from Casey and Lowe report titled "*Non Indigenous Archaeological Assessment and Impact Statement*", dated March 2013, suggests the dam is orientated approximately northeast/southwest from the corner of Harbour Street and Factory Street to the corner of Hay Street and Quay Street. The report states on page 16 that the dam wall "*may have a stone face or skin on the western side, retaining the formed earth, timber and rubble stone core. The top of the embankment may have a stone capping*". Casey and Lowe are currently undertaking an archaeological investigation at the site. Coffey will provide geotechnical advice to the design team, to assist in mitigating the impact of the development on the dam wall.

Table 1 below presents a summary of the depths of occurrence and thickness of each geotechnical unit of relevance to the North East Plot area based on the findings of previous investigations by Coffey and others.

Table 1 - Depth of occurrence and thickness of geotechnical units

Unit	Material / Origin	Depth to Top of Unit (m)	Thickness of Unit (m)	Elevation at Top of Unit (mAHD)
1	Fill	0	2 to 5	2.6 to 3.3
2A	Estuarine Deposits	2 to 3	nil to 4	1.7 to -0.2
2B	Alluvium	3 to 5	nil to 7	0 to -2.5
3	Residual Soil	7m	nil to 3.5	-4 (observed only at NE-BH2)
4A	Class V/IV Sandstone	6.5 to 14	0.5 to 2.5	-3.5 to -11
4B	Class III Sandstone	7 to 16	2.5 to 5	-4 to -13

4C	Class II Sandstone	10 to 16	Not Proven	-7 to -13

Groundwater levels are expected to vary between 0.5m AHD and -0.5m AHD, about 2.6 m to 3.6 m below existing ground level, although higher groundwater levels may occur due to tidal variations and high and persistent rainfall periods.

The site is located in a region with low seismic hazard, and has been classified as sub-soil class C_e with a Seismic Hazard Factor (Z) of 0.08.

7. Conclusion

Based on the findings of our geotechnical assessment, and experience on similar projects, the proposed developments associated with the North East Plot are considered feasible from a geotechnical perspective. The proposed developments should present a low risk to surrounding structures provided appropriate additional site investigation, design assessments, and construction monitoring normally associated with this type of development are carried out and on the assumption that a piled footing design is adopted to transfer the building loads to the underlying bedrock.

For advice pertaining to the above identified geotechnical site constraints for the proposed development, reference should be made to the relevant parts of our Geotechnical Assessment Report (ref: GEOTLCOV24303AG-BM, dated 22 September 2014) attached as Appendix B.

Important information about your **Coffey** Report

As a client of Coffey you should know that site subsurface conditions cause more construction problems than any other factor. These notes have been prepared by Coffey to help you interpret and understand the limitations of your report.

Your report is based on project specific criteria

Your report has been developed on the basis of your unique project specific requirements as understood by Coffey and applies only to the site investigated. Project criteria typically include the general nature of the project; its size and configuration; the location of any structures on the site; other site improvements; the presence of underground utilities; and the additional risk imposed by scope-of-service limitations imposed by the client. Your report should not be used if there are any changes to the project without first asking Coffey to assess how factors that changed subsequent to the date of the report affect the report's recommendations. Coffey cannot accept responsibility for problems that may occur due to changed factors if they are not consulted.

Subsurface conditions can change

Subsurface conditions are created by natural processes and the activity of man. For example, water levels can vary with time, fill may be placed on a site and pollutants may migrate with time. Because a report is based on conditions which existed at the time of subsurface exploration, decisions should not be based on a report whose adequacy may have been affected by time. Consult Coffey to be advised how time may have impacted on the project.

Interpretation of factual data

Site assessment identifies actual subsurface conditions only at those points where samples are taken and when they are taken. Data derived from literature and external data source review, sampling and subsequent laboratory testing are interpreted by geologists, engineers or scientists to provide an opinion about overall site conditions, their likely impact on the proposed development and recommended actions. Actual conditions may differ from those inferred to exist, because no professional, no matter how qualified, can reveal what is hidden by earth, rock and time. The actual interface between materials may be far more gradual or abrupt than assumed based on the facts obtained. Nothing can be done to change the actual site conditions which exist, but steps can be taken to reduce the impact of unexpected conditions. For this reason, owners should retain the services of Coffey through the development stage, to identify variances, conduct additional tests if required, and recommend solutions to problems encountered on site.

Your report will only give preliminary recommendations

Your report is based on the assumption that the site conditions as revealed through selective point sampling are indicative of actual conditions throughout an area. This assumption cannot be substantiated until project implementation has commenced and therefore your report recommendations can only be regarded as preliminary. Only Coffey, who prepared the report, is fully familiar with the background information needed to assess whether or not the report's recommendations are valid and whether or not changes should be considered as the project develops. If another party undertakes the implementation of the recommendations of this report there is a risk that the report will be misinterpreted and Coffey cannot be held responsible for such misinterpretation.

Your report is prepared for specific purposes and persons

To avoid misuse of the information contained in your report it is recommended that you confer with Coffey before passing your report on to another party who may not be familiar with the background and the purpose of the report. Your report should not be applied to any project other than that originally specified at the time the report was issued.

Interpretation by other design professionals

Costly problems can occur when other design professionals develop their plans based on misinterpretations of a report. To help avoid misinterpretations, retain Coffey to work with other project design professionals who are affected by the report. Have Coffey explain the report implications to design professionals affected by them and then review plans and specifications produced to see how they incorporate the report findings.

coffey

Important information about your **Coffey** Report

Data should not be separated from the report*

The report as a whole presents the findings of the site assessment and the report should not be copied in part or altered in any way. Logs, figures, drawings, etc. are customarily included in our reports and are developed by scientists, engineers or geologists based on their interpretation of field logs (assembled by field personnel) and laboratory evaluation of field samples. These logs etc. should not under any circumstances be redrawn for inclusion in other documents or separated from the report in any way.

Geoenvironmental concerns are not at issue

Your report is not likely to relate any findings, conclusions, or recommendations about the potential for hazardous materials existing at the site unless specifically required to do so by the client. Specialist equipment, techniques, and personnel are used to perform a geoenvironmental assessment. Contamination can create major health, safety and environmental risks. If you have no information about the potential for your site to be contaminated or create an environmental hazard, you are advised to contact Coffey for information relating to geoenvironmental issues.

Rely on Coffey for additional assistance

Coffey is familiar with a variety of techniques and approaches that can be used to help reduce risks for all parties to a project, from design to construction. It is common that not all approaches will be necessarily dealt with in your site assessment report due to concepts proposed at that time. As the project progresses through design towards construction,
speak with Coffey to develop alternative approaches to problems that may be of genuine benefit both in time and cost.

Responsibility

Reporting relies on interpretation of factual information based on judgement and opinion and has a level of uncertainty attached to it, which is far less exact than the design disciplines. This has often resulted in claims being lodged against consultants, which are unfounded. To help prevent this problem, a number of clauses have been developed for use in contracts, reports and other documents. Responsibility clauses do not transfer appropriate liabilities from Coffey to other parties but are included to identify where Coffey's responsibilities begin and end. Their use is intended to help all parties involved to recognise their individual responsibilities. Read all documents from Coffey closely and do not hesitate to ask any questions you may have.

* For further information on this aspect reference should be made to "Guidelines for the Provision of Geotechnical information in Construction Contracts" published by the Institution of Engineers Australia, National headquarters, Canberra, 1987.

Appendix A - Preliminary Geotechnical Assessment (ref: GEOTLCOV24303AG-AD, dated 6 March 2013)

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

PRELIMINARY GEOTECHNICAL ASSESSMENT 'THE HAYMARKET' STAGE 1 DEVELOPMENT APPLICATION (DA) – SSDA2 (SICEEP)

GEOTLCOV24303AG-AD
6 March 2013

Coffey Geotechnics Pty Ltd ABN 93 056 929 483
Level 18, Tower B, 799 Pacific Highway, Chatswood NSW 2067 Australia

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

6 March 2013

Lend Lease
The Bond
30 Hickson Road,
MILLERS POINT, NSW 2000

Attention: Warwick Bowyer

Dear Sir,

RE: Preliminary Geotechnical Assessment

Sydney International Convention Exhibition and Entertainment Precinct (SICEEP)

"The Haymarket" Stage 1 Development Application (DA) – SSDA2

Coffey Geotechnics Pty Ltd (Coffey) is pleased to present the results of a geotechnical assessment carried out for the proposed Sydney International Convention, Exhibition and Entertainment Precinct (SICEEP), southern precinct "The Haymarket" Stage 1 Development Application (DA) – SSDA2 in the following report.

Coffey understands that "The Haymarket" development is to include a mix of land uses including commercial office, residential; including student accommodation, retail and public open space. Residential podium and tower forms (up to 40 storeys) are proposed. Generally, car parking is proposed to be above grade within the podium. New infrastructure services (including diversions and augmentations) will be provided to service new developments. In addition, it is likely that excavation works associated with remediation and archaeological works will also be required.

Coffey Geotechnics has assessed the proposed development scheme in the context of the existing geotechnical conditions on the site and concludes that the site is suitable for its intended use.

While the site contains a number of geotechnical challenges including the presence of The Great Sydney Dyke, a high groundwater table, acid sulphate soils and rock at depth, Coffey is satisfied that these challenges can be adequately addressed through the utilisation of industry standard design and construction techniques and practices.

Coffey Geotechnics Pty Ltd ABN 93 056 929 483
Level 18 Tower B 799 Pacific Highway Chatswood NSW 2067 Australia
PO Box 125 North Ryde NSW 1670 Australia
T (+61) (2) 9406 1000 F (+61) (2) 9406 1002 www.coffey.com

If you have any questions regarding our report please contact the undersigned on 9406 1000.

For and on behalf of Coffey Geotechnics Pty Ltd

Dan Butterworth

Engineering Geologist

Distribution: Original held by Coffey Geotechnics Pty Ltd

1 copy held by Coffey Geotechnics Pty Ltd

1 copy to Lend Lease

CONTENTS

CONTENTS

1 INTRODUCTION

At the request of Lend Lease, Coffey Geotechnics Pty Ltd (Coffey) has carried out a preliminary geotechnical assessment for the proposed Sydney International Convention, Exhibition and Entertainment Precinct (SICEEP), southern precinct 'The Haymarket' Stage 1 Development Application (DA) – SSDA2. The objectives of the geotechnical assessment include:

- Development of a preliminary geotechnical model for the site based on site investigations carried out by Coffey, or information gathered by others for previous investigations;
- Assessment of the proposed development scheme in the context of the geotechnical conditions on the site and confirm that the site is, or can be made suitable for its intended use; and
- Provide preliminary assessment and recommendations for the following aspects in context of the proposed development(s) scheme:
    - Excavation conditions and support requirements;
    - Suitable building footing types and preliminary geotechnical parameters;
    - Groundwater conditions and dewatering requirements;
    - Expected soil aggressivity to buried structural elements;
    - Contingency planning for unexpected finds during works (both groundwater and soil);
    - Expected seismic design parameters; and
    - Presence of the Great Sydney Dyke and likely management requirements/considerations.

A contamination assessment and acid sulphate soils management plan are being carried out by Coffey concurrently with this assessment and will be reported separately.

2 PROJECT OVERVIEW

2.1 General

This report supports a State Significant Development Application (SSD 12_5752) submitted to the Minister for Planning and Infrastructure pursuant to Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

The Application seeks approval for the establishment of building envelopes and design parameters for a new neighbourhood and a community hub (referred to as The Haymarket) as part of the Sydney international convention, exhibition and entertainment precinct (SICEEP Project) at Darling Harbour.

The project will develop The Haymarket into one of Sydney's most innovative residential and working districts. Through the delivery of the overall project, Daring Harbour will also become home to Australia's largest convention and exhibition facilities, Sydney's largest red carpet entertainment venue, and a hotel complex of up to 900 rooms. The SICEEP Project importantly forms a critical element of the NSW Government's aspiration to "make NSW number one again".

2.2 Background

The existing convention, exhibition and entertainment centre facilities at Darling Harbour were constructed in the 1980s and have provided an excellent service for Sydney and NSW. The facilities however have limitations in their ability to service the contemporary exhibition and convention industry which has led to a loss in events being held in Sydney. The NSW Government considers that a precinct-wide renewal and expansion is necessary and is accordingly committed to Sydney reclaiming its position on centre stage for hosting world-class events with the creation of the Sydney international convention, exhibition and entertainment precinct.

Following an extensive and rigorous Expressions of Interest and Request for Proposals process, Darling Harbour Live (formerly known as ‘Destination Sydney’- a consortium comprising AEG Ogden, Lend Lease, Capella Capital and Spotless) was announced by the NSW Government in December 2012 as the preferred proponent to transform Darling Harbour and create the new Sydney international convention, exhibition and entertainment Precinct.

Key features of the Darling Harbour Live Preferred Master Plan include:

- Delivering world-class convention, exhibition and entertainment facilities, including:
  - Up to 40,000m^2 exhibition space;
  - Over 8,000m^2 of meeting rooms space, across 40 rooms;
  - Overall convention space capacity for more than 12,000 people;
  - A ballroom capable of accommodating 2,000 people; and
  - A premium, red-carpet entertainment facility with a capacity of 8,000 persons.
- Providing up to 900 hotel rooms in a hotel complex at the northern end of the precinct.
- A vibrant and authentic new neighbourhood at the southern end of the precinct, called ‘The Haymarket’, home to an IQ Hub focused on the creative industries and high-tech businesses, apartments, student accommodation, shops, cafes and restaurants.
- Renewed and upgraded public domain, including an outdoor event space for up to 25,000 people at an expanded Tumbalong Park.
- Improved pedestrian connections linking to the proposed Ultimo Pedestrian Network drawing people between Central, Chinatown and Cockle Bay Wharf as well as east-west between Ultimo/Pyrmont and the City.

2.3 Site Description

The SICEEP Site is located within a 60 hectare waterfront precinct on the south-western edge of the Sydney Central Business District known as Darling Harbour that provides a mix of functions including recreational, tourist, entertainment and business. With an area of approximately 20 hectares, the SICEEP Site is generally bound by the Light Rail Line to the west, Harbourside Shopping Centre and Cockle Bay to the north, Darling Quarter, the Chinese Garden and Harbour Street to the east, and Hay Street to the south.

The SICEEP Site has been divided into three distinct redevelopment areas (from north to south) – Bayside, Darling Central and The Haymarket. The Application Site area relates to The Haymarket as shown below.

2.4 Planning Approvals Strategy

In response to separate contractual agreements with the NSW Government and staging requirements, Lend Lease (Haymarket) Pty Ltd is proposing to submit a number of separate development applications for key elements of the overall Project.

This staged development application involves the establishment of building envelopes and design parameters for a new neighbourhood and a community hub (The Haymarket) within the southern part of the SICEEP Site. Detailed development applications will accordingly follow, seeking approval for specific aspects of The Haymarket in accordance with the approved staged development application.

Separate development applications will be lodged for the PPP component of the SICEEP Project (comprising the convention centre, exhibition centre, entertainment facility and associated public domain upgrades) and Hotel complex. An overview of the preferred masterplan is provided below.

3 THE HAYMARKET SITE AND PROPOSED DEVELOPMENT

Figure 1 shows "The Haymarket" site footprint which comprises an area of approximately 6 hectares, located towards the southern end of Darling Harbour, Sydney. The irregularly shaped site is bound by Harbour Street to the east, Pier Street Overpass to the north and Hay Street to the west. A light rail corridor forms the western site boundary.

The site is currently occupied by the Sydney Entertainment Centre (SEC) towards the eastern site boundary with a multi storey car park, Darling Drive road alignment and monorail line towards the western boundary.

Coffey understands that "The Haymarket" development is to include a mix of land uses including commercial office, residential including student accommodation, retail and public open space. Residential podium and tower forms (up to 40 storeys) are proposed. Generally, car parking is proposed to be above grade within the podium. New infrastructure services (including diversions and augmentations) will be provided to service new developments.

An outline of the proposed development footprint(s) is shown in Figure 1.

Based on review of the indicative architectural design drawings supplied by Lend Lease, the proposed development will not have deep basements, with excavation expected to be limited to half basement, footing excavations and for underground services installation. In addition, it is likely that excavation works associated with remediation and archaeological works will also be required.

Buildings are expected to generally be founded on piles.

4 DESK STUDY INFORMATION

4.1 Geology and Site History

Based on Macquarie's Map of 1822, the site is located over what was originally known as Cockle Bay. The bay and its tributaries extended almost 1km inland from the southern boundary of the present harbour. The present shoreline has been formed progressively by infilling since the 1820's. The fill deposits are underlain by slope wash and alluvial deposits, which are underlain by residual soil and Hawkesbury Sandstone bedrock of the Triassic Age.

After reclamation in the 1820's, factory buildings and roadways were developed progressively within the site. In the 1930's, most of the site was demolished to allow construction of a council depot. In 1949, the site was redeveloped into City Markets No.4. Subsequently in the 1980's, the City Market structures were demolished and the site was redeveloped with a multi-storey car park and the Sydney Entertainment Centre. Further details on historical land use of the site can be found in our environmental desk study report GEOTLCOV24303AA-AC, dated 13 July 2011.

An igneous dyke known as "The Great Sydney Dyke" intrudes the Hawkesbury Sandstone through the site in a northwest to southeast direction. The GPO fault zone with associated sub parallel shear zones is inferred to be present within the site, striking approximately north east/south west.

4.2 Previous Geotechnical Investigations

Coffey has extensive existing geotechnical information within the site and immediate environs. This includes site investigations carried out by Coffey and information gathered by others for previous projects. Borehole data from the references listed in Table 1 was used to assess the geotechnical/geological conditions of the site.

Table 1 – Results of Previous Investigations Used in Preparation of this Report

Ref No.	Description of Previous Project
R1	Department of Main Roads, "North Western Expressway Project", 1971*****
R2	Coffey & Partners Pty Ltd, "Haymarket Redevelopment – Report on Preliminary Foundation Investigation", May 1978 (S6063-AA)
R3	Coffey & Partners Pty Ltd, "Haymarket Redevelopment – Parking Station Foundation Investigation", July 1979 (S6269-AB)
R4	Coffey & Partners Pty Ltd, "Proposed Haymarket Carpark – Additional Foundation Investigation", June 1980 (S6269/2-AA)
R5	Arup Geotechnics, " Darling Harbour Redevelopment – Site Investigation Report", November 1984
R6	Coffey & Partners Pty Ltd, " Darling Harbour Development Maritime Structures Geotechnical Investigation Zones 1 to 6" May 1985 (S7559/1-AE)*****
R7	Coffey & Partners Pty Ltd, " Darling Harbour Development Project Convention Centre – Geotechnical Investigation" June 1985 (S7559/3-AD)
R8	Arup Geotechnics, " Darling Harbour Development Western Boulevard – Site Investigation Report", December 1985
R9	Coffey & Partners Pty Ltd, " Darling Harbour Light Monorail Geotechnical Investigation", May 1986 (S7769/1-AG)
R10	Coffey & Partners Pty Ltd, "Studio City Development – Geotechnical investigation", July 1988 (S8283/1-AH)
R11	City of Sydney, City Engineer's Department, "William Henry Street Bridge – Eastern Approach", July 1967
R12	Coffey Geosciences Pty Ltd, " Geotechnical Investigation Proposed Multi-storey Development – Bullecourt Place, Ultimo", December 2001 (S21012/1-AS)
R13	Arup Geotechnics, "Darling Harbour Development – Western Boulevard Sewer Tunnel", December 1985
R14	Coffey & Partners Pty Ltd, "Merino Central Two Project, Pyrmont – Geotechnical Investigation", November 1986 (S7960/1-AC)
R15	Jeffery and Katauskas Pty Ltd, "Geotechnical Investigation Proposed Refurbishment of Woolstores", April 1986
R16	Arup Geotechnics, "Darling Harbour Development – Pier Street, Harbour/Day Streets" April 1986
R17	Coffey Geotechnics Pty Ltd, "Sydney International Convention and Entertainment Centre – Geotechnical Investigation Report", August 2011 (GEOTLCOV24303AA-AE)
R18	Coffey Geotechnics Pty Ltd, "Proposed Sydney International Convention, Exhibition and Entertainment Precinct (SICEEP)", May 2012 (GEOTLCOV24303AC-AD)
R19	Coffey Environments Pty Ltd, "Supplementary Site Investigation – Sydney International Conference, Exhibition and Entertainment Precinct, Darling Harbour" August 2012 (GEOTLCOV24303AD-AA)

Ref No.	Description of Previous Project
R20	Coffey Environments Pty Ltd, “Supplementary Site Investigation: Factual Report – Sydney International Conference, Exhibition and Entertainment Precinct, Darling Harbour” January 2013 (GEOTLCOV24303AF_R0-01a)

5 PRELIMINARY GEOTECHNICAL MODEL

The geotechnical conditions at the site are complex, comprising the following main features:

- Variable fill;
- An in-filled palaeochannel, incised into the Sandstone bedrock and orientated roughly north/south;
- An igneous dyke intrusion through the Sandstone bedrock, striking north west/south east;
- Sheared zones and joints in the Sandstone bedrock, associated with the ‘GPO’ Fault regionally mapped as striking north north east/south south west beyond the eastern site boundary; and
- High groundwater levels.

5.1 General Soil and Rock Profiles

The material infilling the palaeochannel that has been incised in the Sandstone bedrock comprises man-made fill and alluvium / estuarine deposits. Based on the available borehole information, an overview of the respective subsurface strata is presented in Table 2, with material types divided into geotechnical units for the purposes of this report.

Table 2 – Overview of Subsurface Conditions and Geotechnical Units

Unit	Material Description
1	Fill – comprising heterogeneous mixtures of sand, sandy gravel, clay and sandy clay/silt with cobbles and occasional boulder sized rock fragments. Concrete and Asphalt materials were encountered at shallow depths at most of the borehole locations. The density/consistency of the fill is variable, and may range from loose to dense or very soft to stiff. Due to its variability and likely non-uniform placement procedure, it would be classified as “uncontrolled fill”.
2	Alluvium and Estuarine Deposits – comprising clayey sands and clays with occasional shell layers and organic matters. These materials range from very loose to medium dense or very soft to very stiff in consistency. Some of the underlying residual soil (Unit 3) may have been disturbed and mixed within the alluvium.
3	Residual Soil – derived from weathering of the underlying sandstone rock, and generally comprising clayey sand or sandy clay having stiff consistency. In many places, however, this unit is relatively thin or absent due to the geological erosion process.
4	Bedrock – comprising Sandstone ranging from extremely weathered to fresh with low to medium strength shale bands (up to 1.2m thick). This unit has been subdivided based on strength, fracturing, and defects in accordance with Pells et al (1998) as follows:

Unit	Material Description
	• 4a – Class V and Class IV Sandstone • 4b – Class III Sandstone • 4c – Class II Sandstone or better Class V Sandstone is extremely low to low strength with significant amounts of defects while Class II Sandstone or better is generally medium and high rock strength with limited defects. It should be noted that the buried bedrock surface is likely to vary as a series of sub-horizontal benches and sub-vertical cliff lines, in a similar fashion to the variations in level that can be observed on the Sydney harbour foreshores.
5A	Clay – comprising high plasticity clay derived from completely weathered dyke material. This unit is found within the dyke to significant depths as recorded in the past investigations. This material was not encountered during the current investigations.
5B	Dolerite – highly weathered to fresh dyke material found within the dyke shown in Figure 2 from observations made during previous investigations.

Note: Rock classified in accordance with Pells et al (1998) "Foundations on Sandstone and Shale in the Sydney Region" Aust. Geomech. Jnl, Dec 1998.

Table 3 presents a summary of the depths of occurrence and thickness of each geotechnical unit observed at the site based on the findings of previous investigations by Coffey and others.

Table 3 – Depth of Occurrence and Thickness of Geotechnical Units

Unit	Material / Origin	Depth to Top of Unit (m)	Thickness of Unit (m)	Elevation at Top of Unit (mAHD)
1	Fill	0	0.4 to 4.5	2.4 to 3.8
2	Alluvium/Estuarine	0.4 to 6.5	1.5 to 14.5 (Where proven)	1.2 to -1.5
3	Residual Soil	4.6 to 9.8	0.4 to 4.2	-1.8 to -11.7
4a	Class V and IV Sandstone	5.6 to 13.3	0.1 to 3	-3.2 to -13.2
4b	Class III Sandstone	7.2 to 20.8	4.8 to >9.6	-3.9 to -15.8
4c	Class II Sandstone or better	12.9 to 23.5	Not Proven	-12.2 to -20.8

Note: Rock classified in accordance with Pells et al (1998) "Foundations on Sandstone and Shale in the Sydney Region" Aust. Geomech. Jnl, Dec 1998.

Based on the information obtained from past investigations referenced in Section 3, Coffey has inferred subsurface contours for the base of fill / top of alluvial deposits (Figure 2) and top of extremely weathered/highly weathered bedrock (Class V and Class IV) (Figure 3).

The inferred rock contours indicate a highly irregular rock profile to be present, particularly at the northern part of the site and the centreline of the inferred palaeochannel. The difference in rock level is expected to be about 14m across the width of The Haymarket site footprint, deepening from the western edge and the eastern edge towards middle of the site.

Three cross sections have been drawn through the site and are presented as Figure 4 to Figure 6.

5.2 Igneous Dyke

The approximate location of the igneous intrusion known as the ‘Great Sydney Dyke’ is shown on Figure 2 and Figure 3. The dyke comprises extremely weathered dolerite with stiff clay properties to depths of between about RL-16m to RL-24m. Below these depths better quality dolerite is likely to occur.

Based on available previous borehole information, the dyke was found to have a width ranging from about 3m to 8m, with an average width of typically 4.5m. It should be noted that the dyke may thin, thicken, side step or branch. The location and shape of dyke as presented on Figure 2 and Figure 3 should be taken as approximate only.

The sandstone/dyke interface is expected to be vertical to sub vertical. Typically sandstone on either side of dyke is altered and fractured by the intrusion.

Information gathered during a web search (source: development application documents for City West Cable Tunnel project) indicates that the dyke was observed in excavations near the corner of Thomas Street and Hay Street and that seepage flow from within the surrounding sandstone was highly saline, with iron, manganese and sulphate. It is also suggested in these documents that it is likely that the dyke zone is connected to groundwater in the Darling Harbour sediments.

5.3 Fault and Shear Zones

Besides the dyke, shear zones and isolated joints sub parallel to the GPO fault zone are also inferred to be present within the site. The approximate known location of the main GPO fault zone extends from the Circular Quay area to the intersection of Bathurst Street and Harbour Street (i.e. about 400m north of site) with an approximate strike of NNE. The approximate inferred alignment of the GPO fault zone is shown in Figure 2 and Figure 3.

5.4 Groundwater

The results of monitoring undertaken during previous investigations indicate groundwater levels to be between RL1.7m and RL-1.3m. No discernible influence of tidal levels within Cockle Bay to the north and groundwater levels at The Haymarket site was noted over the course of the monitoring.

Groundwater is likely to be encountered within the Unit 2 Alluvium and the Unit 1 Fill that has been placed to raise site levels from what was probably low lying swampy ground. Groundwater may also be encountered within the bedrock in joints and bedding partings.

6 PRELIMINARY DISCUSSION AND RECOMMENDATIONS

Based on the findings of our geotechnical assessment, and experience on similar projects, the proposed development is considered feasible from a geotechnical perspective. The proposed development should present a low risk to surrounding structures provided appropriate additional site investigation, design assessments, and construction monitoring normally associated with this type of development are carried out.

6.1 Excavations

6.1.1 Excavation Conditions

Based on the architectural concept drawings supplied by Lend Lease, the proposed development will not have deep basements, with excavation expected to be limited to half basement, footing excavations and for underground services installation. Such excavations are therefore expected to be within Unit 1 Fill and Unit 2 Alluvium/Estuarine Deposits. The proposed buildings are generally expected to be founded on piles.

6.1.2 Bulk Excavation Batter Slopes

The stability of excavations in Unit 1 Fill will be influenced by the presence of the underlying low strength Unit 2 soils (even if Unit 1 fill is replaced by Engineered Fill) and groundwater. As a result there will be a significant risk of excavation instability if relatively steep temporary batter slopes are adopted without site specific investigation and geotechnical input during both design and construction. For preliminary design we recommend the following temporary batters and shoring:

- Above the Groundwater Table, Excavations in Unit 1 or Engineered Fill: flatter than 2H:1V; and
- Below the Groundwater Table or into Unit 2 Soils: adopt shoring.

Instability due to bottom heave is not anticipated for shallow excavations. However, further assessment should be carried out for deeper excavations if proposed.

6.1.3 Excavation Support Requirements

Depending on project requirements for a sufficiently watertight, and/or stiff retention system the following options could be considered.

- Driven sheet piles;
- Contiguous pile wall; or
- Secant pile wall.

For a sheet piled wall, overlapping or interlocking sheets would be vibrated or driven into the ground around the proposed basement perimeter prior to excavation. The steel sheet piles could be used to provide formwork for the permanent basement walls, but this would preclude their recovery. Sheet piles would likely refuse on the weathered bedrock, and groundwater seepage would be expected to occur through the clutches and toe of the wall.

Contiguous pile walls may be practicable where the fill or natural soils are cohesive and excavations do not extend to significant depth below the groundwater table. Contiguous pile walls are not watertight because of the installation tolerance of the piles. It may be difficult to achieve a watertight permanent wall where contiguous piles are adopted.

Secant piling involves drilling "soft" piles using low strength concrete at centres of 1.5 pile diameters. Normal strength "hard" piles are then drilled between, cutting into the soft piles to form a relatively water tight seal. Unless bored carefully, secant piles can deviate off vertical centre during installation creating gaps between the piles and result in groundwater seepage and ground loss.

For the preliminary design of retaining walls the parameters in Table 4 should be adopted.

Table 4: Preliminary Retaining Wall Design Parameters

Unit	Description	Bulk Unit Weight (kN/m^3)	Effective Cohesion (kPa)	Friction Angle (degree)
1	Fill	20	0	30
2	Alluvium/Estuarine	18	0	26
3 & 5A	Residual Soil/weathered dyke	20	5	28
4a	Class V and IV Sandstone	21	30	35

Retaining walls should be designed for appropriate hydrostatic and surcharge loads.

Where cantilevered walls are not practicable, lateral stability could be provided by anchors installed progressively as the excavation proceeds. Anchors may need to be installed beneath adjacent properties and would need the permission of adjacent property owners. Where installation of anchors is not practicable, internal strutting or bracing may be required to provide lateral stability.

Excavations associated with installation of utilities are expected to be relatively shallow. Where it is not practicable to adopt temporary batters as recommended in Section 6.1.2 above due to land take restrictions, or where excavations are below standing groundwater levels; lateral excavation support should be provided using a temporary shoring box, internal strutting or similar.

6.1.4 Groundwater Conditions

Where excavations are proposed to extend below standing groundwater levels, extensive dewatering of the alluvial soils is not desirable as this could lead to consolidation settlement of the fill and alluvium and may need special permits to discharge off site. Cut-off walls will be required during excavation works and the final basement walls should be designed as tanked to maintain standing groundwater levels and prevent groundwater ingress into the basement.

Where excavations for the purpose of utilities, remediation and archaeological works are to extend below standing groundwater levels, localised dewatering will be required. Where inflow rates are relatively low and cohesive soils are encountered, sump and pump techniques may be practicable. However, where higher inflow rates occur, installation and operation of drilled wells or jetted spear points around the excavation perimeter would be required.

The detailed assessment and design of groundwater management is beyond the scope of this report and should be addressed by a hydrogeological investigation.

6.1.5 Excavation Induced Ground Movements

Walls retaining soil strength material will laterally deflect up to 1% of the retained height, depending on the stiffness of the retaining wall system.

The potentially damaging effects of stress redistribution in the vicinity of excavations should be assessed as part of the detailed design. Lateral displacements of retaining walls due to stress redistribution may also result in settlement. For preliminary assessment of impacts we recommend that potential settlement be assumed to be equal to predicted lateral displacements. Typically, ground movements (lateral displacement and settlement) are greatest at the excavation face and decrease to negligible values at a distance of up to 3 times the excavation depth.

For preliminary impact assessment purposes the above guidelines on displacements may be used. If such movements cannot be tolerated for sensitive features, then retaining walls should be designed for higher earth pressures. Depending on the specific retention system, basement excavation details and the nature of adjacent structures, a more detailed analysis will be required. Coffey has specialist capability in applying numerical modelling techniques to the estimation of ground movements.

6.2 Building Foundations

6.2.1 Expected Arrangements and Issues

The Haymarket is understood to comprise construction of various multi-storey buildings expected to be between 4 storeys and 40 storeys as shown on Figure 1.

Based on the nature of subsurface conditions; comprising a variable thickness of fill and alluvial/estuarine soils, we expect that footings for this development may comprise cased bored piles or continuous flight auger (CFA) piles socketed into the underlying sandstone bedrock, or pad/strip footings where rock is shallow.

Stress relief effects due to the palaeochannel formation process are likely to have caused opening and weathering of defects (bedding planes and joints). Therefore, poor foundation conditions may occur near the current rock surface level. Depending on the proposed bulk excavation level relative to the current rock level, significant clay seams may be encountered and these may affect both bearing capacity and settlement of pad footings.

Difficulties in construction of deep piles at SEC have been reported (e.g. Malcom D.J., 1997) when the dyke is in contact with recent marine and alluvial sediments. An indurated sandstone or ironstone capping layer at the boundary of recent sediments and the underlying, lower strength, dyke could pose construction difficulties for driven piles. Possible difficulties to cased bored and CFA piling include drilling in very strong Dolerite/altered Sandstone (i.e. Sandstone could be significantly altered to a distance of several meters on either side of dyke), collapse of dyke material and management of groundwater.

As mentioned in previous sections, the igneous dyke may thin, thicken, sidestep or branch. Foundation construction difficulties may occur if the dyke is encountered at previously unknown locations. Geotechnical verification during construction will be required to mitigate the risks associated with the potentially complex foundation conditions. In the vicinity of the Dyke, column loads need to be supported on reinforced beams spanning the dyke and founded on the adjacent sandstone. Depending on the proximity of the footings and the condition of the sandstone which may have been adversely affected by the dyke material, it may be necessary to reduce rock design parameters.

6.2.2 Preliminary Foundation Design

Design end bearing pressures and shaft adhesion for piled foundations are provided in Table 5 for both Limit State and Working Stress design methods. Where Limit State design parameters are used, a geotechnical strength reduction factor Φ_g of 0.75 should be applied and the Serviceability Limit State deflections should be checked using the elastic properties presented in Table 5.

If piles are required to resist uplift, the shaft adhesion values in Table 5 should be reduced by a factor of 0.7, in addition to adopting a Φ_g value of 0.6. A cone pull out check should also be carried out assuming a cone angle of $70^{0.}$

The allowable end bearing pressures provided in Table 5 are based on a settlement criterion of up to 1% of the pile diameter. Ultimate capacities (for better quality rocks) are significantly higher, however, can only be mobilised under large settlements. Use of limit state design of piles using ultimate capacities, appropriate reduction factors and settlement calculations is likely to allow higher load capacities to be adopted.

Table 5 – Preliminary Design Parameters for Footings and Bored Piles

Unit	Working Stress Design Values(1)		Limit State Design Values(2)		
	Allowable End Bearing Pressures (MPa) 3	Allowable Shaft Adhesion3,4 (kPa)	Ultimate End Bearing (MPa) 3	Ultimate Shaft Adhesion3,4 (kPa)	Elastic Modulus (MPa)
3 (Residual Soil)	-	-	-	-	40
4a (Class V and IV Sandstone)	1 to 3.5	75 to 150	3 to 10	150 to 250	100
4b (Class III Sandstone)	5 to 6	500 to 600	20 to 40	800 to 1,000	1000
4c (Class II Sandstone or better)	8 to 12	800 to 1,200	60 to 120	1,500 to 2,000	1500

(1) Structure specific assessments should be carried out to assess design values, particularly if the values at the upper end

of the ranges provided are to be adopted.

(2) These values are based on Pells et al. (1998), for presumptive settlement limits of up to 1% footing width or pile diameter. Higher design values may be possible based on first principle engineering design (refer to limit state design values) and appropriate settlement and differential settlement assessment.

(3) Design values for specific structures should be selected from within the ranges provided in the table depending on factors such as rock quality, particularly rock strength. Lower values than the ranges provided in the table may apply for shear / fracture affected zones adjacent to the dyke. Appropriate values should be confirmed by additional investigation and with construction stage verification by a geotechnical engineer.

(4) Shaft Adhesion should be ignored for pad or strip footings.

The values in Table 5 assume that an appropriate level of foundation verification and testing is carried out. This may include additional cored boreholes both at the design and construction phase to assess the variability in rock quality. Pile load testing may be required; particularly if relatively high shaft adhesion and end bearing values are adopted.

6.3 Contingency Planning

Subsurface conditions at the site are expected to be highly variable in terms of unit thickness/material type and consistency. Based on the expected variable nature of subsurface conditions, some form of contingency planning is recommended should adverse conditions be encountered such as soft soils and/or higher groundwater levels than those observed during previous investigations at the site.

Contingency planning should include allowance for items such as:

- Importation of granular fill for construction of access roads and temporary working platforms for heavy plant such as cranes and piling rigs;
- Removal and replacement of existing fill where required;
- Shoring and dewatering of excavations where groundwater / soft saturated soils are encountered;
- Permissions for discharge of water to stormwater where dewatering is required;
- Permissions from adjacent property owner(s) where anchoring of excavations is required; and
- Redesign of footings to accommodate variable ground conditions associated with features such as the Great Sydney Dyke or the GPO fault zone joint swarm.

6.4 Soil Aggressivity

The majority of chemical test results from previous investigations at the site indicate "non-aggressive" to "mildly aggressive" conditions for buried concrete and steel structural elements when assessed in accordance with AS 2159-2009 However, a number of chemical test results would classify as "mildly aggressive" to "severely aggressive" based on resistivity values.

Further soils and groundwater aggressivity testing should be carried out at the site to allow greater site coverage and better understanding of chemical conditions to assist detailed design.

Acid sulphate soils have been encountered on sites within the Darling Harbour area. An acid sulphate soils management plan is being carried out by Coffey concurrently with this assessment and will be reported separately.

6.5 Seismic Design

Based on our interpretation of site conditions and review of AS1170.4-2007, we recommend the following parameters be adopted for seismic design:

- Seismic Hazard Factor (Z) 0.08
- Sub-Soil Class C_e

6.6 Conclusion

Coffey understands that "The Haymarket" development is to include a mix of land uses including commercial office, residential including student accommodation, retail and public open space. Residential podium and tower forms (up to 40 storeys) are proposed. Generally, car parking is proposed to be above grade within the podium. New infrastructure services (including diversions and augmentations) will be provided to service new developments. In addition, it is likely that additional excavation works associated with remediation and archaeological works will also be required.

Coffey has assessed the proposed development scheme in the context of the existing geotechnical conditions on the site and have concluded that the site is suitable for its intended use.

While the site contains a number of geotechnical challenges including the presence of The Great Sydney Dyke, high groundwater table, acid sulphate soils and rock at depth, Coffey is satisfied that these challenges can be adequately addressed through the utilisation of industry standard design and construction techniques and practices.

6.7 Limitations and Further Geotechnical Investigations

The preliminary geotechnical assessment and recommendations presented in this report are based on a desk study of previous investigations by Coffey and others. Ground conditions can vary over relatively short distances and site specific investigation for the various individual structures for the development and construction stage geotechnical assessments should be undertaken to manage geotechnical risk.

The attached document entitled "Important Information about your Coffey Report" provides additional information on the uses and limitations of this report.

For and on behalf of Coffey Geotechnics Pty Ltd

Dan Butterworth

Engineering Geologist

Important information about your **Coffey** Report

As a client of Coffey you should know that site subsurface conditions cause more construction problems than any other factor. These notes have been prepared by Coffey to help you interpret and understand the limitations of your report.

Your report is based on project specific criteria

Your report has been developed on the basis of your unique project specific requirements as understood by Coffey and applies only to the site investigated. Project criteria typically include the general nature of the project; its size and configuration; the location of any structures on the site; other site improvements; the presence of underground utilities; and the additional risk imposed by scope-of-service limitations imposed by the client. Your report should not be used if there are any changes to the project without first asking Coffey to assess how factors that changed subsequent to the date of the report affect the report's recommendations. Coffey cannot accept responsibility for problems that may occur due to changed factors if they are not consulted.

Subsurface conditions can change

Subsurface conditions are created by natural processes and the activity of man. For example, water levels can vary with time, fill may be placed on a site and pollutants may migrate with time. Because a report is based on conditions which existed at the time of subsurface exploration, decisions should not be based on a report whose adequacy may have been affected by time. Consult Coffey to be advised how time may have impacted on the project.

Interpretation of factual data

Site assessment identifies actual subsurface conditions only at those points where samples are taken and when they are taken. Data derived from literature and external data source review, sampling and subsequent laboratory testing are interpreted by geologists, engineers or scientists to provide an opinion about overall site conditions, their likely impact on the proposed development and recommended actions. Actual conditions may differ from those inferred to exist, because no professional, no matter how qualified, can reveal what is hidden by earth, rock and time. The actual interface between materials may be far more gradual or abrupt than assumed based on the facts obtained. Nothing can be done to change the actual site conditions which exist, but steps can be taken to reduce the impact of unexpected conditions. For this reason, owners should retain the services of Coffey through the development stage, to identify variances, conduct additional tests if required, and recommend solutions to problems encountered on site.

Your report will only give preliminary recommendations

Your report is based on the assumption that the site conditions as revealed through selective point sampling are indicative of actual conditions throughout an area. This assumption cannot be substantiated until project implementation has commenced and therefore your report recommendations can only be regarded as preliminary. Only Coffey, who prepared the report, is fully familiar with the background information needed to assess whether or not the report's recommendations are valid and whether or not changes should be considered as the project develops. If another party undertakes the implementation of the recommendations of this report there is a risk that the report will be misinterpreted and Coffey cannot be held responsible for such misinterpretation.

Your report is prepared for specific purposes and persons

To avoid misuse of the information contained in your report it is recommended that you confer with Coffey before passing your report on to another party who may not be familiar with the background and the purpose of the report. Your report should not be applied to any project other than that originally specified at the time the report was issued.

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

Important information about your **Coffey** Report

Interpretation by other design professionals

Costly problems can occur when other design professionals develop their plans based on misinterpretations of a report. To help avoid misinterpretations, retain Coffey to work with other project design professionals who are affected by the report. Have Coffey explain the report implications to design professionals affected by them and then review plans and specifications produced to see how they incorporate the report findings.

Data should not be separated from the report*

The report as a whole presents the findings of the site assessment and the report should not be copied in part or altered in any way.

Logs, figures, drawings, etc. are customarily included in our reports and are developed by scientists, engineers or geologists based on their interpretation of field logs (assembled by field personnel) and laboratory evaluation of field samples. These logs etc. should not under any circumstances be redrawn for inclusion in other documents or separated from the report in any way.

Geoenvironmental concerns are not at issue

Your report is not likely to relate any findings, conclusions, or recommendations about the potential for hazardous materials existing at the site unless specifically required to do so by the client. Specialist equipment, techniques, and personnel are used to perform a geoenvironmental assessment. Contamination can create major health, safety and environmental risks. If you have no information about the potential for your site to be contaminated or create an environmental hazard, you are advised to contact Coffey for information relating to geoenvironmental issues.

Rely on Coffey for additional assistance

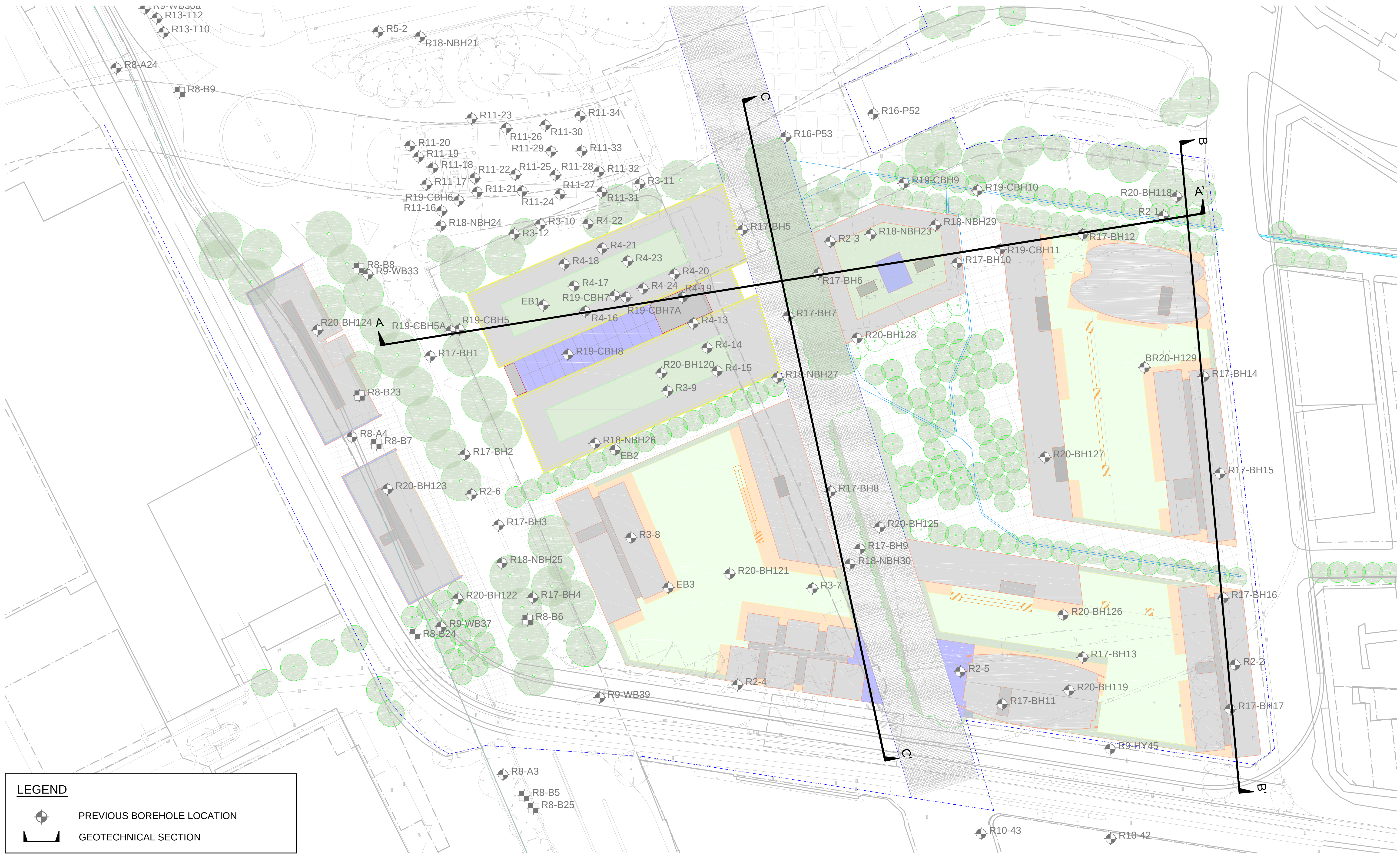
Coffey is familiar with a variety of techniques and approaches that can be used to help reduce risks for all parties to a project, from design to construction. It is common that not all approaches will be necessarily dealt with in your site assessment report due to concepts proposed at that time. As the project progresses through design towards construction, speak with Coffey to develop alternative approaches to problems that may be of genuine benefit both in time and cost.

Responsibility

Reporting relies on interpretation of factual information based on judgement and opinion and has a level of uncertainty attached to it, which is far less exact than the design disciplines. This has often resulted in claims being lodged against consultants, which are unfounded. To help prevent this problem, a number of clauses have been developed for use in contracts, reports and other documents. Responsibility clauses do not transfer appropriate liabilities from Coffey to other parties but are included to identify where Coffey's responsibilities begin and end. Their use is intended to help all parties involved to recognise their individual responsibilities. Read all documents from Coffey closely and do not hesitate to ask any questions you may have.

* For further information on this aspect reference should be made to "Guidelines for the Provision of Geotechnical information in Construction Contracts" published by the Institution of Engineers Australia, National headquarters, Canberra, 1987.

Figures



LEGEND

PREVIOUS BOREHOLE LOCATION

GEOTECHNICAL SECTION

revision	description	drawn	approved	date

N

10 0 10 30 50

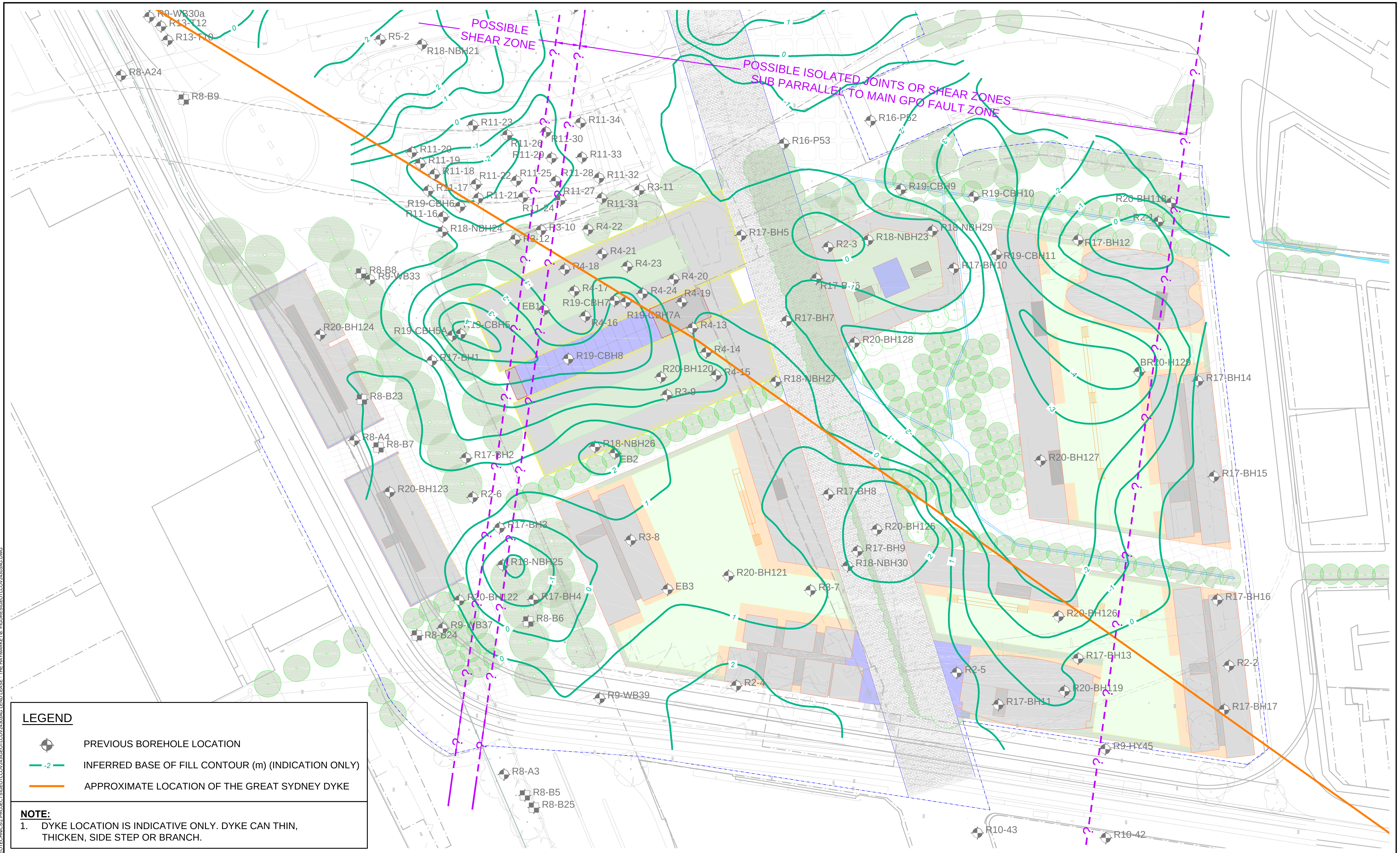
Scale (metres) 1:1000

drawn	DB / AW
approved	PJW
date	26 / 02 / 13
scale	AS SHOWN
original size	A3

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

client:	LEND LEASE
project:	SYDNEY INTERNATIONAL CONVENTION EXHIBITION AND ENTERTAINMENT PRECINCT (SICEEP) 'THE HAYMARKET' - STAGE 1 DA-SSDA2
title:	PROPOSED DEVELOPMENT LAYOUT AND PREVIOUS BOREHOLE LOCATIONS
project no:	GEOTLCOV24303AG
figure no:	FIGURE 1

PLOT DATE: 26/02/2013 11:58:03 AM DWG FILE: F:\GEOTECHNICAL\31 PROJECTS\GEOTLCOV24303AG LEND LEASE - THE HAYMARKET\8. FIGURES\GEOTLCOV24303AG.DWG



LEGEND

- PREVIOUS BOREHOLE LOCATION
- -2 INFERRED BASE OF FILL CONTOUR (m) (INDICATION ONLY)
- APPROXIMATE LOCATION OF THE GREAT SYDNEY DYKE

NOTE:

1. DYKE LOCATION IS INDICATIVE ONLY. DYKE CAN THIN, THICKEN, SIDE STEP OR BRANCH.

revision	description	drawn	approved	date

10 0 10 30 50

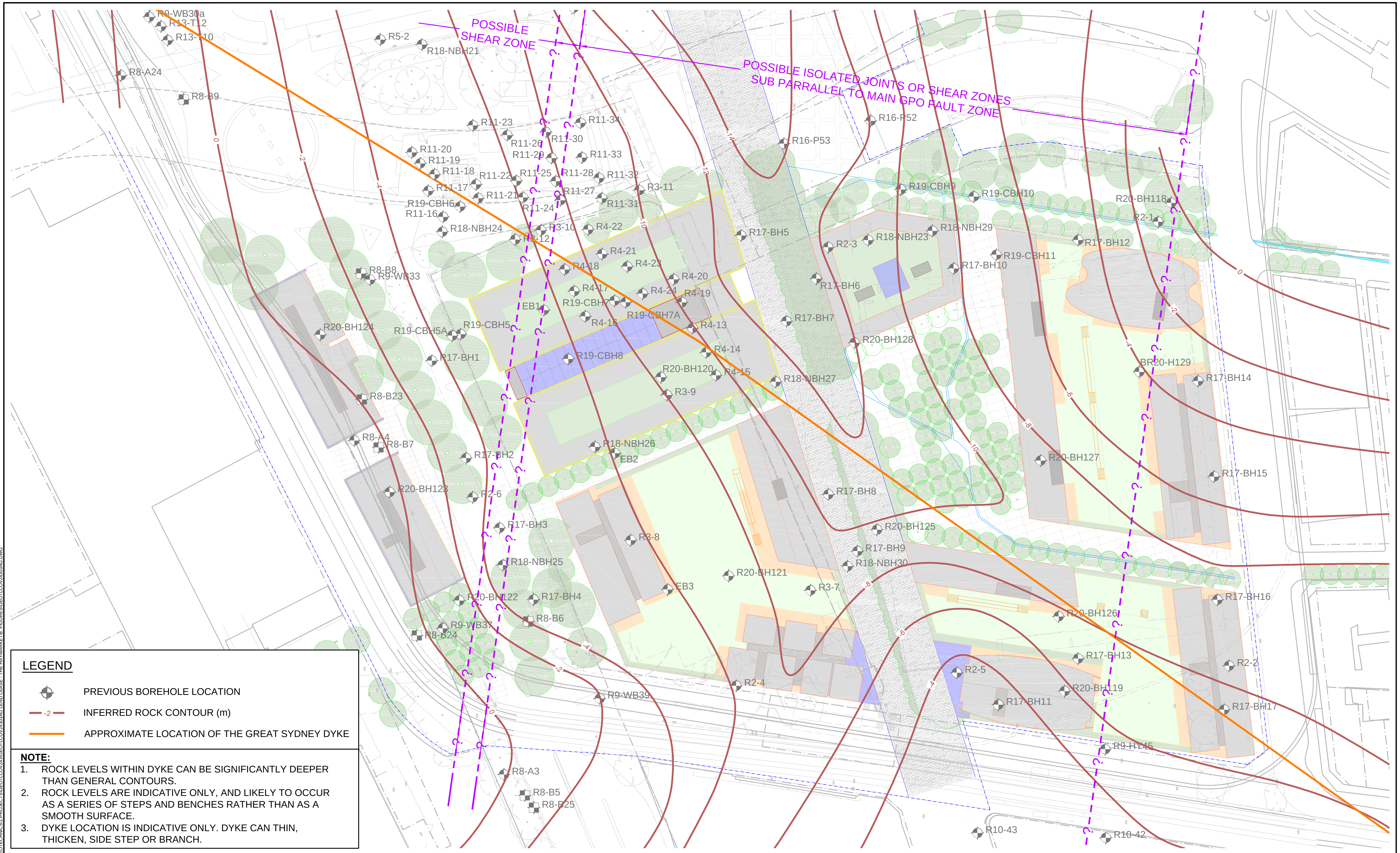
Scale (metres) 1:1000

drawn	DB / AW
approved	PJW
date	26 / 02 / 13
scale	AS SHOWN
original size	A3

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

client:	LEND LEASE
project:	SYDNEY INTERNATIONAL CONVENTION EXHIBITION AND ENTERTAINMENT PRECINCT (SICEEP) 'THE HAYMARKET' - STAGE 1 DA-SSDA2
title:	INFERRED BASE OF FILL / TOP OF ALLUVIAL SOIL CONTOURS
project no:	GEOTLCOV24303AG
figure no:	FIGURE 2

PLOT DATE: 26/02/2013 11:58:25 AM DWG FILE: F:\GEOTECHNICS\1 PROJECTS\GEOTLCOV24303AG LEND LEASE - THE HAYMARKET\8. FIGURES\GEOTLCOV24303AG.DWG



LEGEND

- PREVIOUS BOREHOLE LOCATION
- INFERRED ROCK CONTOUR (m)
- APPROXIMATE LOCATION OF THE GREAT SYDNEY DYKE

NOTE:

1. ROCK LEVELS WITHIN DYKE CAN BE SIGNIFICANTLY DEEPER THAN GENERAL CONTOURS.
2. ROCK LEVELS ARE INDICATIVE ONLY, AND LIKELY TO OCCUR AS A SERIES OF STEPS AND BENCHES RATHER THAN AS A SMOOTH SURFACE.
3. DYKE LOCATION IS INDICATIVE ONLY. DYKE CAN THIN, THICKEN, SIDE STEP OR BRANCH.

revision	description	drawn	approved	date

Scale (metres) 1:1000

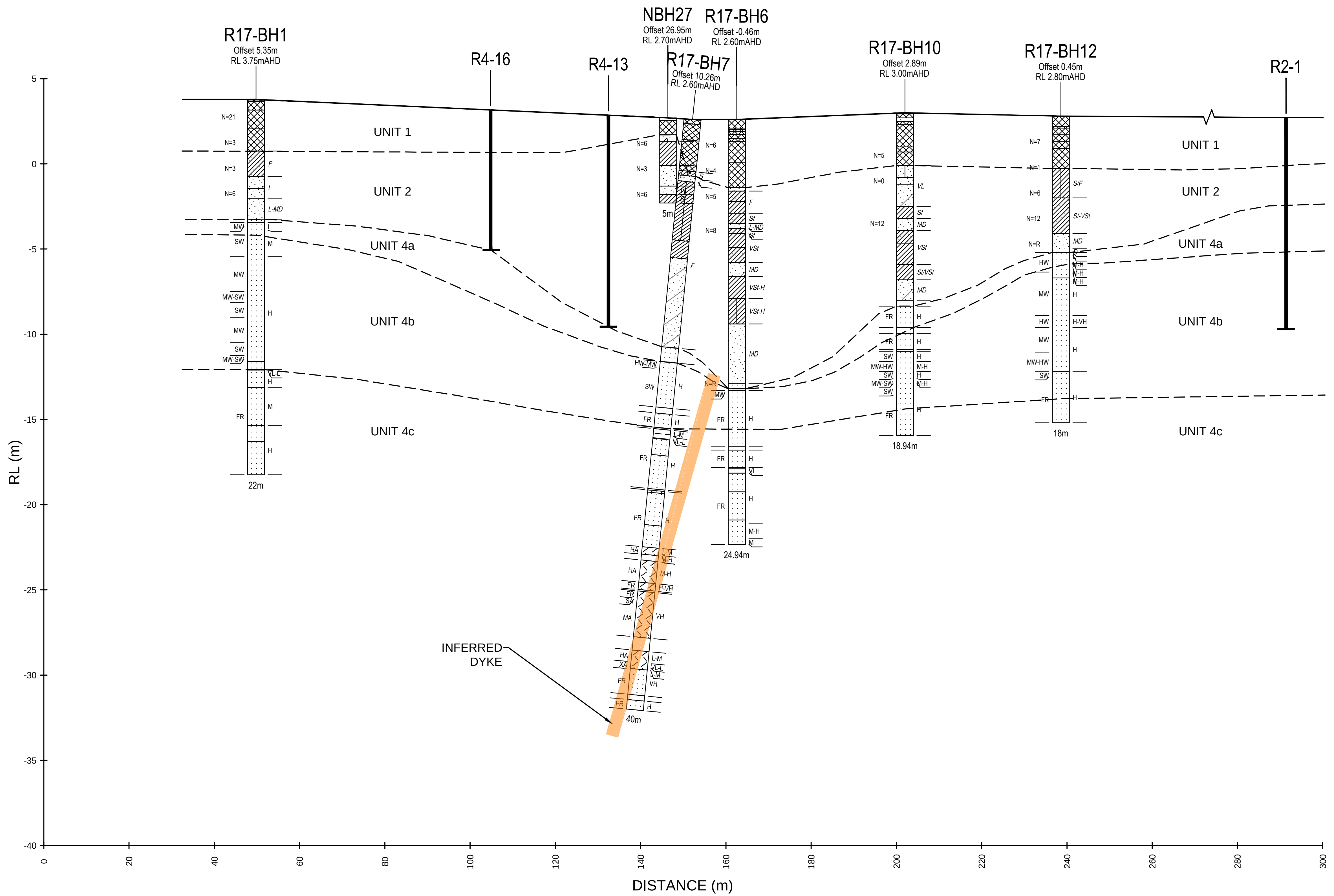
10 0 10 30 50

drawn	DB / AW
approved	PJW
date	26 / 02 / 13
scale	AS SHOWN
original size	A3

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

client:	LEND LEASE
project:	SYDNEY INTERNATIONAL CONVENTION EXHIBITION AND ENTERTAINMENT PRECINCT (SICEEP) 'THE HAYMARKET' - STAGE 1 DA-SSDA2
title:	INFERRED TOP OF ROCK CONTOURS (UNIT 4a - CLASS V & IV SANDSTONE)
project no:	GEOTLCOV24303AG
figure no:	FIGURE 3

PLOT DATE: 26/02/2013 11:58:47 AM DWG FILE: F:\GEOTECHNICS\1 PROJECTS\GEOTLCOV24303AG LEND LEASE - THE HAYMARKET\6. FIGURES\GEOTLCOV24303AG.DWG



SECTION A-A'

LEGEND

- FILL
- CLAYEY SAND
- SANDSTONE
- SHALE
- CLAY
- SANDY CLAY
- SAND
- SILTY CLAY
- SILTY SAND
- DOLERITE
- IV ROCK CLASSIFICATION (PELLS ET AL, 1998)
- DX WEATHERING (SEE EXPLANATION SHEETS)
- WATER LEVEL
- N*=17 STANDARD PENETRATION TEST RESULT

UNIT 1	FILL
UNIT 2	ALLUVIUM / ESTUARINE
UNIT 3	ALLUVIUM SOIL
UNIT 4a	CLASS V / IV SANDSTONE
UNIT 4b	CLASS III SANDSTONE
UNIT 4c	CLASS II SANDSTONE

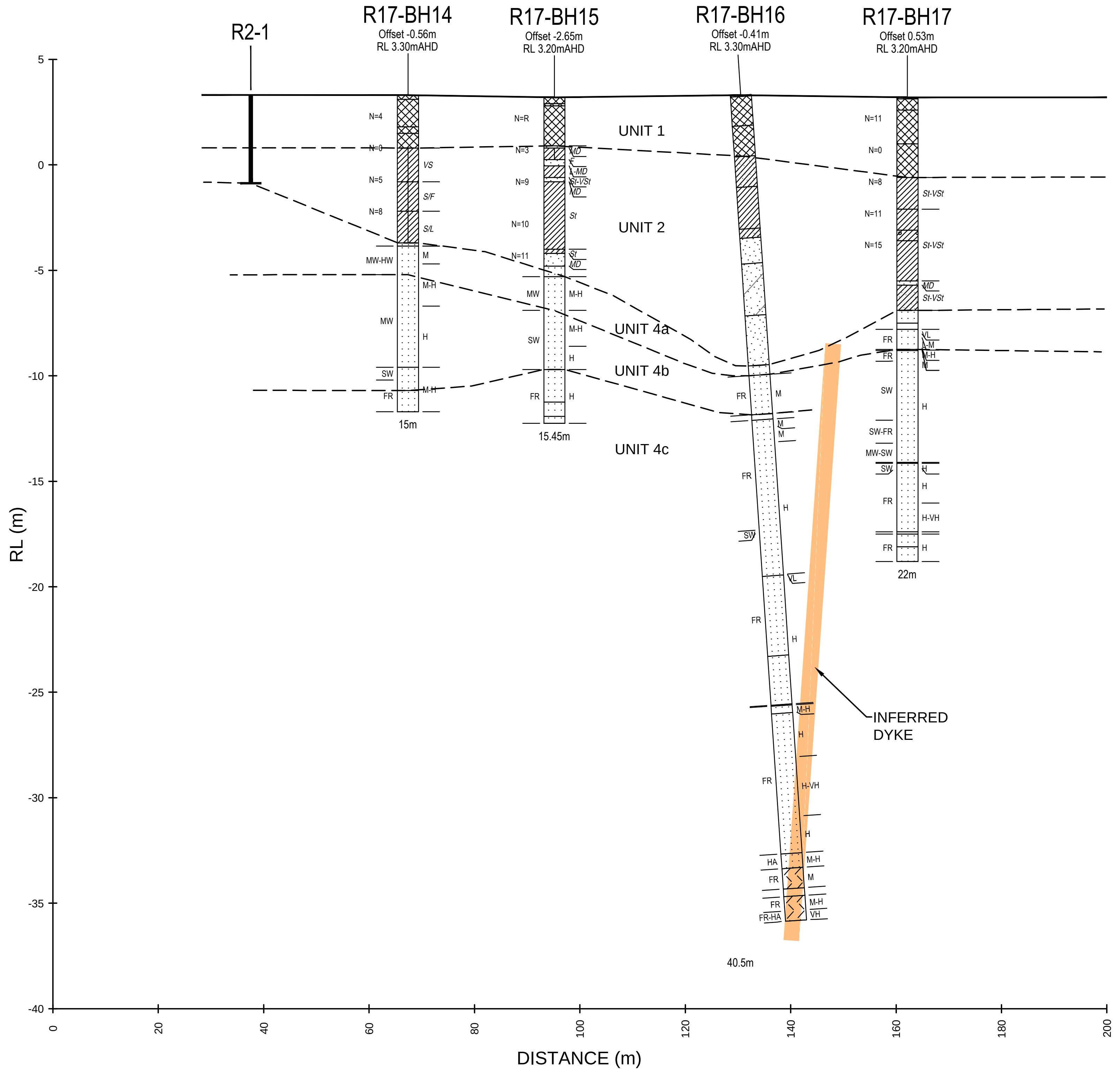
revision	description	drawn	approved	date

Scale (metres) 1:1000

drawn	DB / AW
approved	PJW
date	26 / 02 / 13
scale	AS SHOWN
original size	A3

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

client:	LEND LEASE
project:	SYDNEY INTERNATIONAL CONVENTION EXHIBITION AND ENTERTAINMENT PRECINCT (SICEEP) 'THE HAYMARKET' - STAGE 1 DA-SSDA2
title:	SECTION A-A' INFERRED GEOLOGICAL CONDITIONS
project no: GEOTLCOV24303AG	figure no: FIGURE 4



SECTION B-B'

LEGEND

- FILL
- CLAYEY SAND
- SANDSTONE
- SHALE
- CLAY
- SANDY CLAY
- SAND
- SILTY CLAY
- SILTY SAND
- DOLERITE
- IV — ROCK CLASSIFICATION (PELLS ET AL, 1998)
- DX — WEATHERING (SEE EXPLANATION SHEETS)
- WATER LEVEL
- N*=17 — STANDARD PENETRATION TEST RESULT
- UNIT 1 — FILL
- UNIT 2 — ALLUVIUM / ESTUARINE
- UNIT 3 — ALLUVIUM SOIL
- UNIT 4a — CLASS V / IV SANDSTONE
- UNIT 4b — CLASS III SANDSTONE
- UNIT 4c — CLASS II SANDSTONE

revision	description	drawn	approved	date

10 0 10 30 50

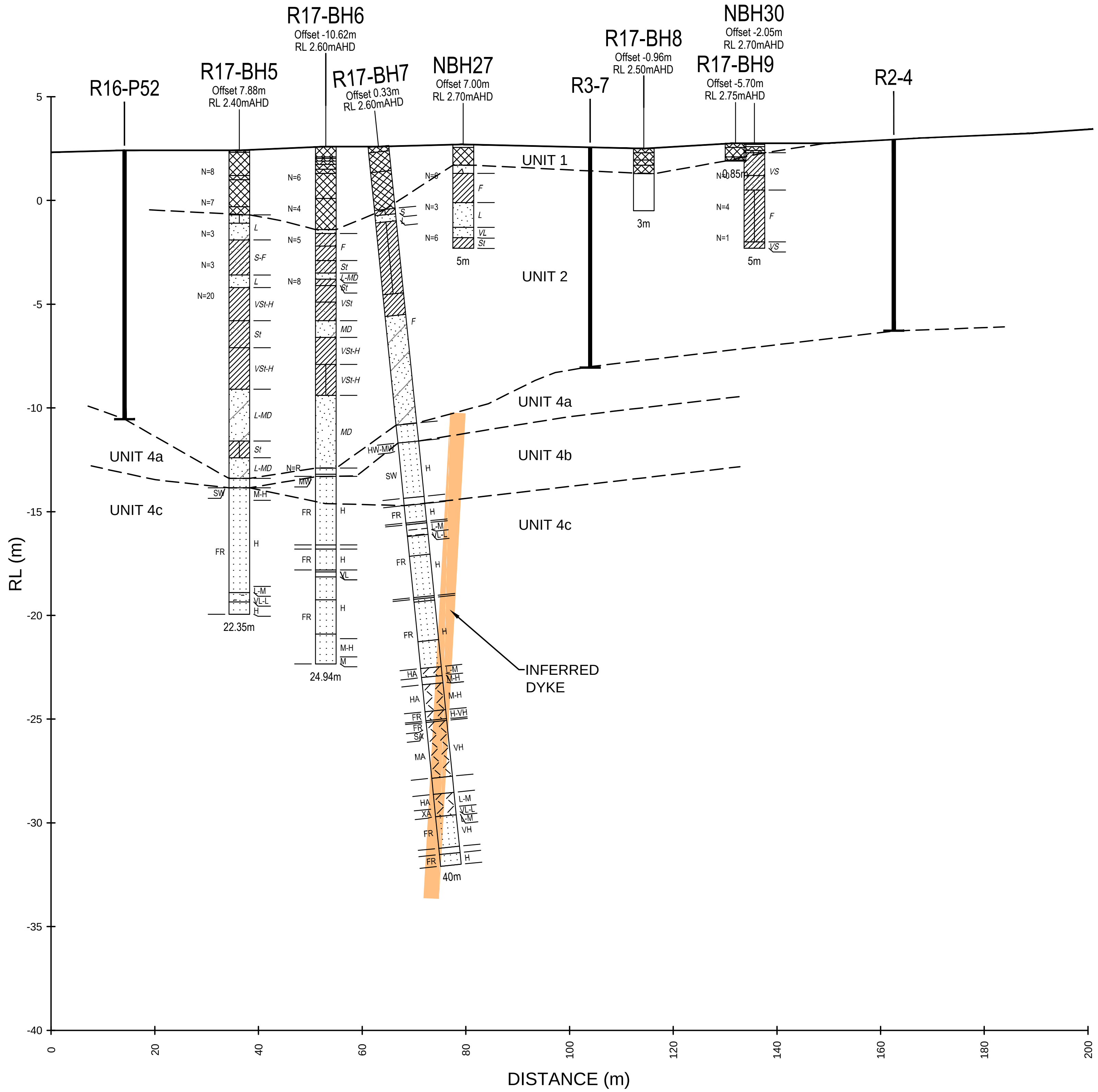
Scale (metres) 1:1000

drawn	DB / AW
approved	PJW
date	26 / 02 / 13
scale	AS SHOWN
original size	A3

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

client:	LEND LEASE
project:	SYDNEY INTERNATIONAL CONVENTION EXHIBITION AND ENTERTAINMENT PRECINCT (SICEEP) 'THE HAYMARKET' - STAGE 1 DA-SSDA2
title:	SECTION B-B' INFERRED GEOLOGICAL CONDITIONS
project no:	GEOTLCOV24303AG
figure no:	FIGURE 5

PLOT DATE: 26/02/2013 11:58:54 AM DWG FILE: F:\GEOTECHNICS\1 PROJECTS\GEOTLCOV24303AG LEND LEASE - THE HAYMARKET\8. FIGURES\GEOTLCOV24303AG.DWG



SECTION C-C'

LEGEND

- FILL
- CLAYEY SAND
- SANDSTONE
- SHALE
- CLAY
- SANDY CLAY
- SAND
- SILTY CLAY
- SILTY SAND
- DOLERITE
- IV ROCK CLASSIFICATION (PELLS ET AL, 1998)
- DX WEATHERING (SEE EXPLANATION SHEETS)
- WATER LEVEL
- N*=17 STANDARD PENETRATION TEST RESULT

UNIT 1	FILL
UNIT 2	ALLUVIUM / ESTUARINE
UNIT 3	ALLUVIUM SOIL
UNIT 4a	CLASS V / IV SANDSTONE
UNIT 4b	CLASS III SANDSTONE
UNIT 4c	CLASS II SANDSTONE

revision	description	drawn	approved	date

Scale (metres) 1:1000

drawn	DB / AW
approved	PJW
date	26 / 02 / 13
scale	AS SHOWN
original size	A3

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

client:	LEND LEASE
project:	SYDNEY INTERNATIONAL CONVENTION EXHIBITION AND ENTERTAINMENT PRECINCT (SICEEP) 'THE HAYMARKET' - STAGE 1 DA-SSDA2
title:	SECTION C-C' INFERRED GEOLOGICAL CONDITIONS
project no: GEOTLCOV24303AG	figure no: FIGURE 6

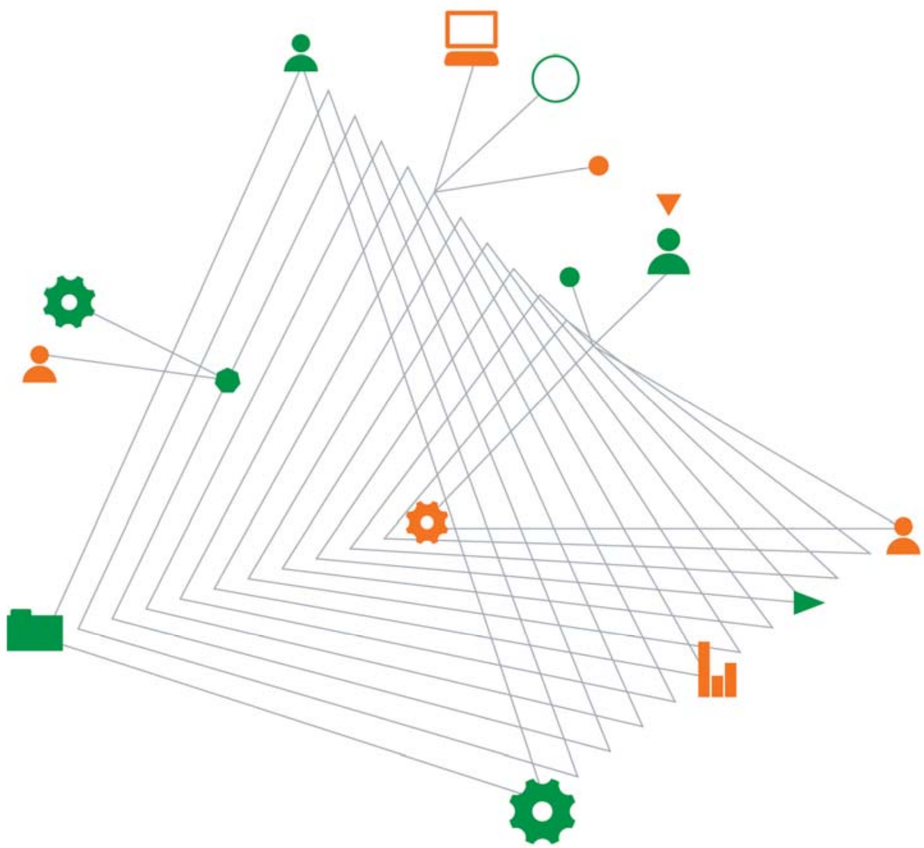
Appendix B - Geotechnical Assessment (ref: GEOTLCOV24303AG-BM, dated 22 September 2014)

Lend Lease Building Pty Limited

Sydney International Convention Exhibition and Entertainment Precinct (SICEEP) Darling Square

North East Plot Geotechnical Investigation Report

22 September 2014



Experience comes to life when it is powered by expertise

This page has been left intentionally blank

Sydney International Convention Exhibition and Entertainment Precinct (SICEEP) Darling Square

Prepared for
Lend Lease Building Pty Limited

Prepared by
Coffey Geotechnics Pty Ltd
Level 19, Tower B, 799 Pacific Highway
Chatswood NSW 2067 Australia
t: +61 2 9406 1058 f: +61 2 9406 1002
ABN: 93 056 929 483

22 September 2014

Document authorisation

Our ref: GEOTLCOV24303AG-BM

For and on behalf of Coffey

Patrick Wong
Senior Consultant

Quality information

Revision history

Revision	Description	Date	Author	Reviewer	Signatory
v1	Interim Report	22/09/2014	RC	PKW	PKW

Distribution

Report Status	No. of copies	Format	Distributed to	Date
v1 issued	1	PDF	Mark Reynolds, Greg Smith	22/09/2014

Table of contents

Tables

Figures

Appendices

1 Introduction

This report presents the results of a geotechnical investigation for the proposed North East (NE) plot of the Darling Square Development. Coffey Geotechnics Pty Ltd (Coffey) was commissioned to carry out the investigation by Lend Lease Building Pty Limited (Lend Lease) under Professional Services Agreement 163389 – PS 0008 and did so in general accordance with our proposal Ref. GEOTLCOV24303AG-AU, dated 31 March 2014.

Coffey understands that the Darling Square site is to be developed for a mix of residential and non-residential uses, including, but not limited to residential buildings, commercial, retail, community and open space. The North East Plot is one of six development plots within the Darling Square site.

The purpose of the geotechnical investigation was to provide further targeted information on sub surface conditions as a basis for providing an updated geotechnical model and recommendations for design and construction.

2 Project overview

The redevelopment of the North East Plot is understood to include:

- Demolition of the existing Sydney Entertainment Centre building;
- Construction and use of a five storey mixed use podium across the North East Plot, including:
  - Retail and residential lobbies on Ground Level;
  - Above ground parking; and
  - Residential apartments.
- Construction and use of three residential towers above podium:
  - NE1 along the east side of the plot, to an approximate height of 65m above existing surface levels.
  - NE2 along the west side of the plot, to an approximate height of 33m above existing surface levels.
  - NE3 along the north side of the plot, to an approximate height of 135m above existing surface levels.
- Public domain improvements, including:
  - a new north-south pedestrian connection (known as the Boulevard) eventually linking Quay Street to Darling Harbour;
  - a public pedestrian square between the Boulevard and the NE Plot;
  - a new east-west pedestrian laneway (Little Hay Street) south of the NE Plot linking Harbour Street to the Boulevard; and
  - Upgrade of Hay Street (part) to provide for a pedestrian share way.
- Extension and augmentation of physical infrastructure / utilities as required.

3 Previous geotechnical investigations

Coffey has extensive existing geotechnical information within the site and immediate environs. This includes site investigations carried out by Coffey and information gathered by others for previous projects. Borehole data from the references listed in Table 3.1 was used to assess the geotechnical/geological conditions of the site.

Table 3.1: Results of previous investigations used in preparation of this report

Ref No.	Description of Previous Project
R1	Department of Main Roads, "North Western Expressway Project", 1971*
R2	Coffey & Partners Pty Ltd, "Haymarket Redevelopment – Report on Preliminary Foundation Investigation", May 1978 (S6063-AA)
R3	Coffey & Partners Pty Ltd, "Haymarket Redevelopment – Parking Station Foundation Investigation", July 1979 (S6269-AB)
R4	Coffey & Partners Pty Ltd, "Proposed Haymarket Carpark – Additional Foundation Investigation", June 1980 (S6269/2-AA)
R5	Arup Geotechnics, " Darling Harbour Redevelopment – Site Investigation Report", November 1984
R6	Coffey & Partners Pty Ltd, " Darling Harbour Development Maritime Structures Geotechnical Investigation Zones 1 to 6" May 1985 (S7559/1-AE)*
R7	Coffey & Partners Pty Ltd, " Darling Harbour Development Project Convention Centre – Geotechnical Investigation" June 1985 (S7559/3-AD)
R8	Arup Geotechnics, " Darling Harbour Development Western Boulevard – Site Investigation Report", December 1985
R9	Coffey & Partners Pty Ltd, " Darling Harbour Light Monorail Geotechnical Investigation", May 1986 (S7769/1-AG)
R10	Coffey & Partners Pty Ltd, "Studio City Development – Geotechnical investigation", July 1988 (S8283/1-AH)
R11	City of Sydney, City Engineer's Department, "William Henry Street Bridge – Eastern Approach", July 1967
R12	Coffey Geosciences Pty Ltd, " Geotechnical Investigation Proposed Multi-storey Development – Bullecourt Place, Ultimo", December 2001 (S21012/1-AS)
R13	Arup Geotechnics, "Darling Harbour Development – Western Boulevard Sewer Tunnel", December 1985
R14	Coffey & Partners Pty Ltd, "Merino Central Two Project, Pyrmont – Geotechnical Investigation", November 1986 (S7960/1-AC)
R15	Jeffery and Katauskas Pty Ltd, "Geotechnical Investigation Proposed Refurbishment of Woolstores", April 1986
R16	Arup Geotechnics, "Darling Harbour Development – Pier Street, Harbour/Day Streets" April 1986
R17	Coffey Geotechnics Pty Ltd, "Sydney International Convention and Entertainment Centre – Geotechnical Investigation Report", August 2011 (GEOTLCOV24303AA-AE)
R18	Coffey Geotechnics Pty Ltd, "Proposed Sydney International Convention, Exhibition and Entertainment Precinct (SICEEP)", May 2012 (GEOTLCOV24303AC-AD)

R19	Coffey Environments Pty Ltd, "Supplementary Site Investigation – Sydney International Conference, Exhibition and Entertainment Precinct, Darling Harbour" August 2012 (GEOTLCOV24303AD-AA)
R20	Coffey Environments Pty Ltd, "Supplementary Site Investigation: Factual Report – Sydney International Conference, Exhibition and Entertainment Precinct, Darling Harbour" January 2013 (GEOTLCOV24303AF_R0-01a)

4 Method of investigation

Fieldwork for the geotechnical investigation for the North East Plot comprised:

- Drilling 5 cored boreholes (NE-BH1 to NE-BH5) into bedrock to depths ranging from 17.3m to 21.1m below current surface levels; and
- Vertical Seismic Shear wave Profiling (VSSP) in borehole NE-BH1.

4.1 Borehole drilling

NE-BH2, NE-BH3 and NE-BH5 were drilled within the existing Entertainment Centre building using a small difficult access drilling rig with a low mast due to restricted headroom and access required through pedestrian doors.

NE-BH1 and NE-BH4 were drilled around the perimeter of the Entertainment Centre using a larger, track mounted, drilling rig.

Each borehole was started using solid flight augers with a tungsten carbide (TC) drill bit. Boreholes were continued to bedrock by washboring using a casing advancer. Rock coring was carried out in all boreholes using the NMLC or NQ wireline coring techniques.

Standard Penetration Tests (SPT) were carried out at 2m intervals in soils at the internal borehole locations. Only one SPT was carried out at the external borehole locations due to time restriction on the works in the public domain.

A Coffey Geotechnical Engineer recorded testing and sampling, boxed and photographed the rock core and logged the soil and rock materials encountered.

Groundwater inflows and soil moisture observations were recorded during auger drilling. Observations of drill fluid return/loss were recorded during wash boring and core drilling.

A 50mm internal diameter PVC pipe was inserted into NE-BH1 and surrounded with grout in preparation for VSSP geophysics testing. The other 4 boreholes were backfilled with cuttings and capped with about 200mm thick concrete flush with the ground surface.

The borehole locations and reduced levels were measured by the project surveyor and are recorded on the borehole logs. The borehole locations are shown on Figures 1 and 2.

4.2 Vertical seismic shear wave profiling

Vertical Seismic Shear wave Profiling (VSSP) was undertaken in borehole NE-BH1, located at the north-western corner of the North East plot. Measurements were made at 0.5 m intervals from the ground surface to 11 m depth and at 1 m intervals from 11 m to the base of the borehole at 17.3m depth.

Seismic compressional (P) waves were generated near the borehole collar by directly striking a metal plate with a sledge hammer located approximately 1m to 1.3m from the borehole collar. S-waves were generated by alternately striking opposite ends of a 2.3m length wooden sleeper which was centred at the borehole and offset by 1.8m to 1.9m. The wooden sleeper was weighted to improve ground coupling by positioning the front wheels of a vehicle on top of the sleeper. Successive source impacts were summed at each downhole probe location until an adequate seismic amplitude signal was obtained.

Seismic information was detected using a 3 component Geostuff in-hole geophone probe which is coupled against the borehole at pre-determined depths. This probe contains 1 vertical component geophone and 2 horizontal component geophones with a servo-driven compass mechanism for orienting the probe so that at least one of the horizontal geophones paralleled the wooden sleeper direction.

The depth of the probe was measured from the ground surface at the borehole and the seismic data was acquired with a digital Geometrics Geode seismograph and field computer in accordance with Coffey quality management systems.

4.3 Geophysical data processing and analysis

Individual P and S wave travel times were interactively picked for each downhole detector position and used to interpret average and interval P and S wave seismic velocities. These velocities are used to compute average and interval dynamic elastic modulus values in accordance with the relevant equations to 16m below ground level for NE-BH1, i.e.

$$E = \rho V_s^2 \frac{3\left(\frac{V_p}{V_s}\right)^2 - 4}{\left(\frac{V_p}{V_s}\right)^2 - 1}$$

$$G = \rho V_s^2$$

$$\sigma = \frac{V_p^2 - 2V_s^2}{2\left(V_p^2 - V_s^2\right)}$$

Where,

V_p = Compressional (P) wave velocity

V_s = Shear (s) wave velocity

ρ = Bulk Density

σ = Poisson’s Ratio

E = Dynamic Young’s Modulus

G = Dynamic Shear Modulus

The results of the VSSP are presented in Appendix C.

4.4 Laboratory testing

Soil and Rock samples obtained during fieldwork were taken to our laboratory. The following tests were carried out on selected samples.

- Point Load Strength Index tests at approximately 1m intervals on rock core
- 1 x Unconfined Compressive Strength (UCS) test on rock core.

Four soil samples from the NE Plot were taken to a specialist chemical laboratory for aggressivity testing (pH, sulphates and chlorides) of the soil towards buried steel and concrete.

5 Results of investigation

5.1 Borehole drilling

The results of the borehole drilling are presented in the Engineering Borehole Logs in Appendix A. The Point Load Strength Index Test results are presented on the borehole logs. The results of the geotechnical investigation are primarily presented as an updated geotechnical model in Section 6 and the attached figures.

5.2 Vertical seismic shear wave profiling

The standard equations (Section 4.3) for computing dynamic modulus were used with material densities inferred based on geotechnical borehole logs.

The results of the seismic tests are provided in Appendix C. The average modulus values represent the average modulus from the ground surface (0m depth) to each depth while the interval modulus values represent the modulus computed across a selected depth range.

The S-wave velocities at NE-BH1 are shown to be approximately 250 m/s within the sediments and approximately 930 m/s within the sandstone. The P-wave velocities are shown to be approximately 1400 m/s within the sediments and approximately 2500 m/s within the sandstone.

5.3 Laboratory testing

The result of the UCS test on the rock core sample from NE-BH4 was 20.9 MPa at a depth interval of 10.7m to 11.3m. The UCS testing is in general agreement with the Point Load Strength Index Test results, showing medium to high strength sandstone bedrock. The UCS laboratory test report sheet is presented in Appendix B along with the results of the aggressivity testing.

6 Updated geotechnical model

Based on the geotechnical investigation carried out by Coffey and the previous geotechnical investigation by others, the geotechnical constraints for developments within the North East Plot are expected to broadly comprise those associated with the following main subsurface features:

- Variable fill in terms of nature and thickness;
- An in-filled palaeochannel, incised into the Sandstone bedrock at the south end of the NE plot and orientated roughly northwest/southeast;
- Influence zone of an igneous dyke intrusion through the sandstone bedrock, striking north west/south east located just off the south west corner of the NE plot; and
- High groundwater levels.

6.1 General soil and rock profiles

The material infilling the palaeochannel that has been incised in the Sandstone bedrock comprises man-made fill, estuarine deposits and alluvium. Based on the borehole information, an overview of the subsurface strata is presented in Table 6.1.

Table 6.1: Overview of subsurface conditions and geotechnical units

Unit	Material Description
1	**Fill** – comprising heterogeneous mixtures of sand, sandy gravel, clay and sandy clay/silt with cobbles and occasional boulder sized rock fragments. Concrete and Asphalt materials were encountered at shallow depths at most of the borehole locations. The density/consistency of the fill is variable, and may range from loose to dense or very soft to stiff. Due to its variability and likely non-uniform placement procedure, it would be classified as "uncontrolled fill".
2A	**Alluvium and Estuarine Deposits** – comprising clayey sands and clays with trace shell layers and organic matter. These materials range from very loose to medium dense or very soft to very stiff in consistency. Some of the underlying residual soil (Unit 3) may have been disturbed and mixed within the alluvium.
2B	**Alluvium** - this unit is inferred to be similar to Unit 2A, except that it comprises transported colluvium or residual soil on the buried slope of the eroded Cockle Creek banks with slightly better engineering properties. It should be noted that for the purpose of this report, the differentiation between 2A and 2B is made primarily based on strength properties rather than their geological origin. As such, material with similar alluvial origin to that of unit 2A with slightly better engineering properties is classified as unit 2B.
3	**Residual Soil** – derived from weathering of the underlying sandstone rock, and generally comprising clayey sand or sandy clay having stiff consistency. In many places, however, this unit is relatively thin or absent due to the geological erosion process.
4A to 4C	**Bedrock** – comprising Sandstone ranging from extremely weathered to fresh with low to medium strength shale bands (up to 1.2m thick). This unit has been subdivided based on strength, fracturing, and defects in accordance with Pells et al (1998) as follows: • 4A – Class V and Class IV Sandstone • 4B – Class III Sandstone • 4C – Class II Sandstone or better Class V Sandstone is extremely low to low strength with significant amounts of defects while Class II Sandstone or better is generally medium and high rock strength with limited defects. It should be noted that the buried bedrock surface is likely to vary as a series of sub-horizontal

	benches and sub-vertical cliff lines, in a similar fashion to the variations in level that can be observed on the Sydney harbour foreshores.

Note: Rock classified in accordance with Pells et al (1998) “Foundations on Sandstone and Shale in the Sydney Region” Aust. Geomech. Jnl, Dec 1998.

The fill is underlain by estuarine sediments and alluvial back-swamp deposits, which have been deposited predominantly in a south-north direction consistent with the historic shape of the bay, with relatively uniform thickness across the NE Plot. Beneath these estuarine deposits, alluvial deposits with variable thickness were encountered. The alluvial deposits comprise a mixture of clayey sand, sandy clay, and clay, which varies from loose to medium dense or firm to very stiff. The residual soil is generally clayey sand or sandy clay in a loose to medium dense or stiff condition.

The rocks encountered are classified based on the Sydney rock classification system given in the footnote of Table 6.1 above. There are five classes of Sandstone (I to V), based on strength, fracturing, and amount of defects such as sheared zones and clay seams. Class I Sandstone is the best quality while Class V Sandstone represents the lowest quality sandstone in the classification system.

Based on the past investigation and geotechnical investigation carried out by Coffey, We have inferred subsurface contours for the following material layers:

- Base of fill/top of alluvial deposits (Figure 7)
- Top of extremely weathered/highly weathered sandstone bedrock - Class V/Class IV Sandstone (Figure 8)
- Top of moderately weathered/slightly weathered sandstone bedrock - Class III Sandstone (Figure 9)

The base of fill level across the NE plot typically varies between -1.5m AHD and +1.5m AHD. Base of fill levels were observed to be higher along the east side of the NE plot, along Harbour Street.

Based on the rock contours, a highly irregular top of rock profile is anticipated. The depth of rock profile increases from the eastern side towards the western and southern sides of the NW Plot and the centreline of the inferred palaeochannel. The difference in rock level is expected to be about 8m between the northeast and southwest corners of the site footprint.

The interpretation of Top of Class III sandstone is highly irregular across the site with levels ranging from -4m to -12m AHD across the NE plot. This irregularity is due to near vertical jointing downgrading the Pell’s classification of the cored rock. The contours shown on Figure 9 are generalised having been produced from this variable borehole data.

Four cross sections have been drawn through the site and are presented as Figures 3 to 6. A summary of levels and thicknesses of soil and rock units encountered at the site is shown in Table 6.2.

Table 6.2: Depth of occurrence and thickness of geotechnical units

Unit	Material / Origin	Depth to Top of Unit (m)	Thickness of Unit (m)	Elevation at Top of Unit (mAHD)
1	Fill	0	2 to 5	2.6 to 3.3
2A	Estuarine Deposits	2 to 3	nil to 4	1.7 to -0.2
2B	Alluvium	3 to 5	nil to 7	0 to -2.5
3	Residual Soil	7m	nil to 3.5	-4 (observed only at NE-BH2)
4A	Class V/IV Sandstone	6.5 to 14	0.5 to 2.5	-3.5 to -11
4B	Class III Sandstone	7 to 16	2.5 to 5	-4 to -13
4C	Class II Sandstone	10 to 16	Not Proven	-7 to -13

6.2 Igneous dyke

Based on the current geotechnical investigation carried out by Coffey, the igneous dyke (known as the “Great Sydney Dyke”) may be encountered at the south-western corner of the NE Plot. Figure 2 and Figure 5 show the inferred dyke location in plan and section. The inferred extent of the igneous dyke crosses the NW and SE Plots in a northwest / southeast direction and is shown adjacent to the south-western corner of the NE Plot. The dyke comprises extremely weathered dolerite with stiff clay properties and highly weathered to fresh dolerite. The weathered clay material extends to about -16m to -24m AHD before dolerite rock of better quality is encountered. The dyke was found to have a width ranging from about 3m to 8m with an inferred average width of 4.5m. The intrusion of the dyke has likely altered and sheared the sandstone bedrock around it. Boreholes drilled in the NW plot indicate that deeper weathering, closely spaced fracturing and rock strengths varying from very low to very high strength should be expected within several metres either side of the dyke.

Information gathered from an internet web search (source: development application documents for City West Cable Tunnel project) indicates that previous excavations in the vicinity of corner of Thomas Street and Hay Street encountered highly permeable dyke material and adjacent sandstone. The seepage flow was highly saline, with iron, manganese and sulphate. These documents suggest it is likely that the dyke zone is connected to water in the Darling Harbour sediments.

6.3 Fault and shear zones

Besides this dyke, shear zones and isolated joints sub parallel to the GPO fault zone are also inferred to be present within the site. The known location of the main GPO fault zone extends from Circular Quay to the intersection of Bathurst Street and Harbour Street (i.e. about 400m north of site) with an approximate strike of NNE. A possible projection of the GPO fault zone through the Haymarket site is shown on Figure 1. The NE Plot is located to the east of the projection of the known GPO Fault zone and to the west of the Martin Place Joint Swarm.

An inferred zone for the possible presence of isolated joints/shear zones is indicated on Figure 1.

7 Discussion and recommendations

7.1 Filling and compaction

Fill encountered at the site is variable and could be classified as "uncontrolled fill" according to AS2870 – Residential Slabs and Footings, 2011. Where slabs or pavements are to be founded on structural fill, all existing fill should be removed and replaced with structural fill. Prior to placement of new fill, the exposed surface should be proof rolled using a static roller weighing at least 8 tonnes. Granular bridging layer and geogrid may also be required if wet and/or heaving conditions occur. Table 7.1 presents compaction requirements for typical earthworks situations. Considering well compacted fill is placed, based on the preliminary assessment, the anticipated settlement will be in excess of 10mm. Further assessment will be required with the appropriate material parameters for the compacted fill.

Table 7.1: Earthwork specifications for typical situations

Application	Depth Profile	Minimum Compaction Relative to Standard Maximum Dry Density (SMDD)	Moisture Content Relative to Standard Optimum Moisture Content (SOMC)
Beneath Building Footings & Raft Slabs	Upper 1m below footing base	98%	±2%
	More than 1m below footing base	95%	±2%
Pavements	Upper 0.3m below pavement layer	100%	±2%
	0.3m to 1m below pavement layer	95%	±2%
	More than 1m below pavement layer	95% for new fill 95% for upper 0.3m of existing fill	±2%

7.2 Excavations

7.2.1 Excavation conditions

Based on the architectural concept and structural drawings supplied by Lend Lease and Robert Bird Group, the proposed development will not have deep basements. The top of ground floor slab level for the NE Plot is 3.6m AHD. Excavations of up to 3m depth below existing surface levels are expected for the construction of pile caps and ground slabs. Such excavations are therefore expected to be within Unit 1 Fill and Unit 2 Alluvium/Estuarine Deposits. The proposed buildings are generally expected to be founded on piles.

7.2.2 Excavation batter slopes

Stability of excavations in Unit 1 Fill will be influenced by the presence of underlying low strength Unit 2 soils (even if Unit 1 fill is replaced by Engineered Fill) and groundwater. As a result there will be a significant risk of excavation instability if relatively steep temporary batter slopes are adopted without site specific investigation and geotechnical input during both design and construction. For preliminary design we recommend the following temporary batters and shoring:

- Above the groundwater table, excavations in Unit 1 or Engineered Fill: flatter than 2H:1V; and
- Below the groundwater table or into Unit 2 soils: adopt shoring.

Instability due to bottom heave is not anticipated for excavations shallower than 3m. However, further assessment should be carried out for deeper excavations if proposed.

7.2.3 Excavation support requirements

Depending on project requirements for a sufficiently watertight, and/or stiff retention system the following options could be considered.

- Driven sheet piles;
- Contiguous pile wall; or
- Secant pile wall.

For a sheet piled wall, overlapping or interlocking sheets would be vibrated or driven into the ground around the proposed excavation perimeter. The steel sheet piles could be used to provide formwork for the permanent walls for the superstructure, but this would preclude their recovery. Sheet piles would likely to be installed within the alluvium. However, if sheet piles have to extend into the weathered bedrock, it is likely that the sheet pile will refuse on the weathered bed rock and groundwater seepage would be expected to occur through the clutches and toe of the wall.

Contiguous pile walls may be practicable where the proposed excavations does not extend below the groundwater level.

Secant piling involves drilling “soft” (mass concrete) piles using low strength concrete and overlapping “hard” (reinforced structural concrete) to form minimum 75mm to 150mm overlaps. The required overlap is a function of the depth of piling and construction tolerance. The interlocks between “soft” and “hard” piles provide a seal to limit groundwater inflow. Unless bored carefully, secant piles can deviate off vertical centre during installation creating gaps between the piles resulting in groundwater seepage and ground loss.

For the preliminary design of retaining walls the parameters in Table 7.2 should be adopted.

Table 7.2: Preliminary retaining wall design parameters

Unit	Description	Bulk Unit Weight (kN/m^3)	Effective Cohesion (kPa)	Friction Angle (degree)
1	Fill	20	0	30 to 35
2	Alluvium/Estuarine	18	0	26
3 & 5A	Residual Soil/weathered dyke	20	5	28
4a	Class V and IV Sandstone	21	30	35

Retaining walls should be designed for appropriate hydrostatic and surcharge loads.

Where cantilevered walls are not practicable, lateral stability could be provided by anchors installed progressively as the excavation proceeds. Where installation of anchors is not practicable, internal strutting or bracing may be required to provide lateral stability.

Excavations associated with installation of utilities are expected to be relatively shallow. Where it is not practicable to adopt temporary batters as recommended in Section 7.2.2 above due to land take restrictions, or where excavations are below standing groundwater levels; lateral excavation support should be provided using a temporary shoring box, internal strutting or similar.

7.2.4 Groundwater conditions

Groundwater levels are expected to vary between 0.5m AHD and -0.5m AHD. Where excavations are proposed to extend below standing groundwater levels, extensive dewatering of the alluvial soils is not desirable as this could lead to consolidation settlement of the fill and alluvium and may need special permits to discharge off site. Cut-off walls will be required during excavation works and the final walls should be designed as tanked to maintain standing groundwater levels and prevent groundwater ingress.

Where excavations for the purpose of utilities, remediation and archaeological works are to extend below standing groundwater levels, localised dewatering will be required. Where inflow rates are relatively low and cohesive soils are encountered, sump and pump techniques may be practicable. However, where higher inflow rates occur, installation and operation of drilled wells or jetted spear points around the excavation perimeter would be required.

The detailed assessment and design of groundwater management is beyond the scope of this report and should be addressed by a hydrogeological investigation.

7.2.5 Excavation induced ground movements

Excavation induced ground movements may be significant given the site ground conditions. Walls retaining soil strength material may laterally deflect up to 1% of the retained height, depending on the stiffness of the retaining wall system. Lateral deflections may be limited to typically 0.3% to 0.5% of the retained height using appropriate design and construction techniques.

The potentially damaging effects of stress redistribution in the vicinity of excavations should be assessed as part of the detailed design. Lateral displacements of retaining walls due to stress redistribution may also result in settlement. For preliminary assessment of impacts we recommend that potential settlement be assumed to be equal to predicted lateral displacements. Typically, ground movements (lateral displacement and settlement) are greatest at the excavation face and decrease to negligible values at a distance of up to 3 times the excavation depth. Dilapidation surveys of adjacent structures within this distance of the excavation should be carried out prior to construction. Close coordination with geotechnical engineers will be required during design and construction stages to assess possible movements and mitigation measures.

For preliminary impact assessment purposes the above guidelines on displacements may be used. If such movements cannot be tolerated for sensitive features, then retaining walls should be designed for higher earth pressures. Depending on the specific retention system, basement excavation details and the nature of adjacent structures, a more detailed analysis will be required. Coffey has specialist capability in applying numerical modelling techniques to the estimation of ground movements.

7.3 Building foundations

7.3.1 Expected arrangements and issues

The NE plot redevelopment is understood to comprise construction of a mixed use podium and three residential buildings above and within the podium structure. Proposed roof levels are shown on Figure 2.

Based on the nature of subsurface conditions; comprising a variable thickness of fill and alluvial/estuarine soils, we expect that footings for this development may comprise cased bored piles or continuous flight auger (CFA) piles socketed into the underlying sandstone bedrock.

Stress relief effects due to the palaeochannel formation process are likely to have caused opening and weathering of defects (bedding planes and joints). Therefore, poor foundation conditions may occur near the current rock surface level. Significant joints and clay seams may be encountered and these may affect bearing capacity, settlement and required socket lengths of pile foundations.

Figure 9 shows interpreted top of Class III levels and the tower locations within the NE plot. Due to the close proximity of the GPO fault zone, the igneous dyke and other near vertical geological structure, piles may encounter Class III rock at higher or lower levels than those shown on Figure 9. Top of Class III rock is not a measurable layer. The quality of the rock is based on the rock mass characteristics and is not depth dependent. Significant contingency should be allowed for in interpreting pile socket depths from Figure 9. Piles should be proof cored to assess rock quality at individual pile group locations.

Difficulties in construction of deep piles for the Entertainment Centre have been reported (e.g. Malcom D.J., 1997) when the dyke is in contact with recent marine and alluvial sediments. An indurated sandstone or ironstone capping layer at the boundary of recent sediments and the underlying, lower strength, dyke could pose construction difficulties for driven piles. Possible difficulties to cased bored and CFA piling include drilling in very strong Dolerite/altered Sandstone (i.e. Sandstone could be significantly altered to a distance of several meters on either side of dyke), ironstone bands, collapse of dyke material and management of groundwater.

As mentioned in previous sections, the igneous dyke may thin, thicken, sidestep or branch. Based on the current geotechnical investigation, the igneous dyke is not encountered within the NE Plot. However, foundation construction difficulties may occur if the dyke is encountered at previously unknown locations. Geotechnical verification during construction will be required to mitigate the risks associated with the potentially complex foundation conditions. In the vicinity of the Dyke, column loads need to be supported on reinforced beams spanning the dyke and founded on the adjacent sandstone. Depending on the proximity of the footings and the condition of the sandstone which may have been adversely affected by the dyke material, it may be necessary to reduce rock design parameters.

7.3.2 Design parameters for footings and piled foundation

Design end bearing pressures and shaft adhesion for piled foundations are provided in Table 7.3 for both Limit State and Working Stress design methods. Where Limit State design parameters are used, a geotechnical strength reduction factor Φ_g of 0.6 should be applied and the Serviceability Limit State deflections should be checked using the elastic properties presented in Table 7.3.

If piles are required to resist uplift, the shaft adhesion values in Table 7.3 should be reduced by a factor of 0.7, in addition to adopting a Φ_g value of 0.6.

The allowable end bearing pressures provided in Table 7.3 are based on a settlement criterion of up to 1% of the pile diameter. Ultimate capacities (for better quality rocks) are significantly higher, however, can only be mobilised under large settlements. Use of limit state design of piles using ultimate capacities, appropriate reduction factors and settlement calculations is likely to allow higher load capacities to be adopted.

Table 7.3: Preliminary design parameters for footings and piled foundation

Unit	Working Stress Design Values(1,2)		Limit State Design Values(1)		
	Allowable End Bearing Pressures (MPa) 3	Allowable Shaft Adhesion3,4 (kPa)	Ultimate End Bearing (MPa) 3	Ultimate Shaft Adhesion3,4 (kPa)	Elastic Modulus (MPa)
2b (Alluvium)					
3 (Residual Soil)	-	-	-	60	40
4a (Class V and IV Sandstone)	1 to 3.5	75 to 150	3 to 10	150 to 250	125
4b (Class III Sandstone)	5 to 6	500 to 600	20 to 40	800 to 1,000	1000
4c (Class II Sandstone or better)	8 to 12	800 to 1,200	60 to 120	1,500 to 2,000	1500

(1) Structure specific assessments should be carried out to assess design values, particularly if the values at the upper end of the ranges provided are to be adopted.

(2) These values are based on Pells et al. (1998), for presumptive settlement limits of up to 1% footing width or pile diameter. Higher design values may be possible based on first principle engineering design (refer to limit state design values) and appropriate settlement and differential settlement assessment.

(3) Design values for specific structures should be selected from within the ranges provided in the table depending on factors such as rock quality, particularly rock strength. Lower values than the ranges provided in the table may apply for shear / fracture affected zones adjacent to the dyke. Appropriate values should be confirmed by additional investigation and with construction stage verification by a geotechnical engineer.

(4) Shaft Adhesion should be ignored for pad or strip footings.

7.3.3 Constructability of piles

The type of pile construction will depend on the capability of construction plant for rock penetration. CFA piles can be constructed with sockets in Class III or II Sandstone using high capacity piling rigs with special rock coring bits. However, the availability of construction plant capable of penetrating into Class II Sandstone is more limited, with associated cost and time implications.

Bored piles can be constructed with sockets into all classes of sandstone using rock drilling buckets, coring and impact tools. Please note that the rock classification has been primarily conducted for the purpose of foundation design and not for the purpose of excavatibility. Harder rock layers may exist at any level within the sandstone bedrock. Piling contractors should inspect the rock cores and make their own assessment on drillability of the rock.

Temporary casing may be required during bored pile construction to avoid the collapse of soil material above the rock into bored holes.

7.3.4 Construction platform for piling

Piling platforms will need to be constructed on Unit 1 Fill. The platform design should be assessed using the BRE 470 Method. Localised testing and/or proof rolling of the subgrade should be observed by a geotechnical engineer prior to construction of the platform.

7.4 Contingency planning

Subsurface conditions at the site are expected to be highly variable in terms of unit thickness/material type and consistency. Shear zones may be encountered within the bedrock.

Based on the expected variable nature of subsurface conditions, some form of contingency planning is recommended should adverse conditions be encountered such as soft soils and/or higher groundwater levels than those observed during site investigations.

Contingency planning should include allowance for items such as:

- Importation of granular fill for construction of access roads and temporary working platforms for heavy plant such as cranes and piling rigs;
- Removal and replacement of existing fill where required;
- Shoring and dewatering of excavations where groundwater / soft saturated soils are encountered;
- Permissions for discharge of water to stormwater where dewatering is required; and
- Redesign of footings/piled foundation to accommodate variable ground conditions associated with features such as the Great Sydney Dyke or the GPO fault zone joint swarm.

Coffey considers predrilling of pile locations to be a prudent measure for Lend Lease to manage the risk associated with poor geotechnical conditions, which may result in foundation redesigns.

7.5 Soil aggressivity

Based on the chemical test results from this investigation and previous investigations, the soil can be classified as “non-aggressive” to “mildly aggressive” conditions for buried concrete and steel structural elements according to AS 2159-2009. However, a number of chemical test results from previous investigations would classify as “mildly aggressive” to “severely aggressive” based on resistivity values.

Acid sulphate soils have been encountered at the Haymarket site. Reference should be made to the Acid Sulphate Soils Management Plan (Ref. ENAURHOD04498AA-RO3), prepared by Coffey.

7.6 Seismic design

In review of AS1170.4-2007, we recommend the following be adopted for seismic design:

- Seismic Hazard Factor (Z) 0.08
- Sub-Soil Class C_e

Based on the interpretation of the geophysical data for the NE Plot, Table 7.4 presents the seismic shear wave velocities, dynamic young's modulus and dynamic shear modulus for the different soil units.

Table 7.4: Seismic shear wave velocity

Soil Unit	S-wave Velocity (m/s)	P-wave Velocity (m/s)	Dynamic Young's Modulus, E (MPa)	Dynamic Shear Modulus, G (MPa)
2a - Alluvium	130	1160	100	50
2b and 3 (Alluvium and Residual Soil)	330	1870	550	200
Sandstone	930	2530	5400	1900

8 Limitations

The geotechnical model and recommendations in this report are based on the available boreholes from the current and past investigations. The engineering logs describe subsurface conditions only at the specific borehole locations. Ground condition can vary over relatively close distances and a geotechnical engineer should be engaged at the construction stage to assess whether site conditions are consistent with design assumptions.

The attached document entitled "Important Information about your Coffey Report" provides additional information on the uses and limitations of this report.

Important information about your Coffey Report

As a client of Coffey you should know that site subsurface conditions cause more construction problems than any other factor. These notes have been prepared by Coffey to help you interpret and understand the limitations of your report.

Your report is based on project specific criteria

Your report has been developed on the basis of your unique project specific requirements as understood by Coffey and applies only to the site investigated. Project criteria typically include the general nature of the project; its size and configuration; the location of any structures on the site; other site improvements; the presence of underground utilities; and the additional risk imposed by scope-of-service limitations imposed by the client. Your report should not be used if there are any changes to the project without first asking Coffey to assess how factors that changed subsequent to the date of the report affect the report's recommendations. Coffey cannot accept responsibility for problems that may occur due to changed factors if they are not consulted.

Subsurface conditions can change

Subsurface conditions are created by natural processes and the activity of man. For example, water levels can vary with time, fill may be placed on a site and pollutants may migrate with time. Because a report is based on conditions which existed at the time of subsurface exploration, decisions should not be based on a report whose adequacy may have been affected by time. Consult Coffey to be advised how time may have impacted on the project.

Interpretation of factual data

Site assessment identifies actual subsurface conditions only at those points where samples are taken and when they are taken. Data derived from literature and external data source review, sampling and subsequent laboratory testing are interpreted by geologists, engineers or scientists to provide an opinion about overall site conditions, their likely impact on the proposed development and recommended actions. Actual conditions may differ from those inferred to exist, because no professional, no matter how qualified, can reveal what is hidden by earth, rock and time. The actual interface between materials may be far more gradual or abrupt than assumed based on the facts obtained. Nothing can be done to change the actual site conditions which exist, but steps can be taken to reduce the impact of unexpected conditions.

For this reason, owners should retain the services of Coffey through the development stage, to identify variances, conduct additional tests if required, and recommend solutions to problems encountered on site.

Your report will only give preliminary recommendations

Your report is based on the assumption that the site conditions as revealed through selective point sampling are indicative of actual conditions throughout an area. This assumption cannot be substantiated until project implementation has commenced and therefore your report recommendations can only be regarded as preliminary. Only Coffey, who prepared the report, is fully familiar with the background information needed to assess whether or not the report's recommendations are valid and whether or not changes should be considered as the project develops. If another party undertakes the implementation of the recommendations of this report there is a risk that the report will be misinterpreted and Coffey cannot be held responsible for such misinterpretation.

Your report is prepared for specific purposes and persons

To avoid misuse of the information contained in your report it is recommended that you confer with Coffey before passing your report on to another party who may not be familiar with the background and the purpose of the report. Your report should not be applied to any project other than that originally specified at the time the report was issued.

Interpretation by other design professionals

Costly problems can occur when other design professionals develop their plans based on misinterpretations of a report. To help avoid misinterpretations, retain Coffey to work with other project design professionals who are affected by the report. Have Coffey explain the report implications to design professionals affected by them and then review plans and specifications produced to see how they incorporate the report findings.

Data should not be separated from the report*

The report as a whole presents the findings of the site assessment and the report should not be copied in part or altered in any way.

Logs, figures, drawings, etc. are customarily included in our reports and are developed by scientists, engineers or geologists based on their interpretation of field logs (assembled by field personnel) and laboratory evaluation of field samples.

These logs etc. should not under any circumstances be redrawn for inclusion in other documents or separated from the report in any way.

Geoenvironmental concerns are not at issue

Your report is not likely to relate any findings, conclusions, or recommendations about the potential for hazardous materials existing at the site unless specifically required to do so by the client. Specialist equipment, techniques, and personnel are used to perform a geoenvironmental assessment. Contamination can create major health, safety and environmental risks. If you have no information about the potential for your site to be contaminated or create an environmental hazard, you are advised to contact Coffey for information relating to geoenvironmental issues.

Rely on Coffey for additional assistance

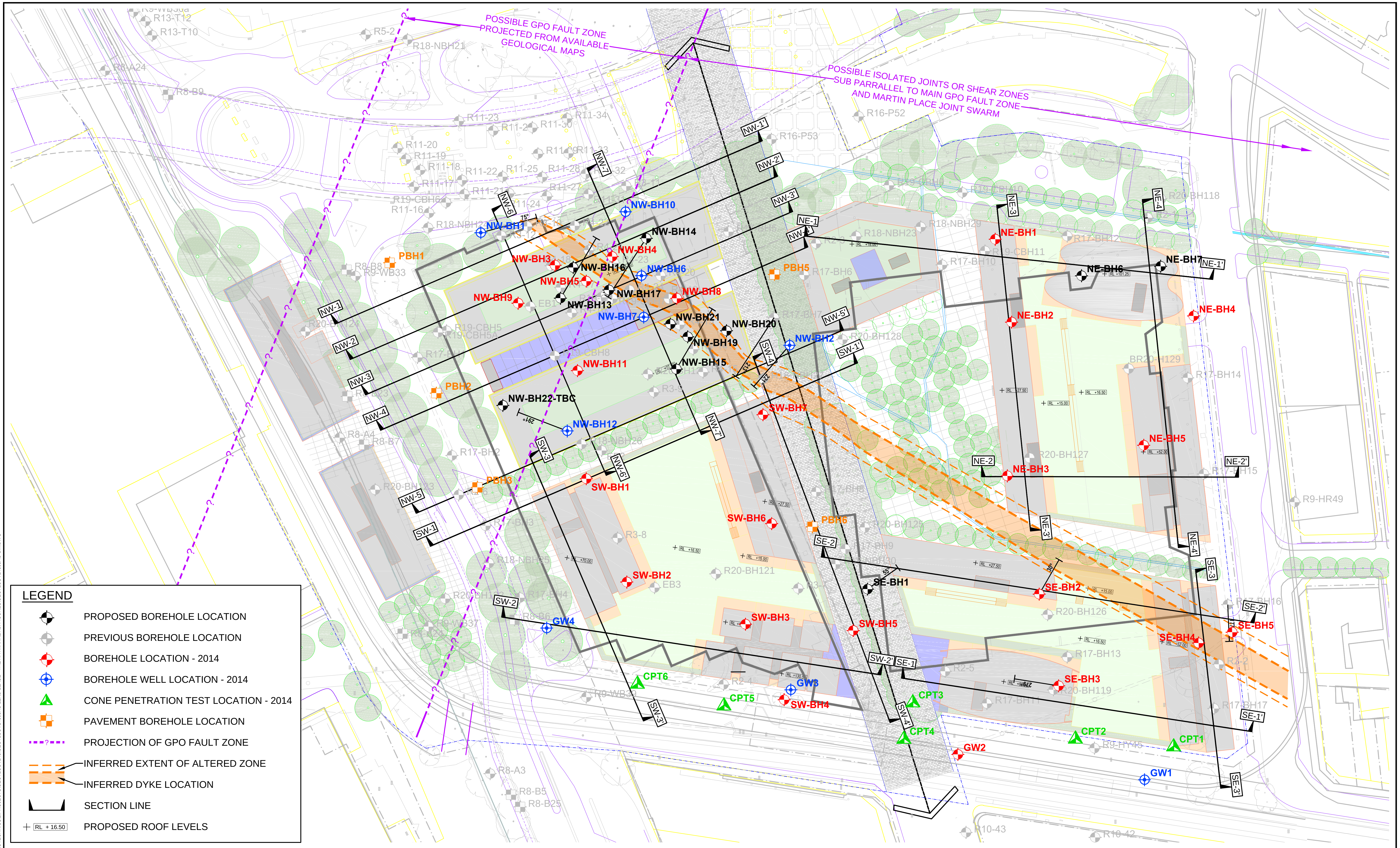
Coffey is familiar with a variety of techniques and approaches that can be used to help reduce risks for all parties to a project, from design to construction. It is common that not all approaches will be necessarily dealt with in your site assessment report due to concepts proposed at that time. As the project progresses through design towards construction, speak with Coffey to develop alternative approaches to problems that may be of genuine benefit both in time and cost.

Responsibility

Reporting relies on interpretation of factual information based on judgement and opinion and has a level of uncertainty attached to it, which is far less exact than the design disciplines. This has often resulted in claims being lodged against consultants, which are unfounded. To help prevent this problem, a number of clauses have been developed for use in contracts, reports and other documents. Responsibility clauses do not transfer appropriate liabilities from Coffey to other parties but are included to identify where Coffey's responsibilities begin and end. Their use is intended to help all parties involved to recognise their individual responsibilities. Read all documents from Coffey closely and do not hesitate to ask any questions you may have.

* For further information on this aspect reference should be made to "Guidelines for the Provision of Geotechnical information in Construction Contracts" published by the Institution of Engineers Australia, National headquarters, Canberra, 1987.

Figures



PLOT DATE: 22/09/2014 3:07:33 PM DWG FILE: F:\GEOTECHNICS\1 PROJECTS\GEOTLCOV24303AG\GEOTLCOV24303AG LEND LEASE - THE HAYMARKET\8. FIGURES\GEOTLCOV24303AG-BM.DWG

no.	description	drawn	approved	date
A	ORIGINAL ISSUE			

revision

N

10 0 10 30 50

Scale (metres) 1:1000

drawn	RC / AW
approved	PKW
date	22 / 09 / 14
scale	AS SHOWN
original size	A3

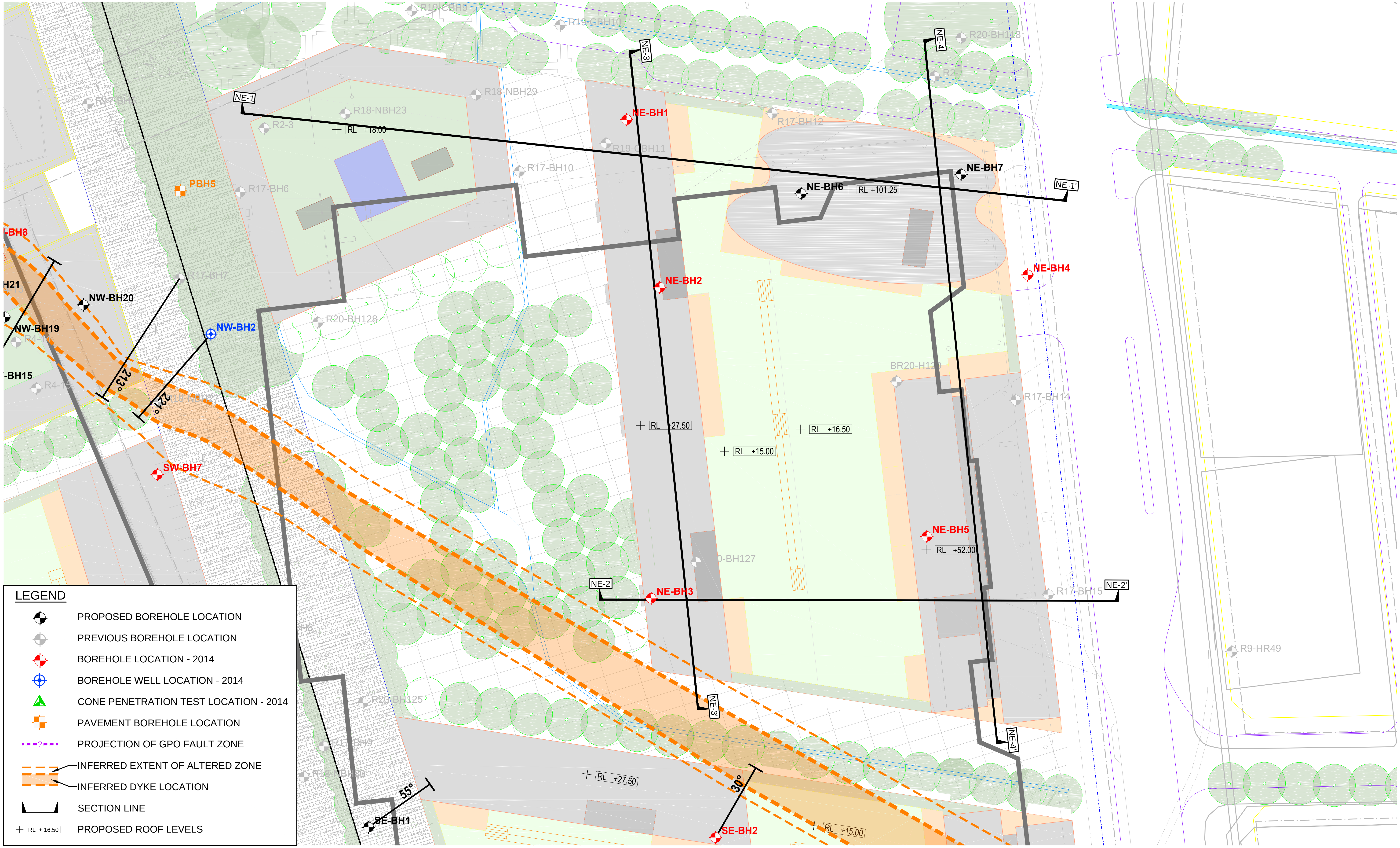
coffey

client: LEND LEASE (HAYMARKET) PTY LIMITED

project: SYDNEY INTERNATIONAL CONVENTION EXHIBITION AND ENTERTAINMENT PRECINCT (SICEEP) "THE HAYMARKET'

title: SITE LOCATION PLAN

project no: GEOTLCOV24303AG-BM | figure no: FIGURE 1 | rev: A



LEGEND

- PROPOSED BOREHOLE LOCATION
- PREVIOUS BOREHOLE LOCATION
- BOREHOLE LOCATION - 2014
- BOREHOLE WELL LOCATION - 2014
- CONE PENETRATION TEST LOCATION - 2014
- PAVEMENT BOREHOLE LOCATION
- ?— PROJECTION OF GPO FAULT ZONE
- INFERRED EXTENT OF ALTERED ZONE
- INFERRED DYKE LOCATION
- SECTION LINE
- RL + 16.50 PROPOSED ROOF LEVELS

N

5 0 5 15 25

Scale (metres) 1:500

revision no.	description	drawn	approved	date
A	ORIGINAL ISSUE			

drawn	RC / AW
approved	PKW
date	22 / 09 / 14
scale	AS SHOWN
original size	A3

coffey

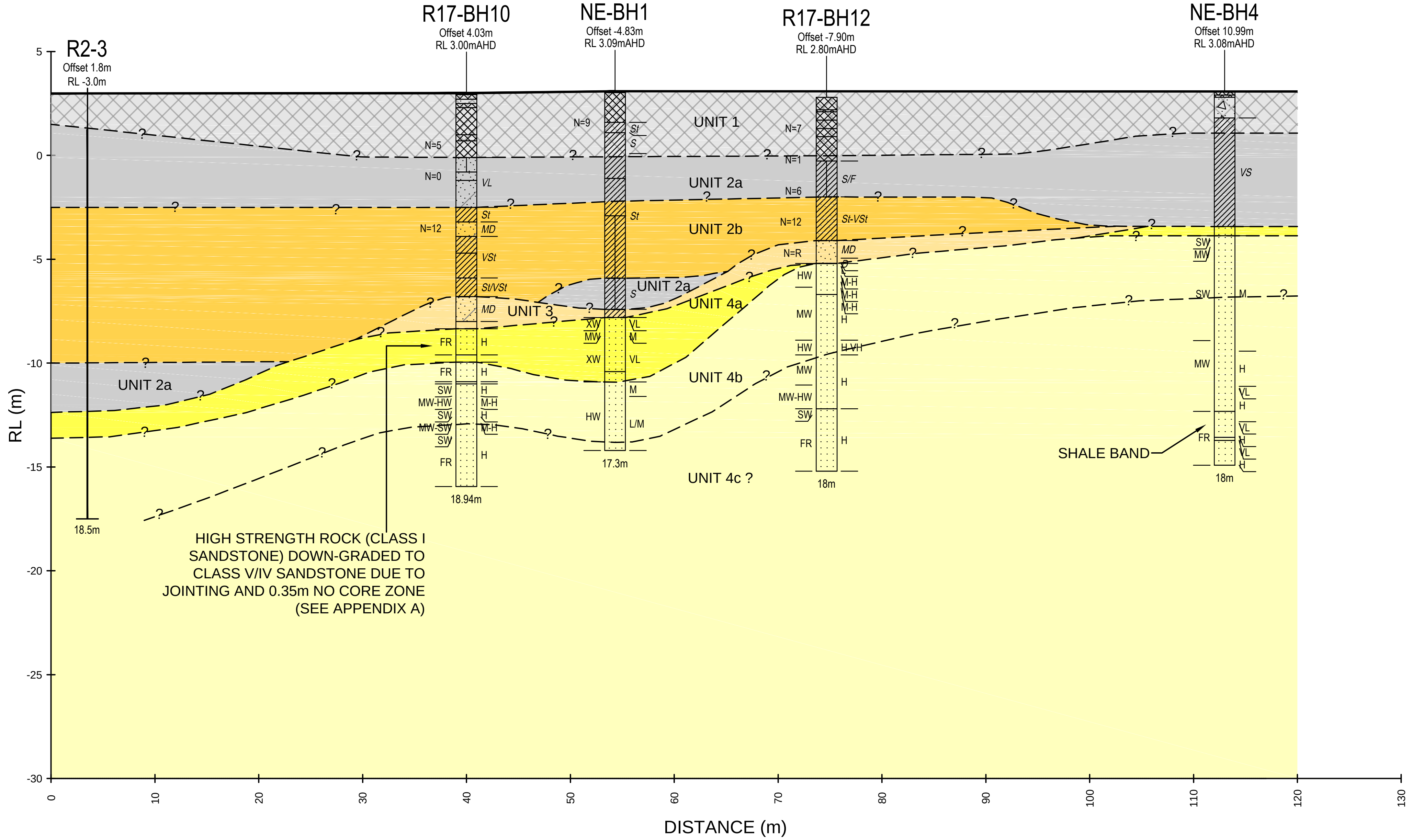
client: LEND LEASE (HAYMARKET) PTY LIMITED

project: SYDNEY INTERNATIONAL CONVENTION EXHIBITION AND ENTERTAINMENT PRECINCT (SICEEP) "THE HAYMARKET"

title: NE PLOT BOREHOLE LOCATION PLAN

project no: GEOTLCOV24303AG-BM | figure no: FIGURE 2 | rev: A

PLOT DATE: 22/09/2014 3:07:52 PM DWG FILE: F:\GEOTECHNICS\1 PROJECTS\GEOTLCOV24303AG\GEOTLCOV24303AG LEND LEASE - THE HAYMARKET\8. FIGURES\GEOTLCOV24303AG-BM.DWG



SECTION NE-1-NE-1'

LEGEND

- FILL
- CLAYEY SAND
- SANDSTONE
- SHALE
- CLAY
- SANDY CLAY
- SAND
- SILTY CLAY
- SILTY SAND
- DOLERITE
- CLAYEY SILT
- SILT
- GRAVELLY SILT
- GRAVELLY SAND
- GRAVEL
- GRAVELLY CLAY
- INTERBEDDED SHALE & SANDSTONE
- DOLERITE
- INTERLAMINATED SILTSTONE & SANDSTONE
- CONCRETE
- ASPHALT
- NO CORE
- IV ROCK CLASSIFICATION (PELLS ET AL, 1998)
- DX WEATHERING (SEE EXPLANATION SHEETS)
- WATER LEVEL
- N*=17 STANDARD PENETRATION TEST RESULT

PROJECT UNITS

UNIT 1	FILL
UNIT 2a	ESTUARINE DEPOSITS
UNIT 2b	ALLUVIUM
UNIT 3	RESIDUAL SOIL
UNIT 4a	CLASS V / IV SANDSTONE
UNIT 4b	CLASS III SANDSTONE
UNIT 4c	CLASS II SANDSTONE

revision

no.	description	drawn	approved	date
A	ORIGINAL ISSUE			

NOTE: 2 x VERTICAL EXAGGERATION

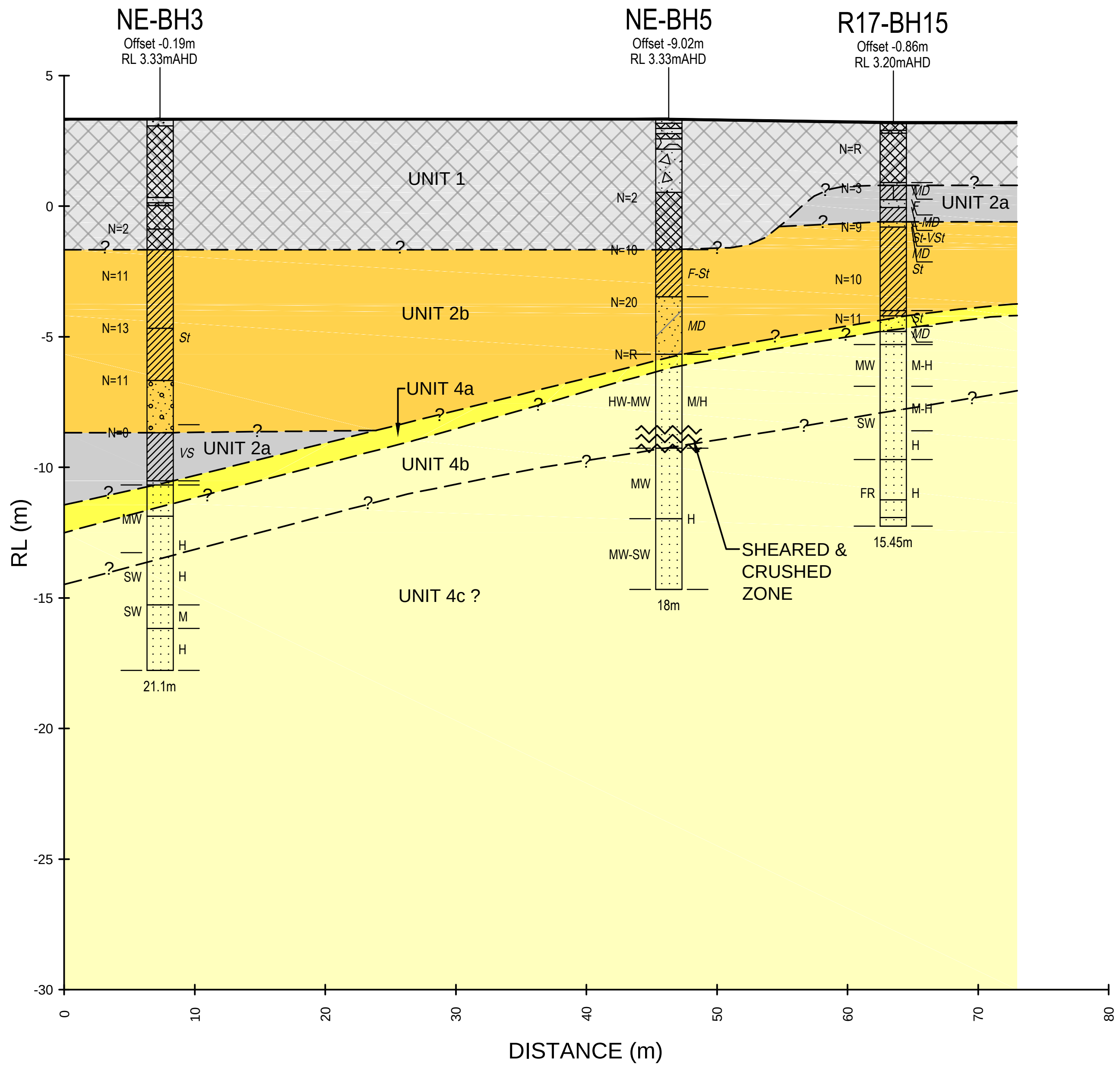
Horizontal Scale (metres) 1:500

Vertical Scale (metres) 1:250

drawn	RC / AW
approved	PKW
date	22 / 09 / 14
scale	AS SHOWN
original size	A3

coffey

client:	LEND LEASE (HAYMARKET) PTY LIMITED
project:	SYDNEY INTERNATIONAL CONVENTION EXHIBITION AND ENTERTAINMENT PRECINCT (SICEEP) "THE HAYMARKET'
title:	SUBSURFACE SECTION NE-1
project no:	GEOTLCOV24303AG-BM
figure no:	FIGURE 3
rev:	A



SECTION NE-2-NE-2'

LEGEND

- FILL
- CLAYEY SAND
- SANDSTONE
- SHALE
- CLAY
- SANDY CLAY
- SAND
- SILTY CLAY
- SILTY SAND
- DOLERITE
- CLAYEY SILT
- SILT
- GRAVELLY SILT
- GRAVELLY SAND
- GRAVEL
- GRAVELLY CLAY
- INTERBEDDED SHALE & SANDSTONE
- DOLERITE
- INTERLAMINATED SILTSTONE & SANDSTONE
- CONCRETE
- ASPHALT
- NO CORE
- IV ROCK CLASSIFICATION (PELLS ET AL, 1998)
- DX WEATHERING (SEE EXPLANATION SHEETS)
- WATER LEVEL
- N*=17 STANDARD PENETRATION TEST RESULT

PROJECT UNITS

UNIT 1	FILL
UNIT 2a	ESTUARINE DEPOSITS
UNIT 2b	ALLUVIUM
UNIT 3	RESIDUAL SOIL
UNIT 4a	CLASS V / IV SANDSTONE
UNIT 4b	CLASS III SANDSTONE
UNIT 4c	CLASS II SANDSTONE

revision

no.	description	drawn	approved	date
A	ORIGINAL ISSUE			

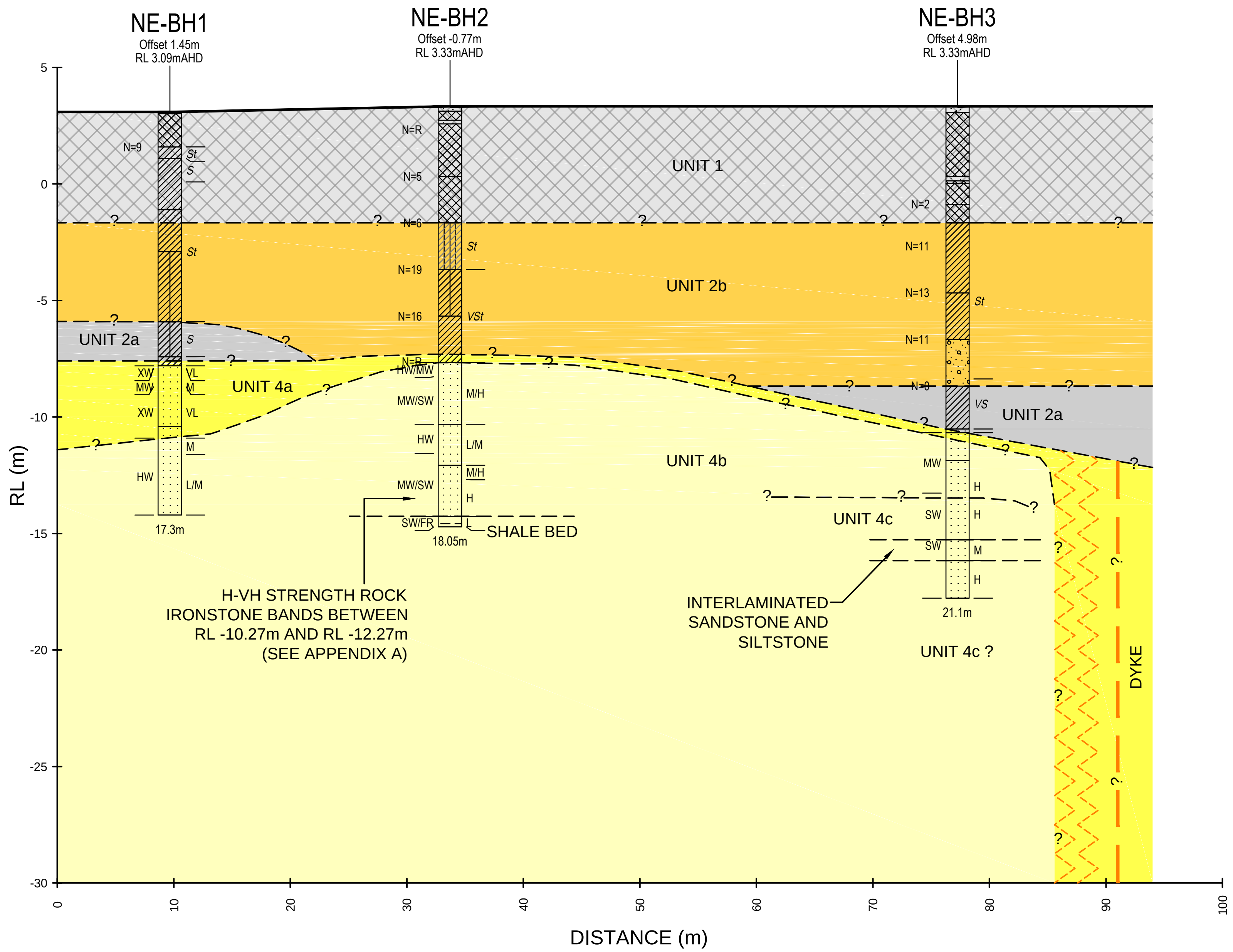
NOTE: 2 x VERTICAL EXAGGERATION

Horizontal Scale (metres) 1:500

Vertical Scale (metres) 1:250

drawn	RC / AW
approved	PKW
date	22 / 09 / 14
scale	AS SHOWN
original size	A3

client:	LEND LEASE (HAYMARKET) PTY LIMITED
project:	SYDNEY INTERNATIONAL CONVENTION EXHIBITION AND ENTERTAINMENT PRECINCT (SICEEP) "THE HAYMARKET'
title:	SUBSURFACE SECTION NE-2
project no: GEOTLCOV24303AG-BM	figure no: FIGURE 4 / rev: A



SECTION NE-3-NE-3'

LEGEND

- FILL
- CLAYEY SAND
- SANDSTONE
- SHALE
- CLAY
- SANDY CLAY
- SAND
- SILTY CLAY
- SILTY SAND
- DOLERITE
- CLAYEY SILT
- SILT
- GRAVELLY SILT
- GRAVELLY SAND
- GRAVEL
- GRAVELLY CLAY
- INTERBEDDED SHALE & SANDSTONE
- DOLERITE
- INTERLAMINATED SILTSTONE & SANDSTONE
- CONCRETE
- ASPHALT
- NO CORE
- IV ROCK CLASSIFICATION (PELLS ET AL, 1998)
- DX WEATHERING (SEE EXPLANATION SHEETS)
- WATER LEVEL
- N*=17 STANDARD PENETRATION TEST RESULT

PROJECT UNITS

UNIT 1	FILL
UNIT 2a	ESTUARINE DEPOSITS
UNIT 2b	ALLUVIUM
UNIT 3	RESIDUAL SOIL
UNIT 4a	CLASS V / IV SANDSTONE
UNIT 4b	CLASS III SANDSTONE
UNIT 4c	CLASS II SANDSTONE

revision no.	description	drawn	approved	date
A	ORIGINAL ISSUE			

NOTE: 2 x VERTICAL EXAGGERATION

Horizontal Scale (metres) 1:500

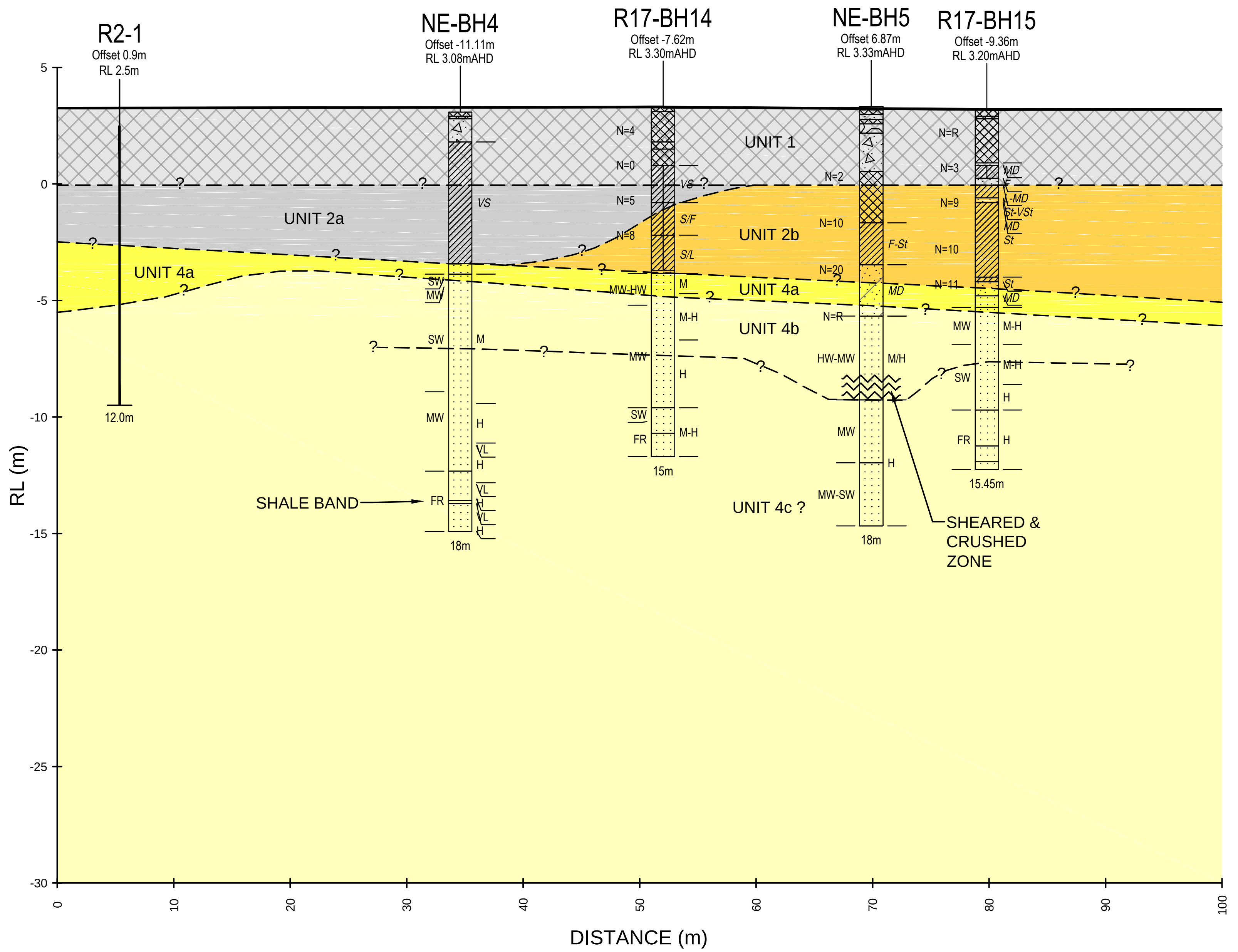
Vertical Scale (metres) 1:250

drawn	RC / AW
approved	PKW
date	22 / 09 / 14
scale	AS SHOWN
original size	A3

coffey

client:	LEND LEASE (HAYMARKET) PTY LIMITED
project:	SYDNEY INTERNATIONAL CONVENTION EXHIBITION AND ENTERTAINMENT PRECINCT (SICEEP) "THE HAYMARKET'
title:	SUBSURFACE SECTION NE-3
project no:	GEOTLCOV24303AG-BM
figure no:	FIGURE 5
rev:	A

PLOT DATE: 22/09/2014 3:08:03 PM DWG FILE: F:\GEOTECHNICS\1 PROJECTS\GEOTLCOV24303AG\GEOTLCOV24303AG LEND LEASE - THE HAYMARKET\8. FIGURES\GEOTLCOV24303AG-BM.DWG



SECTION NE-4-NE-4'

LEGEND

- FILL
- CLAYEY SAND
- SANDSTONE
- SHALE
- CLAY
- SANDY CLAY
- SAND
- SILTY CLAY
- SILTY SAND
- DOLERITE
- CLAYEY SILT
- SILT
- GRAVELLY SILT
- GRAVELLY SAND
- GRAVEL
- GRAVELLY CLAY
- INTERBEDDED SHALE & SANDSTONE
- DOLERITE
- INTERLAMINATED SILTSTONE & SANDSTONE
- CONCRETE
- ASPHALT
- NO CORE
- IV ROCK CLASSIFICATION (PELLS ET AL, 1998)
- DX WEATHERING (SEE EXPLANATION SHEETS)
- WATER LEVEL
- N*=17 STANDARD PENETRATION TEST RESULT

PROJECT UNITS

UNIT 1	FILL
UNIT 2a	ESTUARINE DEPOSITS
UNIT 2b	ALLUVIUM
UNIT 3	RESIDUAL SOIL
UNIT 4a	CLASS V / IV SANDSTONE
UNIT 4b	CLASS III SANDSTONE
UNIT 4c	CLASS II SANDSTONE

PLOT DATE: 22/09/2014 3:08:06 PM DWG FILE: F:\GEOTECHNICS\1 PROJECTS\GEOTLCOV24303\GEOTLCOV24303AG LEND LEASE - THE HAYMARKET\8. FIGURES\GEOTLCOV24303AG-BM.DWG

revision

no.	description	drawn	approved	date
A	ORIGINAL ISSUE			

NOTE: 2 x VERTICAL EXAGGERATION

5 0 5 15 25
Horizontal Scale (metres) 1:500

2.5 0 5 10
Vertical Scale (metres) 1:250

drawn	RC / AW
approved	PKW
date	22 / 09 / 14
scale	AS SHOWN
original size	A3

coffey

client: LEND LEASE (HAYMARKET) PTY LIMITED

project: SYDNEY INTERNATIONAL CONVENTION EXHIBITION AND ENTERTAINMENT PRECINCT (SICEEP) "THE HAYMARKET'

title: SUBSURFACE SECTION NE-4

project no: GEOTLCOV24303AG-BM | figure no: FIGURE 6 | rev: A