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Our ref: PSM2796-002R

11 September 2015

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ATTENTION: ANDY STUBBS
By email: astubbs@urbanest.com.au

Dear Andy

**RE: URBANEST STUDENT ACCOMMODATION**
**DARLING SQUARE BUILDING W1**
**WESTERN PLOT, DARLING DRIVE, HAYMARKET**
**INFRASTRUCTURE IMPACT ASSESSMENT REPORT**

Please find enclosed our Infrastructure Impact Assessment Report for the proposed Urbanest Darling Square Building W1 development. The report presents assessments of the impacts of the proposed building foundations on existing tunnel infrastructure beneath the site, including the Sydney Water Corporation trunk sewer tunnel and the Energy Australia City West Cable Tunnel passing beneath the site of the proposed building.

Please contact Andrew Merritt or the undersigned should you have any questions or comments in regards to this report.

For and on behalf of
PELLS SULLIVAN MEYNINK

S. Clarke

STRATH CLARKE
Senior Principal

Distribution: 1 electronic copy to Buildcorp Contracting
Original held by PSM

# Urbanest Darling Harbour No. 2 Pty Ltd

## URBANEST STUDENT ACCOMMODATION
## DARLING SQUARE BUILDING W1
## WESTERN PLOT, DARLING DRIVE, HAYMARKET
### INFRASTRUCTURE IMPACT ASSESSMENT REPORT

**PSM2796-002R SEPTEMBER 2015**

PSM

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## APPENDICES

# 1 INTRODUCTION

This report supports a State Significant Development (SSD) Development Application (DA) 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 12) 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 a residential building (student accommodation) within the Western development plot (Darling Drive) of Darling Square and associated public domain works. The DA has been prepared and structured to be consistent with the Concept Proposal DA.

## 1.1 Overview of Proposed Development

The proposal relates to a detailed (‘Stage 2’) DA for a residential building (student accommodation) in the Darling Drive 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 Darling Drive Plot is one of six development plots identified within the approved Concept Proposal.

More specifically, this SSD DA seeks approval for the following components of the development:

- Demolition of existing site improvements;
- Associated tree removal and planting;
- Construction and use of one residential building within the Darling Drive Plot, to be used for student accommodation purposes;
- Public domain improvements, including provision of a new urban courtyard space between student accommodation buildings W1 and W2; and
- Extension and augmentation of physical infrastructure / utilities as required.

## 1.2 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 (non-residential and 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 SSDA2, the following approvals have been granted for various stages of the Darling Square site:

- Darling Drive (part) development plot (SSDA3) for the construction and use of a residential building/W2 (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.
- North-East development plot (SSDA7) – construction and use of a mixed use residential development and associated public domain works approved on 16 April 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 a residential building/W1 (student accommodation) and associated public domain works within Darling Square (SSDA 12), consistent with the Concept Proposal (SSDA 2).

## 1.3 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 Concept Proposal DA provides for six (6) separate development plots across the Darling Square Site (refer to Figure 2):

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 northern portion of the Western Plot and surrounds as detailed within the architectural and landscape plans submitted in support of the DA.


**Figure 2:** Concept Proposal Development Plots

## 2 SCOPE OF WORK

This report has been prepared to support a detailed Stage 2 SSD DA for a residential building/W1 (student accommodation) and associated public domain works within Darling Square (SSDA 12), consistent with the Concept Proposal (SSDA 2).

The report presents preliminary assessments of the impacts of the Urbanest Building W1 student accommodation building on existing tunnel infrastructure passing beneath the site, including:

- Sydney Water Corporation (SWC) trunk sewer tunnel
- Energy Australia City West Cable Tunnel (CWCT).

The impact assessments are based on the Building W1 pile foundation layout and loads received from Northrop Consulting Engineers on 26 August 2015 (Ref. 150122, SK-03 Rev. 4).

The work presented in this report was undertaken by Pell Sullivan Meynink (PSM) for Urbanest in accordance with our fee proposal dated 9 July 2015 (Ref. PSM2796-001L) and the instruction to proceed received in an email dated 20 July 2015.

PSM have previously undertaken a number of geotechnical and infrastructure assessment studies for the student accommodation buildings (Ref. PSM1986-009R, dated 11 March 2013; PSM1986-019L, dated 14 May 2013; PSM2627-003R Rev. 2, dated 20 May 2015). This previous work was performed on behalf of Lend Lease during the design development and planning approval stages, and on behalf of Buildcorp Contracting NSW during design and construction of the adjacent Urbanest Building W2. The previous work is referred to where relevant in this report.

## 3 PROPOSED URBANEST BUILDING W1 DEVELOPMENT

The proposed Urbanest Building W1 will comprise 21 storeys within a site approximately 50 m long and 20 m wide. No basement is proposed under the building. The building will be located immediately north of the Urbanest Building W2 currently under construction.

Figure 3 shows a plan of the site, including outlines of the Urbanest Building W2 and the proposed Building W1 and the pile foundations. The positions of the existing CWCT and the SWC trunk sewer tunnel are also shown.

The site was previously covered with vegetation and topsoil / Fill materials to levels of approximately RL 3.5 m and RL 5.5 m. In preparation for the development works, the site was cleared of vegetation and some of the existing Fill material and levelled to approximately RL 3.5 m, similar to the Darling Drive road level.

The currently proposed pile foundation layout for Building W1 is shown in Appendix A (received from Northrop 26 August 2015). The foundations comprise 39 No. 900 mm diameter bored piles, with 2 m thick ground level slabs bridging over the sewer tunnel under part of the building footprint. Three pile types are used with socket lengths of 1.0 m and 2.5 m into Class III sandstone. Working loads for the different pile types are shown in Appendix A.

The Urbanest Building W2 currently under construction covers an area of approximately 19 m by 48.5 m and is founded on 28 No. 900 mm bored piles socketed into Class III sandstone. The pile layout for the Building W2 shown in Figure 3 is based on design drawings received from Northrop as previously used for impact assessments on the CWCT and sewer tunnel (Ref. PSM2627-003R Rev. 2).

# 4 EXISTING TUNNEL INFRASTRUCTURE

The positions of the existing SWC trunk sewer tunnel and CWCT beneath the site of the Urbanest Buildings W1 and W2 are shown in Figure 3.

## 4.1 City West Cable Tunnel

The CWCT was constructed for Energy Australia in about 2008. It has an internal diameter of 3 m and is lined with precast concrete segments. The tunnel is about 20 m below ground level and is overlain by approximately 15 m of bedrock. The tunnel is located beneath the groundwater table and the segmental lining is designed to resist external groundwater pressures. The lining design is intended to result in very low leakage rates into the tunnel. Relevant tunnel drawings are included in Appendix B.

The CWCT passes beneath the south east corner of the Building W1 site over a length of approximately 15 m, and beneath the Building W2 site over a length of approximately 40 m. There is an easement zone around the CWCT based on a 10 m diameter zone centred on the tunnel axis (shown on Figure 3).

## 4.2 Trunk sewer tunnel

The SWC trunk sewer tunnel was constructed in about 1988. As-built drawings of the sewer are included in Appendix C.

The section of the sewer adjacent to the development site comprises a 1.0 m diameter glass reinforced plastic liner embedded within a block of reinforced concrete 1.6 m wide and 1.6 m in height. The void between the concrete and the excavated tunnel (approx. 2.4 m span and 2.4 m height) was filled with grout. The invert level of the sewer beneath the building is about RL -4.0 m, corresponding to a ground cover above the tunnel of approximately 7.5 m.

The sewer tunnel alignment shown in Figure 3 is from a site survey drawing received from Northrop on 26 August 2015 (Ref. Rygate drawing 76272_sewer_RevA.pdf, dated 11 July 2014). As shown on Figure 3, the sewer tunnel passes beneath the eastern side of the Urbanest Building W1 from the southern to northern boundaries of the site, over a length of approximately 50 m. The sewer also passes close to the north-east corner of the Building W2.

# 5 GROUND CONDITIONS

## 5.1 Geotechnical investigations

A number of geotechnical investigations have been undertaken in the area of the Urbanest development site for the SICEEP development, the CWCT project, and the Urbanest Building W2. Boreholes in the immediate vicinity of the Urbanest site are shown on Figure 3, and include:

- Historical third party boreholes drilled for redevelopment of the railway yards, the Darling Harbour redevelopment, the SWC sewer tunnel and the CWCT project;
- Boreholes drilled by Coffey Geotechnics in 2011, 2012 and 2013 for the SICEEP development (Ref. [1], [2], [3]);
- Shallow ground investigations by PSM in 2015 for the Urbanest Building W2 development (Ref. [4]);
- Boreholes drilled by Coffey Geotechnics in 2015 for the Urbanest Building W2 development (Ref. [5]).

These ground investigations provide information for the shallow soils, bedrock and geological features for the area of the Urbanest development site. Additional geotechnical information is available from pile construction records for the Urbanest Building W2.

## 5.2 Ground conditions

A geotechnical model for the site has been prepared based on the information available from the previous geotechnical investigations.

The ground conditions at the site generally comprise a layer of Fill and Alluvium overlying Class III and Class II sandstone bedrock. The geotechnical units, levels, and thicknesses based on the available data for the site area are shown in Table 1.

Inferred bedrock surface contours are shown in Figure 3. These contours indicate that the rock levels reduce from the west to the east (i.e. towards the original harbour) by about 6 m over a distance of roughly 50 m. Within the Building W1 footprint the inferred top of rock level varies from approximately RL -0.5 m to RL -3 m.

Most boreholes encountered Class III sandstone at the top of the bedrock; however, in some boreholes approximately 1.0 m of Class IV/V sandstone was encountered at the top of bedrock.

Construction records from the piles for the Urbanest Building W2 confirmed that the bedrock levels and classes beneath the adjacent site are consistent with the geotechnical model.

**TABLE 1**
**GEOTECHNICAL MODEL**

| GEOTECHNICAL UNIT | REDUCED LEVEL OF TOP OF UNIT (m AHD) | THICKNESS (m) |
|---|---|---|
| FILL, ALLUVIUM | 3.7 | 4.0 to 8.5 |
| CLASS III SANDSTONE | -0.5 to -5 | 5.5 to 11 |
| CLASS II SANDSTONE | -9 to -16 | > 20 |

Note: 1. Rock classification is in accordance with Reference 6.

It is noted that poorer conditions occur north east of the site due to the presence of an intrusive volcanic dyke, as well as possible shear zones or joint swarms. The location of the Great Sydney dyke is shown in Figure 3, approximately 50 m north east of the site. From Ref. [3], this dyke has a typical width of 4.5 m. It is noted that the dyke may branch or sidestep, though is not expected to be present beneath the site.

Groundwater levels encountered in the borehole investigations near the site were measured to be at about RL 0.8 m, approximately 3 m below ground level at the site.

## 6 PILE DESIGN PARAMETERS

Recommended geotechnical design parameters for assessment of the axial capacity of bored piles in sandstone are summarised in Table 2.

The parameters for ultimate shaft adhesion and ultimate end bearing in sandstone in Table 2 are based on the recommendations in Ref. [7]. These are well established and have been widely used for the design of bored pile foundations in Sydney. These parameters assume that the piles are constructed to a high standard, with a roughened shaft, and are cleaned and free of water prior to the placement of concrete.

Allowable (unfactored) geotechnical parameters are included in Table 2. Use of these is intended to result in settlements under working loads of less than 1% of the pile diameter.

It is understood that the ultimate geotechnical parameters in Table 2 were used by Northrop to design the piles for the Urbanest Building W2, using a limit state design approach with a basic geotechnical strength reduction factor ($\phi_{gb}$) of 0.5. As noted in Appendix A, the same parameters and approach were used to determine the pile socket lengths required to resist the axial compression loads for the Urbanest Building W1.

**TABLE 2**
**RECOMMENDED PILE DESIGN PARAMETERS**

| GEOTECHNICAL UNIT | ULTIMATE SHAFT ADHESION (1) (MPa) | ULTIMATE END BEARING (MPa) | YOUNG'S MODULUS (MPa) | ALLOWABLE SHAFT ADHESION (1) (MPa) | ALLOWABLE END BEARING PRESURE (MPa) |
|---|---|---|---|---|---|
| FILL, ALLUVIUM | 0 | 0 | 10 | 0 | 0 |
| CLASS III SANDSTONE | 1.2 | 30 | 800 | 0.5 | 4 |
| CLASS II SANDSTONE | 2 | 60 | 1500 | 0.8 | 6 |
| CLASS I SANDSTONE | 3 | 100 | 2500 | 1.0 | 10 |

Note: 1. For a clean shaft of roughness R2 or better, in accordance with Ref. [8].

# 7 IMPACTS ON CABLE TUNNEL

## 7.1 Deformation criteria

As noted in Section 4, it is understood that there is an easement around the CWCT based on a 10 m diameter zone centred on the tunnel axis. As Energy Australia have not provided deformation criteria for acceptable impacts on the CWCT, relevant criteria were developed by analysis for use in previous impact assessments for the student accommodation buildings. Details of the analysis are included in report PSM1986-009R.

Acceptable deformation limits for the CWCT lining were developed considering three deformation mechanisms that could potentially adversely affect the structural integrity and watertightness of the tunnel lining. The criteria adopted for cracking of the lining segments, spalling of the lining segments and leakage between joints in the lining are summarised in Table 3.

Together with 10 m diameter easement zone, these proposed deformation criteria have been used in the preliminary impact assessments accepted by Energy Australia for development of the student accommodation buildings (Ref. PSM1986-009R).

**TABLE 3**
**PROPOSED DEFORMATION CRITERIA FOR CITY WEST CABLE TUNNEL**

| DEFORMATION MECHANISM | PROPOSED DEFORMATION LIMIT (mm) |
|---|---|
| Cracking of the lining segments | 1.5<br>(vertical convergence) |
| Spalling of lining segments due to increased compressive stresses | 2.5<br>(vertical convergence) |
| Leakage between joints in the lining due to lateral extension | 2<br>(horizontal extension) |

## 7.2 Assessment of impacts

### 7.2.1 Previous assessments

Previous assessments of the impacts of the two proposed student accommodation buildings on the CWCT have been undertaken for preliminary pile foundation layouts and loads at the time of the Development Application (Ref. PSM1986-009R; PSM1986-019L).

Based on these impact assessments and the tunnel deformation criteria proposed in Section 7.1, Ausgrid provided a Letter of No Objection for the proposed development of the two buildings (see Appendix D). In accordance with the previous impact assessments, this letter assumed that the piles would extend to approximately RL -7 m with approximately 10 m of rock cover between the pile toe level and tunnel crown, and that the vertical convergence of the tunnel due to loads in the piles would be less than 2 mm.

An impact assessment of the CWCT for the Urbanest Building W2 (only) was also undertaken based on the pile foundation layout and loads developed during detailed design of the building. This assessment showed negligible impact on the tunnel, based on the requirements and criteria previously agreed by Ausgrid (Ref. PSM2627-003R Rev. 2).

### 7.2.2 Urbanest Building W1 impact assessment

#### 7.2.2.1 FLAC3D model

An impact assessment of the CWCT for the currently proposed Urbanest Building W1 has been undertaken considering both Buildings W1 and W2.

As for the previous assessments, 3D numerical analysis was performed using the analysis package FLAC3D to assess the impacts of the pile foundations on the deformation of the cable tunnel. The model was based on the pile layout, socket lengths and working loads previously considered for the Building W2 (Ref. PSM2627-003R

Rev.2), and the pile foundation details currently proposed for the Building W1 (see Appendix A).

For the Building W2, a number of piles are positioned over the easement zone for the tunnel (see Figure 3), with the design toe levels modelled between RL -2.0 m and RL -5.5 m.

For the Building W1, three piles are positioned over the CWCT easement zone at the south east corner of the building (see Figure 3). Based on 1.0 m socket lengths for these piles and the expected level for the top of Class III sandstone, the pile toe levels modelled were between RL -3.9 m and RL -4.2 m. These are above RL -7 m as required to provide a minimum 10 rock cover between the piles and the cable tunnel.

The toe levels for piles outside the CWCT easement zone were also modelled based on the expected level for the top of Class III sandstone and the design socket lengths in Appendix A. The toe levels for some piles adjacent to the sewer tunnel were extended slightly to minimise impacts on the sewer (see Section 8).

The FLAC3D model comprises a rectangle of plan dimensions 100 m by 150 m, encompassing both of the proposed buildings and the cable tunnel. The base of the model is at RL –50 m, and the surface level roughly coincides with the existing surface levels at the site. There are approximately one million elements within the model, with element sizes ranging from about 0.6 m to 3 m.

The CWCT runs through the centre of the model, as shown in the graphical output included in Appendix E. The tunnel is modelled as an unlined excavation (i.e. the tunnel lining is not included in the analysis).

The pile structural element formulation available in FLAC3D was employed, with the ultimate shaft adhesion and the pile shaft and base stiffness parameters for the model based on the geological units intersected by the piles. This approach is based on the geotechnical parameters considered most representative of the actual conditions. A Young's modulus of 32.8 GPa was assumed for the concrete pile shaft (for a concrete compressive strength of 40 MPa).

The pile model parameters used for the FLAC3D analysis were calibrated against the settlement of single piles determined from elastic calculations and axisymmetric analysis using the finite element programme $Phase^2$ (Rocscience Inc.). The FLAC3D analysis including all piles from the Buildings W1 and W2 calculates the pile settlements including the interactions between adjacent piles.

#### 7.2.2.2 Analysis results

Graphical output from the FLAC3D analysis for both the Buildings W1 and W2 is shown in Appendix E.

Figure 4 shows calculated deformations along the CWCT alignment for the Building W2 only, and Figure 5 shows the calculated deformations for both Buildings W1 and W2.

The results indicate individual pile head settlements of between about 3 mm and 12 mm under the working loads.

The maximum calculated tunnel settlements from the Building W1 and W2 foundation loads are less than 1.5 mm, with a maximum vertical convergence of approximately 0.5 mm from buildings. A maximum horizontal dilation of approximately 0.1 mm is also calculated for the tunnel beneath the Building W2. A lower horizontal dilation of the tunnel is calculated for the Building W1, as the tunnel alignment curves away from the site.

The calculated tunnel deformations are within the proposed deformation criteria summarised in Table 3. The impacts of the foundation loads from the Buildings W1 and W2 are therefore expected to be negligible.

## 8 IMPACTS ON TRUNK SEWER

### 8.1 Adverse mechanisms

As noted in Section 4, the Sydney Water trunk sewer was constructed in a 2.4 x 2.4 m tunnel excavation, with a 1.0 m diameter glass reinforced plastic pipe surrounded by a 1.6 x 1.6 m reinforced concrete block and an annulus of grout between the concrete and rock. The sewer invert level beneath the site is approximately RL -4 m.

Potential impacts of the building foundation piles on the trunk sewer include:

- Physical conflict
- Bending deformation of the reinforced concrete box encasing the sewer
- Bending deformation of the glass fibre reinforced sewer pipe

As shown in Appendix A, the piles closest to the sewer tunnel will be positioned outside a 1.5 m clearance zone between the pile face and extrados of the concrete encasement around the sewer. These piles will be founded below the zone of influence defined by Sydney Water (see Appendix A), with the pile toes below the sewer invert level.

These pile positions and depths relative to the sewer satisfy the preliminary guidance from Sydney Water outlined in the Feasibility Letter dated 18 March 2015 for the Building W1 (Ref. [9]). They also minimise the risk of physical conflict between the piles and the sewer (allowing for construction tolerances), and reduce potential impacts from the pile loads causing excessive deformation of the sewer.

Potential impacts of the pile loads on the sewer were assessed by finite element analyses to estimate the sewer deformations, as described in Section 8.2.

### 8.2 Assessment of impacts

#### 8.2.1 Tolerable deformations

As noted above, the pile loads and resulting ground movements will potentially cause bending deformations of the sewer tunnel.

Tolerable deformations for the concrete and sewer pipe were developed in previous impact assessments for the student accommodation buildings (Ref. reports PSM1986-009R; PSM1986-019L). These indicated that the reinforced concrete box encasing the sewer is much more sensitive to deformation than the glass fibre reinforced sewer pipe. A limiting curvature of 0.0002 $m^{-1}$ was determined to avoid cracking of the concrete sewer. This criterion was used to assess tolerable deformations of the sewer resulting from the pile loads.

### 8.2.2 Finite element analyses

Pile and ground settlements due to the working loads acting on the piles adjacent to the sewer were calculated via axisymmetric finite element analyses using the program $Phase^2$, produced by Rocscience Inc. These settlements were used to estimate the resulting deformations and curvature of the sewer.

Three representative sections along the sewer were assessed in the analyses, based on the pile layout shown in Figure 3:

1. Pile type P2 on one side of the sewer, with 1.5 m offset from the concrete encasement (i.e. Piles 25 to 30 in Figure 3). This case was analysed with the pile toe level at RL -4.0 m.
2. Pile type P2 on both sides bridging over the sewer, with 1.5 m offset from the concrete encasement (i.e. Piles 31 / 33 and 32 / 35 in Figure 3). This case was analysed with the pile toe levels at RL -5.5 m.
3. Pile type P4 on one side of the sewer, with 1.75 m offset from the concrete encasement (i.e. Pile 36 in Figure 3). This case was analysed with the pile toe level at RL -4.9 m.

The working loads analysed for each case were based on the loads shown in Appendix A (6900 kN for Type P2; 8500 kN or Type P4). The pile toe levels were based on a minimum level of RL -4 m (coinciding with the sewer invert level), and the length required to provide the minimum socket length in Class III sandstone (based on the expected rock levels beneath the site). Deeper piles with longer socket lengths were analysed for the Type P2 piles bridging over the sewer to reduce ground movements at the sewer invert level and associated deformations.

The elastic geotechnical parameters listed in Table 2 were adopted for the analyses. A Young's modulus of 32 GPa was adopted for the concrete pile shaft.

### 8.2.3 Analysis output

Graphical output from the $Phase^2$ analysis for the three cases listed above is included in Appendix F.

Ground settlement profiles at the sewer invert level (RL -4 m) versus distance from the pile centre, and the sewer deformations and curvatures calculated along a line representing the centre of the sewer are shown in Figures 6, 7 and 8 for the analysis cases 1, 2 and 3 described above.

The pile toe settlements ranged from approximately 2.5 mm to 3.5 mm, and reduce with distance away from the pile. Calculated settlements at the edge of the concrete encasement around the sewer (approx. 2.0 m to 2.2 m from the pile centre) are approximately 1 mm. The analysis also indicated that the stresses in the rock at sewer position increase by approximately 100 kPa to 120 kPa due to the pile loads.

The calculated sewer deformation profiles for each case show maximum curvatures less than the limiting value of 0.0002 $m^{-1}$ representing the initiation of cracking of the concrete encasement. The analyses for the single piles loaded to 6900 kN (Figure 6) and 8500 kN (Figure 7) show settlements of the sewer less than 1 mm and maximum curvatures well below the limiting value. For the bridging piles both loaded to 6900 kN (Figure 8), maximum sewer settlements of approximately 1.5 mm and curvatures slightly below the limiting value are calculated.

Based on the analyses performed, it is expected that the proposed foundation piles will have negligible impact on the sewer tunnel for the following conditions:

- A minimum 1.5 m horizontal offset between the pile shaft and concrete encasement box around the sewer for all piles
- Piles are designed to achieve settlements in the order of a few millimetres at toe level
- Minimum pile toe levels of RL -4 m for the single P2 piles adjacent to the sewer (i.e. piles 25 to 30 as shown on Figure 3)
- Minimum pile toe levels of RL -4.9 m for the single P4 piles adjacent to the sewer (i.e. pile 36 as shown on Figure 3)
- Minimum pile toe levels of RL -5.5 m for the bridging P2 piles adjacent to the sewer (i.e. piles 31 to 35 as shown on Figure 3)

## 9 CONCLUSIONS AND RECOMMENDATIONS

The impact assessments presented in this report demonstrate that the proposed Urbanest Building W1 can be constructed so as to result in acceptable effects on the existing tunnel infrastructure beneath the site, i.e.:

- Trunk sewer tunnel, and
- City West Cable Tunnel (CWCT)

The assessments are based on current knowledge of the expected ground conditions at the site, and the currently proposed pile foundation layout and loads. This is consistent with the approach taken for the Urbanest Building W2.

The currently proposed pile layout provides with a minimum offset of approximately 1.5 m from the concrete encasement around the sewer.

In order to minimise potential impacts on the sewer, the adjacent piles should have toe levels at or below the sewer invert level. This may result in longer pile sockets than are currently proposed. Recommended toe levels for the piles adjacent to the sewer are provided based on the current pile layout. Alternative pile offsets and lengths may also be feasible and can be assessed further at detailed design stage.

The CWCT is located approximately 20 m below ground level and is overlain by approximately 15 m of bedrock. For the current pile design and expected ground conditions, the pile toe levels are expected to be above RL -7 m, providing a minimum of 10 m rock cover between the piles and the tunnel. Only three piles are currently positioned over the easement zone around the CWCT and the analysis performed shown negligible impact from the piles on the tunnel.

The currently proposed pile layout is consistent with the requirements for protection of the sewer tunnel and cable tunnel previously accepted by the asset owners for the Urbanest Building W2 development.

In summary, PSM are satisfied that the Urbanest Building W1 as proposed in the detailed Stage 2 SSD development application can be developed over the existing tunnelled infrastructure. The building can be designed and constructed utilising industry standard techniques such that impacts on the existing tunnelled infrastructure are within acceptable limits.

It is recommended that once developed building designs are sufficiently progressed, and subject to further consultation with the asset owners, further assessments are undertaken to confirm the conclusions of this report.

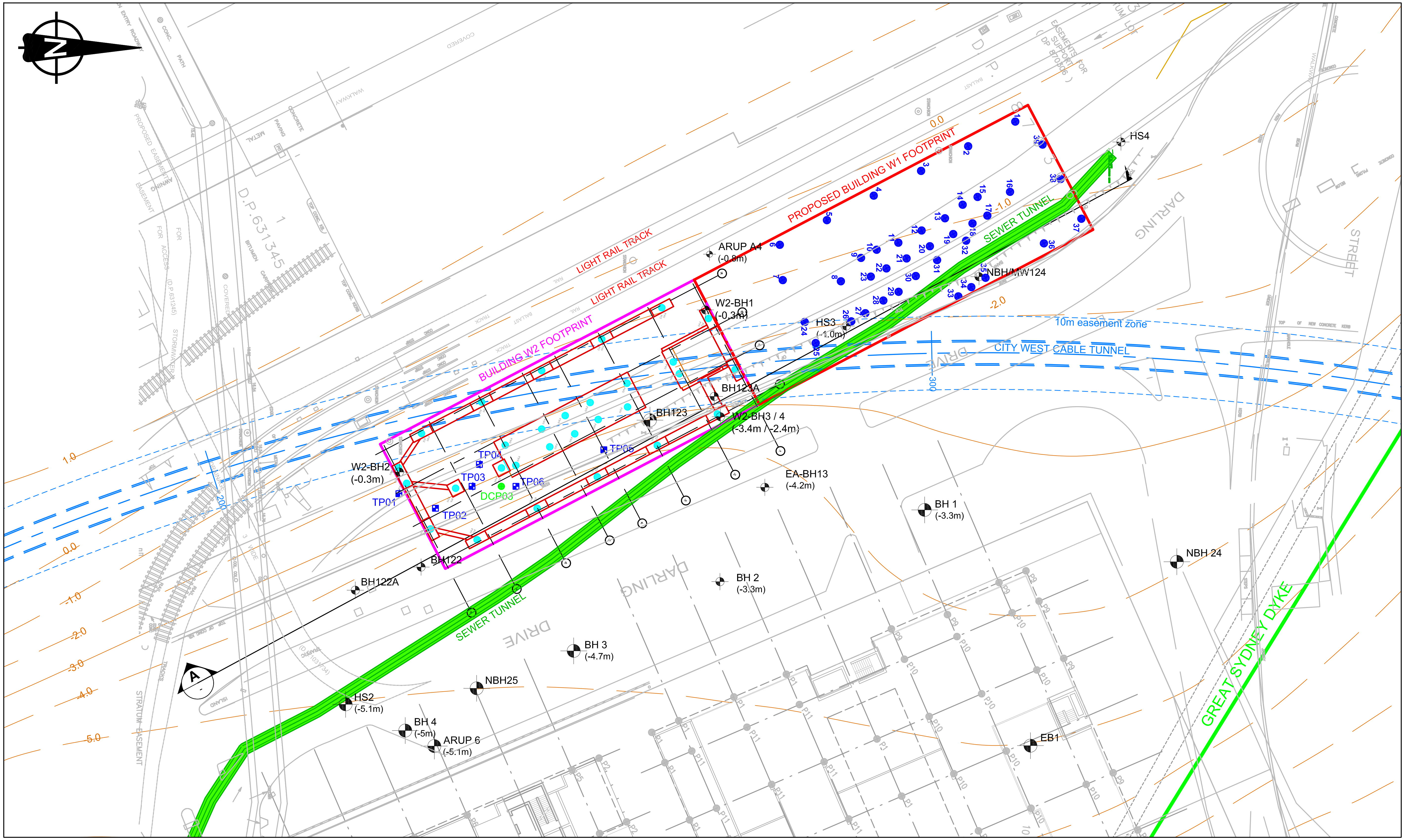
For and on behalf of
PELLS SULLIVAN MEYNINK

ANDREW MERRITT
Associate

STRATH CLARKE
Senior Principal

## REFERENCES


1. Coffey Geotechnics (2011). Geotechnical Investigation Report, Proposed Sydney International Convention and Entertainment Centre, Darling Harbour South. Report GEOTLCOV24303AA-AE, 4 August 2011.
2. Coffey Geotechnics (2013a). Supplementary Site Investigation: Factual Report. Sydney International Conference Exhibition and Entertainment Precinct, Darling Harbour. Report GEOTLCOV24303AF, 30 January 2013.
3. Coffey Geotechnics (2013b). Preliminary Geotechnical Assessment for SSDA3, Sydney International Convention Exhibition and Entertainment Precinct (SICEEP) “The Haymarket”, Western Plot (Darling Drive). Report GEOTLCOV24303AG-AK, 24 April 2013.
4. PSM (2015). Urbanest Haymarket, Stage 2 Geotechnical Report. Report PSM2627-003R Rev. 2, May 2015.
5. Coffey Geotechnics (2015). Urbanest Student Accommodation Haymarket, Borehole Logs. Report GEOTLCOV24303AQ-AE, 14 May 2015.
6. Pells, P.J.N., and Mostyn, G., and Walker, B.F., ‘Foundations on sandstone and shale in the Sydney Region’, Australian Geomechanics Journal, 1998.
7. Pells, P.J.N., ‘Substance and mass properties for the design of engineering structures in the Hawkesbury Sandstone’, Australian Geomechanics Journal, Vol. 39, No. 3, September 2004.
8. Pells, P.J.N., ‘State of practice for the design of socketed piles in rock’, proceedings 8th Australia New Zealand Conference on Geomechanics, Hobart, 1999.
9. Feasibility Letter from Sydney Water to Northrop Consulting Engineers Pty Ltd, dated 18 March 2015 (Case Number: 144392).




LEGEND

- BOREHOLE LOCATIONS (top of bedrock where encountered, m RL)
- TEST PIT LOCATIONS
- DCP LOCATION
- INFERRED TOP OF BEDROCK CONTOURS (RL (m) AHD)

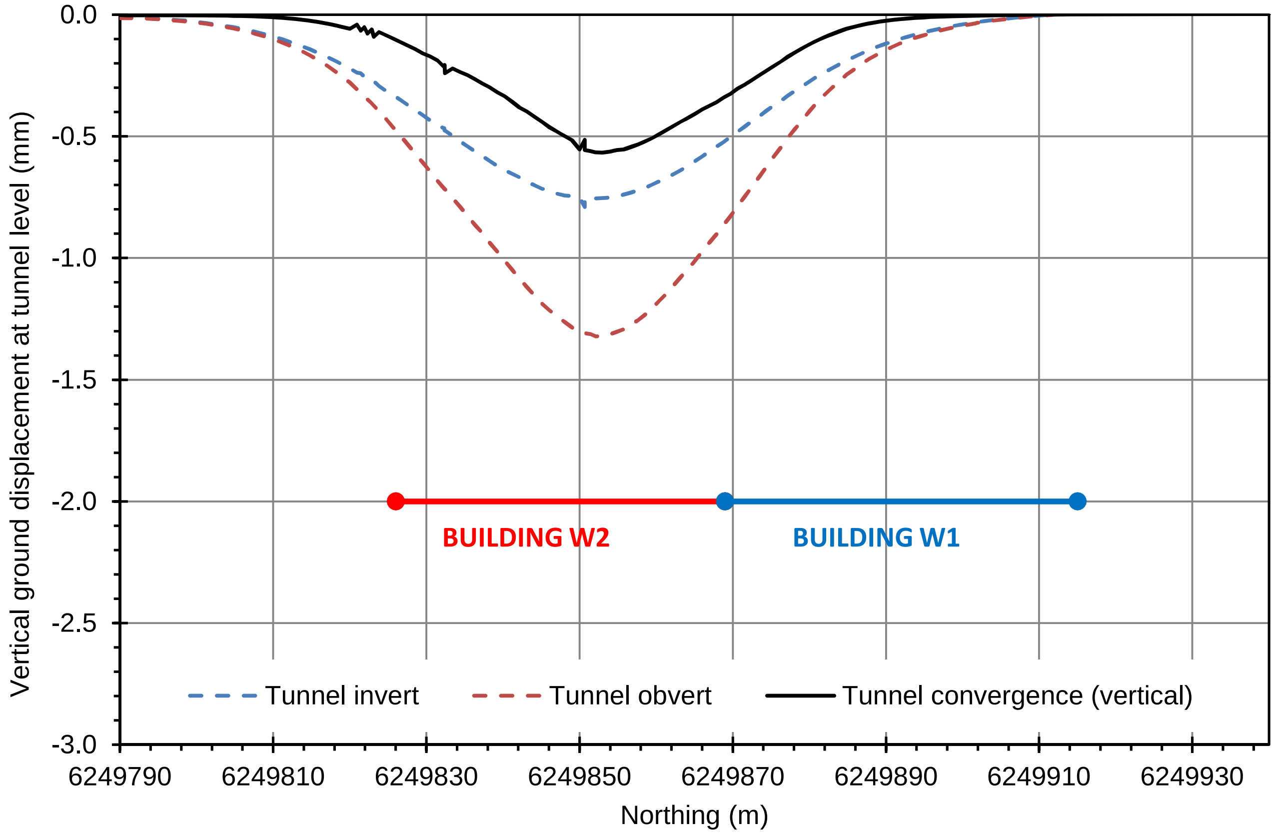
Scale (m): 0 5 10 15 20

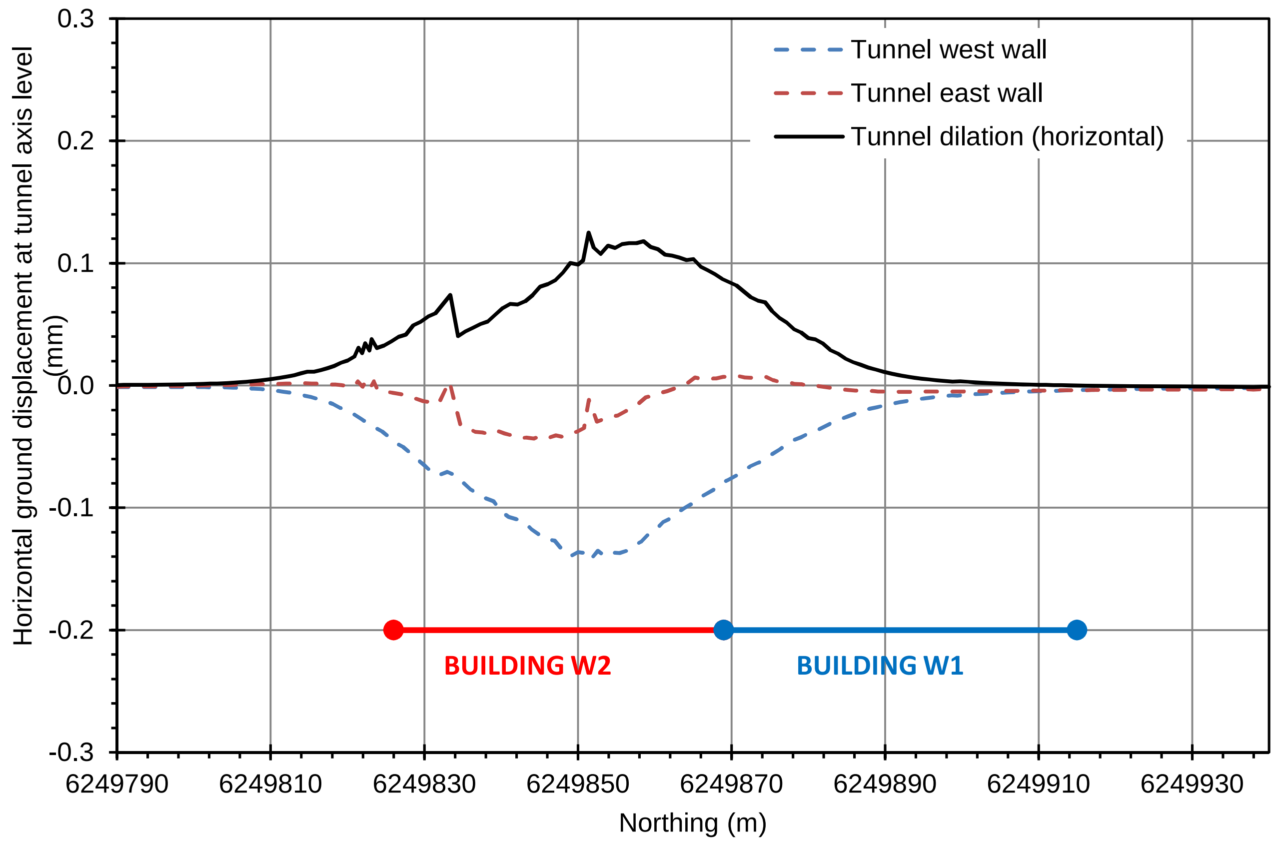
PSM Pells Sullivan Meynink

URBANEST DARLING HARBOUR No.2
Darling Square Building W1

SITE PLAN

PSM2796-002R | FIGURE 3




**URBANEST DARLING HARBOUR No.2**

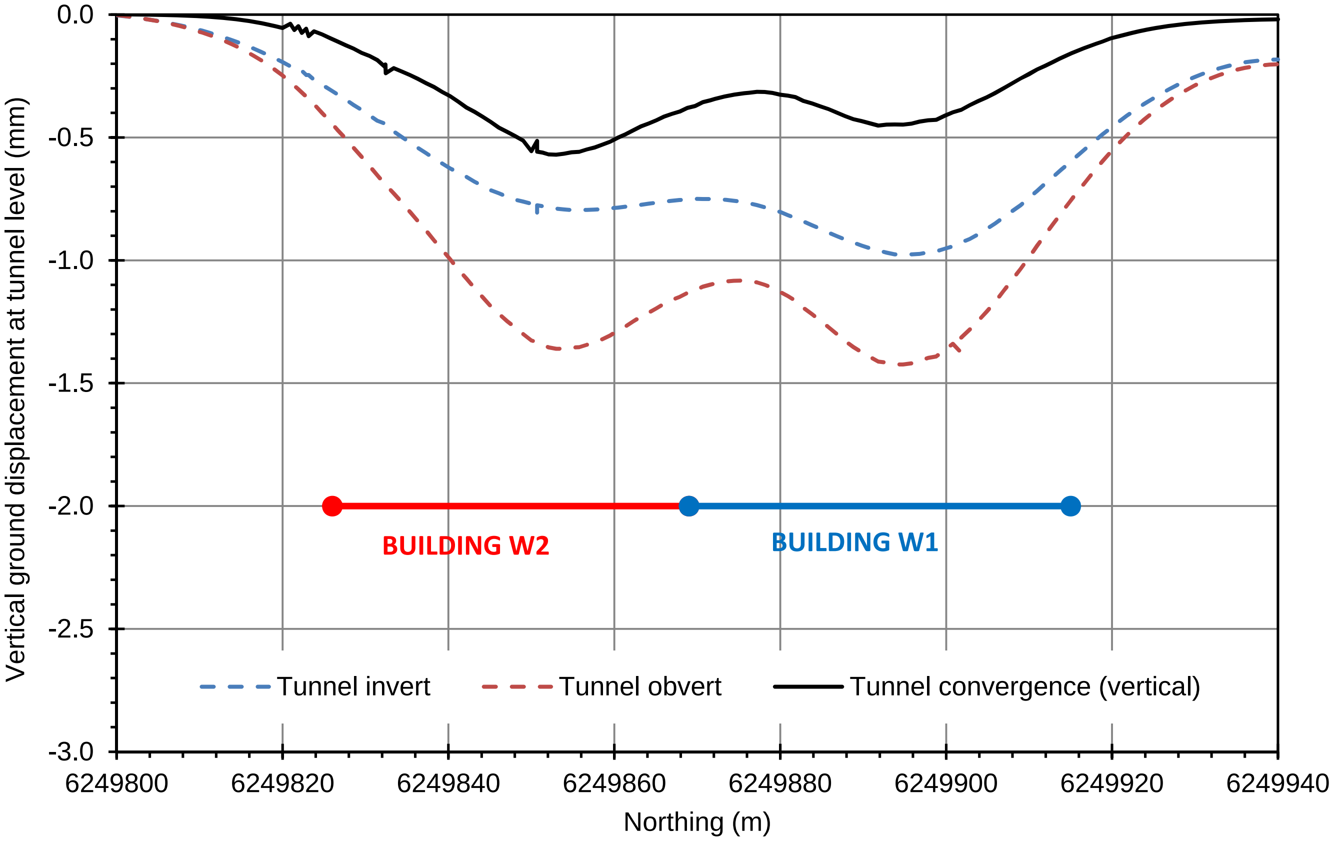
**Darling Square Building W1, Haymarket**

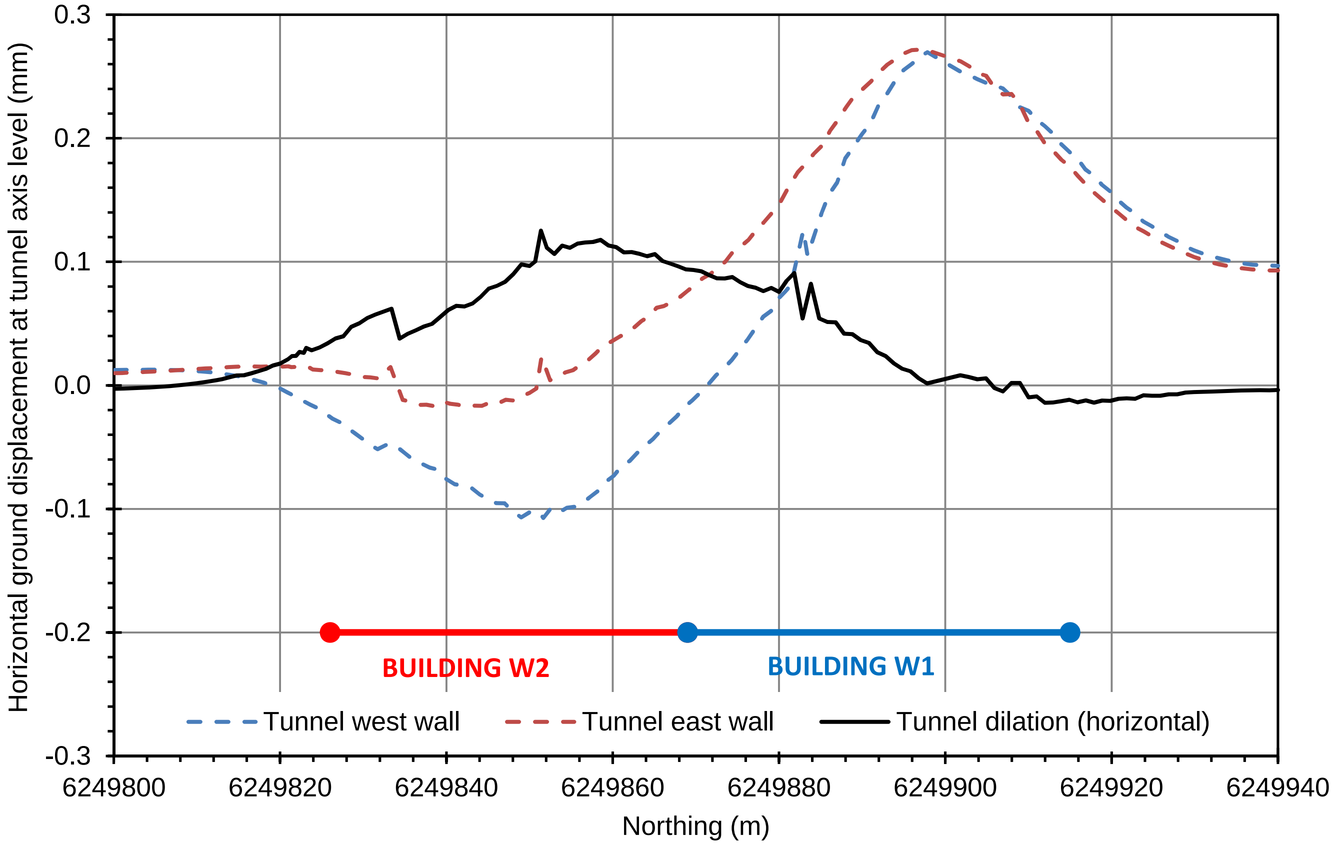
**SUMMARY OF DEFORMATION ANALYSIS OF CWCT (Building W2)**

PSM

**Pells Sullivan Meynink**

| **PSM2796-002R** | **FIGURE 4** |
|---|---|




**URBANEST DARLING HARBOUR No.2**

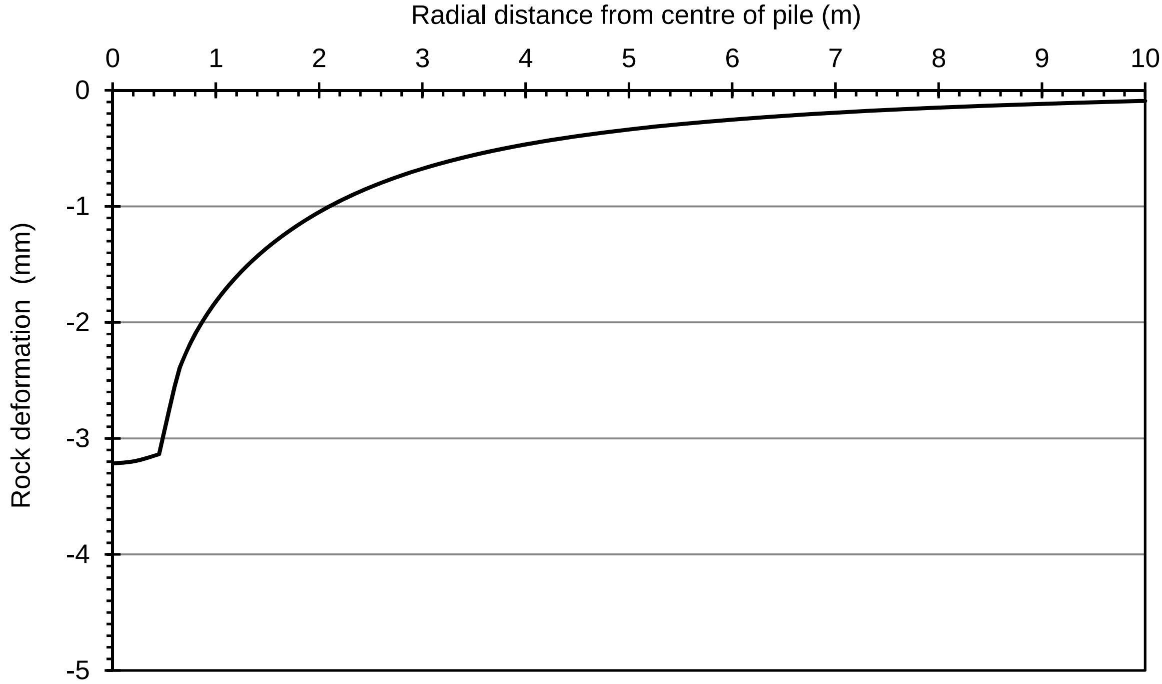
**Darling Square Building W1, Haymarket**

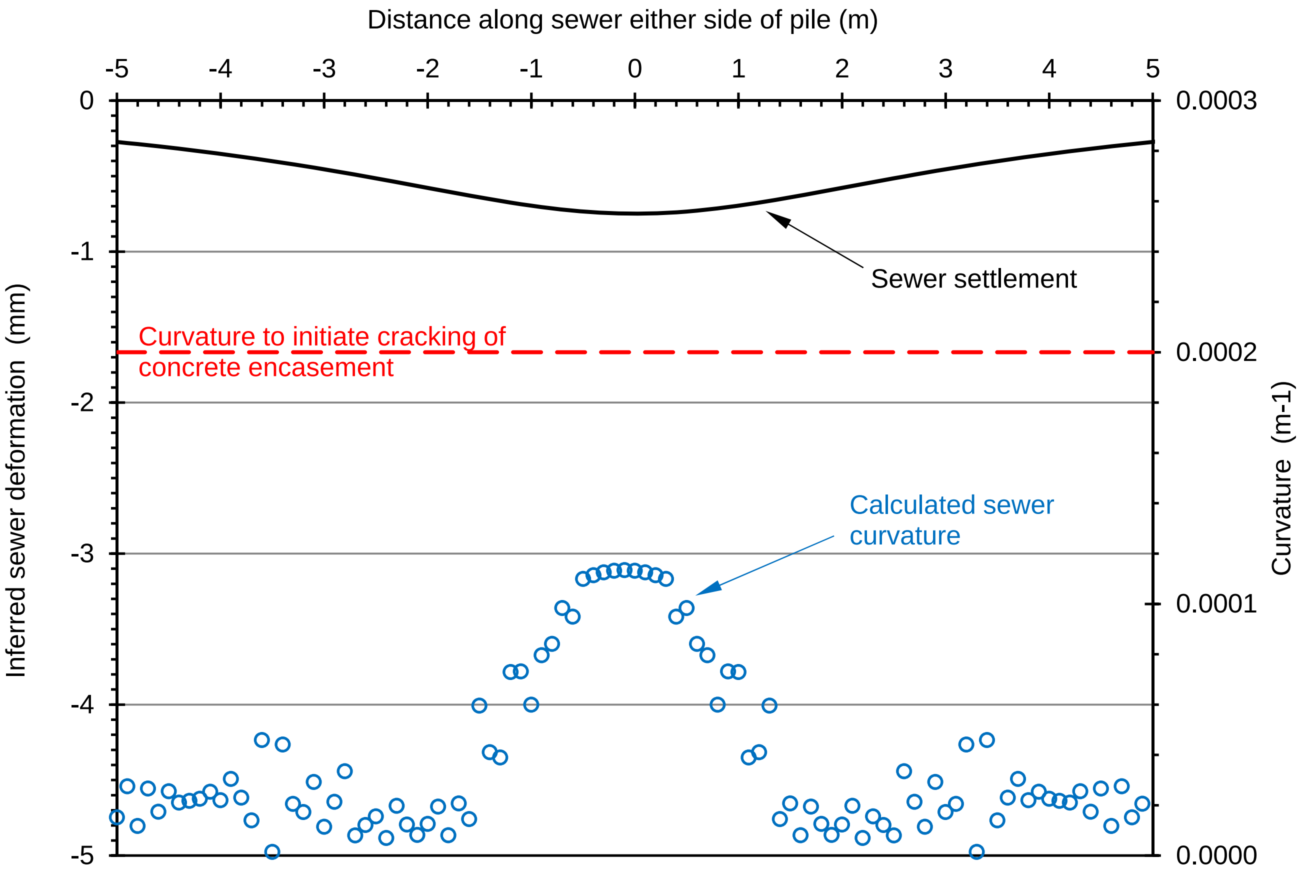
**SUMMARY OF DEFORMATION ANALYSIS OF CWCT (Buildings W1 and W2)**

PSM

**Pells Sullivan Meynink**

| | |
|---|---|
| **PSM2796-002R** | **FIGURE 5** |




Notes:

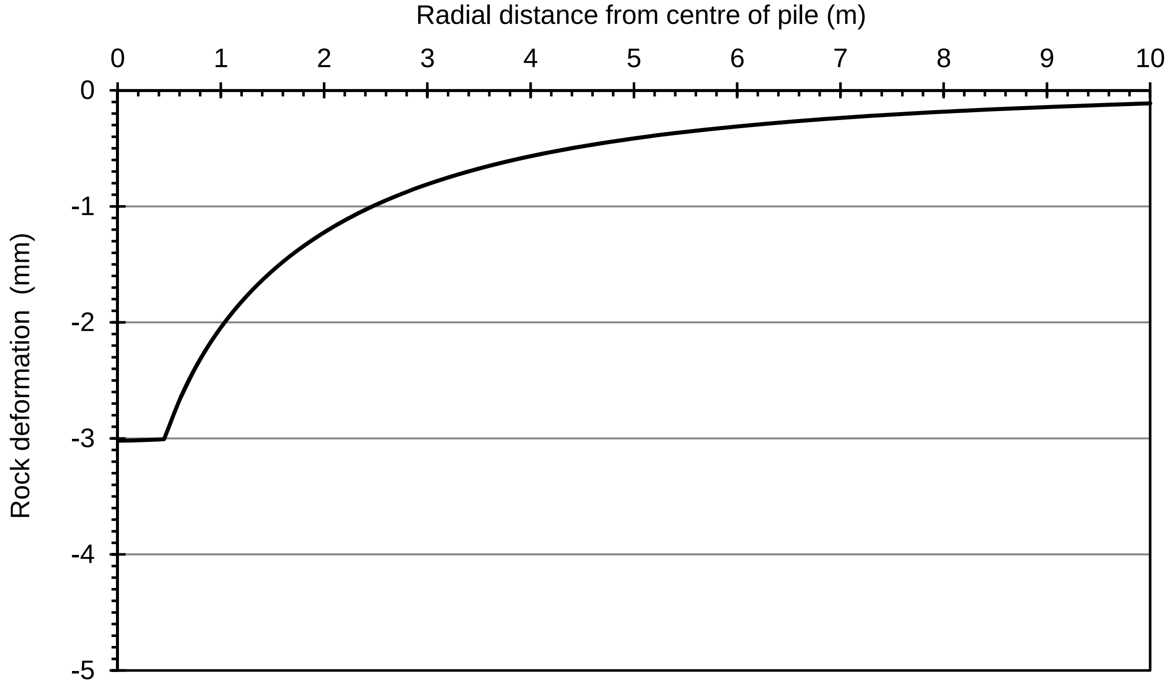
1. Sewer deformation for single pile located approx. 2.75 m from sewer centre line.
2. Pile toe at RL -4 m.

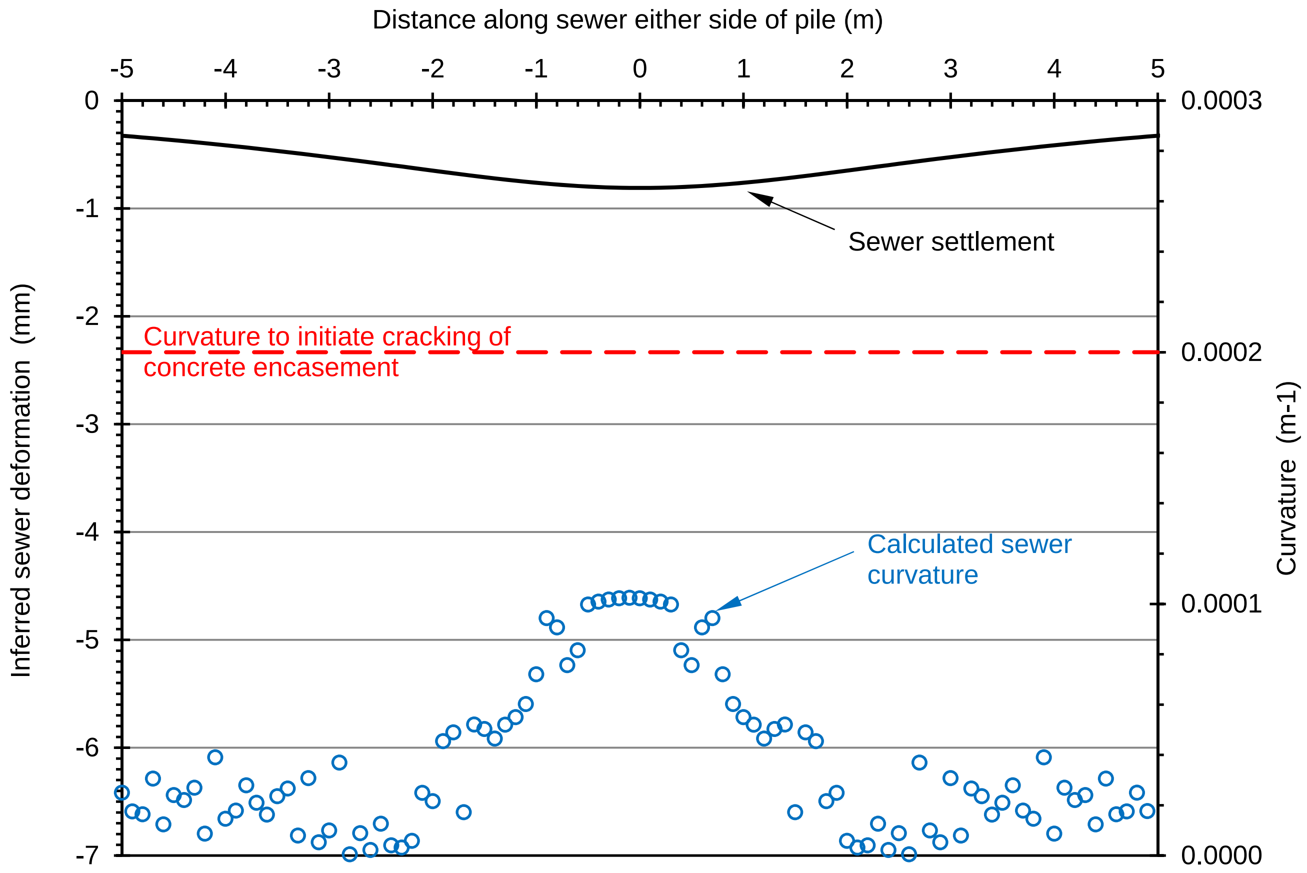
**Pells Sullivan Meynink**

**URBANEST DARLING HARBOUR No.2**
**Darling Square Building W1, Haymarket**

**CURVATURE OF SEWER DUE TO ADJACENT LOADED PILE (RUN 1 - 6900 kN)**

| | |
|---|---|
| **PSM2796-002R** | **FIGURE 6** |




Notes:

1. Sewer deformation for single pile located approx. 3.0 m from sewer centre line.
2. Pile toe at RL -4.9 m.

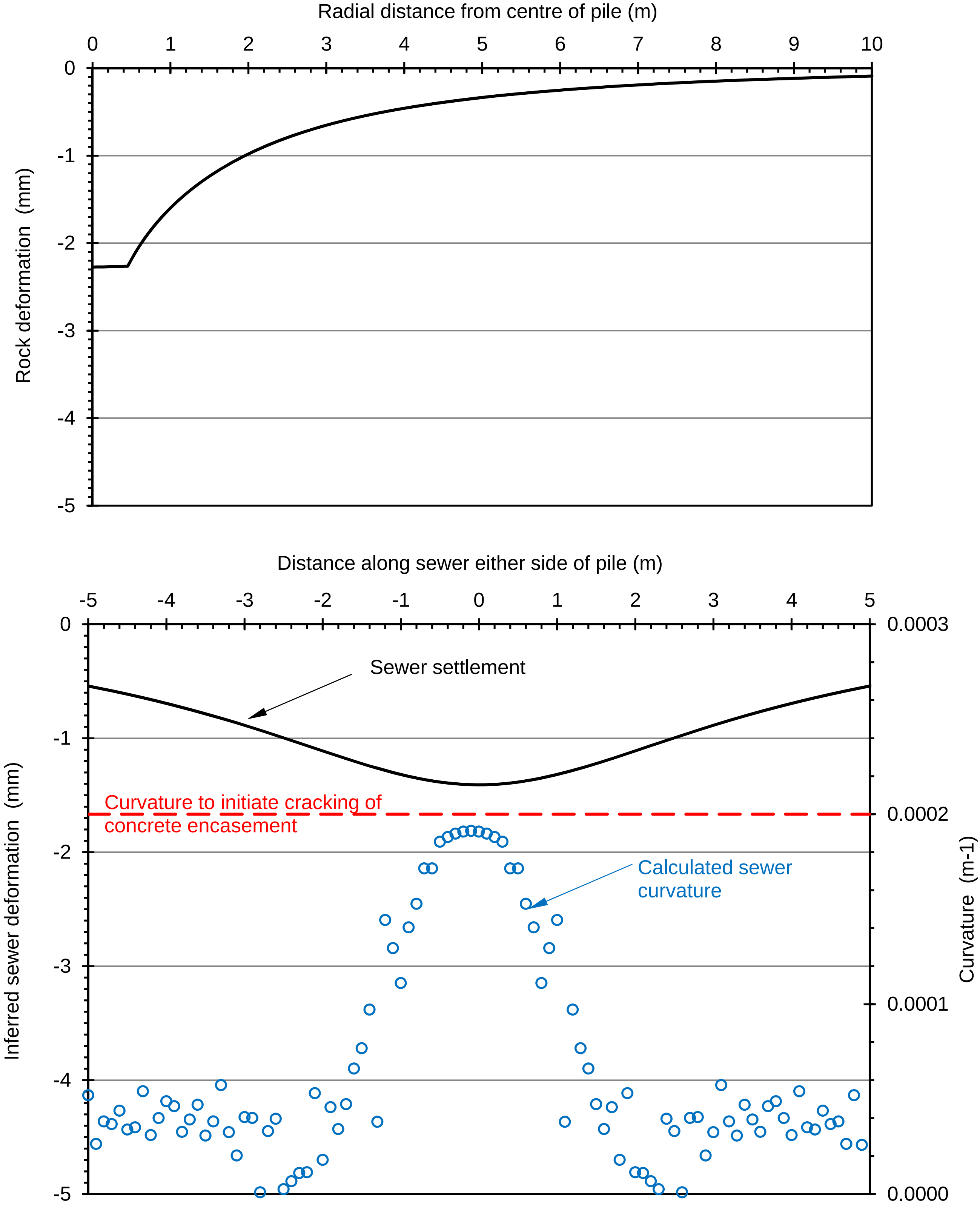
**Pells Sullivan Meynink**

**URBANEST DARLING HARBOUR No.2**

**Darling Square Building W1, Haymarket**

**CURVATURE OF SEWER DUE TO ADJACENT LOADED PILE (RUN 2 - 8500 kN)**

| | |
|---|---|
| **PSM2796-002R** | **FIGURE 7** |




Notes:

1. Sewer deformation for bridging piles (Type P2) located approx. 2.75 m from sewer centre line.
2. Pile toe at RL -5.5 m.

PSM Pells Sullivan Meynink

**URBANEST DARLING HARBOUR No.2**

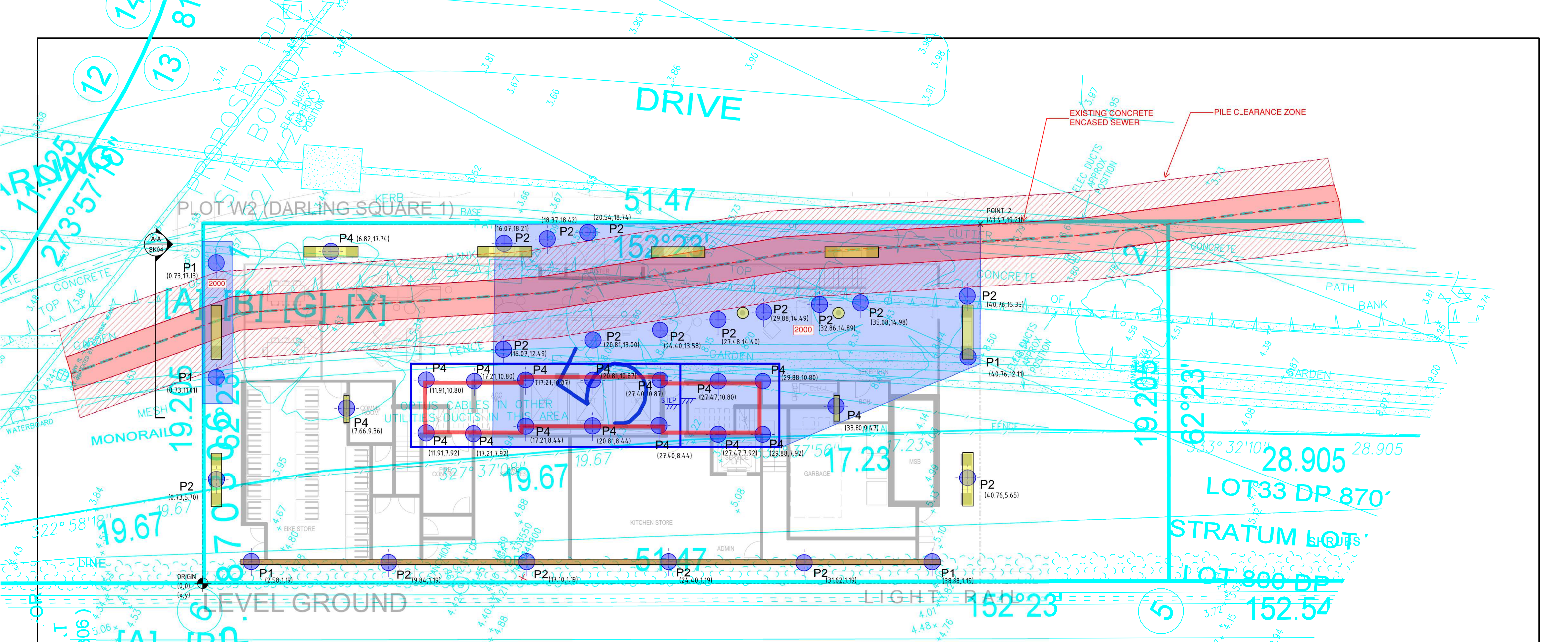
**Darling Square Building W1, Haymarket**

**CURVATURE OF SEWER DUE TO ADJACENT LOADED BRIDGING PILES (RUN 4 - 6900 kN)**

| | |
|---|---|
| **PSM2796-002R** | **FIGURE 8** |

## APPENDIX A

## BUILDING W1 PILE LAYOUT AND SECTION




PROPOSED GROUND FLOOR COLUMNS

INDICATES 900 DIAMETER REINFORCED CONCRETE PILE TO ROCK

MAXIMUM PILE LOAD TABLE

| | G (kN) | Q (kN) | SOCKET LENGTH INTO CLASS 3 SANDSTONE (m) |
|---|---|---|---|
| P1 | 3200 | 1500 | 1.0 |
| P2 | 5200 | 1700 | 1.0 |
| P3 | NOT USED | - | - |
| P4 | 6200 | 2300 | 2.5 |

## ULTIMATE GEOTECHINCAL DESIGN PARAMETERS

CLASS III SANDSTONE

$\phi gb = 0.5$

ULTIMATE SHAFT ADHESION = 1.2 MPa
ULTIMATE END BEARING = 30MPa

VERIFIER:
JOB MANAGER: IMcD
DESIGNED: NI
DRAWN: NI

**NOT FOR CONSTRUCTION**

| REV | DESCRIPTION | ISSUED | VER'D | APP'D | DATE |
|---|---|---|---|---|---|
| 1 | PRELIMINARY | NI | | IMcD | 12/08/15 |
| 2 | FOR INFORMATION | NI | | IMcD | 19/08/15 |
| 3 | FOR INFORMATION 2 | NI | | IMcD | 19/08/15 |
| 4 | SURVEY INCLUDED FOR SYDNEY WATER COORDINATION | NI | | IMcD | 20/08/15 |

CLIENT: **URBANEST**

DRAWING NOT TO BE USED FOR CONSTRUCTION UNLESS VERIFICATION SIGNATURE HAS BEEN ADDED

ARCHITECT: **AJ+C**



ALL SETOUT TO ARCHITECT'S DRAWINGS. DIMENSIONS TO BE VERIFIED WITH ARCHITECT AND BUILDER BEFORE COMMENCING SHOP DRAWINGS OR SITE WORK. NORTHROP ACCEPTS NO RESPONSIBILITY FOR THE USABILITY, COMPLETENESS OR SCALE OF DRAWINGS TRANSFERRED ELECTRONICALLY.

NORTHROP
Sydney
Level 11, 345 George St, Sydney NSW 2000
T (02) 9241 4188
P.O. Box H171 Australia Square, NSW 1215
Email sydney@northrop.com.au ABN 81 094 433 100

PROJECT: **URBANEST DARLING HARBOUR 2**

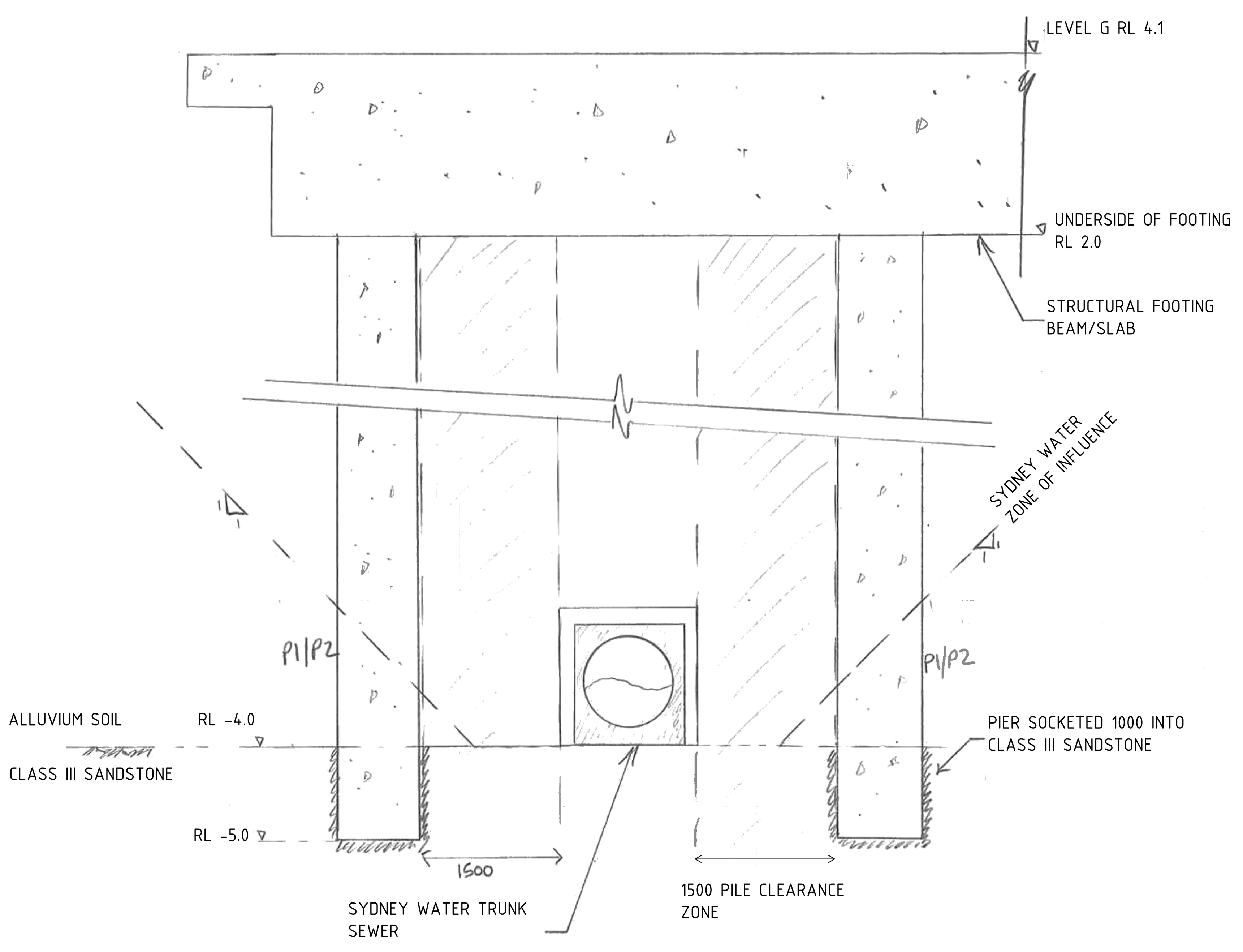
DRAWING TITLE: **PILING LAYOUT**

JOB NUMBER: 150122

DRAWING NUMBER: SK-03

REVISION: 4

DRAWING SHEET SIZE = A1




SECTION A-A
SK-03/4

DRAWN: NI
DESIGNED: NI
JOB MANAGER: IMcD
VERIFIER:

| REV | DESCRIPTION | ISSUED | VER'D | APP'D | DATE |
|---|---|---|---|---|---|
| 1 | FOR SYDNEY WATER COORDINATION | NI | | NI | 20/08/15 |

CLIENT: URBANEST

DRAWING NOT TO BE USED FOR CONSTRUCTION UNLESS VERIFICATION SIGNATURE HAS BEEN ADDED

ARCHITECT: AJ+C



ALL SETOUT TO ARCHITECT'S DRAWINGS. DIMENSIONS TO BE VERIFIED WITH ARCHITECT AND BUILDER BEFORE COMMENCING SHOP DRAWINGS OR SITE WORK. NORTHROP ACCEPTS NO RESPONSIBILITY FOR THE USABILITY, COMPLETENESS OR SCALE OF DRAWINGS TRANSFERRED ELECTRONICALLY.

NORTHROP
Sydney
Level 11, 345 George St, Sydney NSW 2000
T (02) 9241 4188
P.O. Box H171 Australia Square, NSW 1215
Email sydney@northrop.com.au ABN 81 094 433 100

PROJECT: URBANEST DARLING HARBOUR 2

DRAWING TITLE: PILING SECTION

JOB NUMBER: 150122

DRAWING NUMBER: SK-04

REVISION: 1

DRAWING SHEET SIZE = A1

## APPENDIX B

## CITY WEST CABLE TUNNEL DRAWINGS


**NOTES:**
1. FOR GENERAL NOTES REFER DRG No. 172698
2. ∗ DENOTES BUILDING MAXIMUM STRUCTURAL DEPTH, RL ASSUMED TO BASE OF PILE.

FOR TENDER

**CAD DRAWING**
DO NOT MANUALLY AMEND

| AMENDMENTS | | |
|---|---|---|
| A | PRELIMINARY | 17.11.05 |
| B | PRELIMINARY | 29.11.05 |
| C | ISSUED FOR 30% CONCEPT | 19.12.05 |
| D | ISSUED FOR EA REVIEW | 10.04.06 |
| E | ISSUED FOR TENDER | 18.07.06 |

5 0 10 20m
1 : 500 FULL SIZE A1

MAUNSELL | AECOM
Maunsell Australia Pty Ltd
A.B.N. 20 093 846 925

Enerserve
A business of EnergyAustralia
MAJOR PROJECTS
138 HARRIS ST PYRMONT, NSW 2009
TEL: 02 9269 2954 FAX: 02 9269 2960

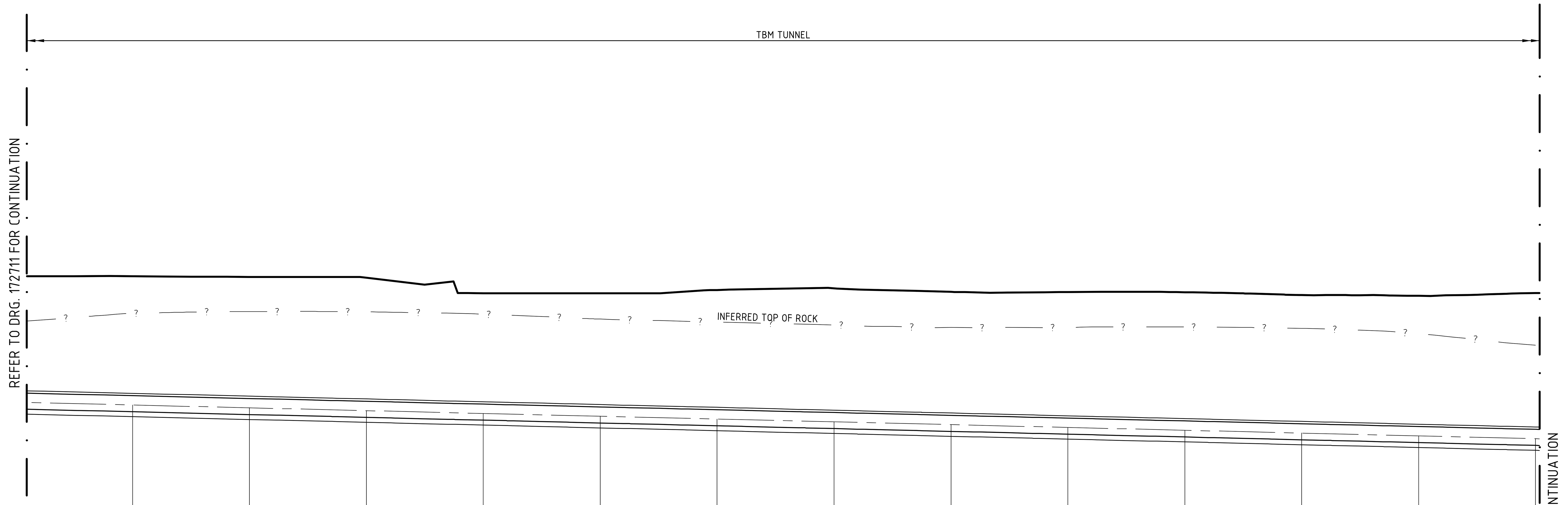
| | |
|---|---|
| SCALE | AS SHOWN |
| DESIGNED | J.A. |
| DRAWN | M.N. |
| CHECKED | W.J. |
| APPROVED | |
| DATE | NOV.05 |
| PRJTRK No. | |
| PROJECT NUMBER | 20026005.00 |

# CITY WEST CABLE TUNNEL
## GENERAL ARRANGEMENT
## HORIZONTAL ALIGNMENT

DRAWING No 172702 | SHEET 2 OF 7 | AMD E | SIZE A1

Cad ref: K:\20026005_00_CWCT\CAD\Dwg\172702.dwg
Last modified: 17 Jul 06 - 18:02

NOTES:
1. FOR GENERAL NOTES REFER DRG No. 172698
2. INFERRED TOP OF ROCK AS INDICATED ON DRG No. PSM828-416




Datum -41

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HORIZONTAL<br>VERTICAL<br>VC LENGTH | 350 R<br>-2.40% | | | | | | | | | | | | |
| TBM CONTROL LINE | -15.649 | -16.129 | -16.609 | -17.089 | -17.569 | -18.049 | -18.529 | -19.009 | -19.489 | -19.969 | -20.449 | -20.929 | -21.409 |
| CWCT TOP OF INVERT SLAB | -16.8 | -17.28 | -17.76 | -18.24 | -18.72 | -19.2 | -19.68 | -20.16 | -20.64 | -21.12 | -21.6 | -22.08 | -22.56 |
| METROWEST FLOOR | | | | | | | | | | | | | |
| CCT VENT FLOOR | | | | | | | | | | | | | |
| CCT FLOOR | | | | | | | | | | | | | |
| TOP OF ROCK | 0.04 | 0.36 | 0.31 | -0.09 | -0.94 | -1.43 | -1.93 | -2.36 | -2.37 | -2.29 | -2.51 | -3.45 | -5.43 |
| EXIST SURFACE | 6.40 | 6.28 | 6.15 | 3.50 | 3.50 | 4.05 | 4.33 | 3.73 | 3.70 | 3.66 | 3.19 | 3.04 | 3.52 |
| CHAINAGE | N 140 | N 160 | N 180 | N 200 | N 220 | N 240 | N 260 | N 280 | N 300 | N 320 | N 340 | N 360 | N 380 |

## LONG SECTION - TBM TUNNEL
## MARY ANN ST. SHAFT TO CITY NORTH SUBSTATION

SCALE 1 : 500

FOR TENDER

CAD DRAWING
DO NOT MANUALLY AMEND

| AMENDMENTS | | |
|---|---|---|
| A | PRELIMINARY | 17.11.05 |
| B | PRELIMINARY | 29.11.05 |
| C | ISSUED FOR 30% CONCEPT | 19.12.05 |
| D | ISSUED FOR EA REVIEW | 10.04.06 |
| E | ISSUED FOR TENDER | 18.07.06 |

5 0 10 20m
1 : 500 FULL SIZE A1

MAUNSELL | AECOM

Maunsell Australia Pty Ltd
A.B.N. 20 093 846 925

Enerserve
A business of EnergyAustralia

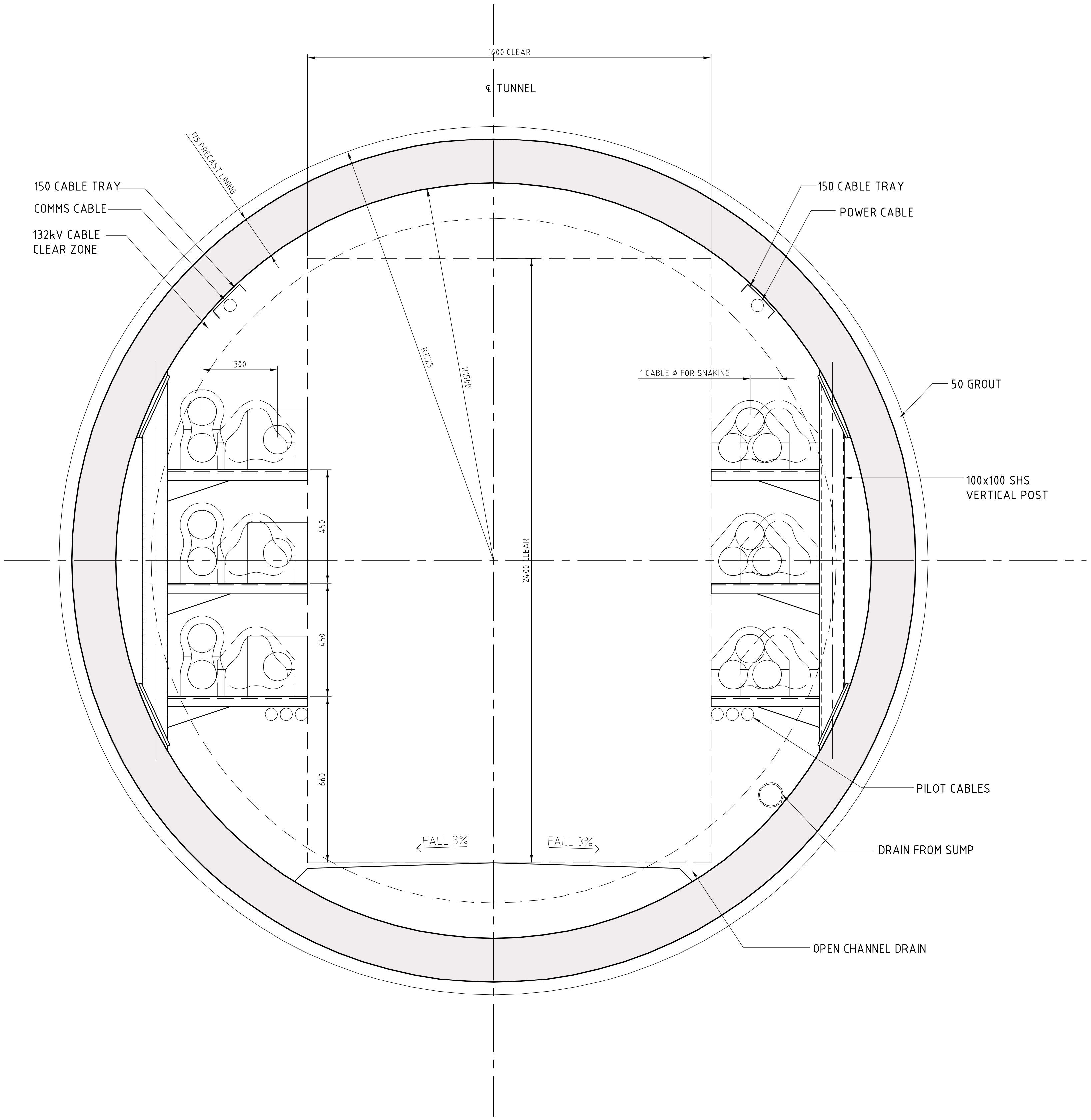
MAJOR PROJECTS
138 HARRIS ST PYRMONT, NSW 2009
TEL: 02 9269 2954 FAX: 02 9269 2960

| | |
|---|---|
| SCALE | AS SHOWN |
| DESIGNED | J.A. |
| DRAWN | M.N. |
| CHECKED | W.J. |
| APPROVED | |
| DATE | NOV.05 |
| PRJTRK No. | |
| PROJECT NUMBER | 20026005.00 |

CITY WEST CABLE TUNNEL
GENERAL ARRANGEMENT
VERTICAL ALIGNMENT

DRAWING No 172712 | SHEET 2 OF 7 | AMD E | SIZE A1

Cad ref: K:\20026005_00_CWCT\CAD\Dwg\172921.dwg Last modified: 11 Nov 05 - 15:55




3.45m O.D. TUNNEL BORE

SCALE 1 : 10

PRELIMINARY

CAD DRAWING
DO NOT MANUALLY AMEND

AMENDMENTS

A PRELIMINARY

0.1 0 0.1 0.2 0.3 0.4 0.5m
1 : 10 FULL SIZE A1

MAUNSELL | AECOM

Maunsell Australia Pty Ltd
A.B.N. 20 093 846 925

Enerserve
A business of EnergyAustralia

MAJOR PROJECTS
138 HARRIS ST PYRMONT, NSW 2009
TEL: 02 9269 2954 FAX: 02 9269 2960

| | |
|---|---|
| SCALE | AS SHOWN |
| DESIGNED | M.S. |
| DRAWN | A.P.T. |
| CHECKED | |
| APPROVED | |
| DATE | |
| PRJTRK No. | |
| PROJECT NUMBER | 20026005.00 |

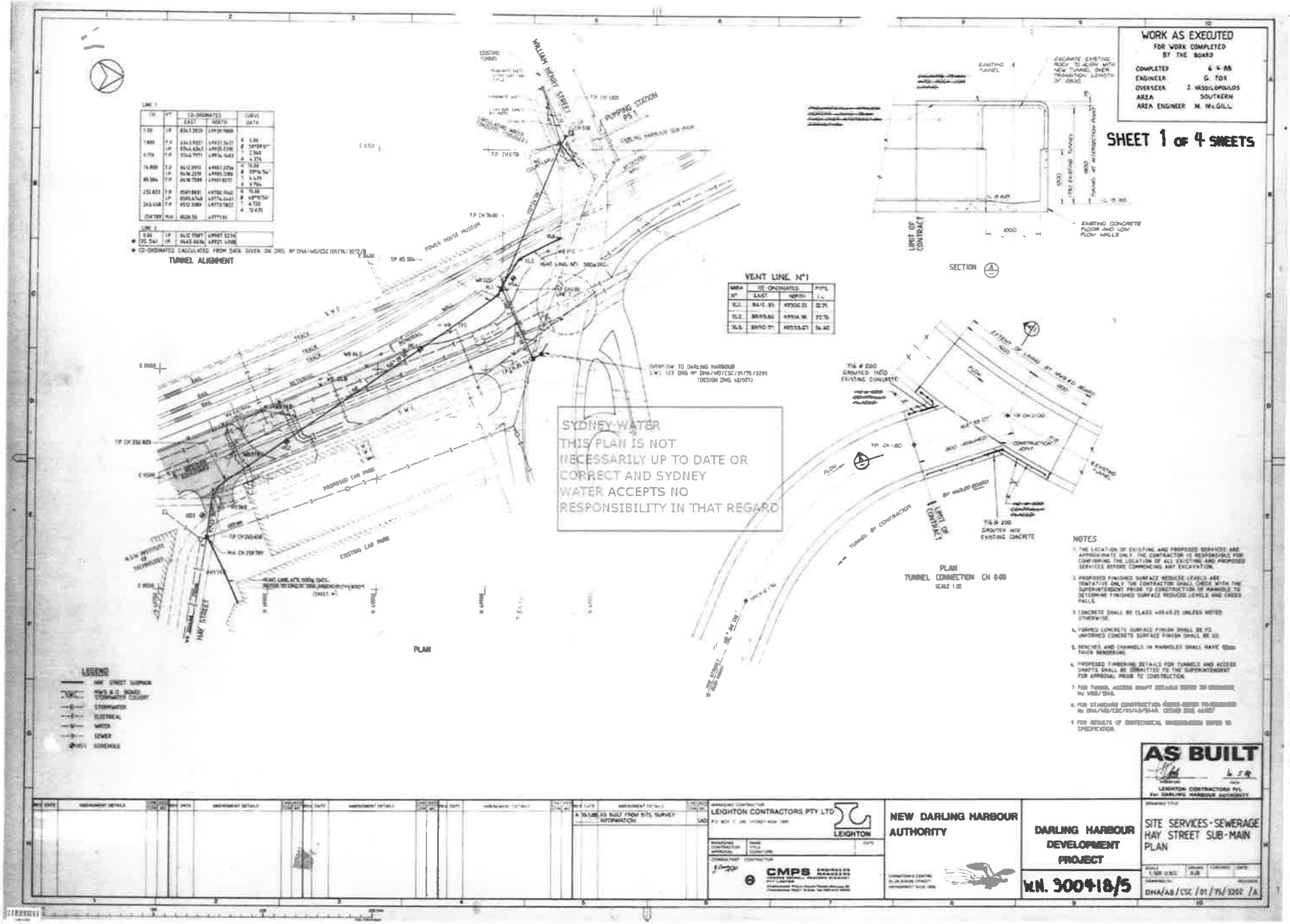
CITY WEST CABLE TUNNEL
MARY ANN STREET SHAFT
TBM TUNNEL
CROSS SECTION

DRAWING No 172921 | SHEET 1 OF 5 | AMD A | SIZE A1

©

## APPENDIX C

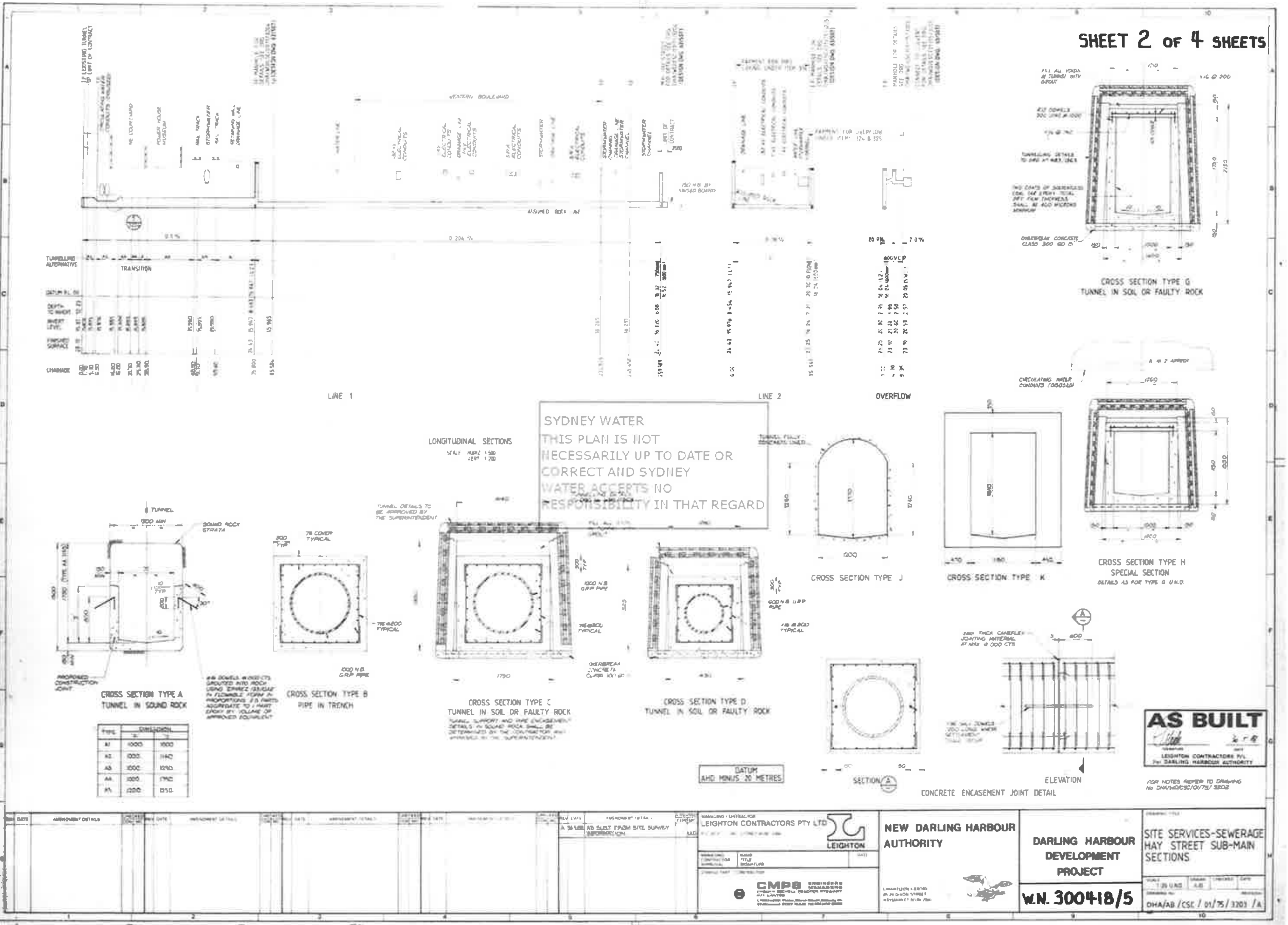
## TRUNK SEWER TUNNEL DRAWINGS




HAY ST. SUBMAIN

SHEET 1 of 4

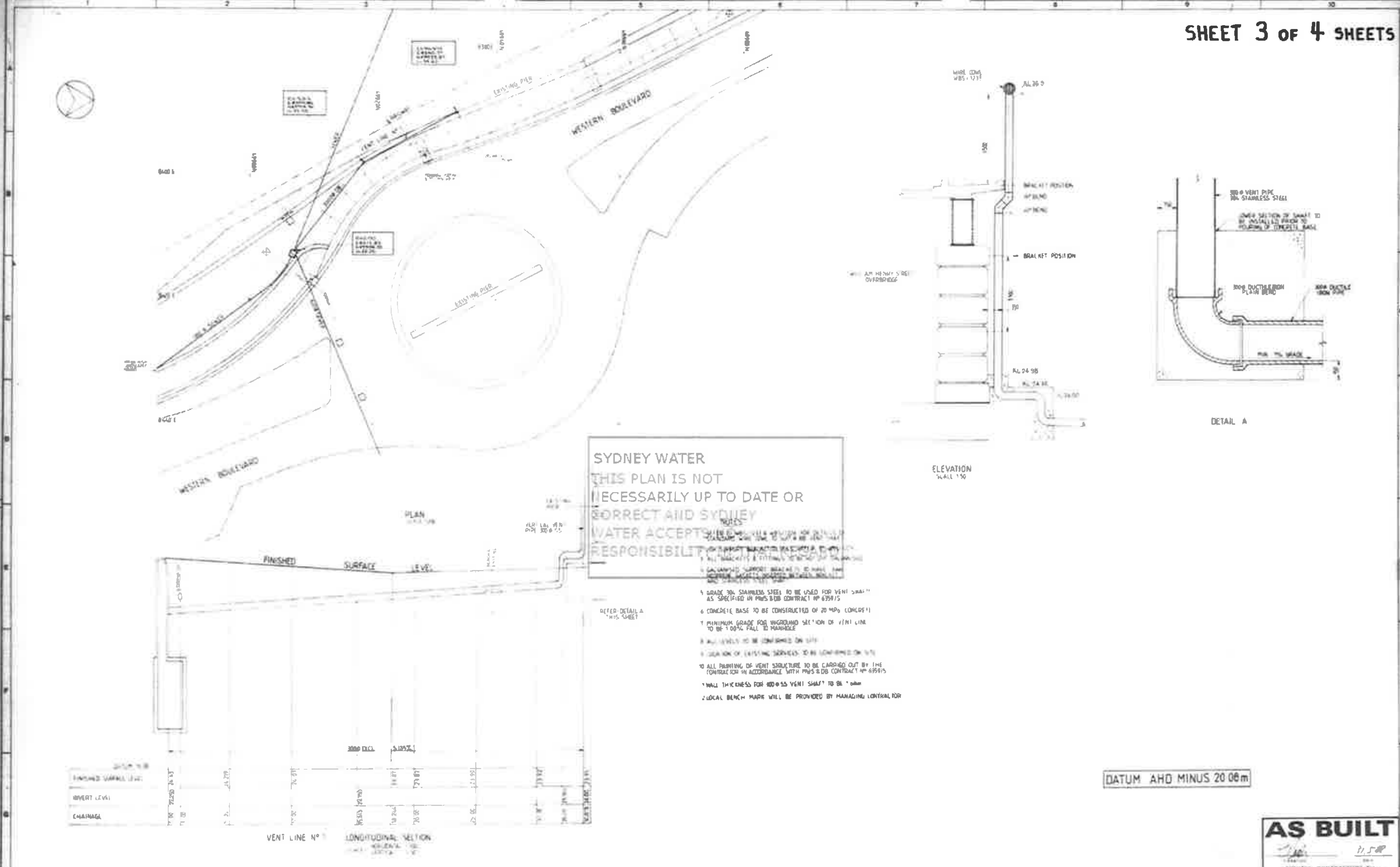
W.N. 300418/5




| TYPE | DIMENSION | |
|---|---|---|
| A1 | 1000 | 1000 |
| A2 | 1000 | 1140 |
| A3 | 1000 | 1290 |
| A4 | 1000 | 1790 |
| A5 | 1200 | 1350 |

SHEET 2 of 4

W.N. 300418/5




NOTES

5. GRADE 304 STAINLESS STEEL TO BE USED FOR VENT SHAFT AS SPECIFIED IN PWS & DB CONTRACT No 6359/5
6. CONCRETE BASE TO BE CONSTRUCTED OF 20 MPa CONCRETE
7. MINIMUM GRADE FOR UNGROUND SECTION OF VENT LINE TO BE 1.00% FALL TO MANHOLE
8. ALL LEVELS TO BE CONFIRMED ON SITE
9. LOCATION OF EXISTING SERVICES TO BE CONFIRMED ON SITE
10. ALL PAINTING OF VENT STRUCTURE TO BE CARRIED OUT BY THE CONTRACTOR IN ACCORDANCE WITH PWS & DB CONTRACT No 6359/5

WALL THICKNESS FOR 300 ø SS VENT SHAFT TO BE [illegible]

LOCAL BENCH MARK WILL BE PROVIDED BY MANAGING CONTRACTOR

**AS BUILT**

LEIGHTON CONTRACTORS P/L FOR DARLING HARBOUR AUTHORITY

LEIGHTON CONTRACTORS PTY LTD

CMPS ENGINEERS MANAGERS

NEW DARLING HARBOUR AUTHORITY

DARLING HARBOUR DEVELOPMENT PROJECT

W.N. 300418/5

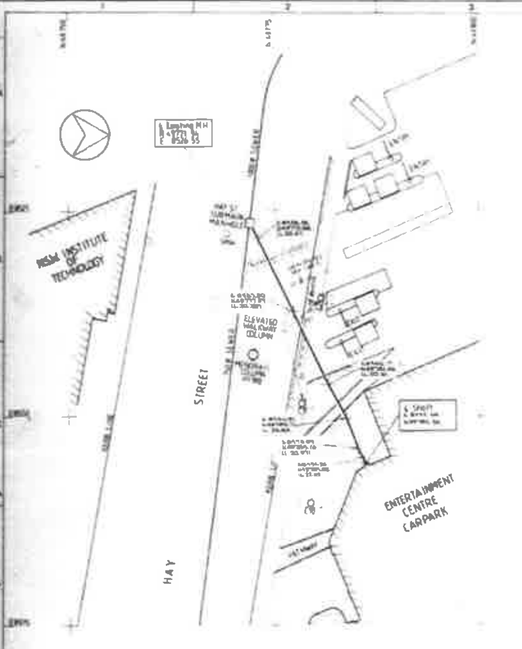
SITE SERVICES - SEWERAGE
HAY STREET SUB-MAIN

VENT LINE No 1
VENT PIPE DETAILS

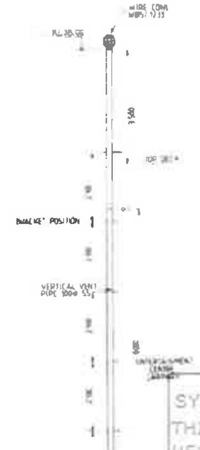
DHA/AB/CSC/01/75/3[illegible]/A

SHEET 3 OF 4

DATUM AHD MINUS 20.00 m

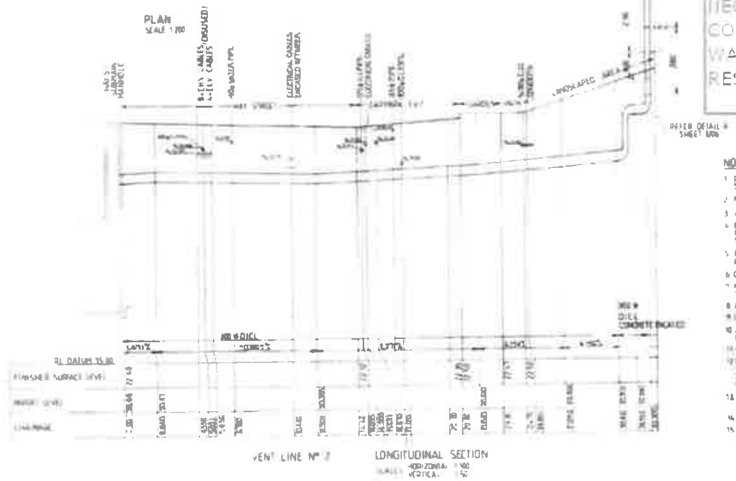



PLAN
SCALE 1:200










VENT LINE Nº 2 LONGITUDINAL SECTION

## NOTES

1. REFER TO WBS/1733 & WBS/1734 FOR DETAILS OF STANDARD WIRE COWL TO SUIT 300 ø VENT SHAFT
2. FOR SUPPORT BRACKET DETAILS REFER TO WBS/1279
3. ALL BRACKETS & FITTINGS TO BE HOT DIP GALVANISED
4. GALVANISED SUPPORT BRACKETS TO HAVE 3mm NEOPRENE GASKETS INSERTED BETWEEN BRACKET AND STAINLESS STEEL SHAFT
5. GRADE 316 STAINLESS STEEL TO BE USED FOR VENT SHAFTS AS SPECIFIED IN MWS & DB CONTRACT Nº 6359/5
6. CONCRETE BASE TO BE CONSTRUCTED OF 20 MPa CONCRETE
7. MINIMUM GRADE FOR INGROUND SECTION OF VENT LINE TO BE 1.00% FALL TOWARDS MANHOLE
8. ALL LEVELS TO BE CONFIRMED ON SITE
9. LOCATION OF EXISTING SERVICES TO BE CONFIRMED ON SITE
10. ALL PAINTING OF VENT STRUCTURE TO BE CARRIED OUT BY THE CONTRACTOR IN ACCORDANCE WITH MWS & DB CONTRACT Nº 6359/5
11. WALL THICKNESS FOR 300 ø SS VENT SHAFT TO BE 1.6mm
12. GARDEN & PATH AREAS ADJACENT TO CARPARK BUILDING TO BE RESTORED TO EXISTING CONDITION. TREES & PLANTS TO BE REMOVED PRIOR TO EXCAVATION, MAINTAINED AND REPLACED AFTER WORKS ARE COMPLETE
13. ACCESS IN & OUT OF CARPARK TO BE MAINTAINED AT ALL TIMES DURING CONSTRUCTION OF VENT LINE
14. FOR DETAILS OF CONCRETE ENCASEMENT REFER TO WBS/1091
15. LOCAL BENCH MARK WILL BE PROVIDED BY MANAGING CONTRACTOR

| REV | DATE | AMENDMENT DETAILS |
|---|---|---|
| A | | AS BUILT FROM SITE SURVEY INFORMATION |

**AS BUILT**
LEIGHTON CONTRACTORS P/L
for DARLING HARBOUR AUTHORITY

MANAGING CONTRACTOR: LEIGHTON CONTRACTORS PTY LTD

CONSULTANT / CONTRACTOR: CMPS ENGINEERING MANAGERS

NEW DARLING HARBOUR AUTHORITY

DARLING HARBOUR DEVELOPMENT PROJECT

DRAWING TITLE: SITE SERVICES-SEWERAGE HAY STREET SUB-MAIN
VENT LINE Nº 2
VENT PIPE DETAILS

SCALE: AS SHOWN

DRAWING No: DHA/AB/CSC/01/75/3207/A

W.N. 300418/5



W.N. 300418/5

## APPENDIX D

## LETTER OF NO OBJECTION – AUSGRID, 10 FEBRUARY 2014

Ausgrid

570 George Street
Sydney NSW 2000
All mail to GPO Box 4009
Sydney NSW 2001
T +61 2 131 525
F +61 2 9269 2830
www.ausgrid.com.au

10 February 2014

Mr Mark Brown
NSW Department of Planning & Infrastructure
GPO Box 39
SYDNEY NSW 2001

**By email: mark.brown@planning.nsw.gov.au**

Dear Mr Brown,

**Re: SSD 6010 – SICEEP – The Haymarket, Residential Building (Student Accommodation)**

We refer to your email dated 29 January 2014, requesting Ausgrid to make a comment on Lend Lease's response. We provide the following advice, using Lend Lease's nomenclature:

iii) In relation to the proposed development Ausgrid has evaluated the information contained in Letter titled "Re: *Student Accommodation Tower, Darling Harbour, Assessment of Impacts on Adjacent Infrastructure"* from Strath Clarke of Pells Sullivan Meynink, dated 14 May 2013, reference PSM1986-019L (**Letter**).

Ausgrid understands that piles for the proposed development would extend to approximately RL -7 m, this would provide approximately 10 m of rock cover between the pile toe level and the crown of the City West Cable Tunnel (**Tunnel**). The vertical convergence of the Tunnel would be less than 2 mm.

Based on the above information, Ausgrid has no objection to the proposal. However, the Proponent shall provide a revised geotechnical report for any changes to the development, which were not contemplated in the Letter.

iv) At this point in time, an Agreement is not necessary.

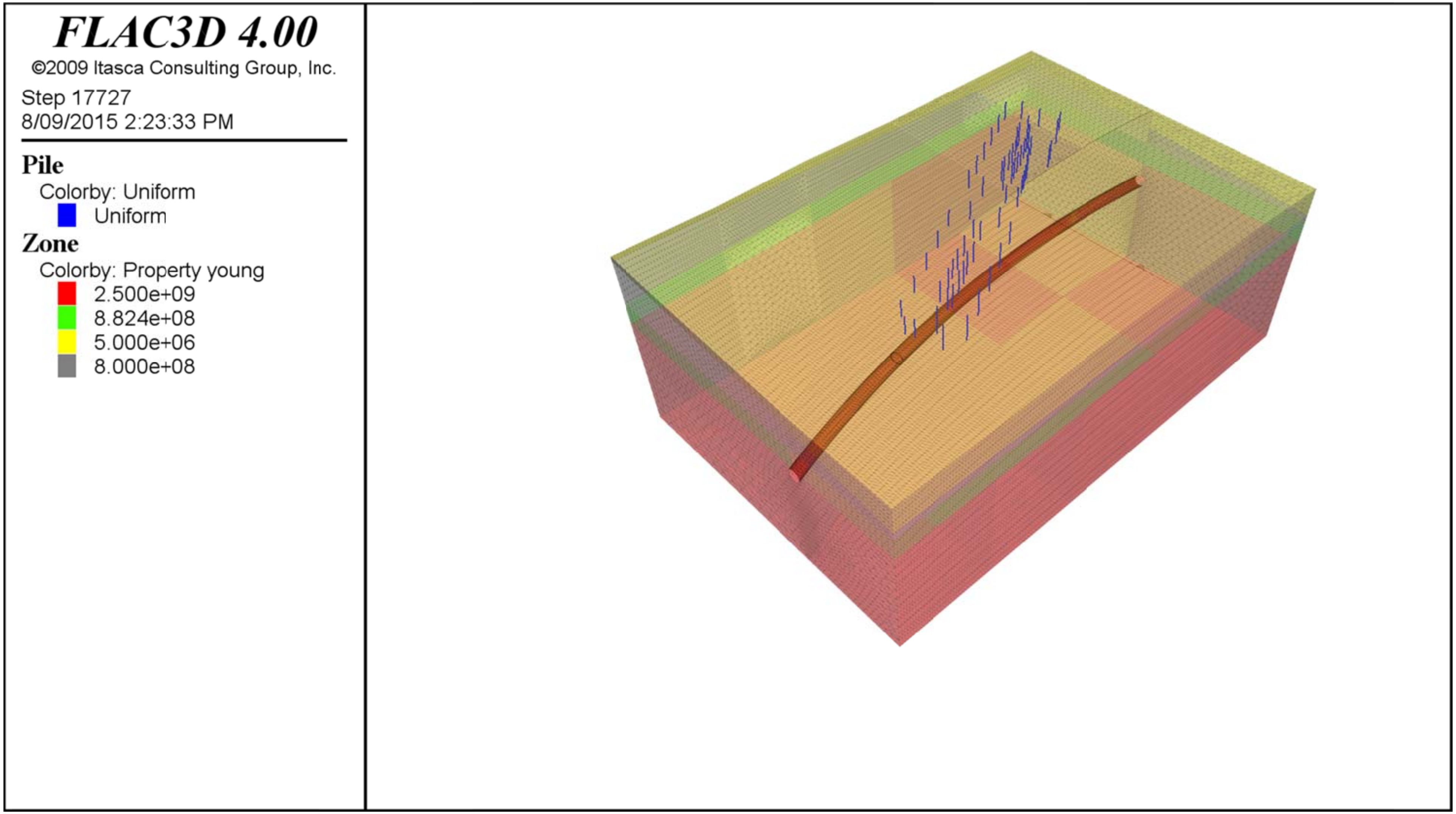
Should you wish to discuss these matters further, please contact Matthew Faferko on 9269 4620 or via email mfaferko@ausgrid.com.au.

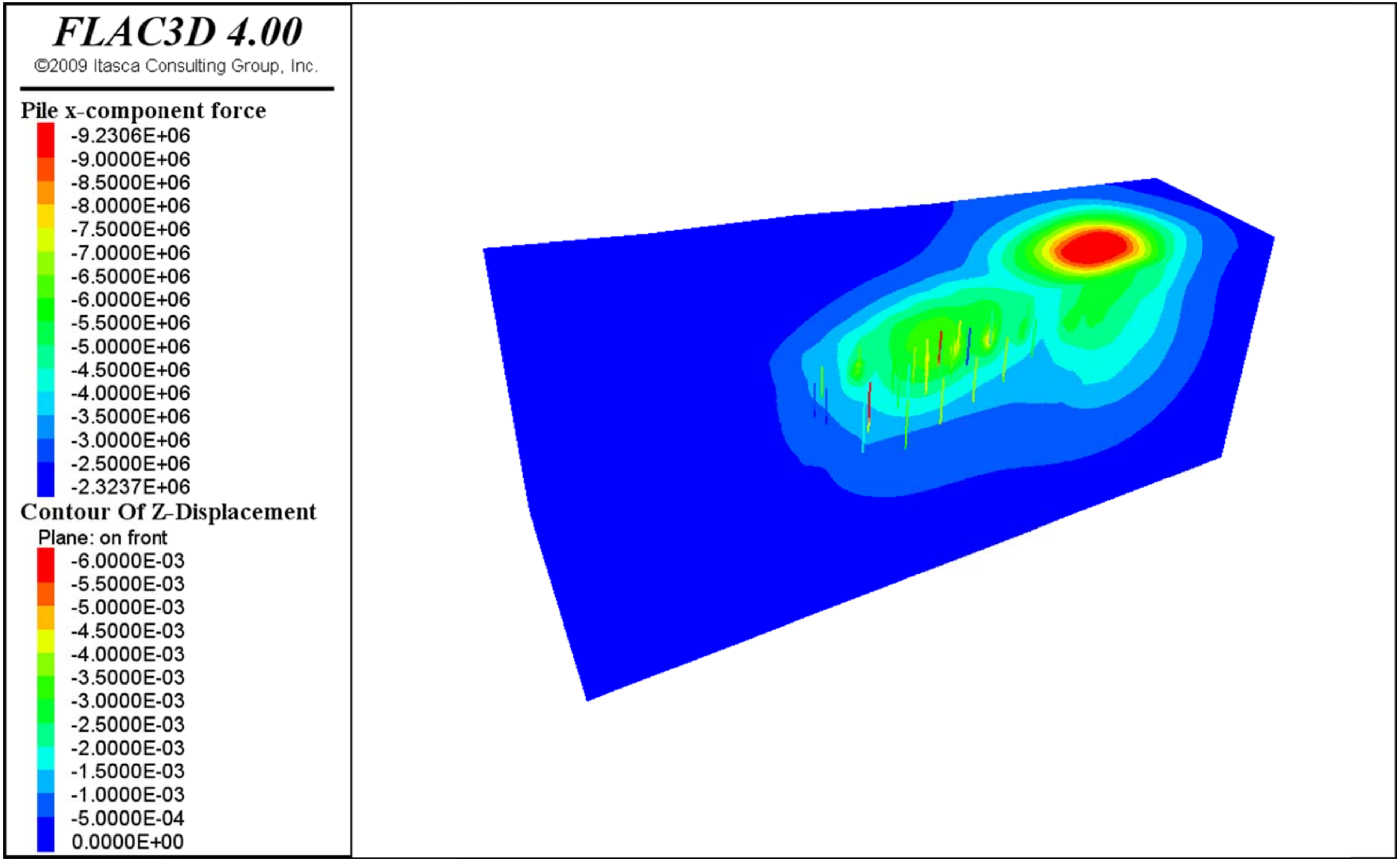
Yours sincerely,

**Wilma Penrose**
Director Area Development - Sydney CBD & East

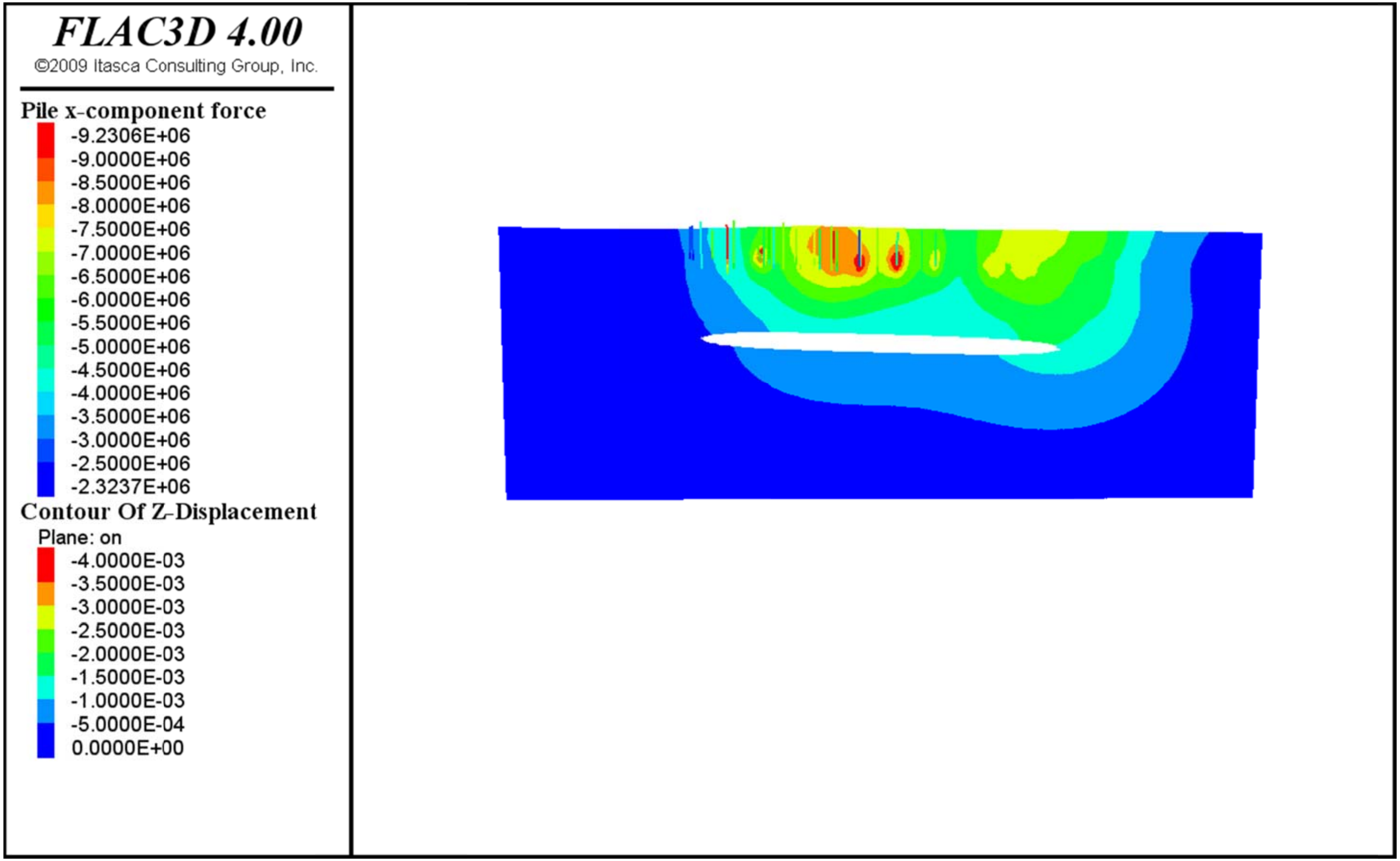
## APPENDIX E

## FLAC3D ANALYSIS – GRAPHICAL OUTPUT


FLAC3D 4.00
©2009 Itasca Consulting Group, Inc.
Step 17727
8/09/2015 2:23:33 PM
Pile
Colorby: Uniform
Uniform
Zone
Colorby: Property young
2.500e+09
8.824e+08
5.000e+06
8.000e+08

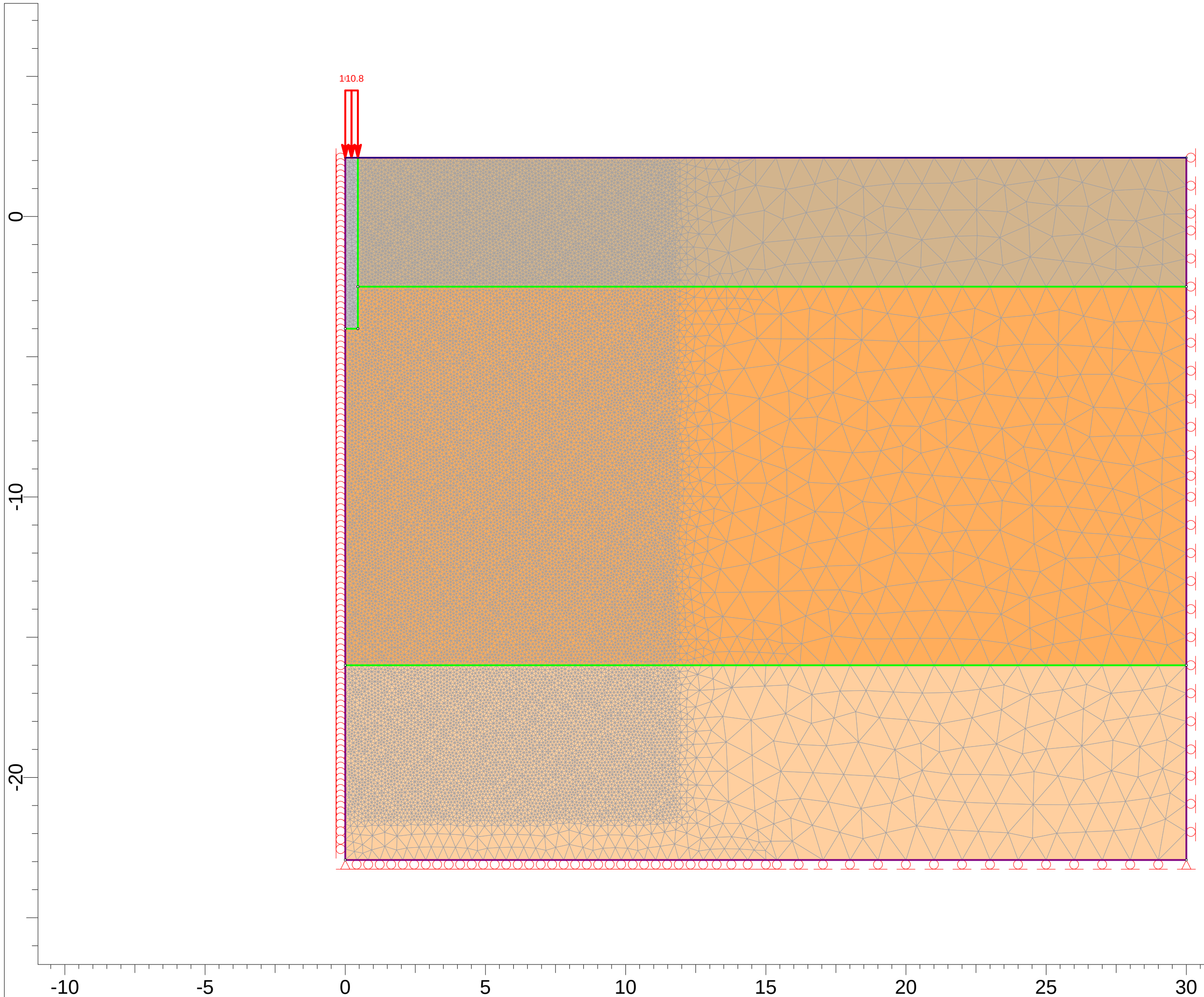


FLAC3D 4.00
©2009 Itasca Consulting Group, Inc.
Pile x-component force
-9.2306E+06
-9.0000E+06
-8.5000E+06
-8.0000E+06
-7.5000E+06
-7.0000E+06
-6.5000E+06
-6.0000E+06
-5.5000E+06
-5.0000E+06
-4.5000E+06
-4.0000E+06
-3.5000E+06
-3.0000E+06
-2.5000E+06
-2.3237E+06
Contour Of Z-Displacement
Plane: on front
-6.0000E-03
-5.5000E-03
-5.0000E-03
-4.5000E-03
-4.0000E-03
-3.5000E-03
-3.0000E-03
-2.5000E-03
-2.0000E-03
-1.5000E-03
-1.0000E-03
-5.0000E-04
0.0000E+00


FLAC3D 4.00
©2009 Itasca Consulting Group, Inc.
Pile x-component force
-9.2306E+06
-9.0000E+06
-8.5000E+06
-8.0000E+06
-7.5000E+06
-7.0000E+06
-6.5000E+06
-6.0000E+06
-5.5000E+06
-5.0000E+06
-4.5000E+06
-4.0000E+06
-3.5000E+06
-3.0000E+06
-2.5000E+06
-2.3237E+06
Contour Of Z-Displacement
Plane: on
-4.0000E-03
-3.5000E-03
-3.0000E-03
-2.5000E-03
-2.0000E-03
-1.5000E-03
-1.0000E-03
-5.0000E-04
0.0000E+00

## APPENDIX F

## PHASE$^2$ ANALYSIS – GRAPHICAL OUTPUT




| Material Name | Color | Unit Weight (MN/m3) | Young's Modulus (MPa) | Poisson's Ratio | Material Type |
|---|---|---|---|---|---|
| Fill / Alluvium | | 0.024 | 10 | 0.3 | Elastic |
| Class III Sandstone | | 0.024 | 800 | 0.2 | Elastic |
| Class II Sandstone | | 0.024 | 1500 | 0.2 | Elastic |
| Class I Sandstone | | 0.024 | 2500 | 0.2 | Elastic |
| Pile | | 0.024 | 32800 | 0.2 | Elastic |

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Engineering Consultants
Rock-Soil-Water

PHASE2 9.003

| | |
|---|---|
| Client: | **Urbanest Darling Harbour No.2** |
| Project: | **PSM2796 Urbanest Darling Square Building W1** |
| Location: | **Haymarket** |
| Analysis description: | **Pile footing adjacent to trunk sewer, axisymmetric analysis, diameter 0.9 m, toe level RL -4.0 m, load 6900 kN** |

| Job No: | By: | Date: | Stage: | Scale: | Run: |
|---|---|---|---|---|---|
| | **MP** | **8/09/2015** | **2 of 2, Apply load** | **1:250** | **Sewer - Run1.fez** |

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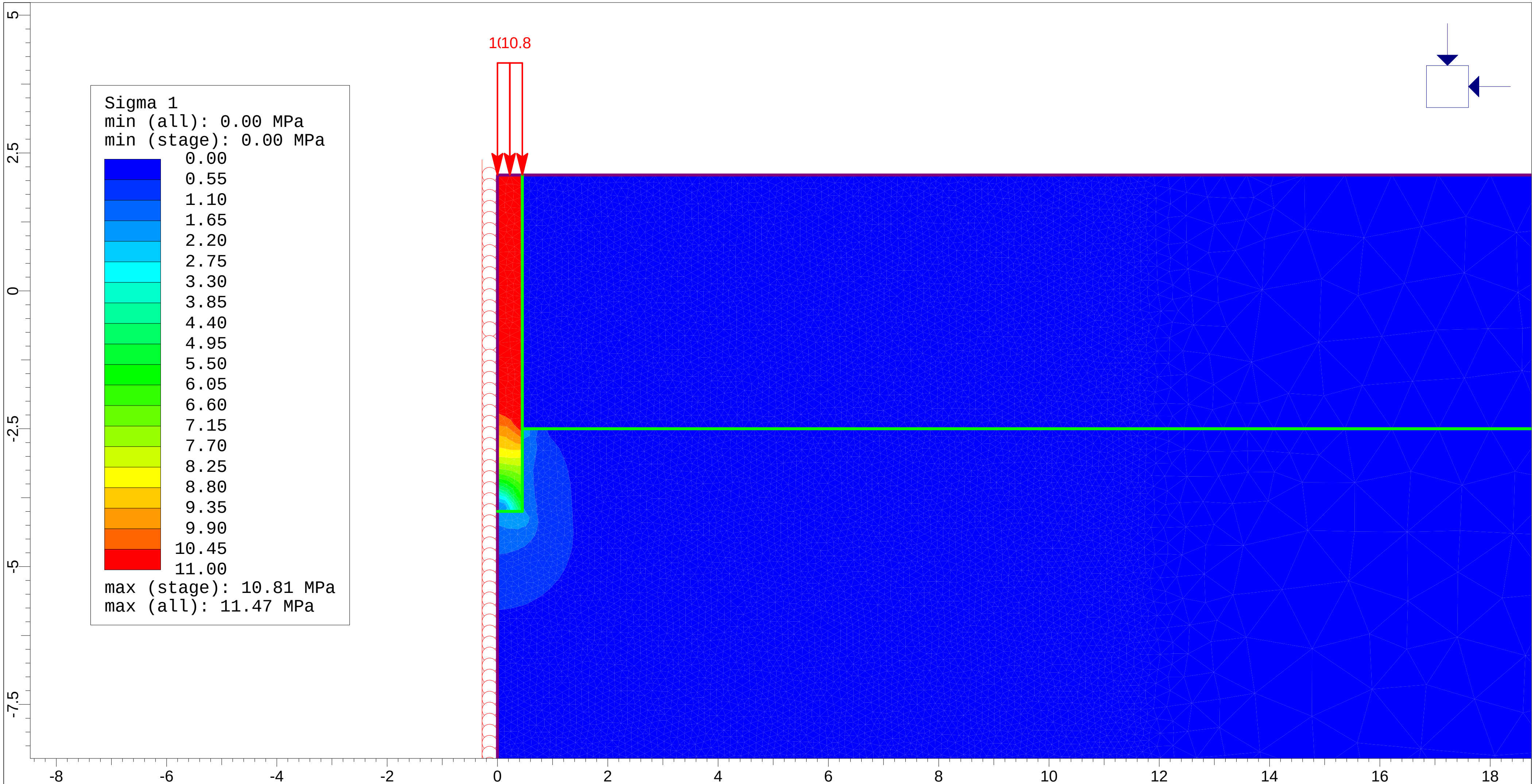


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| | |
|---|---|
| Client: | **Urbanest Darling Harbour No.2** |
| Project: | **PSM2796 Urbanest Darling Square Building W1** |
| Location: | **Haymarket** |
| Analysis description: | **Pile footing adjacent to trunk sewer, axisymmetric analysis, diameter 0.9 m, toe level RL -4.0 m, load 6900 kN** |

| Job No: | By: | Date: | Stage: | Scale: | Run: |
|---|---|---|---|---|---|
| | **MP** | **8/09/2015** | **2 of 2, 2. Apply load** | **1:100** | **Sewer - Run1.fez** |

INTERPRET 9.003

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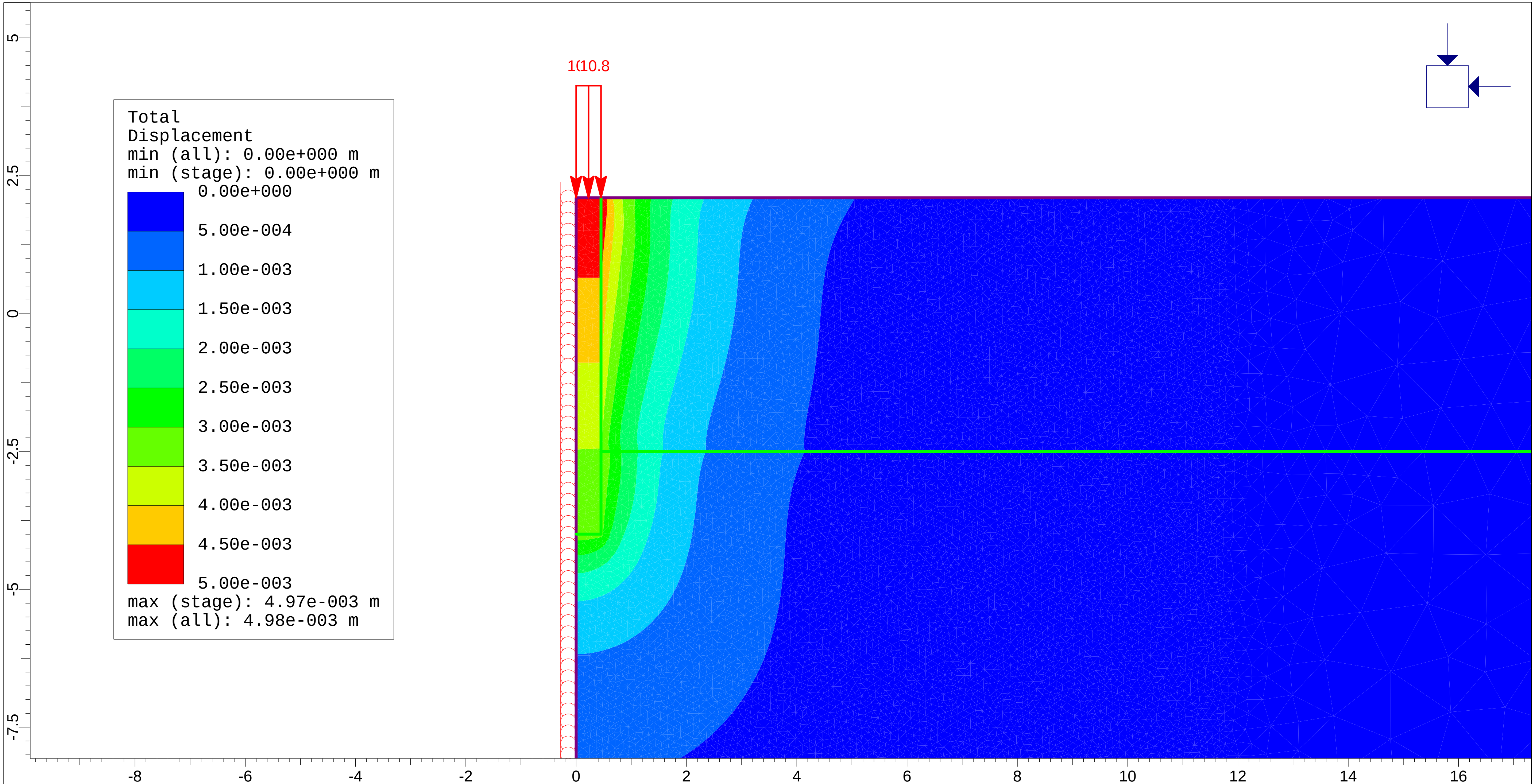


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INTERPRET 9.003

Client: **Urbanest Darling Harbour No.2**

Project: **PSM2796 Urbanest Darling Square Building W1**

Location: **Haymarket**

Analysis description: **Pile footing adjacent to trunk sewer, axisymmetric analysis, diameter 0.9 m, toe level RL -4.0 m, load 6900 kN**

| Job No: | By: | Date: | Stage: | Scale: | Run: |
|---|---|---|---|---|---|
| | MP | 8/09/2015 | 2 of 2, 2. Apply load | 1:100 | Sewer - Run1.fez |

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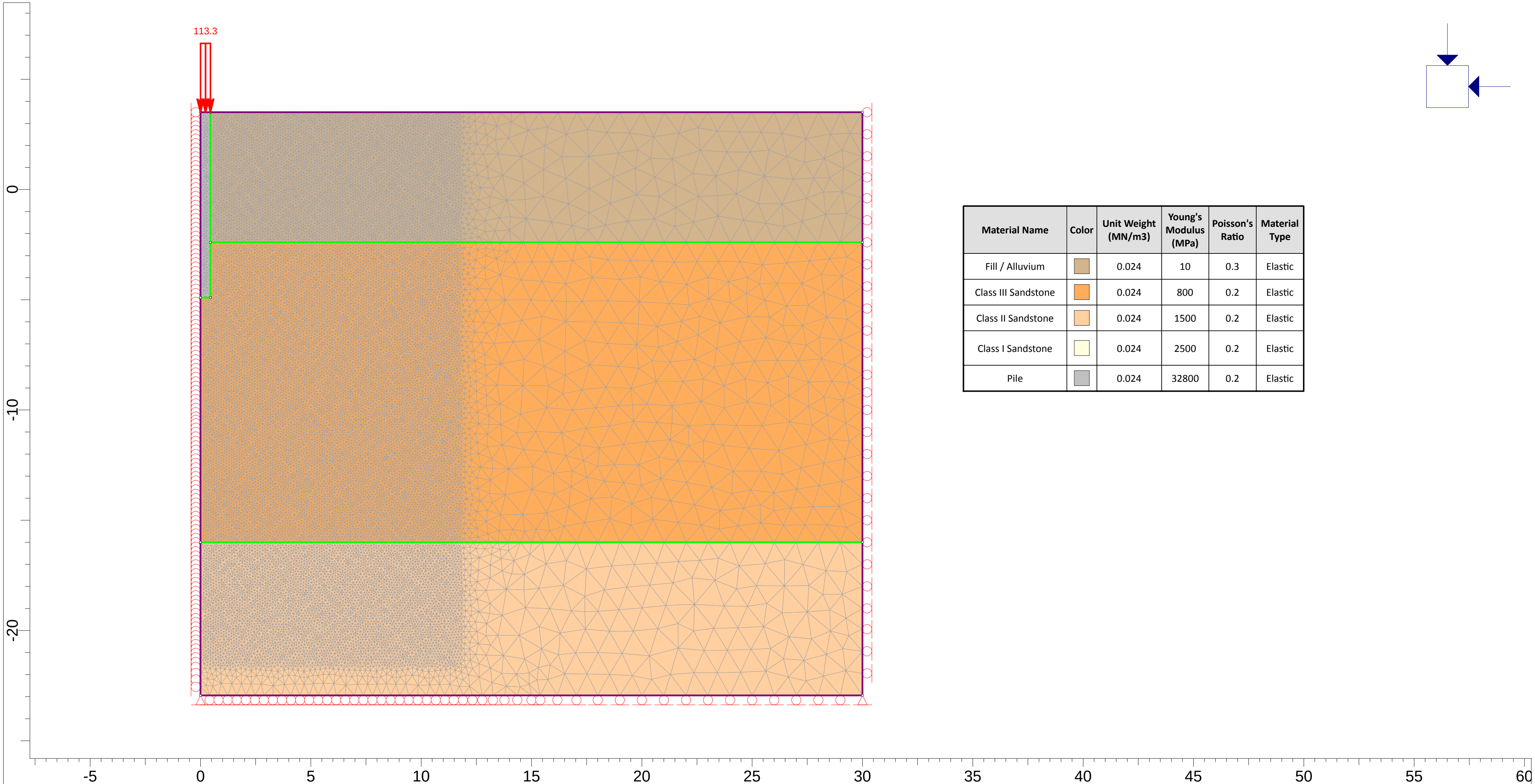


| Material Name | Color | Unit Weight (MN/m3) | Young's Modulus (MPa) | Poisson's Ratio | Material Type |
|---|---|---|---|---|---|
| Fill / Alluvium | | 0.024 | 10 | 0.3 | Elastic |
| Class III Sandstone | | 0.024 | 800 | 0.2 | Elastic |
| Class II Sandstone | | 0.024 | 1500 | 0.2 | Elastic |
| Class I Sandstone | | 0.024 | 2500 | 0.2 | Elastic |
| Pile | | 0.024 | 32800 | 0.2 | Elastic |

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| | |
|---|---|
| Client: | **Urbanest Darling Harbour No.2** |
| Project: | **PSM2796 Urbanest Darling Square Building W1** |
| Location: | **Haymarket** |
| Analysis description: | **Pile footing adjacent to trunk sewer, axisymmetric analysis, diameter 0.9 m, toe level RL -4.9 m, load 8500 kN** |

| Job No: | By: MP | Date: 8/09/2015 | Stage: 2 of 2, Apply load | Scale: 1:250 | Run: Sewer - Run2.fez |
|---|---|---|---|---|---|

PHASE2 9.003
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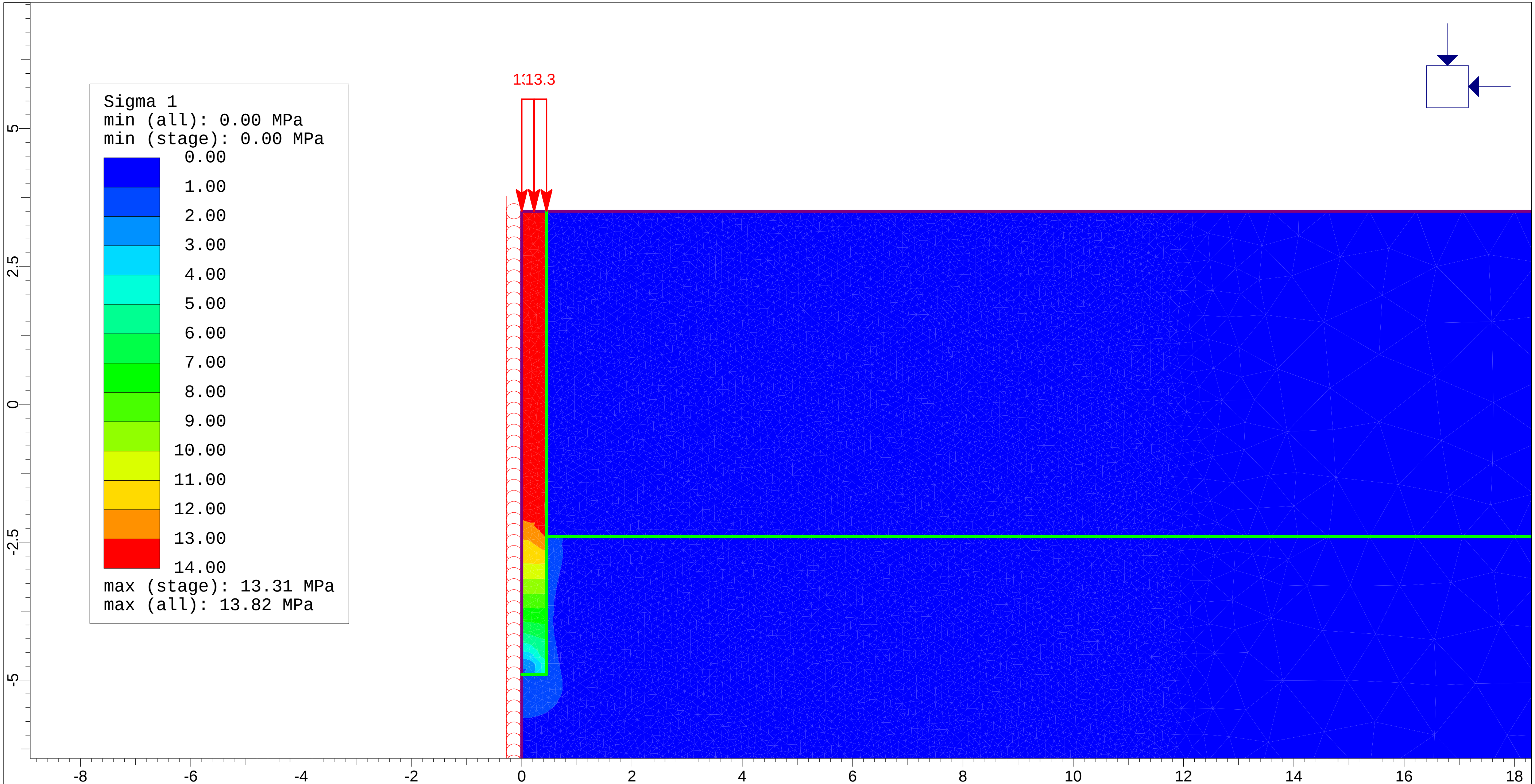


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| | |
|---|---|
| Client: | **Urbanest Darling Harbour No.2** |
| Project: | **PSM2796 Urbanest Darling Square Building W1** |
| Location: | **Haymarket** |
| Analysis description: | **Pile footing adjacent to trunk sewer, axisymmetric analysis, diameter 0.9 m, toe level RL -4.9 m, load 8500 kN** |

| Job No: | By: | Date: | Stage: | Scale: | Run: |
|---|---|---|---|---|---|
| | **MP** | **8/09/2015** | **2 of 2, 2. Apply load** | **1:100** | **Sewer - Run2.fez** |

INTERPRET 9.003

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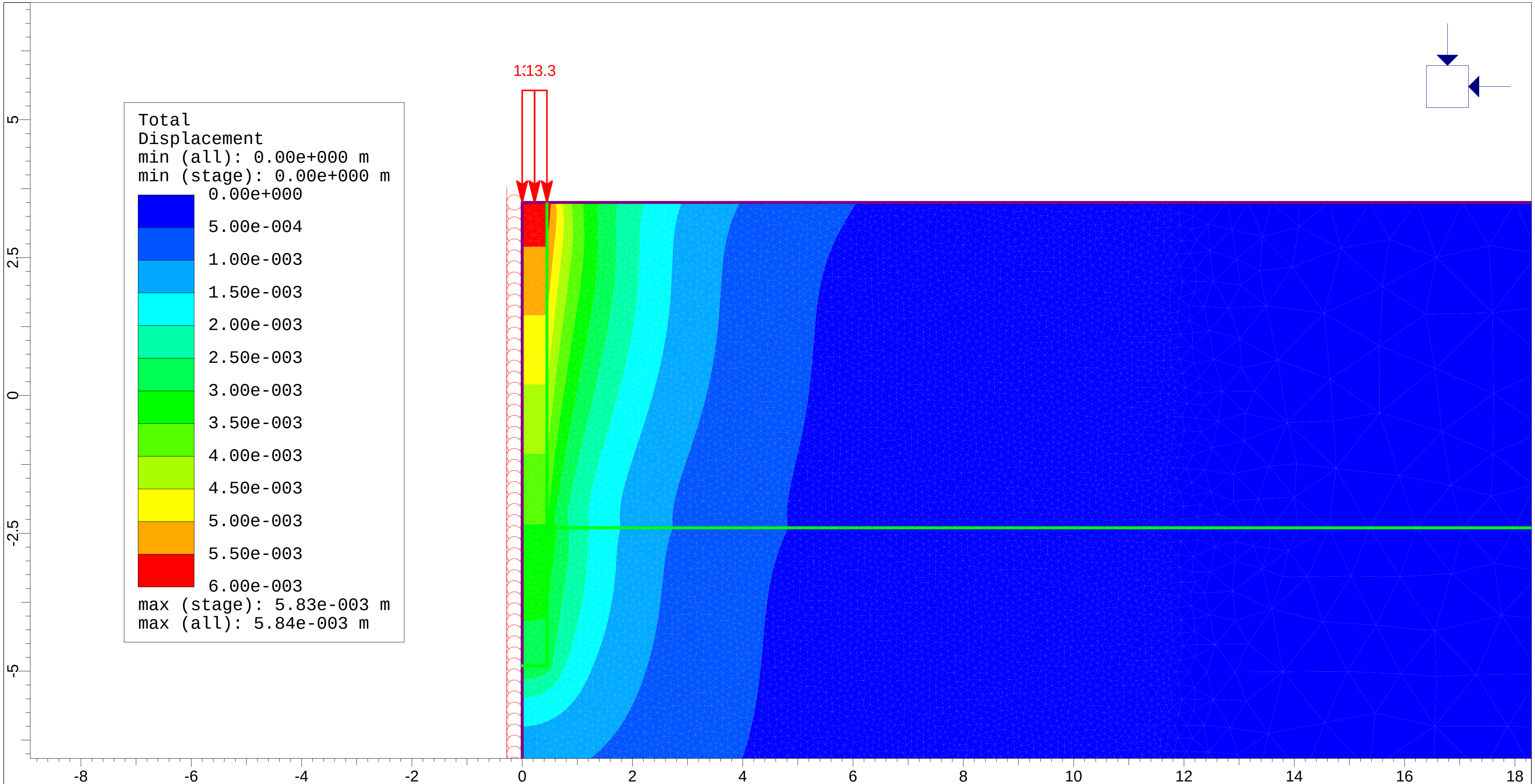


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| | |
|---|---|
| Client: | **Urbanest Darling Harbour No.2** |
| Project: | **PSM2796 Urbanest Darling Square Building W1** |
| Location: | **Haymarket** |
| Analysis description: | **Pile footing adjacent to trunk sewer, axisymmetric analysis, diameter 0.9 m, toe level RL -4.9 m, load 8500 kN** |

| Job No: | By: | Date: | Stage: | Scale: | Run: |
|---|---|---|---|---|---|
| | **MP** | **8/09/2015** | **2 of 2, 2. Apply load** | **1:100** | **Sewer - Run2.fez** |

INTERPRET 9.003

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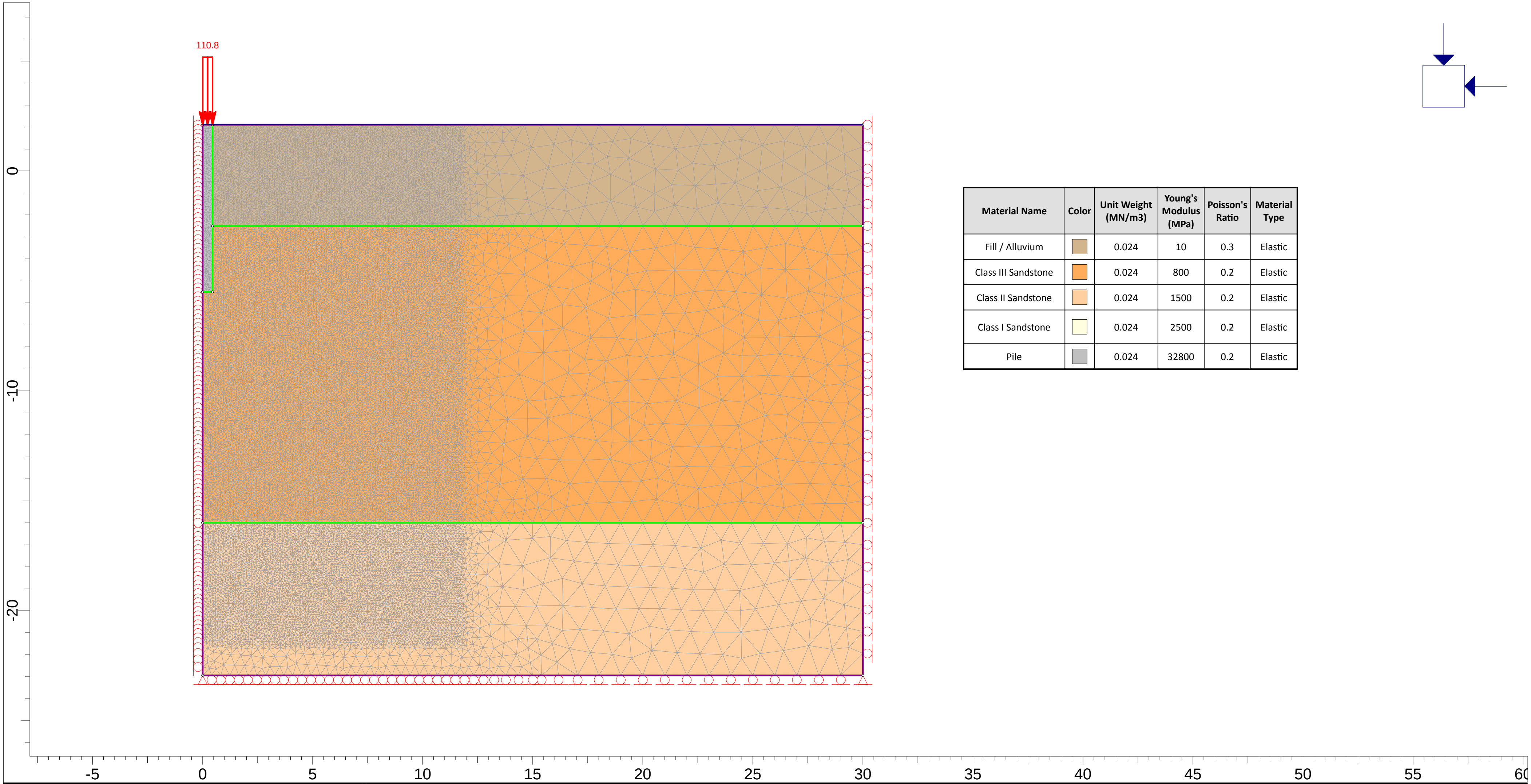


| Material Name | Color | Unit Weight (MN/m3) | Young's Modulus (MPa) | Poisson's Ratio | Material Type |
|---|---|---|---|---|---|
| Fill / Alluvium | | 0.024 | 10 | 0.3 | Elastic |
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| Class I Sandstone | | 0.024 | 2500 | 0.2 | Elastic |
| Pile | | 0.024 | 32800 | 0.2 | Elastic |

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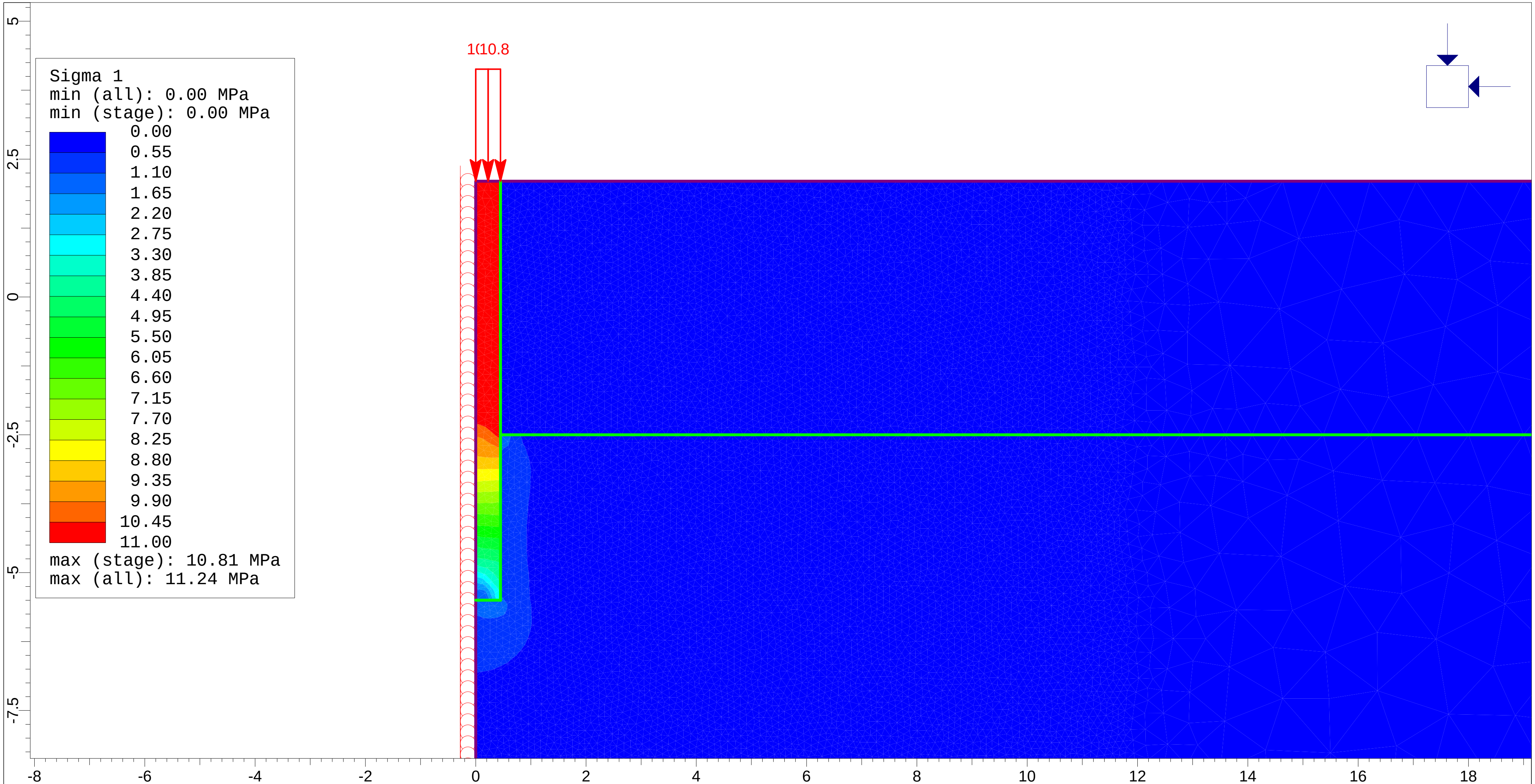
Engineering Consultants
Rock-Soil-Water

| | |
|---|---|
| Client: | **Urbanest Darling Harbour No.2** |
| Project: | **PSM2796 Urbanest Darling Square Building W1** |
| Location: | **Haymarket** |
| Analysis description: | **Pile footing adjacent to trunk sewer, axisymmetric analysis, diameter 0.9 m, toe level RL -5.5 m, load 6900 kN** |

| Job No: | By: | Date: | Stage: | Scale: | Run: |
|---|---|---|---|---|---|
| | **MP** | **8/09/2015** | **2 of 2, Apply load** | **1:250** | **Sewer - Run4.fez** |

PHASE2 9.003
W:\2701-2800\PSM2796\Eng\Sewer assessment\Sewer - Run4.fez

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Engineering Consultants
Rock-Soil-Water

| | |
|---|---|
| Client: | **Urbanest Darling Harbour No.2** |
| Project: | **PSM2796 Urbanest Darling Square Building W1** |
| Location: | **Haymarket** |
| Analysis description: | **Pile footing adjacent to trunk sewer, axisymmetric analysis, diameter 0.9 m, toe level RL -5.5 m, load 6900 kN** |

| Job No: | By: | Date: | Stage: | Scale: | Run: |
|---|---|---|---|---|---|
| | **MP** | **8/09/2015** | **2 of 2, 2. Apply load** | **1:100** | **Sewer - Run4.fez** |

INTERPRET 9.003

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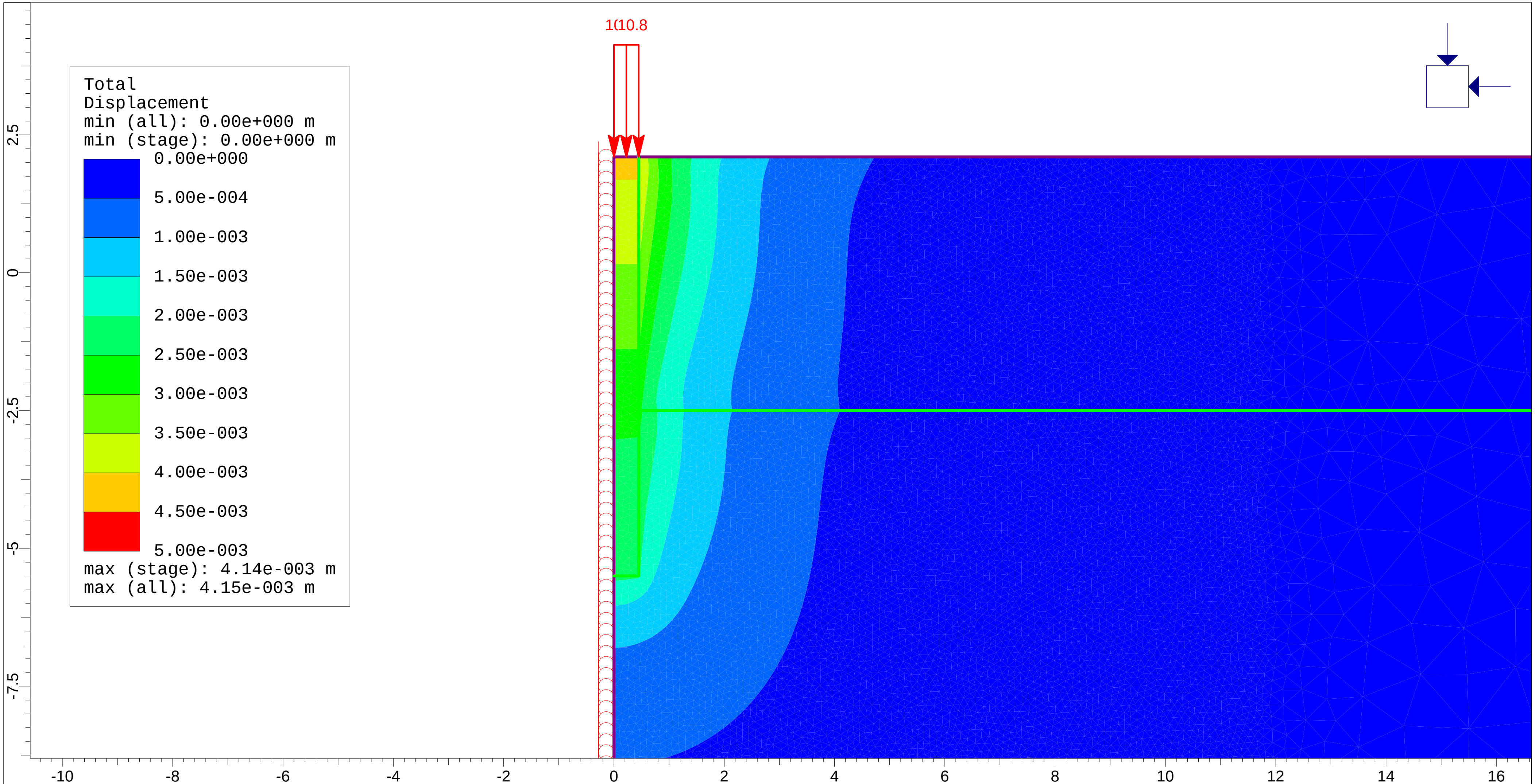


| | |
|---|---|
| PSM **Pells Sullivan Meynink** Engineering Consultants Rock-Soil-Water | Client: **Urbanest Darling Harbour No.2** |
| | Project: **PSM2796 Urbanest Darling Square Building W1** |
| | Location: **Haymarket** |
| | Analysis description: **Pile footing adjacent to trunk sewer, axisymmetric analysis, diameter 0.9 m, toe level RL -5.5 m, load 6900 kN** |
| INTERPRET 9.003 | Job No: / By: **MP** / Date: **8/09/2015** / Stage: **2 of 2, 2. Apply load** / Scale: **1:100** / Run: **Sewer - Run4.fez** |

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