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Report on
Preliminary Numerical Analysis - Sydney Metro

Fiveways Project
Falcon Street, Pacific Highway and Alexander Street,
Crows Nest

Prepared for
Deicorp Pty Ltd

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Douglas Partners acknowledges Australia's First Peoples as the Traditional Owners of the Land and Sea on which we operate. We pay our respects to Elders past and present and to all Aboriginal and Torres Strait Islander peoples across the many communities in which we live, visit and work. We recognise and respect their ongoing cultural and spiritual connection to Country

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

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Falcon Street, Pacific Highway and Alexander Street, Crows Nest

1. Introduction

This report presents the results of a preliminary 3D numerical analysis undertaken by Douglas Partners Pty Ltd (DP) for the proposed Fiveways development. The assessment was undertaken in general accordance with Douglas Partners' proposal 86645.03.P.003.Rev0, dated 3 August 2023 and acceptance received from Deicorp Pty Ltd on 18 August 2023.

It is understood that the proposed development will include the demolition of the existing buildings and construction of a mixed-use structure (residential with retail uses) with a 7-level basement.

The numerical analysis has been carried out to assess the potential impact of the proposed development (demolition/excavation and building load stages) on the adjacent Sydney Metro tunnel infrastructure.

The input parameters, model sequence and results are discussed within this report.

2. Site Description

The site is triangular and covers approximately 3,300 m^2, located in the suburb of Crows Nest. The site is bounded by Falcon Street, Pacific Highway and Alexander Street (refer Figure 1). The existing surface slopes gradually from west to east along Falcon Street (from RL 99.1 m to RL 96.7 m) and north to south along Pacific Highway (from RL 99.1 m to RL 96.0 m). Along Alexander Street the existing surface slopes towards the south (from RL 96.7 m to RL 96.0 m).

The site is currently occupied by a number of commercial properties, between 2 and 4 levels high, with some properties having an existing 1 level basement.

Dual Sydney Metro tunnels pass beneath the site, as shown in Figure 1, with tunnel crown level understood to be between RL 65 m and RL 63 m (refer "for construction" TfNSW Drawing SMCSWTSE-JAB-TPW-AL-DRG-505123-02 attached in Appendix B for further details). The closest cross-passage (XP45) between the two tunnels is shown to be at the northern site boundary. Stantec Survey Drawing 3050-01019-001-002-2 is also attached in Appendix B which details the tunnel location relative to the site.

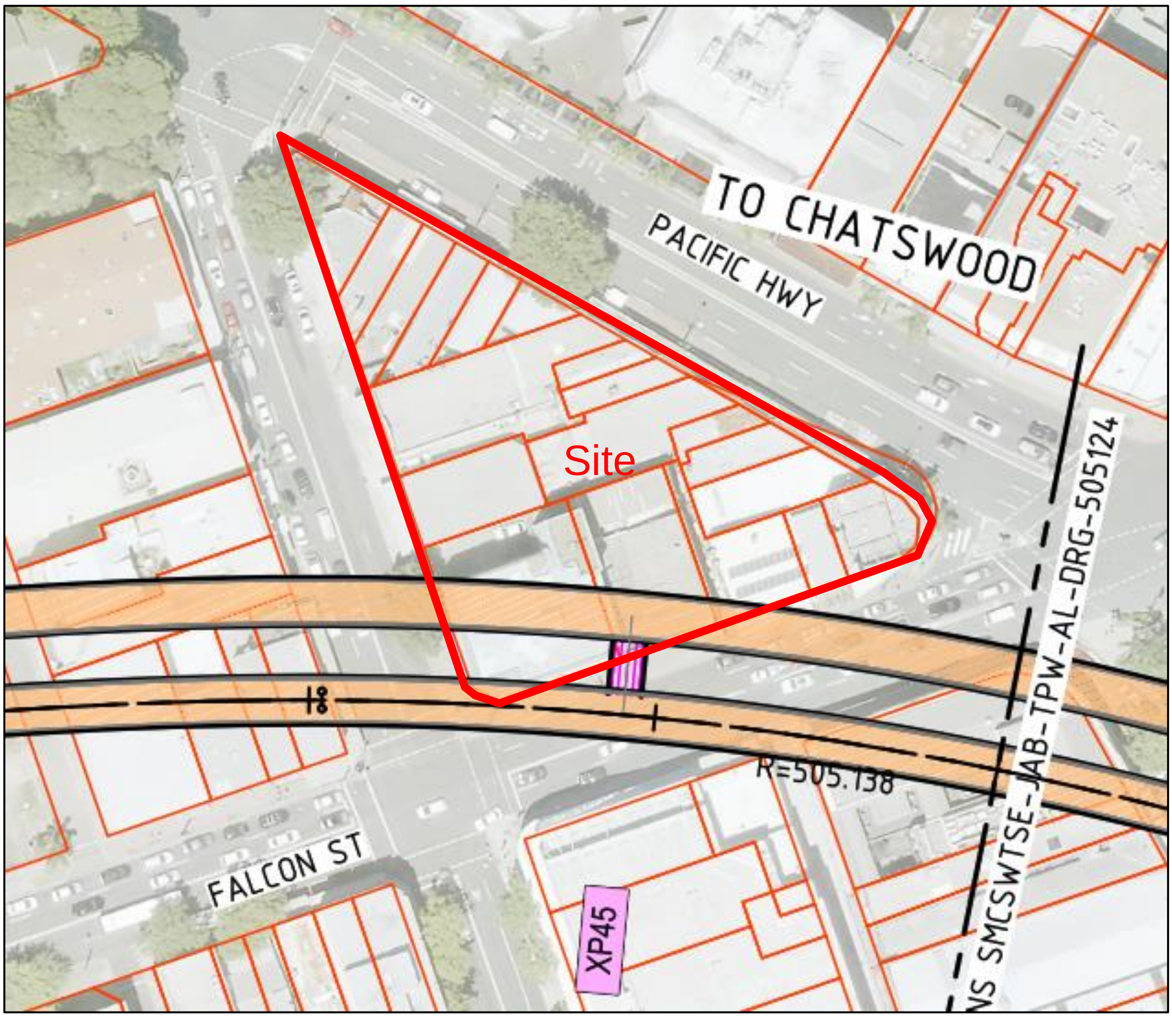

Figure 1: Aerial View of Site with Sydney Metro Tunnel Overlay (note, south up the page)

3. Proposed Development

It is understood that the proposed development will include demolition of the existing buildings on site and construction of a mixed-use structure (residential with retail uses) with a 7-level basement with finished floor level at RL 74.5 m (AHD[1] - refer abc Consultant Drawing S01-101-P2 and S01-102-P2 attached in Appendix B).

[1] Australian Height Datum

The proposed development is understood to be located partly in the Sydney Metro tunnel second reserve, with the dual tunnels (RT01 and RT02) running beneath the northeastern corner of the site (refer TfNSW "for construction" drawing SMCSWTSE-JAB-TPW-AL-DRG-505123-02 attached in Appendix B). The tunnels are shown to plunge towards the east with the tunnel crown increasing in depth from approximately RL 65 m to RL 63 m. A cross passage is shown between the two tunnels, located just to the north of the site. Both tunnels are shown to be circular with a diameter of approximately 7.05 m (refer sheet 2 to 4 of drawing 3050-01019-001-002-02, prepared by Stantec attached in Appendix B).

4. Information Provided

For the purpose of the assessment, the following documents and information were provided by Deicorp Pty Ltd:

- Drawings titled "PLAN SHOWING RELATIONSHIP OF ROPOSED BOREHOLES TO SYDNEY METRO TUNNELS AT FIVE WAYS, CROWS NEST", Stantec Drawing No. 3050-01019-001-002-02, dated 5/05/2023.
- Drawing titled "SITE RETENTION PLAN WITH METRO RAIL TUNNEL", abc Consultants Drawing No. 23012-S01-101-P2, dated 9/06/2023.
- Drawing titled "SITE SECTIONS WITH METRO RAIL TUNNEL", abc Consultants Drawing No. 23012-S01-102-P2, dated 9/06/2023.
- Drawing titled "GA PLAN AND LONGITUDINAL SECTION", TfNSW For Construction Drawing No. SMCSWTSE-JAB-TPW-AL-DRG-505123-02, dated 17/05/2019.
- Drawing titled "Concrete Profile -B6", abc Consultant Drawing No. 22091-SK-B6, dated 15/08/2023.
- Document summary titled "References for Coordination - Fiveways Crows Nest Assessment - Crows Nest.pdf", Delve Underground.

5. Geotechnical Model

The geotechnical model has been based on geotechnical investigations[2] undertaken at the site. The subsurface profile has been divided into four material units as outlined in Table 1.

[2] Douglas Partners Geotechnical Investigation Report 86645.03.R.001.Rev0, dated 4 July 2023

Table 1: Geotechnical Model

Unit	Material Description (Pell`s Classification[3])	Description
A	Fill and Residual Soils	Fill comprising sandy gravel, sandy and clayey soils / Residual, low to high plasticity, stiff to hard clay soils and dense sands.
B	Very Low to Low Strength Shale / Laminite (Ashfield Shale) CLASS IV/III	Shale and laminite bedrock of very low and low strength with some medium strength bands. Mainly highly weathered then fresh, with extremely weathered bands, highly fractured to slightly fractured.
C	Very Low to Medium Strength Siltstone / Sandstone (Mittagong Formation) CLASS IV/III	Sandstone and siltstone bedrock of generally very low and low strength with medium strength bands, mainly fresh, fractured to slightly fractured.
D	Medium to High Strength Sandstone (Hawkesbury Sandstone) CLASS II	Sandstone of medium to high and high strength. Mainly fresh, slightly fractured to unbroken.

Refer Table 2 for underside of the individual units.

The geotechnical investigation (DP, 2023) and general expected trends in Sydney indicate the following defects could be expected within the rock mass:

- Unit B: Closely bedding (dipping 0° to 5°) material with possible decomposed seams and an orthogonal pair of smooth, planar, steeply dipping (70° to 90°) joint sets, typically striking NNE and ESE, spaced at 0.5 m to 5.0 m. Randomly oriented ubiquitous joints (some slickensided), dipping 20° to 45°, is common in the shale.
- Unit C: Randomly oriented, low angle (dipping 20° to 45°) smooth and planar joints. A pair of orthogonal steeply dipping (75º to 90º) joint sets striking NNE and ESE are also expected.
- Unit D: Typical bedding dipping 0º to 20º. An orthogonal pair of rough, planar, steeply dipping (70º to 90º) joint sets, typically striking NNE and ESE and spaced at 0.5 m to 10 m.

Groundwater monitoring on site indicates the groundwater level ranges from RL 93.1 to RL 86.1 m.

6. Numerical Analysis

DP has used FLAC^{3D} to analyse the potential impact of the proposed development on the adjacent Sydney Metro tunnel infrastructure. FLAC^{3D} (Fast Lagrangian Analysis of Continua) is a three-dimensional explicit finite difference program for modelling of soil, rock, and structural behaviour. FLAC^{3D} is an analysis and design tool for geotechnical, civil, and mining engineers that can be applied to a broad range of problems in engineering studies. Materials are represented by elements, or zones, which form a grid that is adjusted by the user to fit the shape of the object to be modelled. Each element behaves according to a prescribed linear or non-linear stress / strain law in response to the applied forces or boundary restraints.

FLAC^{3D} is ideally suited for modelling geomechanically problems that consist of several stages, such as sequential excavation, loading and de-stressing. The explicit Lagrangian calculation scheme and the mixed-discretization zoning technique used in FLAC^{3D} ensure that plastic collapse and flow are modelled accurately. The material can yield and flow and the grid can deform (in large-strain mode) and move with the material that is represented. The formulation can accommodate large displacements and strains and non-linear material behaviour, even if yield or failure occurs over a large area or if total collapse occurs.

The geometry of the model is based on the information provided by the Deicorp Pty Ltd and their design team. Plots 1 to 3 in Appendix D present the 3D geometry of the Sydney Metro tunnels and proposed development used in the modelling.

6.1 Geotechnical Model Profile

The surface and rock levels in the model were set up to approximate the surveyed ground levels and rock unit RL's from the boreholes (DP, 2023). The simplified geotechnical profile used in the numerical model is provided in Table 2 with unit depth referenced to BH3.

Table 2: Geotechnical Profile for Numerical Model at BH3 Location (DP, 2023)

Geotechnical Unit	Material Description	Depth to Underside of Unit (m)
1	Stiff Clay	3
2	Very Low Strength Shale	16
3	Low Strength Sandstone	18
4	High Strength Sandstone	20 (Model depth)

6.2 Geotechnical Material Properties

In order to estimate the rock strength parameters of Unconfined Compressive Strengths (UCS) and Intact Elastic Modulus (Ei), testing undertaken during the geotechnical investigation (DP, 2023) was correlated against Axial Point Load Strength values ($Is_{(50)}$). UCS correlation values around Sydney generally vary between 16 to 29 times the $Is_{(50)}$. For this analysis a correlation value of 20 was used. Figure 2 shows a plot of inferred and tested UCS values versus the model strength profile adopted.

The correlation, or Modulus Ratio (MR), between UCS and Ei (secant) varied from 110 to 205. The MR adopted for Unit 4 was 165, based on the median value of test results (refer Table 3). The inferred UCS values, estimated Geological Strength Index range (GSI) and MR were then processed with RocLab[4] to estimate the rock properties, as listed in Table 4. Note that only Unit 4 was modelled as a Mohr Coulomb material. All other units were modelled using an elastic constitutive model.

A sensitivity run was included with rock properties for Unit 4 consistent with those reported by Bertuzzi, 2014[5].

Table 3: Results of UCS and Deformation Testing

Bore	Depth (m)	Uniaxial Compressive Strength (MPa)	Tangent		Secant	
			Elastic Modulus (GPa)	Poisson's Ratio	Elastic Modulus (GPa)	Poisson's Ratio
BH102	17.0-17.3	12.7	2.9	0.22	2.6	0.12
BH103	19.1–19.3	29.5	6.4	0.39*	5.1	0.21
BH104	16.2-16.5	29.6	6.3	0.40*	4.6	0.24
BH105	12.5-12.8	10.8	1.6	0.12	1.2	0.07
BH105	16.0-16.3	18.1	1.1	0.42*	2.3	0.31*
BH106	21.6-21.9	20.5	4.4	0.31*	3.7	0.25

* Poisson's ratio values should not be relied upon.

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Table 4: Geotechnical Material Properties

Geotechnical Unit	1	2	3	4
Material	Stiff Clay	Very Low Strength Shale	Low Strength Sandstone	High Strength Sandstone
Constitutive Model	Elastic	Elastic	Elastic	Mohr Coulomb
Pells Class	-	IV	IV	II
GSI	-	40	65	80 (65)
Unit Weight (kN/m3)	20	22	23	24
UCS (MPa)	-	2	4	22
Friction angle (°)	-	-	-	60 (50)
Case 1 - Erm (MPa)	15	200	400	3400 (2000)
Poisson's Ratio	0.3	0.25	0.25	0.2 (0.25)
Cohesion (kPa)	-	-	-	1400 (500)
Tension (kPa)	-	-	-	420 (100)

Bracketed values are sensitivity values from Bertuzzi, 2014

Groundwater was included in the model at RL 94 m (on the rock/soil interface). It should be noted that groundwater levels are transient in nature and affected by factors such as climatic conditions and soil permeability and will therefore vary with time.

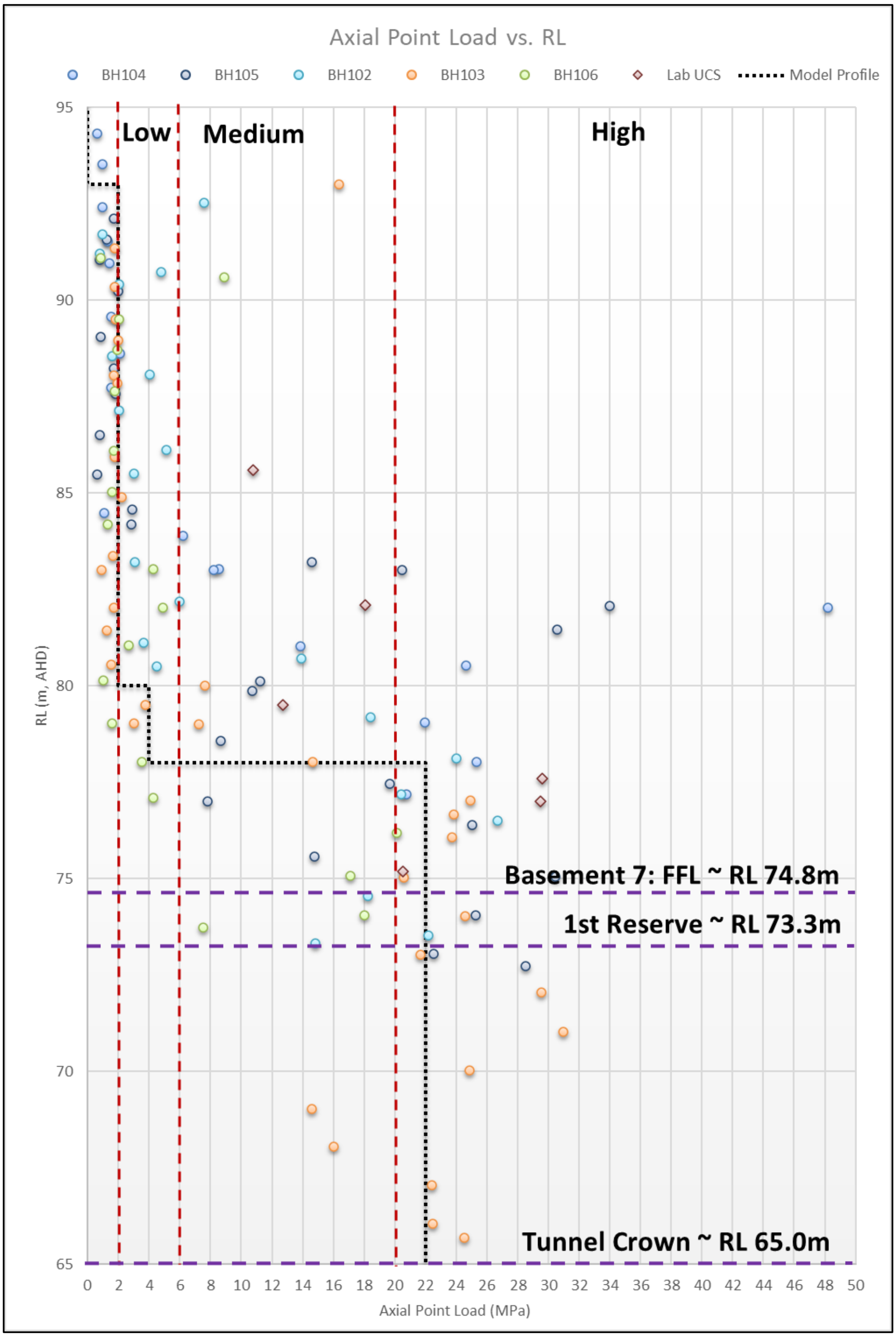

Figure 2: Estimated UCS Vs RL and Adopted Model Strength Profile

6.3 In-Situ Stress

The following in-situ stress relationship, adopted from Pells (2002), was used for the high strength sandstone in Geotechnical Unit 4.

σ_1= 1.5 MPa + (2 x σ_3)

σ_2 = 1.0 MPa + (1.2 x σ_3)

σ_3 = γ x H

where,

σ_1	= maximum principal stress (north-south direction)
σ_2	= intermediate principal stress (east-west direction)
σ_3	= minor principal stress (vertical)
γ	= unit weight = 24 kN/m^3
H	= depth below surface (m)

For the very low to low strength units (Unit 2 and 3), a ratio of 1:1 (horizontal to vertical stress) was used. For the soil (Unit 1), a ratio of 0.5:1 (horizontal to vertical stress) was used.

The following in-situ stress relationship, adopted from Bertuzzi (2014), was used in the sensitivity analysis for the high strength sandstone in Geotechnical Unit 4.

σ1= 2.5 MPa + (2 x σ3)
σ2 = 0.7.σ1
σ3 = γ x H

6.4 Bedding and Jointing

The bedding and jointing in the geological model have been simplified in a rock mass model (i.e., joints have not been explicitly included). The rock mass properties, however, have been downgraded to account for some defects, based on the defects (GSI) observed in the recovered cores (Serviceability Case Properties) and the GSI presented in Burtuzzi, 2014 (Sensitivity Case Properties).

Sydney Metro to provide mapping of the cross-passage excavation for review prior to final impact assessment.

6.5 Structural Elements

As the tunnels have been developed in high strength sandstone, well below the excavation, shoring was not explicitly included in the model, with the soils and lower strength rock units modelled as an elastic medium, making it possible to run the model without actually supporting these materials (allowing the material to fully destress). Shoring design therefore needs to be assessed separately by the structural engineer during the design phase.

Structural elements were used in the model to represent the tunnel and cross-passage linings. Details of the structural element properties adopted for the analysis are presented in Table 5. These properties have been provided by Delve Underground (DU). The thickness of the liners vary slightly from the drawings as they are scaled based on the estimated moment of inertia provided by DU.

The running tunnel linings have been installed after the tunnel excavation has been run to 90% relaxation, in order to be consistent with the TBM design approach (as advised by DU). The cross-passage lining, however, has been installed close to 100% ground relaxation. The liner includes pore pressure but does not include other design loads such as wedge loads, track loads, grout pressures, etc (to be assessed separately by DU).

Table 5: Properties of Elastic Structural Liner Elements (provided by Delve Underground)

Type	Interface Stiffness (GPa/m)		Unit Weight (kN/m^3)	Elastic Modulus (GPa)	Poisson's Ratio	Thickness (mm)
	Normal (K_n)	Shear (K_s)				
Running Tunnel	1.0	0.1	25	37	0.2	192
Cross Passage - Section A1	1.0	0.1	25	35	0.2	737 in sidewall 528 in crown 650 in invert
Cross Passage - Section B1	1.0	0.1	25	35	0.2	1380 in sidewall 1250 in crown 800 in invert

6.6 Foundation Loads

Existing building loads within the site have been estimated from site photographs and 10 kPa surcharge per floor (as confirmed by the abc Consultants). Uniform applied pressures were used to model the existing buildings.

The proposed development loads are shown on the abc Consultants Drawing SK-B6 attached in Appendix C. Point loads per column were applied on the grid at bulk excavation level.

6.7 Modelling Geometry

The model geometry has been based on the abc Consultant drawings attached in Appendix B and Sydney Metro Drawing SMCSWTSE-JAB-TPW-AL-DRG-505123-02 (also attached in Appendix B). The 3D drawing prepared by DP was sent to the design team for verification.

No existing basement excavations were modelled as this is a preliminary analysis.

6.8 Assumed Modelling Sequence and Sensitivity Analysis

Three assumed modelling sequences were analysed.

Case 1: Serviceability Rock Mass Properties.

The following sequence was modelled:

Stage 0: Initial Conditions

- Set up geology, geometry, water table and stress conditions prior to any development and run to equilibrium.
- Reset displacements, existing building loads and run to equilibrium.
- Excavate the Metro running tunnels to 90% relaxation and install tunnel liners and run to equilibrium.
- Excavate the Metro cross-passage and run to equilibrium.
- Install the Metro cross-passage liner and run to equilibrium.

Stage 1: Proposed Excavation

- Reset displacements, apply construction surcharge, excavate proposed basement and run to equilibrium. Note, the existing building loads were removed in areas that excavation had taken place, simulating demolition and excavation in the same stage.
- Groundwater level drawdown to bulk excavation level and run to equilibrium..

Stage 2: Proposed Construction

- Apply proposed building loads and run to equilibrium.

Case 2: Lower Bound Rock Mass Properties (Sensitivity Run)

Case 2 comprised a sensitivity run with lower bound properties presented in Burtuzzi (2014). The same sequence used for Case 1 was used for Case 2. The purpose of the sensitivity run is to provide upper bound predictions on displacement only, using lower bound properties used for tunnel design (and not to assess the rock stress and behaviour).

Case 3: Lower Bound Rock Mass Properties and No Water Table (Sensitivity Run)

Case 3 comprised a sensitivity run ignoring the water table and using the lower bound properties from Case 2. The same sequence used for Case 1 was used for Case 3. The purpose of this sensitivity run is to provide liner outputs for DU to assess the groundwater pressures on the tunnel in their structural model separately.

Results are discussed in the sections to follow.

7. Results

The results of the analysis have been presented as plots of induced displacement and stress in the rock mass. Limited structural outputs for the tunnel and cross-passage liners have also been provided. The plots are attached in Appendix D.

Rock mass, tunnel and cross-passage liners displacements were reset after Stage 0 (existing conditions). Stage 1 therefore only represents displacement of the rock mass and liners due to the excavation proposed by the current development. Stage 2 Plots represent the cumulative effects of the proposed excavation and building loads. Stresses were not reset and hence predict the total stress within the materials.

Is should be noted that the results are provided in SI units in metres and kilopascals, and that:

- Negative stress represents compression.
- Total displacement or 'displacement magnitude' represents the sum of all magnitudes/direction of displacement.
- Certain contour plots have adjusted to focus the displacements around the tunnel and have been limited to the values shown.

The cross section shown on the plots was chosen through the intersection between the cross-passage and the Metro tunnels. Plots of other sections and liner outputs are available on request.

The following plots have been included:

- Plots of the 3D geometry modelled (Plot 1 & 2); and
- Plot of the geotechnical units and section for analysis (Plot 3).

<u>Case 1: Serviceability Rock Mass Properties</u>

- Plots of total displacement (including tunnels and cross-passage liners) for Stage 1 and Stage 2 along Section 1 (Plot 4).
- Plots of total displacement on tunnel and cross-passage liners in perspective 3D views (Plot 5).
- Plots of minimum and maximum principal stress for Stage 0, Stage 1 and Stage 2 along Section 1 (Plots 6 & 7).

Case 2/3: Lower Bound Rock Mass Properties (Sensitivity Run)

- Plots of total displacement (including tunnels and cross-passage liners) for Stage 1 and Stage 2 along Section 1 (Plot 8).
- Plots of total displacement on tunnel and cross-passage liners in perspective 3D views (Plot 9).
- Plots of minimum and maximum principal stress for Stage 0, Stage 1 and Stage 2 along Section 1 (Plots 10 & 11).

A summary of the results presenting the displacements and stress around the underground structures is shown in Table 6 and 7 for Case 1, Table 8 and 9 for Case 2 and Table 10 and 11 for Case 3.

The serviceability model (Case 1) indicated that:

- Maximum rock mass displacement of 2.6 mm, 2.6 mm and 2.5 mm are predicted in RT01, RT02 and cross-passage, respectively (at the end of Stage 1).
- Maximum rock mass displacement of 2.1 mm, 2.5 mm and 2.4 mm are predicted in RT01, RT02 and cross-passage, respectively (at the end of Stage 2).
- The liner displacements are similar to that the rock mass with maximum liner displacements of 1.6 mm, 2.2 mm and 2.1 mm predicted in RT01, RT02 and cross-passage, respectively (at the end of Stage 2). A maximum angular distortion of 0.09 mm/m was calculated over ¼ of the tunnel diameter.
- The plots indicate that the maximum and minimum principal stress at the crown of the tunnels and cross-passage generally increased after Stage 1 and Stage 2, with some cases of stress relaxation as shown in Table 6. The maximum principal stress had increases of 620 kPa up to 370 kPa for Stage 1 and Stage 2 respectively, in comparison to Stage 0. The minimum principal stress had increases of 50 kPa and up to 120 kPa for Stage 1 and Stage 2 respectively, in comparison to Stage 0.

Table 6: Case 1 Results – Predicted Displacements

Underground structure	Maximum Rock Mass Displacement (mm)		Maximum Liner Displacement (mm)	
	Stage 1	Stage 2	Stage 1	Stage 2
RT01	2.6	2.1	2	1.6
RT02	2.6	2.5	2.5	2.2
Cross-passage	2.5	2.4	1.6	2.1

Table 7: Case 1 Results – Predicted Stress Change in the Rock Mass in Tunnel Crown

Underground structure	Location	Change in Maximum Principal Stress*		Change in Minimum Principal Stress*	
		Stage 1	Stage 2	Stage 1	Stage 2
RT01	Crown	-50	110	-20	30
RT02	Crown	620	370	50	80
Cross-passage	Crown	90	100	20	120

**change relative to Stage 0, positive value indicate increase, negative value indicates relaxation*

The sensitivity model (Case 2) indicated that:

- Maximum rock mass displacement of 11.5 mm, 9.4 mm and 10.7 mm are predicted in RT01, RT02 and cross-passage, respectively (at the end of Stage 1).
- Maximum rock mass displacement of 10.6 mm, 9.2 mm and 10.2 mm are predicted in RT01, RT02 and cross-passage, respectively (at the end of Stage 2).
- The liner displacements are slightly less than the rock mass movements with maximum liner displacements of 8.4 mm, 7.6 mm and 7.6 mm predicted in RT01, RT02 and cross-passage, respectively (at the end of Stage 2). A maximum angular distortion of 0.56 mm/m was calculated over ¼ of the tunnel diameter.
- The plots indicate that the maximum and minimum principal stress at the crown of the tunnels and cross-passage generally increased after Stage 1 and Stage 2, with some cases of stress relaxation as shown in Table 7. The maximum principal stress had a decrease of 1.1 MPa and an increase of up to 190 kPa for Stage 1 and Stage 2 respectively, in comparison to Stage 0. The minimum principal stress had decreases of 300 kPa and 280 kpa for Stage 1 and Stage 2 respectively, in comparison to Stage 0.

Table 8: Case 2 Results – Predicted Displacements

Underground structure	Maximum Rock Mass Displacement (mm)		Maximum Liner Displacement (mm)	
	Stage 1	Stage 2	Stage 1	Stage 2
RT01	11.5	10.6	9.2	8.4
RT02	9.4	9.2	6.9	7.6
Cross-passage	10.7	10.2	6.3	7.6

Table 9: Case 2 Results – Predicted Stress Change in the Rock Mass in Tunnel Crown

Underground structure	Location	Change in Maximum Principal Stress*		Change in Minimum Principal Stress*	
		Stage 1	Stage 2	Stage 1	Stage 2
RT01	Crown	-790	-670	-20	20
RT02	Crown	390	190	120	280
Cros-passage	Crown	-1120	-1070	-300	-160

**Relative to Stage 0, positive value indicate increase, negative value indicates relaxation*

Table 10: Case 3 Results – Predicted Displacements

Underground structure	Maximum Rock Mass Displacement (mm)		Maximum Liner Displacement (mm)	
	Stage 1	Stage 2	Stage 1	Stage 2
RT01	6.8	6.2	5.7	4.9
RT02	5.2	5.9	4.2	5.5
Cross-passage	6.1	6	4	5.2

Table 11: Case 3 Results – Predicted Stress Change in the Rock Mass in Tunnel Crown

Underground structure	Location	Change in Maximum Principal Stress*		Change in Minimum Principal Stress*	
		Stage 1	Stage 2	Stage 1	Stage 2
RT01	Crown	-450	-300	-20	25
RT02	Crown	10	-140	-2	160
Cros-passage	Crown	-100	-70	-20	60

**Relative to Stage 0, positive value indicate increase, negative value indicates relaxation*

8. Comments on Results

The objective of the analysis was to provide preliminary estimates of displacements in rock mass and tunnels and cross-passage lining due to the proposed development (basement excavation and foundation loading). The objective was to also provide structural liner outputs to DU for preliminary structural assessment on the liner.

8.1 Assumptions

The following assumptions, which should be considered when interpreting the results, were made:

- After the segmental lining has been installed, the gap between the tunnel lining and rock mass is understood to be grouted. The model, however, assumes a continuous liner rather than a segmental liner. A high normal stiffness with no tension, and low cohesion values, have been assumed for the interface between the lining and the rock, which results in a relatively immediate lining response to any movement in the rock mass surrounding the tunnel. This also allows for the liner to become detached from the rock mass which should be taken into account when assessing the plots and modelling results.
- In the modelling, the tunnel lining of the Metro tunnel has been installed after the tunnel excavation has achieved 90% relaxation (stress relief), in order to simulate the stress relief and deformation that occurs between the time the tunnels are excavated, and the void between the lining and rock mass is grouted (as is the case when developing the tunnel with a TBM). This has been based on the design assumptions provided by DU.
- This study included a sensitivity analysis where the rock properties for Unit 4 were reduced, in line with Bertuzzi (2014). A higher stress was also used for the sensitivity analysis. It is understood that these properties have been used in the design of the Sydney Metro tunnels for Class II Sandstone. It should be noted that these properties are design properties and may not reflect the true changes in the rock in terms of stress change and failure. They have, however, been included to provide upper bound structural liner outputs for the structural assessment.
- Point loads per column were applied on the grid at bulk excavation level with values provided by the structural engineer.
- Angular distortion (differential displacement) was estimated over ¼ of the tunnel diameter. The angular distortion may be higher in some localised areas such as where the tunnel liners join the

cross-passage liners, however, it should be kept in mind that the liner is rigidly attached which may influence the displacements (DU to structurally assess the liners).

- This report is not intended to be used to assess the requirements for excavation shoring. DP has assumed that the shoring will be designed separately, adequately braced, and anchored back to limit soil movements around the perimeter and to support the overburden materials and weak rock.
- If additional information that may impact the results of this assessment becomes available at a later stage, or if the design changes in any way (i.e., basement excavation depth, building loading and additional tunnel information), then it will be necessary to update the current assessment.

8.2 Displacements and Stresses in the Rock Mass (Case 1 - Serviceability Case)

The analysis indicates that, for the properties and construction sequence modelled, deformation within the tunnel linings due to the proposed development will be up to 2.6 mm in Stage 1 and 2.5 mm in Stage 2.

The predicted movements indicate an upward movement during excavation due to stress relief, followed by downward movement due to loading during construction of the new building. The predicted displacements are lower than the allowable movement (10 mm) as outlined in the Sydney Metro Technical guidelines (SMA, 2021).

Demolition of the existing structures is predicted to have almost no effect on the tunnels and has been included as part of Stage 1.

The rock mass displacements and resulting tunnel lining deformation equate to a maximum angular distortion in the lining of 0.09 mm/m for Case 1 (over ¼ of the tunnel diameter) which is also less than the allowable limit (0.5 mm/m) outlined in the Sydney Metro Technical guidelines.

The stress in rock mass does show some minor tensile increases, however, the maximum predicted stress increases after Stage 2 were in compression and up to 370 Kpa (total stress change from Stage 0). According to Hoek & Martin (2014), the onset of tensile crackling/spalling of the rock mass starts at approximately 40 to 60% x UCS (uniaxial compressive strength of the rock), i.e., at 8.8 MPa to 13.2 MPa for a 22 MPa sandstone. The rock ultimately remains in compression around the tunnels with a maximum principal stress concentration of 6 MPa recorded in the RT02 Metro tunnel crown which is also less than the expected onset of cracking.

8.3 Sensitivity Analysis (Case 2)

The sensitivity analysis (Case 2) was carried out to provide upper bound limits of displacements using tunnel design properties.

The analysis indicates that, for the properties and construction sequence modelled, deformation within the tunnel linings due to the proposed development will be up to 9.2 mm in Stage 1 and 8.4 mm in Stage 2.

The angular distortion of the tunnel lining was estimated to be 0.56 mm/m for Case 2, which is higher than the 0.5 mm/m limit.

The results of the sensitivity case should be assessed in the context that they are upper bound and quite conservative as tunnel design properties were used with a significantly low GSI for the expected rock conditions. It is considered that the Burtuzzi parameters were adopted for the tunnel design because of the conservatism.

Parameters used for Case 1 are considered more in line with those used in Sydney (still incorporating some inherent conservatism) and hence is therefore considered more appropriate for comparison with the Sydney Metro Technical Guidelines (SMA, 2021), however, it is still recommended that the structural engineer comment on Case 2 results.

9. Conclusions

This report presents the results of numerical analysis for a mixed-use development bounded by Falcon Street, Pacific Highway and Alexander Street, Crow Nest, Sydney. The numerical modelling has been based on input loads from the client and parameters obtained from geotechnical assessment. A sensitivity case was carried out to evaluate the proposed development for upper bound conditions based on the original tunnel design parameters.

The predicted values of the displacements for Case 1 are less than the limits stipulated by the Sydney Metro Technical Guidelines (SMA, 2021), which allow total displacements of up to 10 mm and an angular distortion of 0.5 mm/m of 1:2000.

From a geotechnical engineering point of view, the modelled serviceability stresses and displacements are likely to be within tolerances that are acceptable for the rock surrounding the rail tunnels and cross-passage. Monitoring should be carried out to confirm that the deformations are as predicted and remain within the tolerances. The predicted rock/lining deformations and lining stresses from the model have been provided to DU for the structural assessment of the tunnel liners.

A mentioned above, it will be necessary to monitor displacement and deformation of the tunnel linings during excavation to confirm that the measured displacements are less than the predicted displacements for the base case (Case 1), and that, if additional movement does occur, it is addressed in a timely manner with suitable adjustments to the excavation sequencing or installation of additional support, as required to reduce such movements. Accordingly, a detailed excavation and monitoring plan should be prepared prior to construction.

10. References

DP. (2023). Douglas Partners Geotechnical Investigation Report 86645.03.R.001.Rev0, dated 4 July 2023

Pells, Moyston & Walker, (1998). Design Values for Foundations on Sandstone and Shale in the Sydney Region. AGS 1998.

RocLab Software by Rocscience Inc.

Bertuzzi, R (2014), Sydney Sandstone and Shale Parameters for Tunnel Design, Australian Geomechanics Vol 49 No 2, June 2014

Pells, P.J.N (2002), Developments in the Design of Tunnels and Caverns in the Triassic Rocks of the Sydney Region, Int J Rock Mech and Min Sci, 39:569-587.

SMA. (2021). Sydney Metro Underground Corridor Protection Guidelines Revision - June 2021

Hoek, E & Martin, C.D. (2014), Fracture initiation and propagation in intact rock – A review, Journal of Rock Mechanics and Geotechnical Engineering 6 (2014) 287 - 300

11. Limitations

Douglas Partners (DP) has prepared this report for this project at Falcon Street, Pacific Highway and Alexander Street, Crows Nest in accordance with DP's proposal 86645.03.P.003.Rev0. The work was carried out under DP's Conditions of Engagement. This report is provided for the exclusive use of Deicorp Pty Ltd for this project only and for the purposes as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of DP, does so entirely at its own risk and without recourse to DP for any loss or damage. In preparing this report DP has necessarily relied upon information provided by the client and / or their agents.

The results provided in the report are indicative of the sub-surface conditions on the site only at the specific sampling and / or testing locations, and then only to the depths investigated and at the time the work was carried out. Sub-surface conditions can change abruptly due to variable geological processes and also as a result of human influences. Such changes may occur after DP's field testing has been completed.

DP's advice is based upon the conditions encountered during this investigation. The accuracy of the advice provided by DP in this report may be affected by undetected variations in ground conditions across the site between and beyond the sampling and / or testing locations. The advice may also be limited by budget constraints imposed by others or by site accessibility.

The assessment of atypical safety hazards arising from this advice is restricted to the (geotechnical / environmental / groundwater) components set out in this report and based on known project conditions and stated design advice and assumptions. While some recommendations for safe controls may be provided, detailed 'safety in design' assessment is outside the current scope of this report and requires additional project data and assessment.

This report must be read in conjunction with all of the attached and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion stated in this report.

This report, or sections from this report, should not be used as part of a specification for a project, without review and agreement by DP. This is because this report has been written as advice and opinion rather than instructions for construction.

The scope of work for this investigation / report did not include the assessment of surface or sub-surface materials or groundwater for contaminants, within or adjacent to the site. Should evidence of fill of unknown origin be noted in the report, and in particular the presence of building demolition materials, it should be recognised that there may be some risk that such fill may contain contaminants and hazardous building materials.

Douglas Partners Pty Ltd

Appendix A

About This Report

About this Report

Introduction

These notes have been provided to amplify DP's report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

DP's reports are based on information gained from limited subsurface excavations and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

Copyright

This report is the property of Douglas Partners Pty Ltd. The report may only be used for the purpose for which it was commissioned and in accordance with the Conditions of Engagement for the commission supplied at the time of proposal. Unauthorised use of this report in any form whatsoever is prohibited.

Borehole and Test Pit Logs

The borehole and test pit logs presented in this report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable or possible to justify on economic grounds. In any case the boreholes and test pits represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

Groundwater

Where groundwater levels are measured in boreholes there are several potential problems, namely:

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole is left open;
- A localised, perched water table may lead to an erroneous indication of the true water table;
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical and environmental aspects, and recommendations or suggestions for design and construction. However, DP cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

If these occur, DP will be pleased to assist with investigations or advice to resolve the matter.

About this Report

Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

Information for Contractual Purposes

Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

Appendix B

Drawings

BEFORE YOU DIG
www.byda.com.au

NOTES:
1. THE LOCATION OF THE METRO LOT HAS BEEN DERIVED FROM DP1231642
2. THE LOCATION OF THE METRO TUNNELS HAVE BEEN DERIVED FROM 'FOR CONSTRUCTION' DRAWINGS PROVIDED BY TRANSPORT FOR NSW FOR THE SYDNEY METRO CITY & SOUTHWEST PROJECT INDICATING VARIOUS ALIGNMENT COORDINATES AND LEVELS ADJACENT TO THE DEVELOPMENT SITE
3. THE BOUNDARIES OF THE DEVELOPMENT SITE HAVE BEEN DERIVED FROM A PLAN PREPARED BY DAW AND WALTON CONSULTING SURVEYORS TITLED 'DETAIL SURVEY @ PACIFIC HIGHWAY CROWS NEST' DRAFTED 12-04-23, JOB NUMBER 4950-20
4. THE PROPOSED BOREHOLE POINT INDICATED ON THE PLAN AND SECTIONS IS THE CLOSEST PINK PAINT MARK LOCATED ON SITE TO THE METRO TUNNELS

SHORT LINE TABLE

Number	Bearing	Distance
1	189°25'40"	1.07
2	9°25'40"	4.175
3	189°33'40"	0.025
4	99°26'40"	3.685
5	279°25'40"	0.025
6	189°25'40"	6.655
7	189°25'40"	5.66
8	99°33'40"	0.115
9	189°33'40"	6.94
10	189°21'20"	5.38
11	9°31'20"	3.7
12	9°31'20"	0.825
13	99°33'40"	1.48
14	9°22'40"	1.56
15	189°31'20"	1.655
16	99°40'40"	0.11
17	9°40'40"	2.955
18	101°48'40"	1.055
19	99°31'20"	6.115
20	9°31'40"	1.265
21	99°23'40"	2.005
22	99°25'40"	0.115
23	9°25'40"	2.82
24	99°28'	0.975

NOTES:
'A' DENOTES RIGHT OF CARRIAGEWAY (AS SHOWN IN DP29672)
'B' DENOTES RIGHT OF FOOTWAY (AS SHOWN IN DP29672)
'C' DENOTES EASEMENT FOR SEWERAGE (AS SHOWN IN DP29672)
'D' DENOTES EASEMENT FOR DRAINAGE (AS SHOWN IN DP29672)
'E' DENOTES EASEMENT FOR ROOF WATER DRAINAGE (AS SHOWN IN DP29672)
'F' DENOTES RIGHT OF WAY (AS SHOWN IN DP29672)
'G' DENOTES EASEMENT FOR SULLAGE WATER (AS SHOWN IN DP29672)
'H' DENOTES RIGHT OF CARRIAGEWAY (VIDE K770818)
'P' DENOTES 0.23 BRICK PARTY WALL

LEGEND
- GULLY PIT & LINTEL

Registered Surveyor
Date 05 / 05 / 2023

Stantec
23-25 Frederick Street
PO Box 175
Rockdale NSW 2216
t: (02) 9597 9700
f: (02) 9599 2146
e: surveynsw@cardno.com.au
w: www.stantec.com

SCALE 1: 200 @ A1
SCALE 1: 400 @ A3

IMPORTANT NOTE:
This plan is prepared for DEICORP from a combination of field survey and existing records for the purpose of designing new constructions on the land and should not be used for any other purpose.
The title boundaries shown hereon were not marked by the author at the time of survey and have been determined by plan dimensions only and not by field measurement.

A services search of the area surveyed above has not been undertaken.
Visible services shown hereon have been located where possible by field survey.
Prior to any demolition, excavation or construction on the site, the relevant authority should be contacted for possible location of further underground services and detailed locations of all services.

REVISION	DATE	DESCRIPTION	CCAD REF	APPROVED
02	05/05/2023	TITLE BLOCK AMENDED	-	A.K.
01	04/05/2023	ORIGINAL ISSUE	-	A.K.

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COORD. SYSTEM MGA2020
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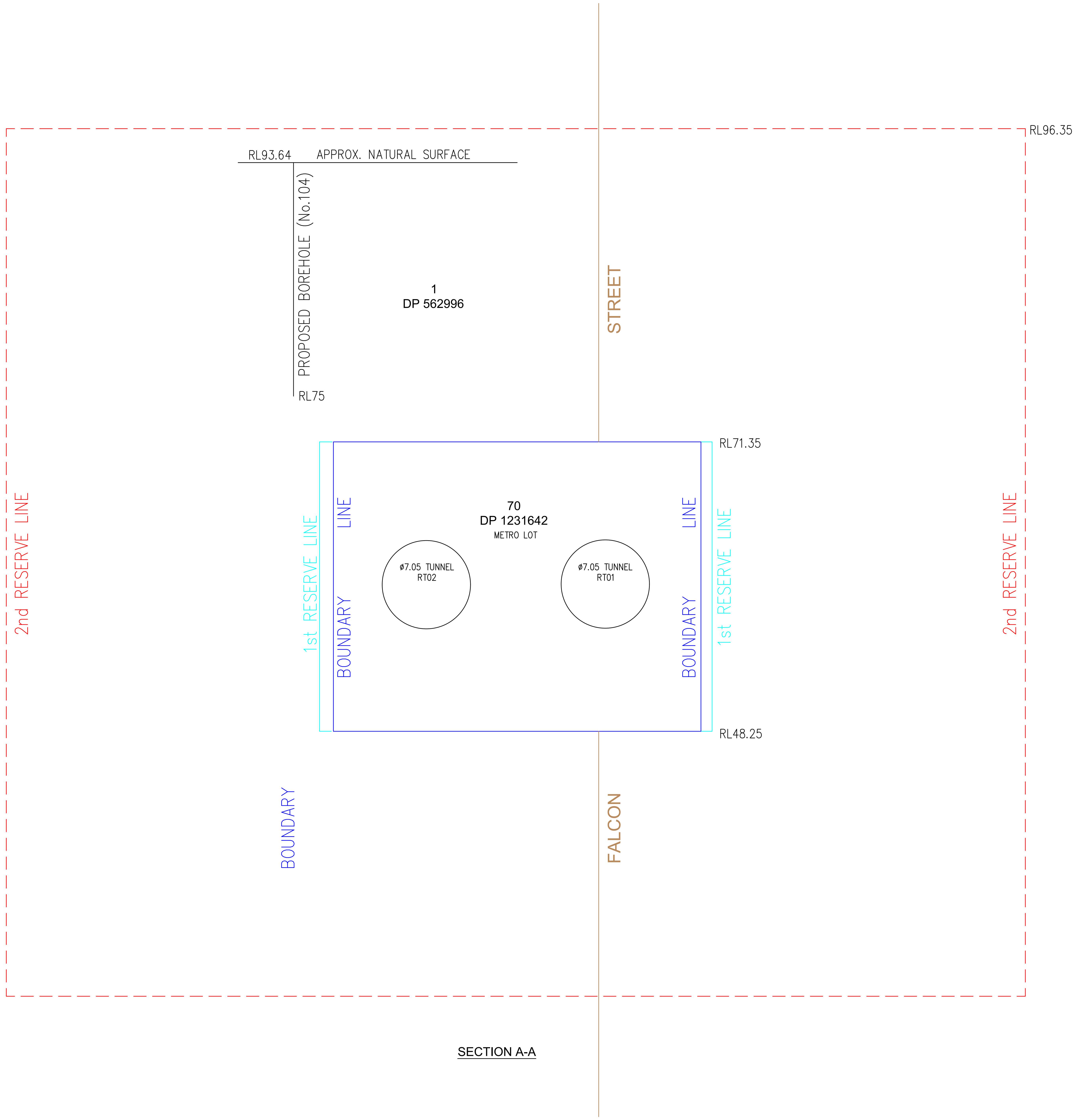
COORDINATES: E 333 681.947 N 6255 172.989
VERTICAL DATUM
DATUM: AHD
BM ADOPTED: PM 286
RL: 96.802

SURVEYED	DRAWN	CHECKED	PASSED
L.Z.	A.G.	A.K.	A.K.

PROJECT: PROJECT
PLAN SHOWING RELATIONSHIP OF PROPOSED BOREHOLES TO SYDNEY METRO TUNNELS AT FIVE WAYS, CROWS NEST

CLIENT: DEICORP

SHEET 1 OF 1
DRAWING NUMBER 3050-01019-001-002
REV 02



SECTION A-A

NOTES:

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4. THE PROPOSED BOREHOLE POINT INDICATED ON THE PLAN AND SECTIONS IS THE CLOSEST PINK PAINT MARK LOCATED ON SITE TO THE METRO TUNNELS

0 4 6 8 12 16 20
SCALE 1: 200 @ A1

0 8 12 16 24 32 40
SCALE 1: 400 @ A3

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SCALE:
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VERTICAL DATUM
DATUM: AHD
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23-25 Frederick Street
PO Box 175
Rockdale NSW 2216
t: (02) 9597 9700
f: (02) 9599 2146
e: surveynsw@cardno.com.au
w: www.stantec.com

SURVEYED	DRAWN	CHECKED	PASSED
L.Z.	A.G.	A.K.	A.K.

PROJECT: PROJECT

PLAN SHOWING RELATIONSHIP OF PROPOSED BOREHOLES TO SYDNEY METRO TUNNELS AT FIVE WAYS, CROWS NEST

CLIENT: DEICORP

SHEET 2 OF 1

DRAWING NUMBER	REV
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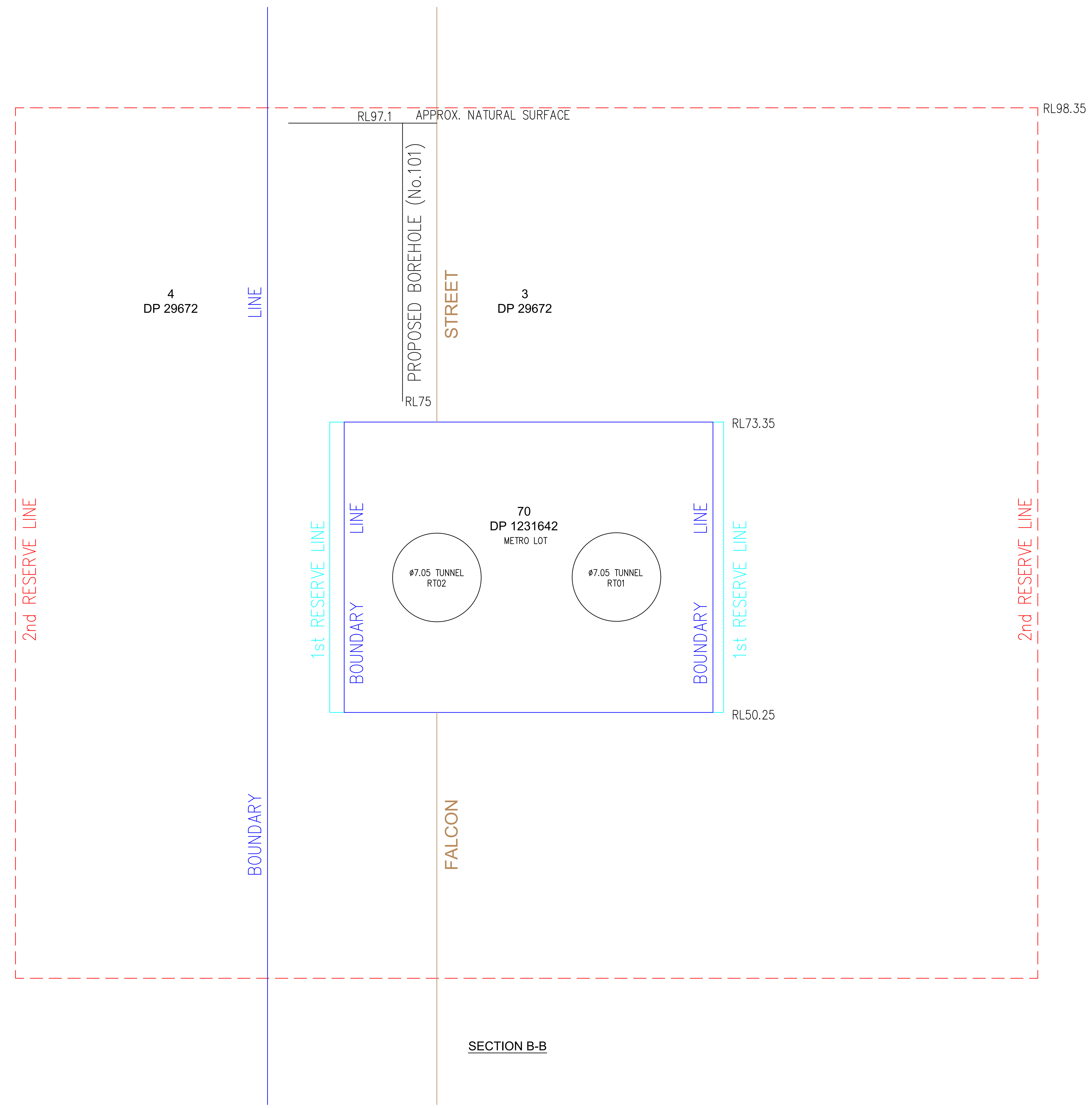

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SECTION B-B

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SCALE 1: 200 @ A1

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SCALE 1: 400 @ A3

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PROJECT: PROJECT

PLAN SHOWING RELATIONSHIP OF PROPOSED BOREHOLES TO SYDNEY METRO TUNNELS AT FIVE WAYS, CROWS NEST

CLIENT: DEICORP

SHEET 3 OF 1

DRAWING NUMBER	REV
3050-01019-001-002	02

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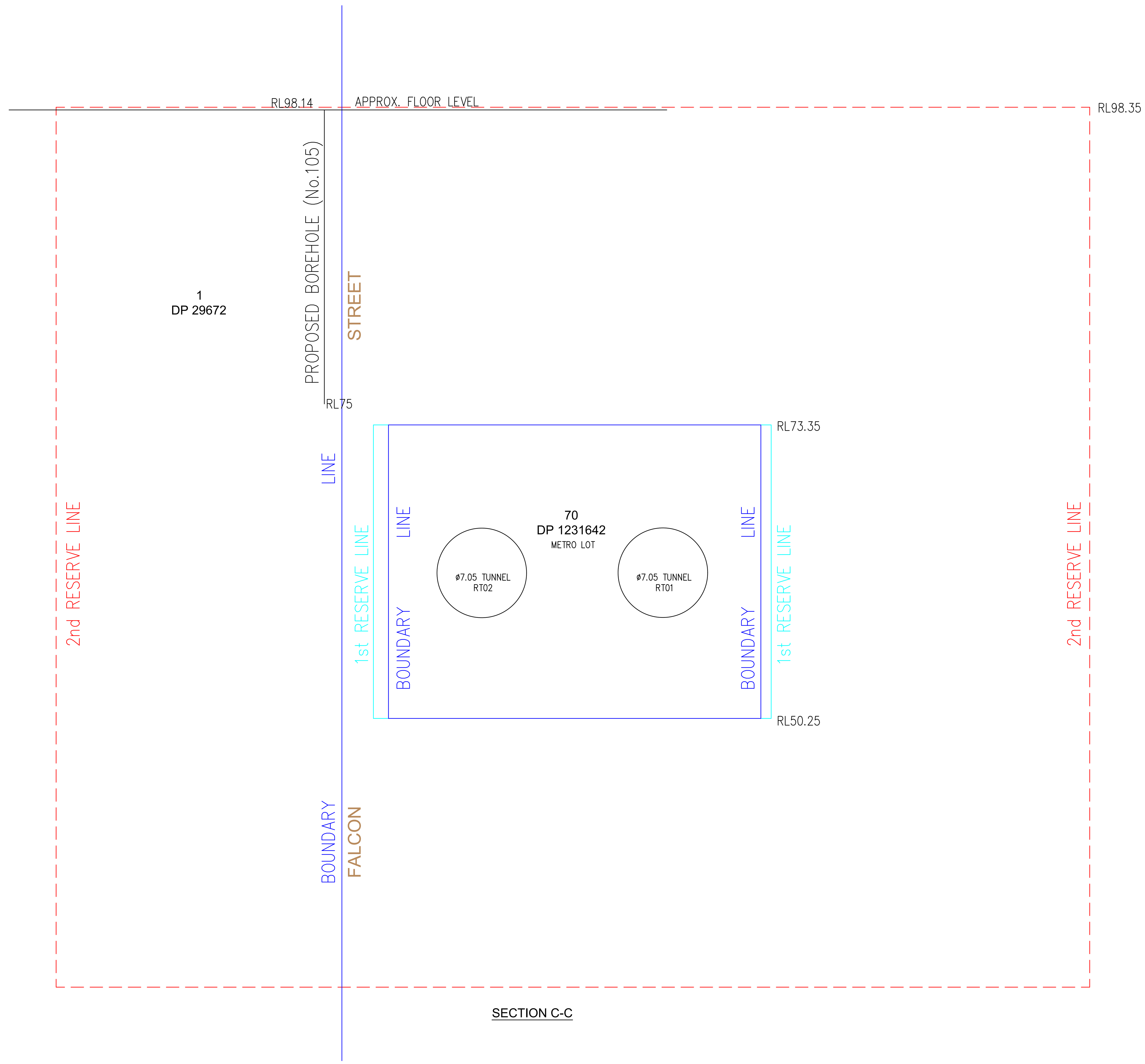

SECTION C-C

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0 8 12 16 24 32 40
SCALE 1: 400 @ A3

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CONTOUR INTERVAL:
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SURVEYED	DRAWN	CHECKED	PASSED
L.Z.	A.G.	A.K.	A.K.

PROJECT: PROJECT

PLAN SHOWING RELATIONSHIP OF PROPOSED BOREHOLES TO SYDNEY METRO TUNNELS AT FIVE WAYS, CROWS NEST

CLIENT: DEICORP

SHEET 4 OF 1

DRAWING NUMBER	REV
3050-01019-001-002	02

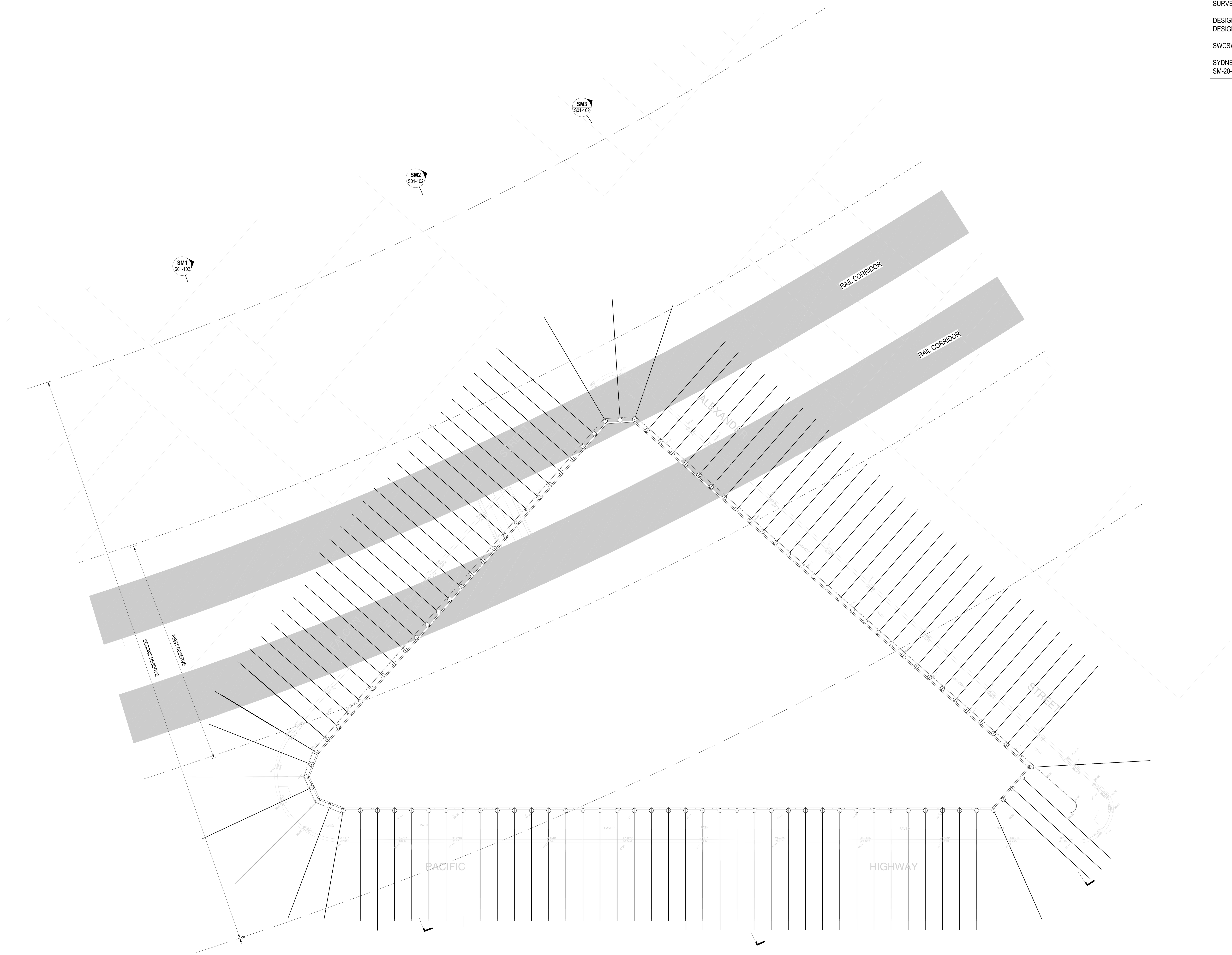
REFERENCED DRAWINGS

SURVEY - JOB NUMBER 4950-20 REVISION 02 DATE 23-04-20 BY DAW & WALTON CONSULTING SURVEYORS

DESIGN APPROACH BASEMENT DRAWINGS BY TURNER
DESIGN APPROACH METRO SECTION DRAWING BY TURNER

SWCSWTSE-JAB-TPW-AL-DRG-505123 REVISION 02 DATE 17-05-19, CLIENT TRANSPORT FOR NSW

SYDNEY METRO UNDERGROUND CORRIDOR PROTECTION TECHNICAL GUIDELINES, REFERENCE iCentral SM-20-00081444 VERSION 2 DATE APRIL 2021 BY WSP



SITE RETENTION PLAN WITH METRO RAIL TUNNEL

SCALE 1 : 200

PRELIMINARY ISSUE

NOTE: DO NOT SCALE OFF DRAWINGS. REFER TO ARCHITECTURAL PLANS. VERIFY DIMENSIONS ON SITE.

REV	DATE	REVISION DESCRIPTION	BY
P2	09.06.23	ISSUED FOR PRELIMINARY INFORMATION	RCL
P1	22.05.23	ISSUED FOR PRELIMINARY INFORMATION	RCL

CLIENT: DEICORP

abc CONSULTANTS structural & civil engineers

Contact
Phone: (02) 9746 9201
Email: info@abc-consultants.com.au
Web: www.abc-consultants.com.au

Street Address
Suite 2.02, Level 2
3 Thomas Holt Drive
MACQUARIE PARK NSW 2113

Postal Address
PO Box 77
NORTH RYDE BC NSW 1670

PROJECT: **FIVEWAYS CROWS NEST**
391/423 PACIFIC HIGHWAY
CROWS NEST NSW 2065

TITLE: SITE RETENTION PLAN WITH METRO RAIL TUNNEL

JOB NUMBER:	DRG NUMBER:
23012	S01-101
DESIGNED BY: RC	DATE:
DRAWN BY: RCL	SCALE: 1:200 @ A0

SIZE: A0 REV: P2

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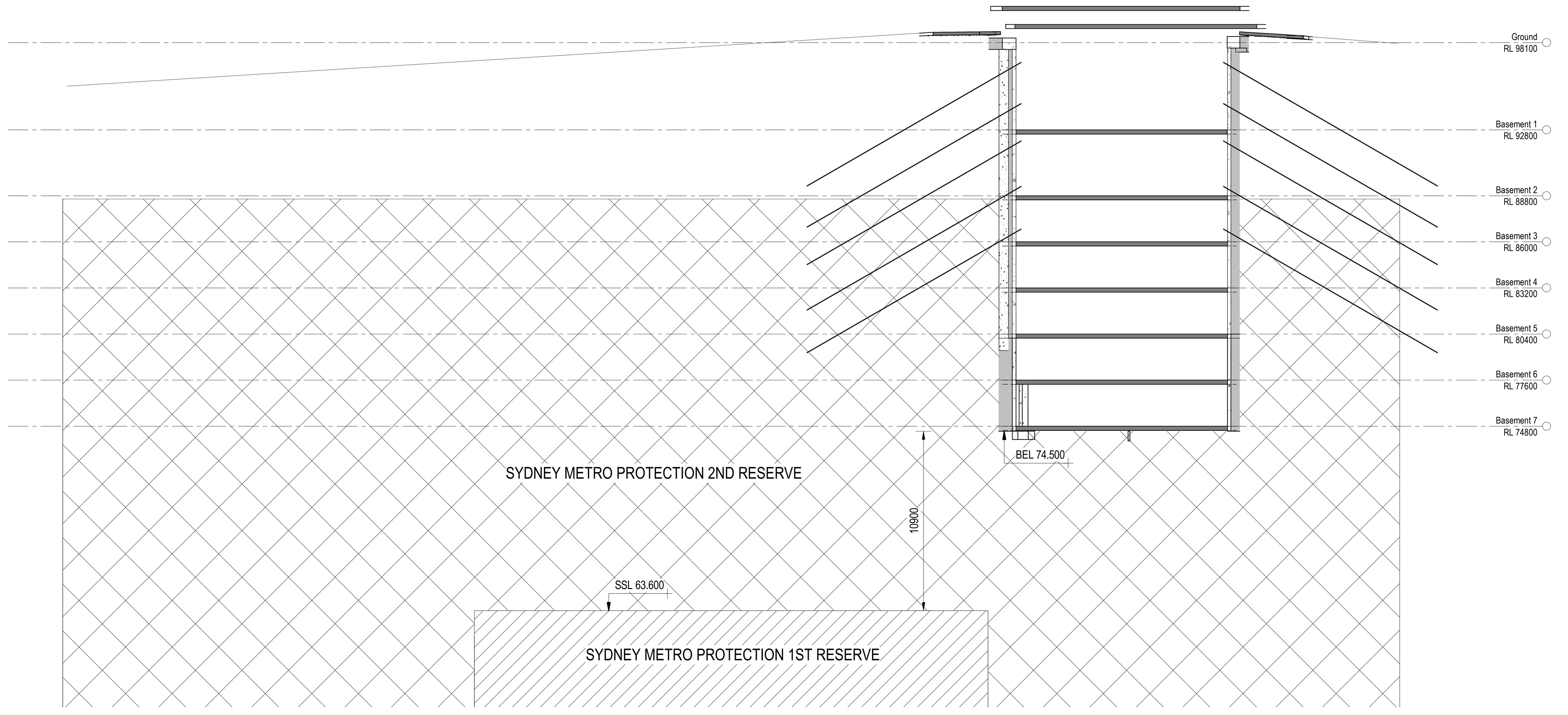

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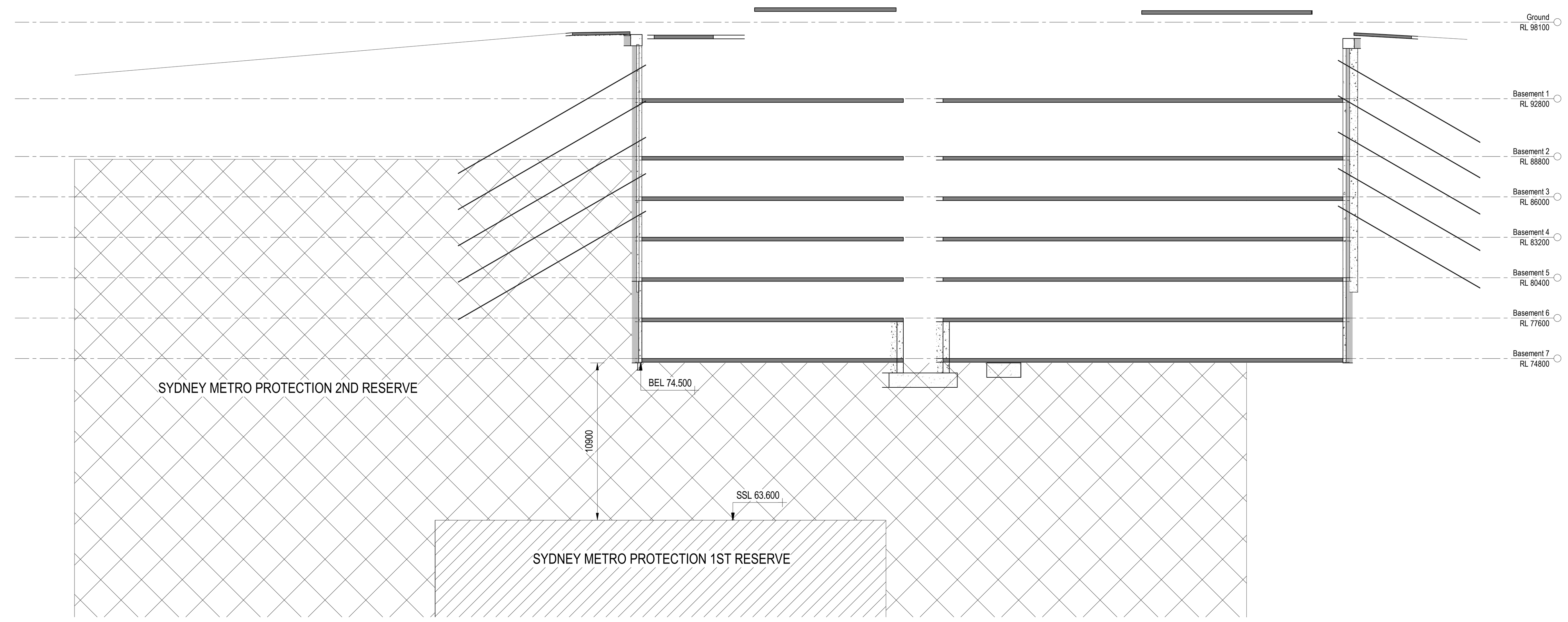

SECTION SM2
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SECTION SM3
Scale 1 : 200 S01-101

PRELIMINARY ISSUE

NOTE: DO NOT SCALE OFF DRAWINGS. REFER TO ARCHITECTURAL PLANS. VERIFY DIMENSIONS ON SITE.

REV	DATE	REVISION DESCRIPTION	BY
P2	09.06.23	ISSUED FOR PRELIMINARY INFORMATION	RCL
P1	22.05.23	ISSUED FOR PRELIMINARY INFORMATION	RCL

CLIENT: DEICORP

abc CONSULTANTS structural & civil engineers
Contact
Phone: (02) 9746 9201
Email: info@abc-consultants.com.au
Web: www.abc-consultants.com.au
Street Address
Suite 2.02, Level 2
3 Thomas Holt Drive
MACQUARIE PARK NSW 2113
Postal Address
PO Box 77
NORTH RYDE BC NSW 1670

PROJECT: **FIVEWAYS CROWS NEST**
391/423 PACIFIC HIGHWAY
CROWS NEST NSW 2065

TITLE: **SITE SECTIONS WITH METRO RAIL TUNNEL**

JOB NUMBER:	DRG NUMBER:		
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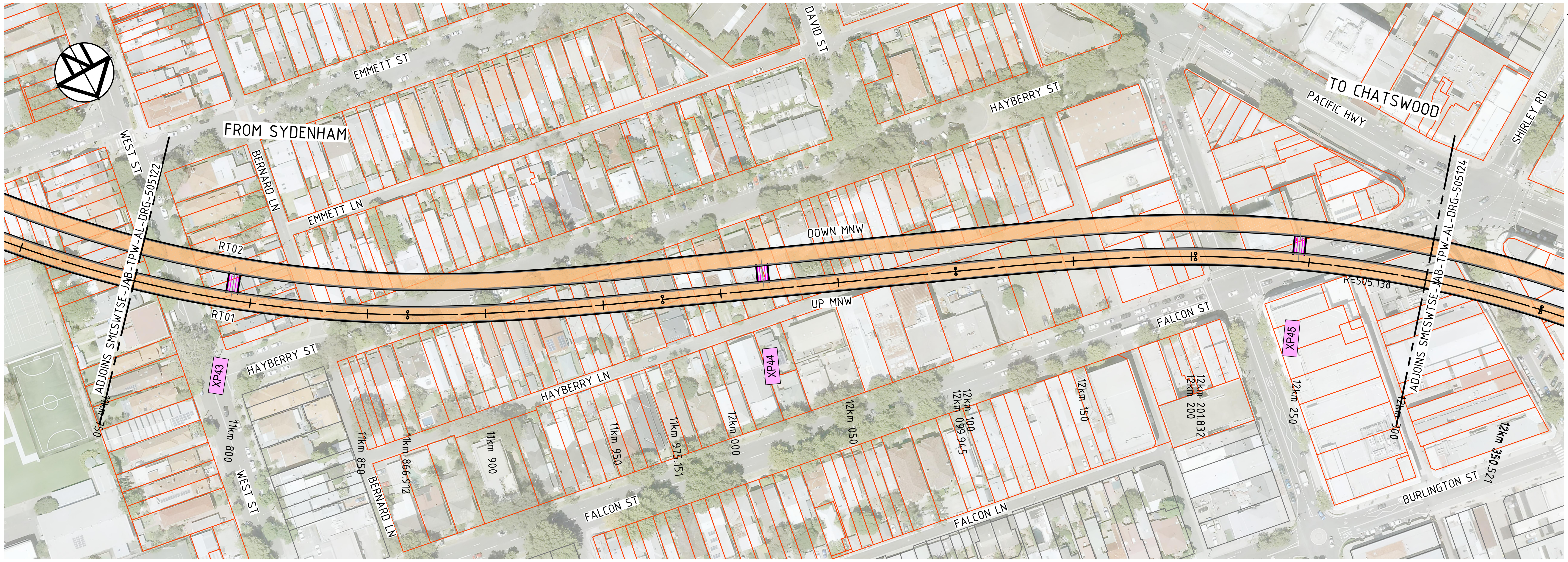


LEGEND

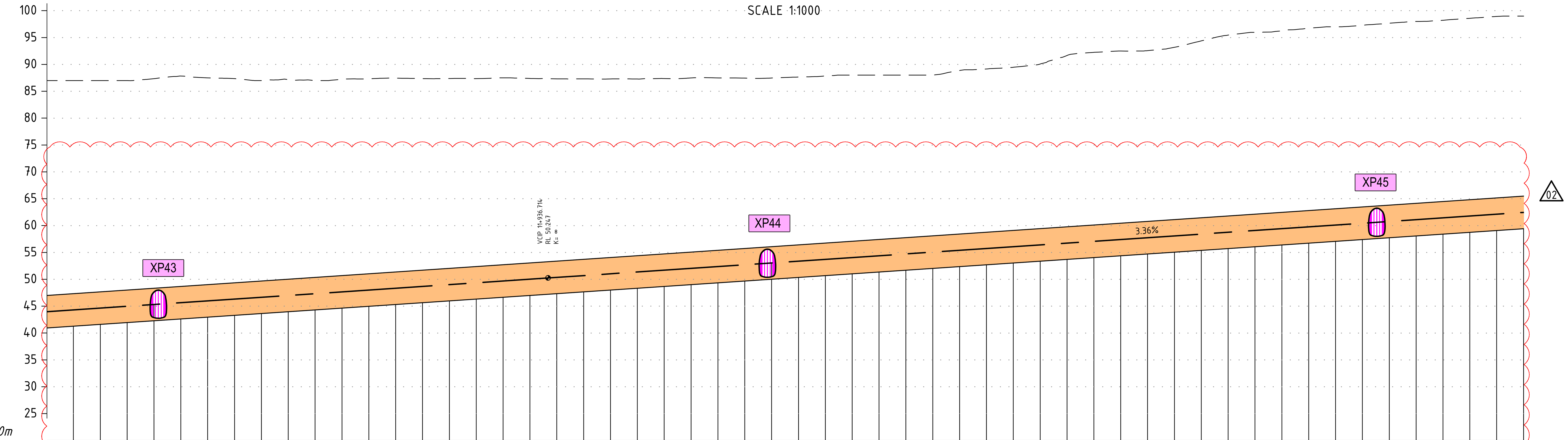
- TUNNEL ALIGNMENT CONTROL LINE
- RUNNING TUNNELS
- CROSS PASSAGES AND CROSS PASSAGES WITH SUMP
- STUB TUNNEL
- DIVE STRUCTURES
- STATION EXCAVATIONS
- NOZZLE ENLARGEMENTS
- CROSSOVER CAVERN
- STATION SHAFTS
- STATION CAVERNS
- STATION ADITS
- SHAFT
- LIFT SHAFTS

CADASTRAL MODEL (BASED ON PR124656-SACM-001-E)

- SURVEY ACCURATE CADASTRAL MODEL
- NEAR SURVEY ACCURATE CADASTRE
- DIGITAL CADASTRAL DATABASE

PLAN

SCALE 1:1000



DATUM R.L 20.0m

HORIZONTAL ALIGNMENT: L=108.239 SPIRAL; D=124.794; L=101.888 SPIRAL; L=148.688 R=505.138

VERTICAL ALIGNMENT: P=3.36% L=424.517; P=3.36% L=446.530

KILOMETRAGE	TUNNEL CENTRE LEVEL	EXISTING LEVELS
11km 750.000	43.971	87.000
11km 760.000	44.307	87.000
11km 770.000	44.643	86.994
11km 780.000	44.979	87.000
11km 790.000	45.315	87.343
11km 800.000	45.651	87.839
11km 810.000	45.988	87.497
11km 820.000	46.324	87.352
11km 830.000	46.660	87.000
11km 840.000	46.996	87.160
11km 850.000	47.332	87.000
11km 860.000	47.668	87.206
11km 866.912	47.901	87.296
11km 870.000	48.005	87.337
11km 880.000	48.341	87.439
11km 890.000	48.677	87.362
11km 900.000	49.013	87.384
11km 910.000	49.349	87.362
11km 920.000	49.685	87.498
11km 930.000	50.022	87.390
11km 940.000	50.358	87.316
11km 950.000	50.694	87.302
11km 960.000	51.029	87.297
11km 970.000	51.365	87.280
11km 975.151	51.538	87.354
11km 980.000	51.701	87.375
11km 990.000	52.037	87.481
12km 000.000	52.373	87.485
12km 010.000	52.709	87.449
12km 020.000	53.045	87.465
12km 030.000	53.381	87.644
12km 040.000	53.717	87.858
12km 050.000	54.053	88.000
12km 060.000	54.389	88.000
12km 070.000	54.725	88.000
12km 080.000	55.061	88.014
12km 090.000	55.396	88.866
12km 099.945	55.731	89.151
12km 100.000	55.732	89.154
12km 110.000	56.068	89.465
12km 120.000	56.404	90.078
12km 130.000	56.740	91.663
12km 140.000	57.076	92.253
12km 150.000	57.412	92.489
12km 160.000	57.748	92.568
12km 170.000	58.084	93.182
12km 180.000	58.420	94.384
12km 190.000	58.756	95.463
12km 200.000	59.092	95.975
12km 201.832	59.153	95.990
12km 210.000	59.428	96.281
12km 220.000	59.763	96.751
12km 230.000	60.099	97.000
12km 240.000	60.435	97.290
12km 250.000	60.771	97.668
12km 260.000	61.107	98.000
12km 270.000	61.443	98.221
12km 280.000	61.779	98.589
12km 290.000	62.115	98.929
12km 300.000	62.451	99.000

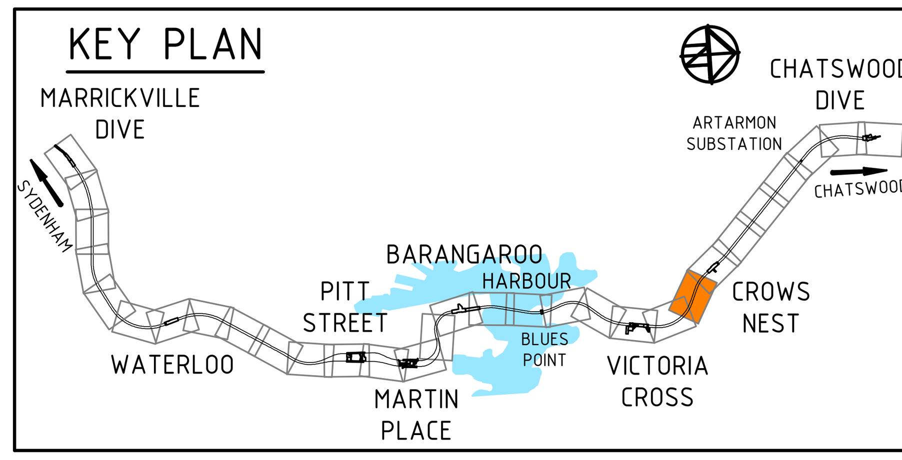
DESIGN CONTROL RT01 - UP MNW

SCALE - HORIZ. 1:1000, VERT. 1:500

NOTE

1. FOR ALL ALIGNMENT NOTES REFER DRAWING NO. SMCSWTSE-JAB-TPW-AL-DRG-505005.

KEY PLAN



DRAWING COLOUR CODED - PRINT ALL COPIES IN COLOUR

FOR CONSTRUCTION

AMD	DESCRIPTION	DESIGNER SIGN./DATE	VERIFIED SIGN./DATE	APPROVED SIGN./DATE
02	AMENDMENTS TO VERTICAL ALIGNMENT DESIGN FOR RT01 AND RT02	17.05.19	17.05.19	17.05.19
01	ASSURED FOR CONSTRUCTION	17.04.19	17.04.19	17.04.19
00	ASSURED FOR CONSTRUCTION	09.01.18	09.01.18	09.01.18

CO-ORDINATE SYSTEM: MGA | HEIGHT DATUM: AHD | SCALE: AS SHOWN

SCALES
0 10 20 30 40 50 60m — SCALE 1:1000 AT A1 SIZE
0 5 10 15 20 25 30m — SCALE 1:500 AT A1 SIZE

IC CERTIFIED - IC CERTIFICATE SMCSWTSE-IC-CER-B2-008

CLIENT
NSW GOVERNMENT — Transport for NSW

SERVICE PROVIDERS: JOHN HOLLAND, CPB, Ghella; ARCADIS; BG&E; NOMA CONSULTING; HOCHTIEF; PSM; McMILLEN JACOBS ASSOCIATES

DRAWN	E. ESTORES JR.	17.05.19
DESIGNED	TINSW	-
DRG CHECK	F. BATHAN	17.05.19
DESIGN CHECK	N/A	-
APPROVED	D.ROBERTSON	17.05.19

SYDNEY METRO CITY & SOUTHWEST
TSE PROJECT WIDE
ALIGNMENT
GA PLAN AND LONGITUDINAL SECTION
TUNNEL ALIGNMENT CONTROL LINE RT01 - SHEET 23

FILE No. | SHEET: 39 OF 76 | A1
STATUS: FOR CONSTRUCTION | ©
DRG No. SMCSWTSE-JAB-TPW-AL-DRG-505123 | 02 | EDMS No.

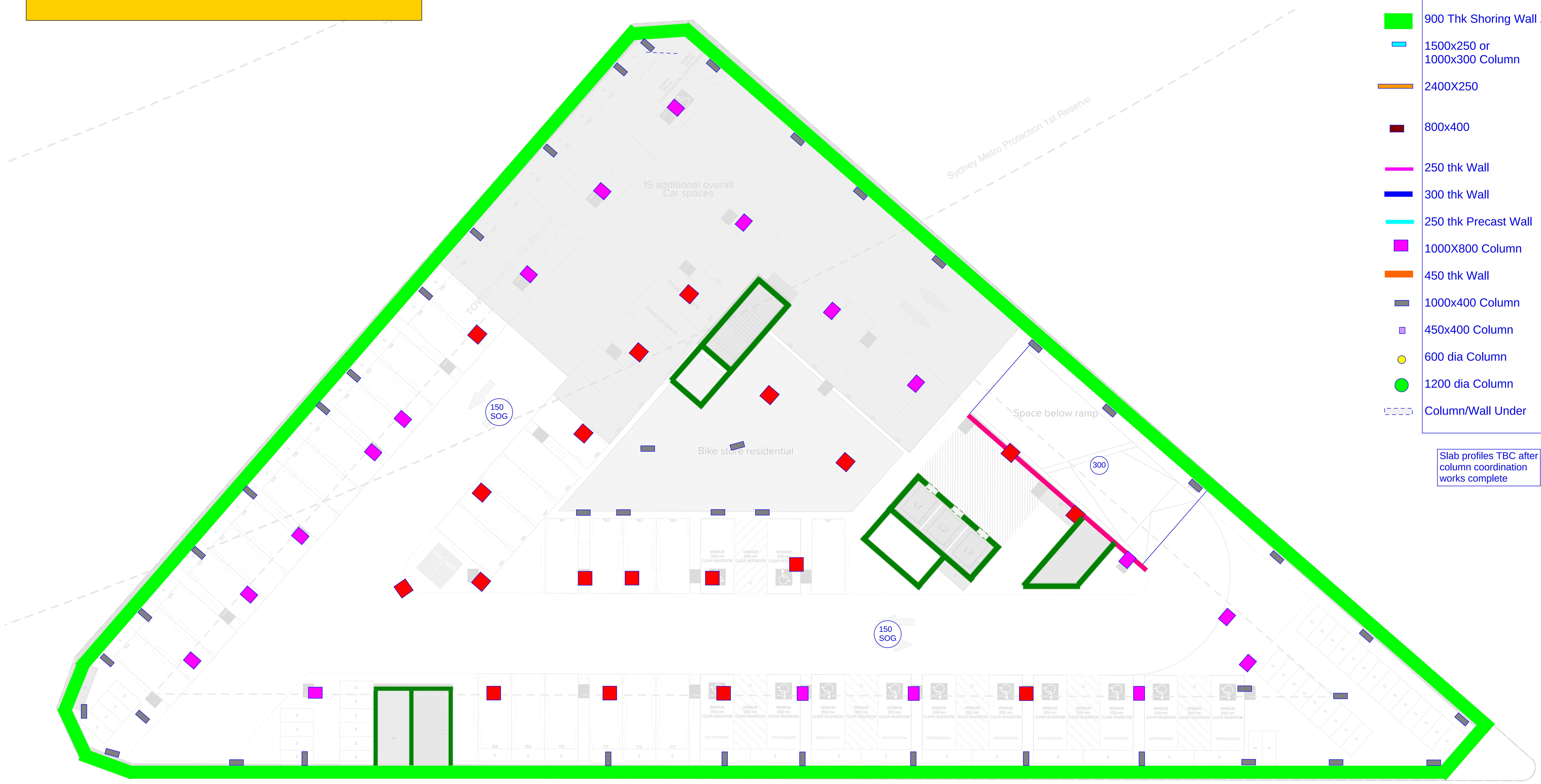
File Plotted C:\SMCSW-TSE-Export\
Plot Date & Time 5/17/2019 12:27 PM
Plotted by EE424049
DF 801*SS4

Appendix C

Structural Information

Preliminary Structural Loads Received 15/08/2023

Notes: column loads under the tower in the order of 21,000 kN service loads for the columns in red/pink on the attached schemes and 7000 kN service load for the grey columns



Preliminary Member Schedule:

- 1000x1000 Column
- 3500x600
- 400 Thk Wall
- 900 Thk Shoring Wall Zone
- 1500x250 or 1000x300 Column
- 2400X250
- 800x400
- 250 thk Wall
- 300 thk Wall
- 250 thk Precast Wall
- 1000X800 Column
- 450 thk Wall
- 1000x400 Column
- 450x400 Column
- 600 dia Column
- 1200 dia Column
- Column/Wall Under

Slab profiles TBC after column coordination works complete

NOTE: DO NOT SCALE OFF DRAWINGS. REFER TO ARCHITECTURAL PLANS. VERIFY DIMENSIONS ON SITE

REV	DATE	DESCRIPTION	BY
P6	15/8/23	Issued for Comment	RC
P5	31/7/23	Issued for Comment	RC
P4	24/05/23	Issued for Comment	RC
P3	03/04/23	Issued for Comment	RC

CLIENT: DEICORP

abc CONSULTANTS structural&civilengineers
Phone: (02) 9746 9201
Fax: (02) 9746 9207
Email: info@abc-consultants.com.au
Web: www.abc-consultants.com.au
Street address: Suite 2, Level 1, Building C, 1 Homebush Bay Drive, RHODES NSW 2138
Postal Address: PO Box 3339, NORTH STRATHFIELD NSW 2137

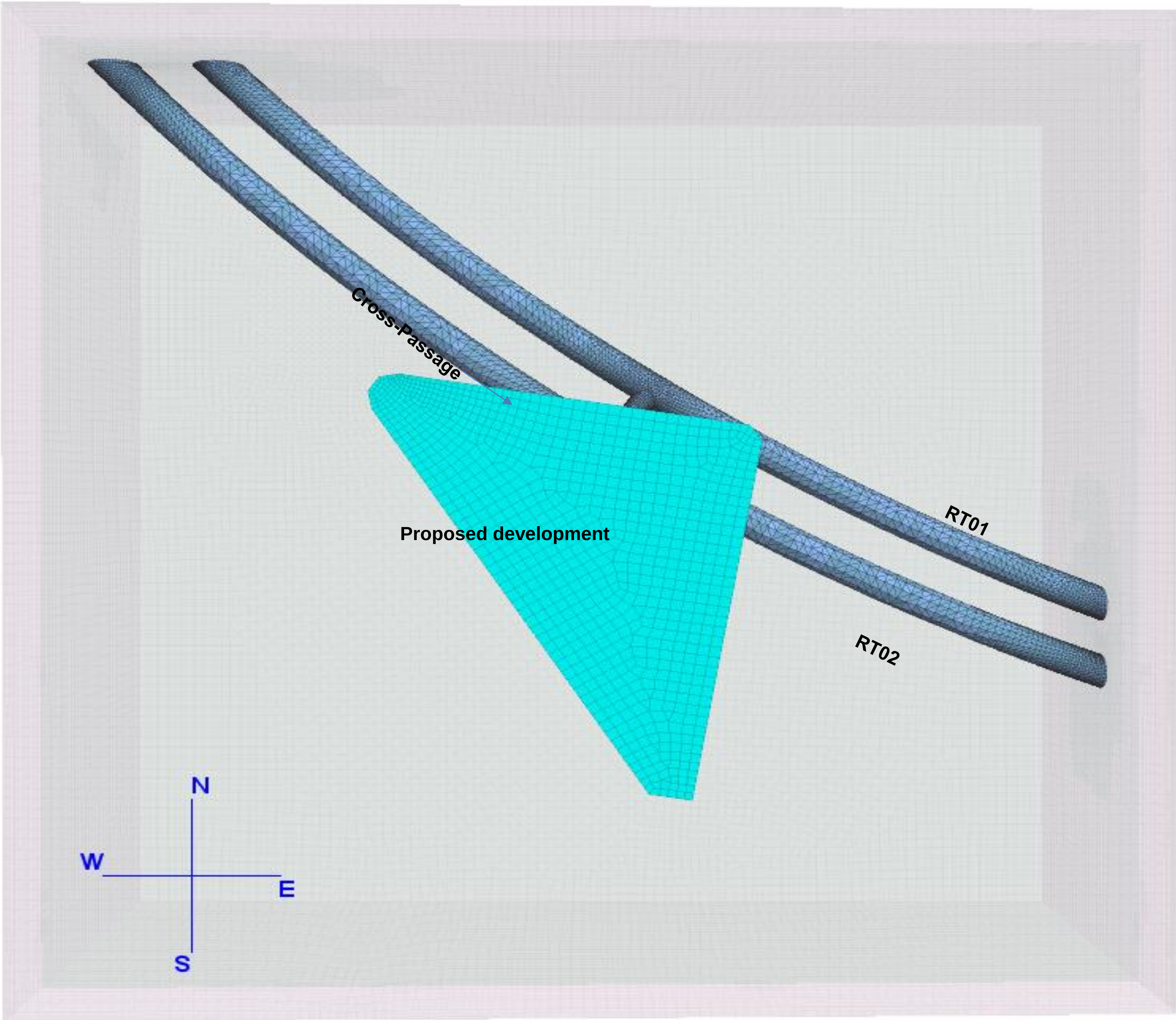
Fiveways, Crows Nest

Concrete Profile -B6

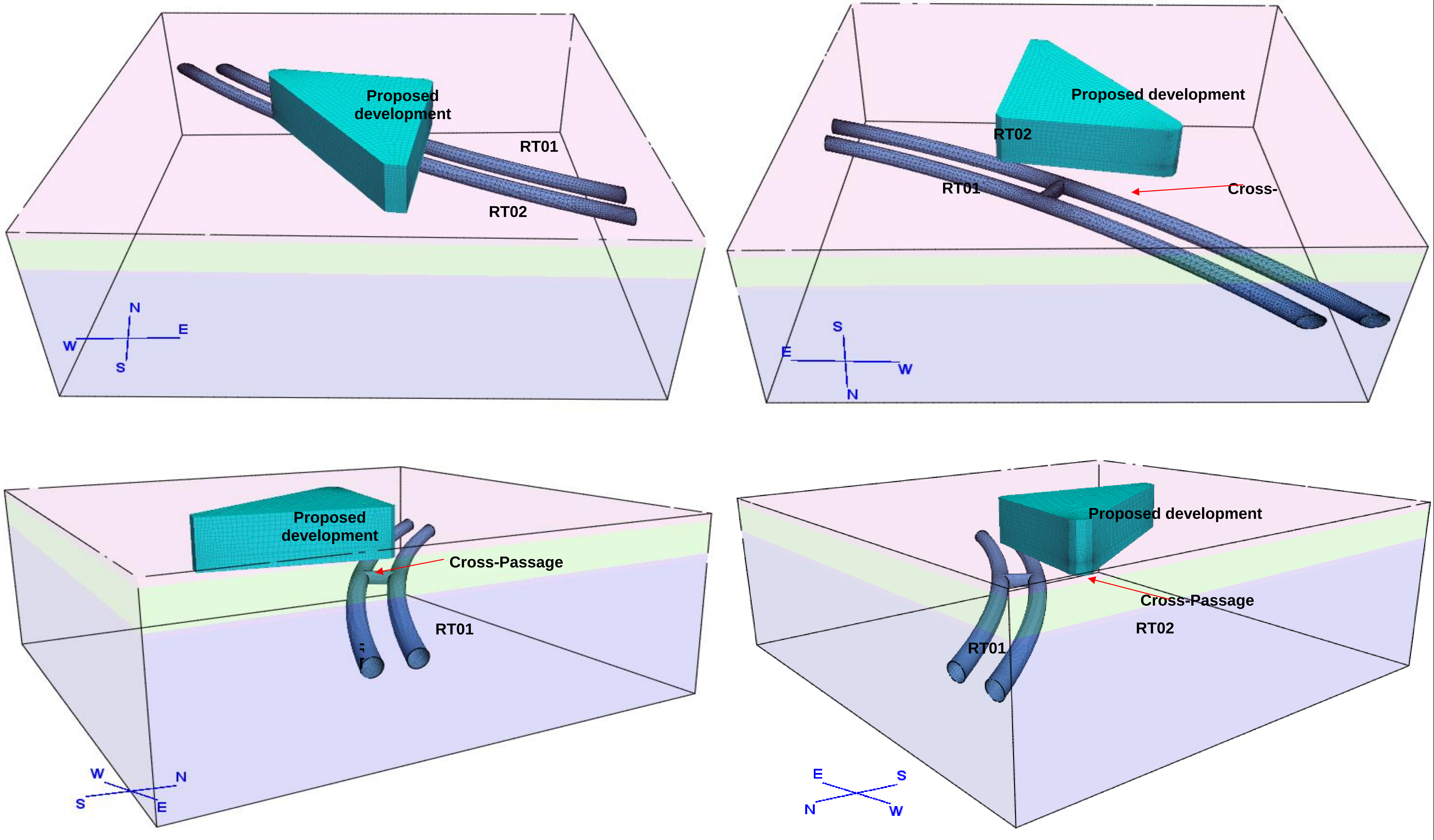
JOB NUMBER: 22091	DWG NUMBER: SK - B6	ORIGINAL SIZE: A0
DESIGNED BY: RC	DATE: Mar 23	
DRAWN BY: RC	SCALE: 1:100 @ A0	

Appendix D

Numerical Analysis Results

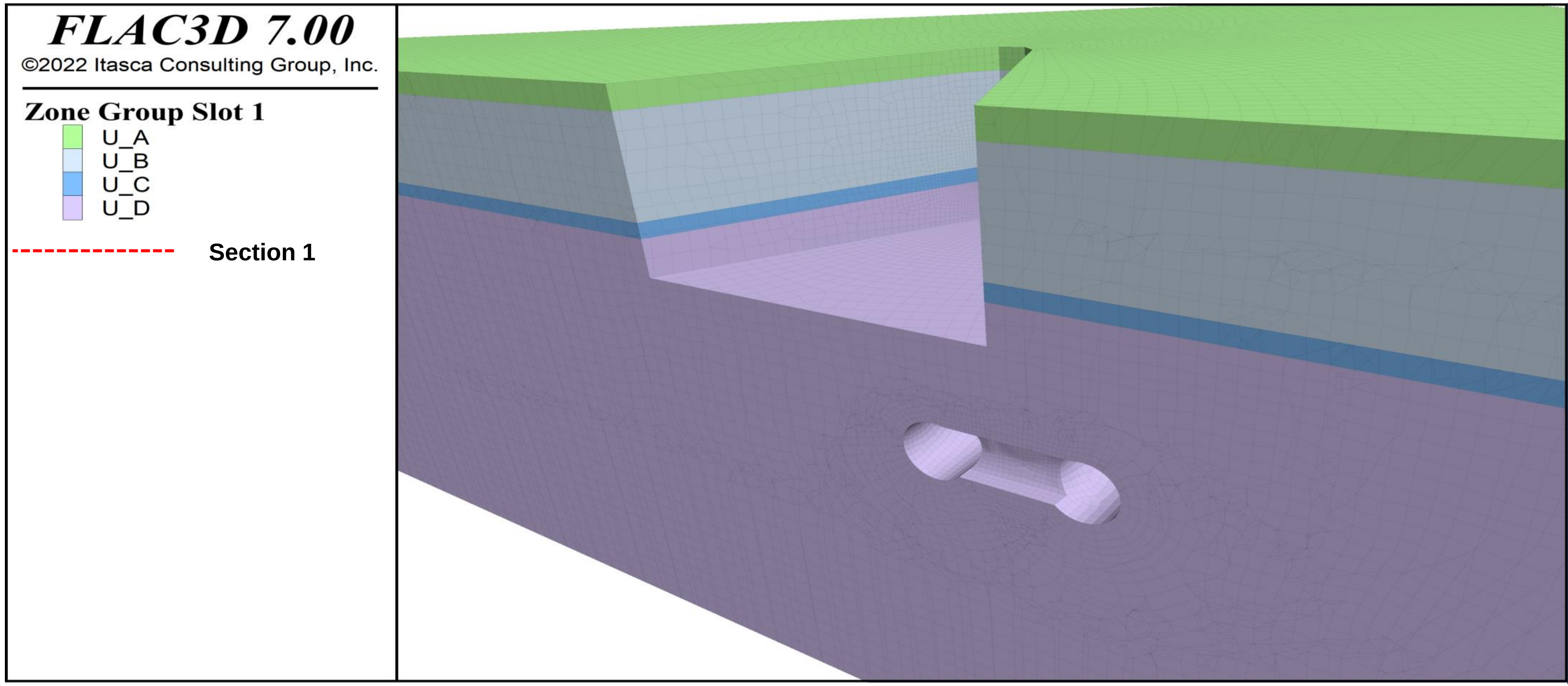


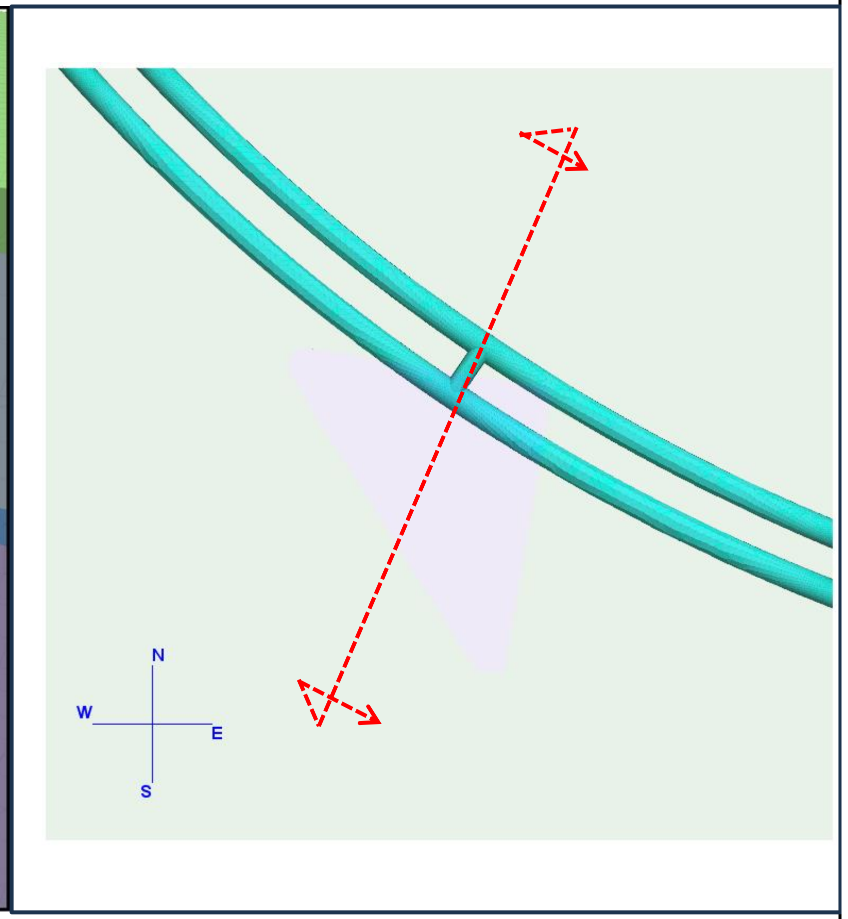
Douglas Partners Geotechnics / Environment / Groundwater	CLIENT:	Deicorp Pty Ltd	TITLE:	**Conceptual Geometry Plot**	PROJECT No:	86645.03
	OFFICE:	Sydney		**3D Numerical Analysis**	PLOT No:	1
	DATE:	6 Sep 2023		**Fiveways Project, Crows Nest**	REVISION:	1



Douglas Partners
Geotechnics / Environment / Groundwater

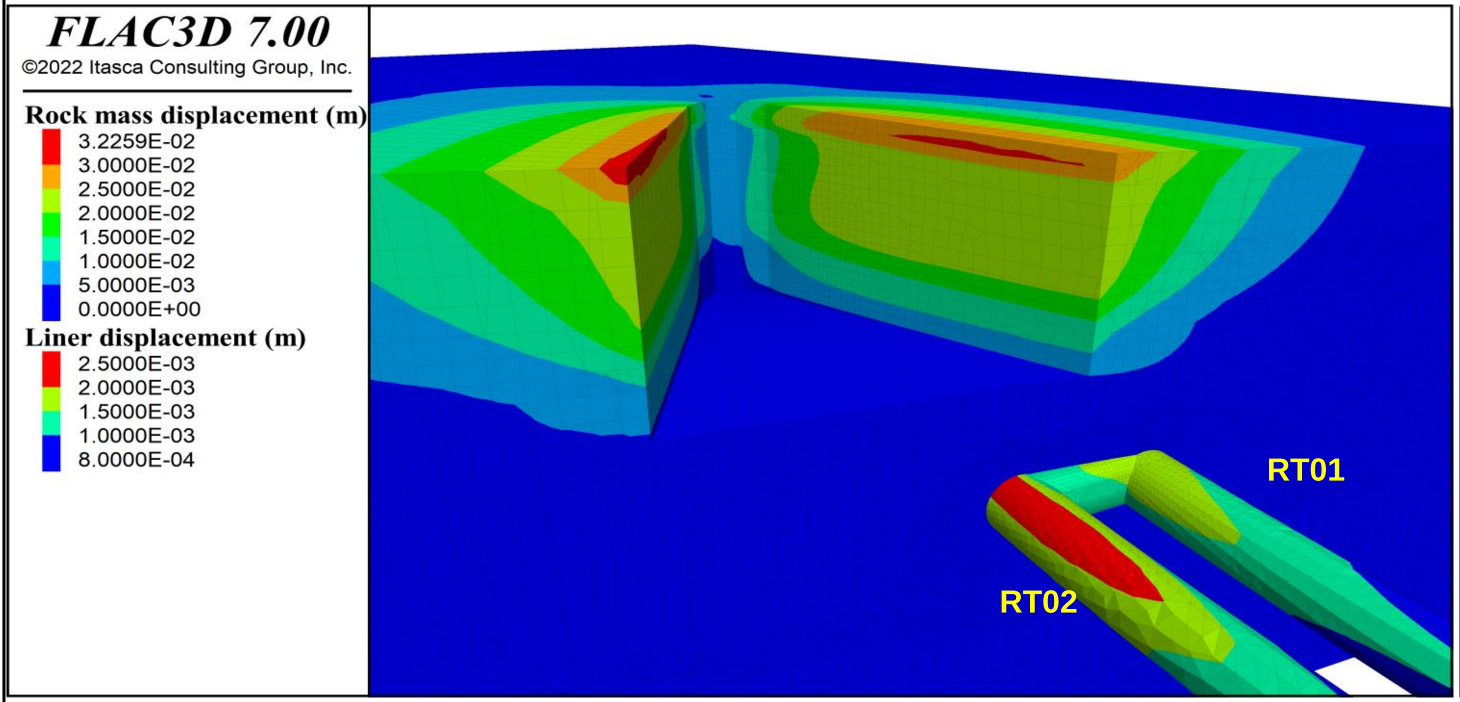
CLIENT: Deicorp Pty Ltd	TITLE: Perspective Views	PROJECT No:	86645.03
OFFICE: Sydney	3D Numerical Analysis	PLOT No:	2
DATE: 6 Sep 2023	Fiveways Project, Crows Nest	REVISION:	1

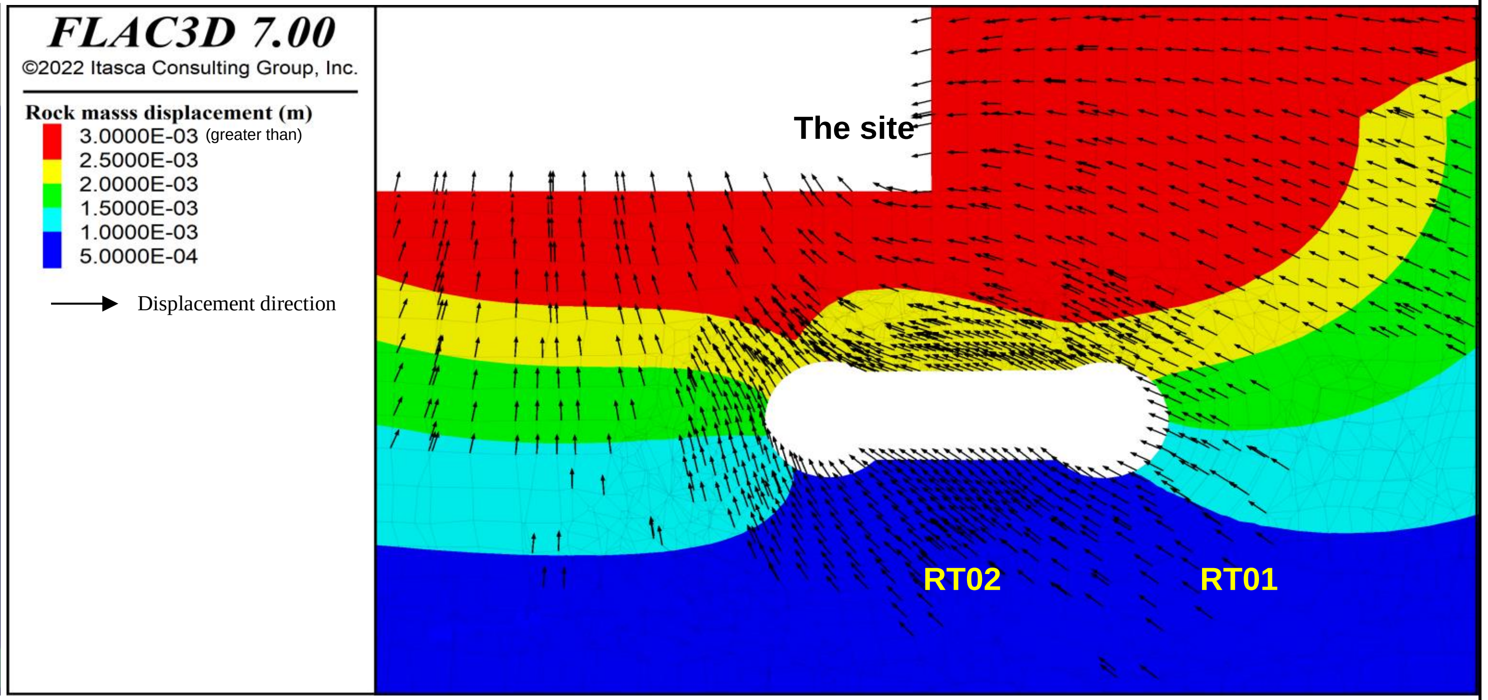




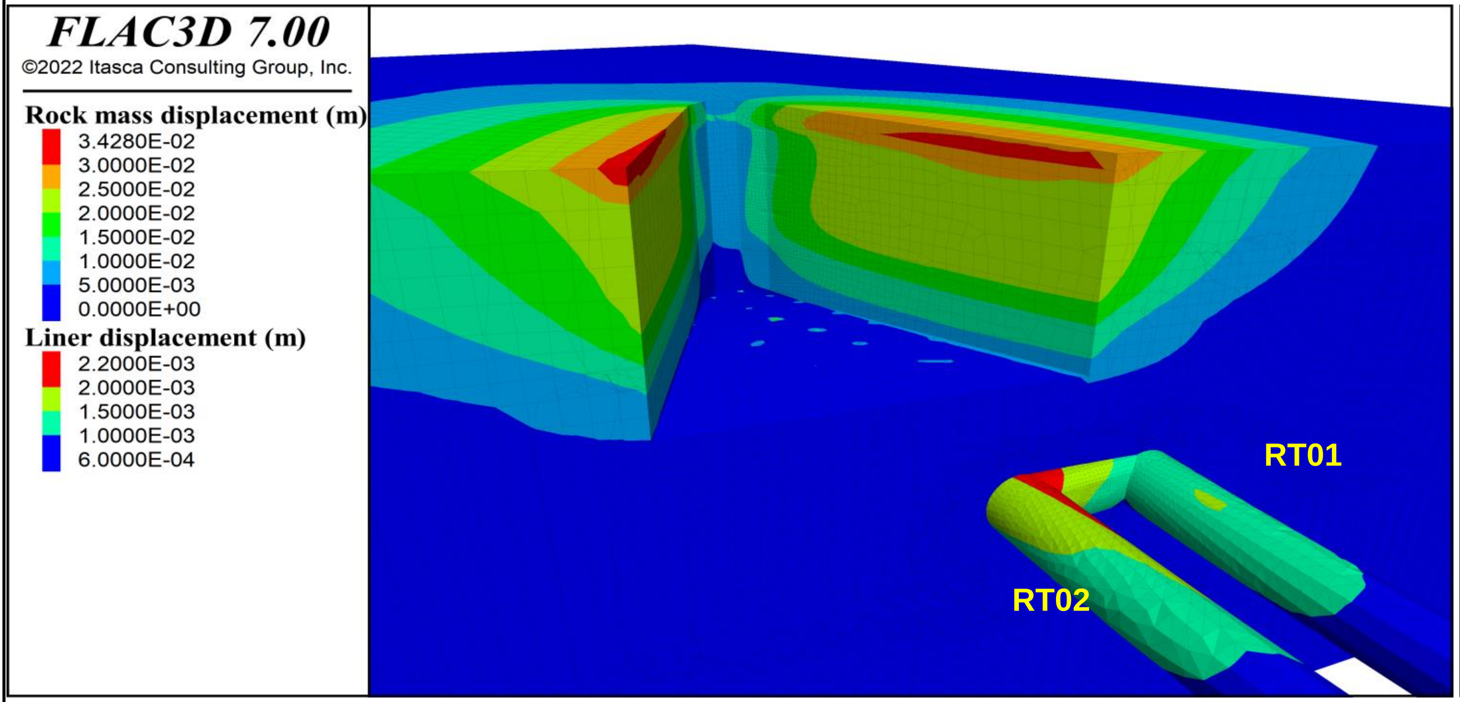
Douglas Partners Geotechnics / Environment / Groundwater	CLIENT: Deicorp Pty Ltd	TITLE:	Geotechnical Units and Section for Analysis	PROJECT No: 86645.03
	OFFICE: Sydney		3D Numerical Analysis	PLOT No: 3
	DATE: 6 Sep 2023		Fiveways Project, Crows Nest	REVISION: 1

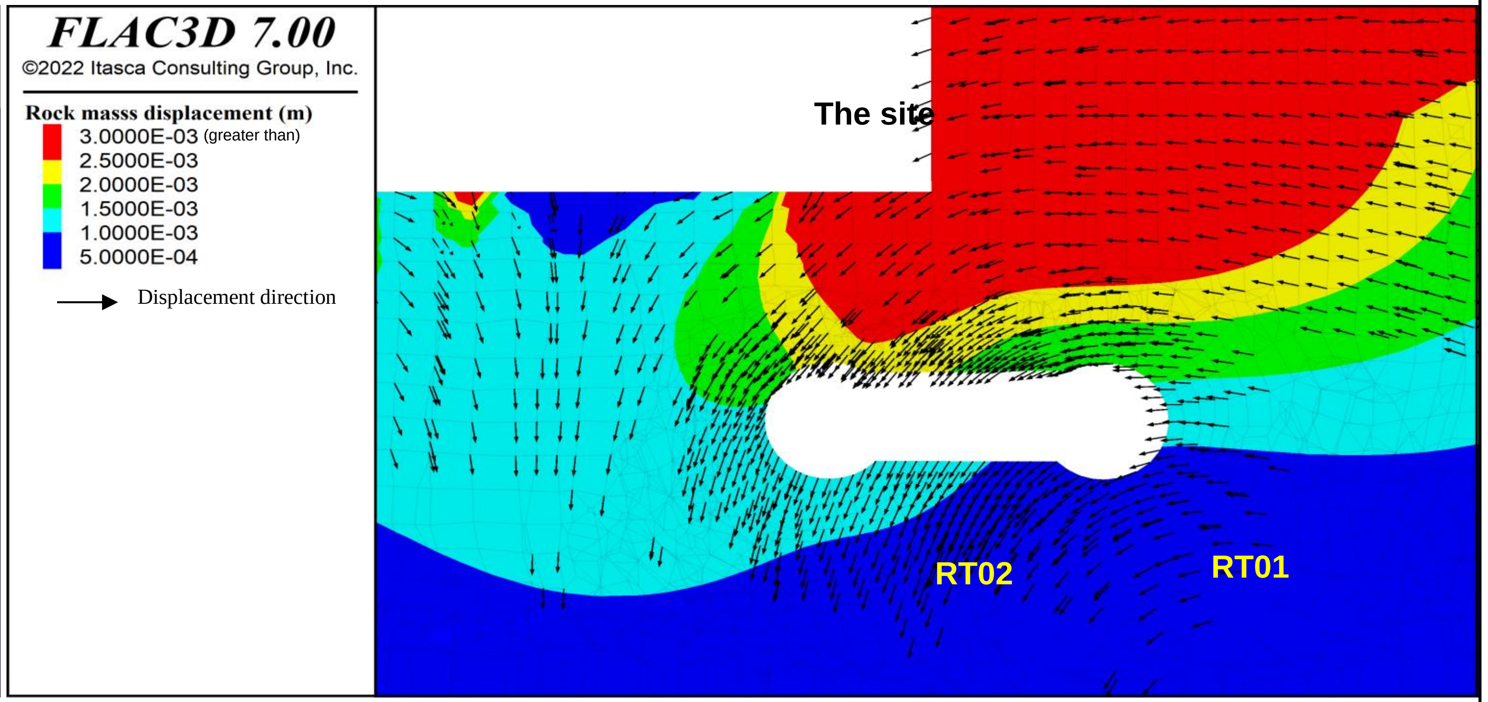
Case 1 - Stage 1 - Perspective View and Section 1 View





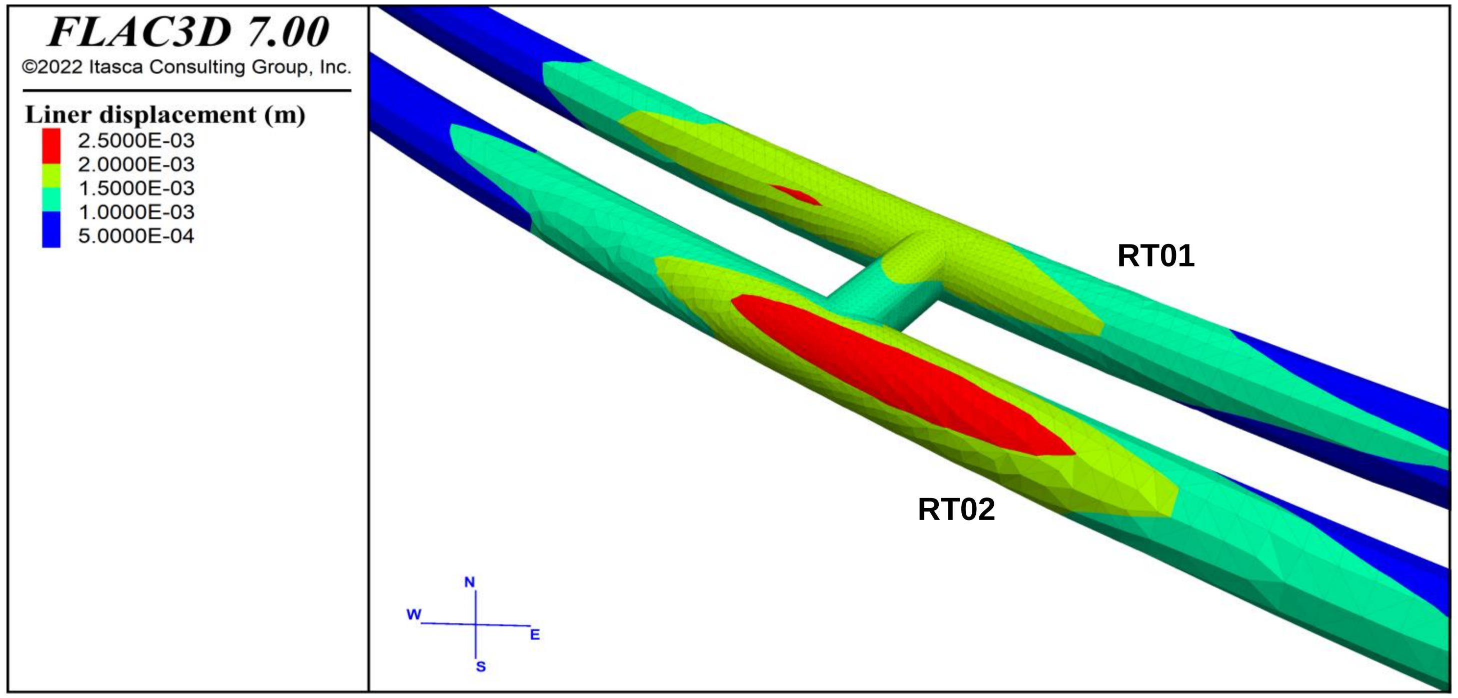
Case 1 - Stage 2 - Perspective View and Section 1 View

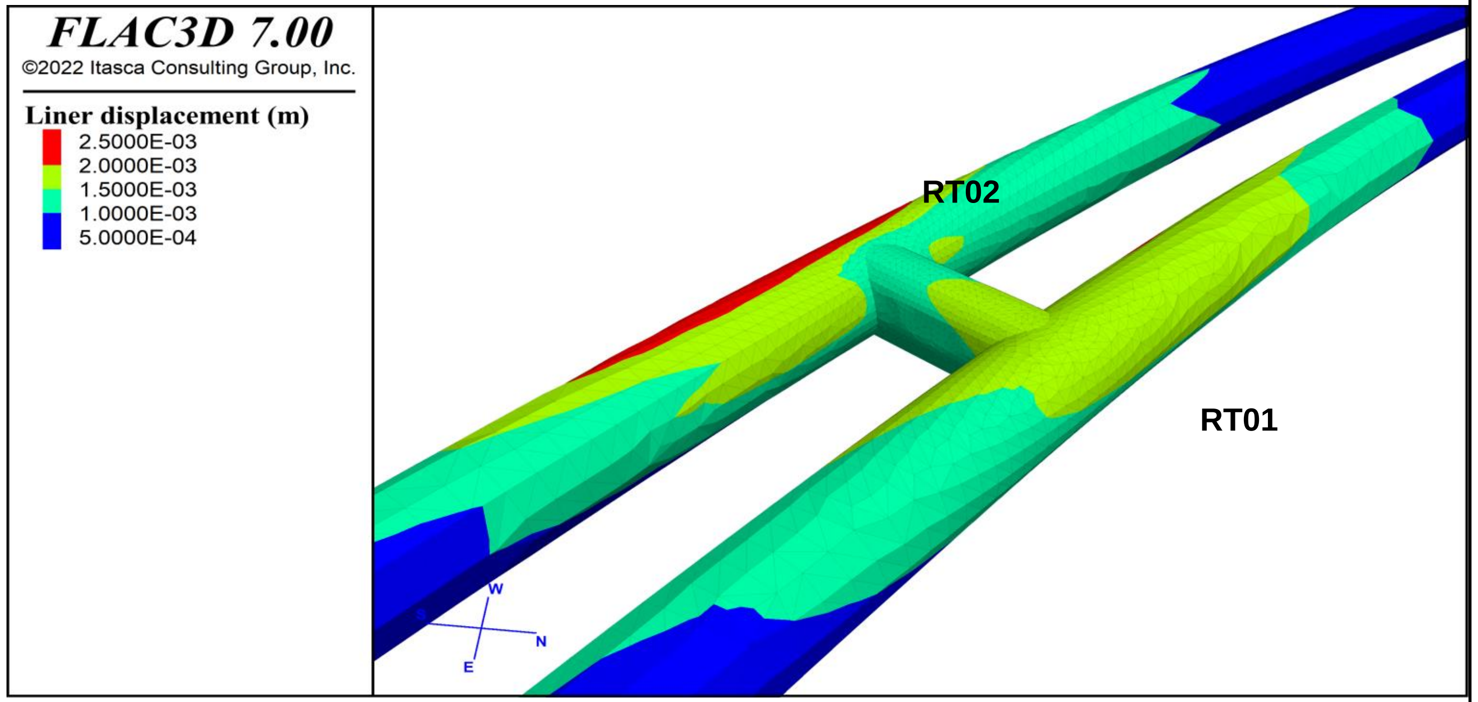




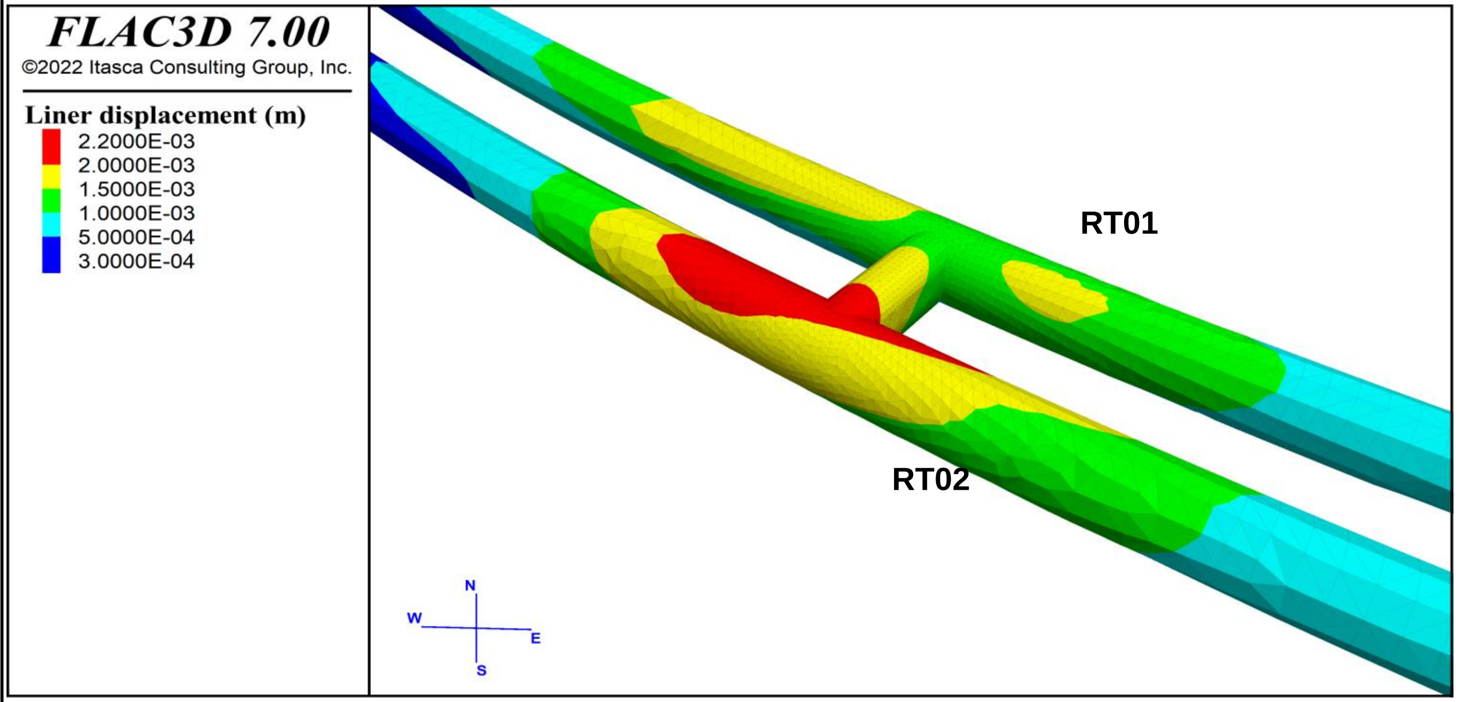
Douglas Partners Geotechnics / Environment / Groundwater	CLIENT: Deicorp Pty Ltd	TITLE: **Total Displacement (m)**	PROJECT No: 86645.03
	OFFICE: Sydney	**Case 1 - Stage 1 & 2 - Section 1**	PLOT No: 4
	DATE: 6 Sep 2023	**Fiveways Project, Crows Nest**	REVISION: 1

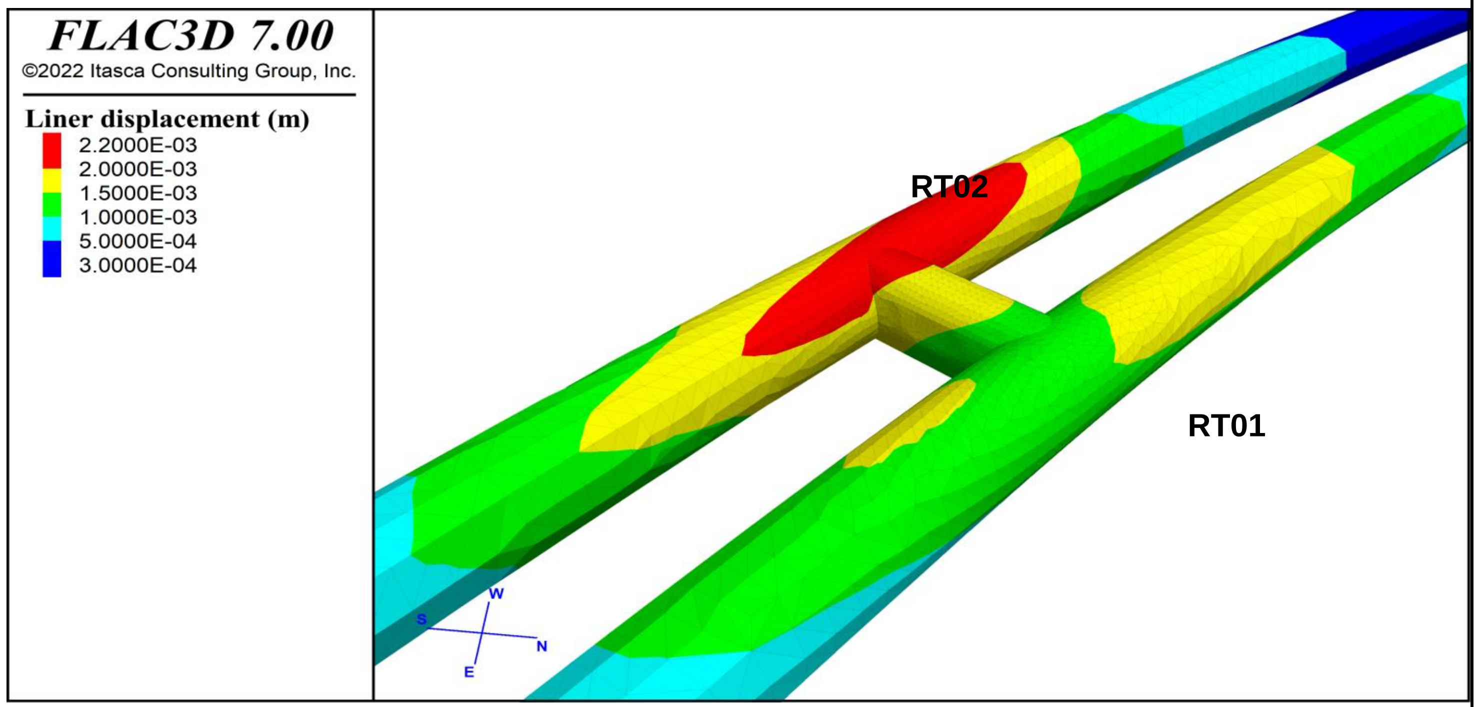
Case 1 - Stage 1 - Perspective Views





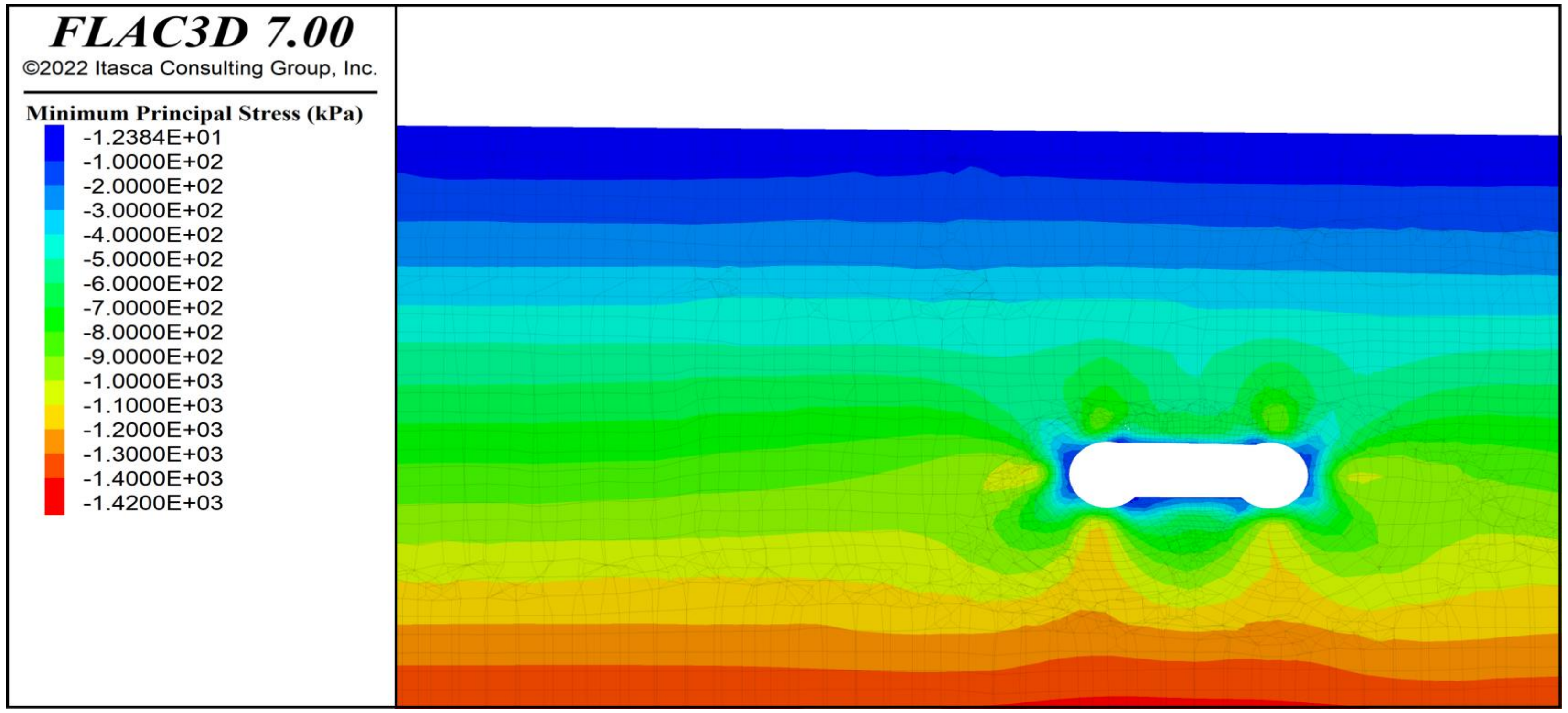
Case 1 - Stage 2 - Perspective Views



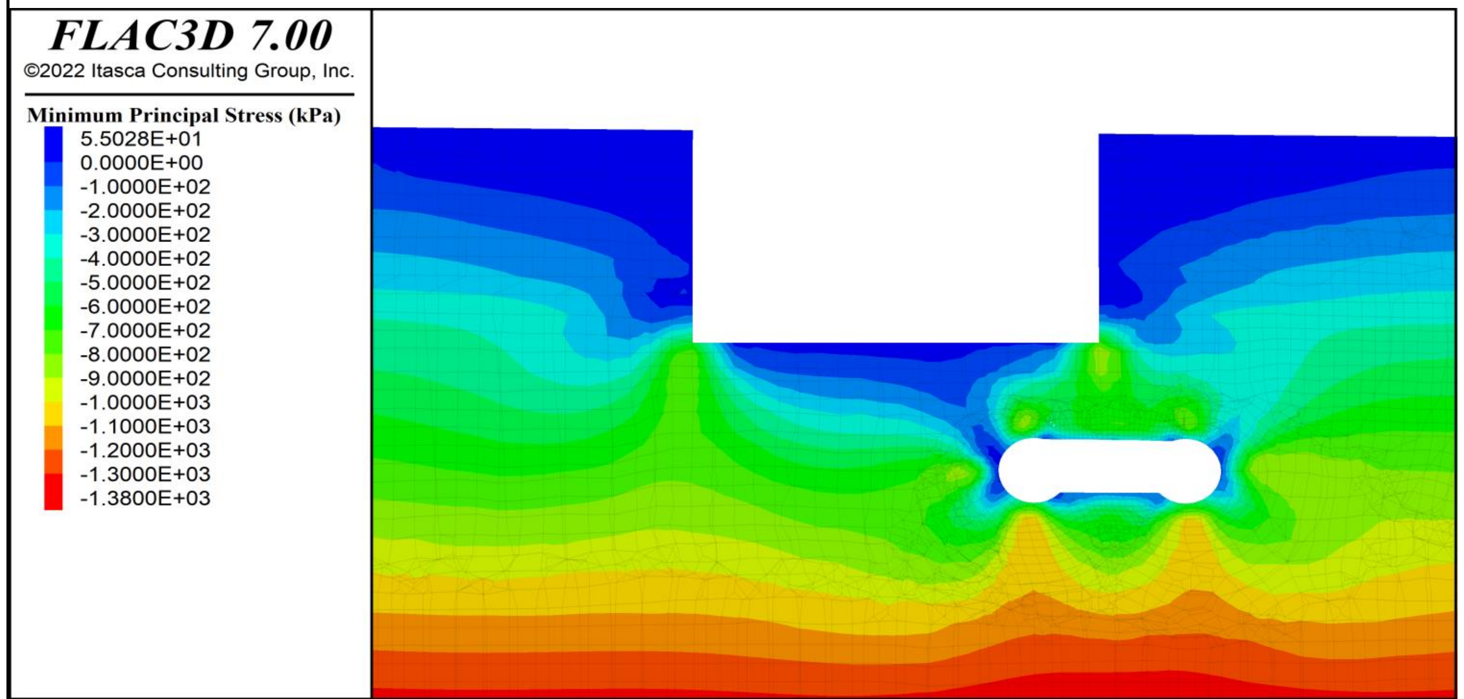


Douglas Partners Geotechnics / Environment / Groundwater	CLIENT: Deicorp Pty Ltd	TITLE:	**Total Displacement (m)**	PROJECT No: 86645.03
	OFFICE: Sydney		**Case 1 - Stage 1 & 2**	PLOT No: 5
	DATE: 6 Sep 2023		**Fiveways Project, Crows Nest**	REVISION: 1

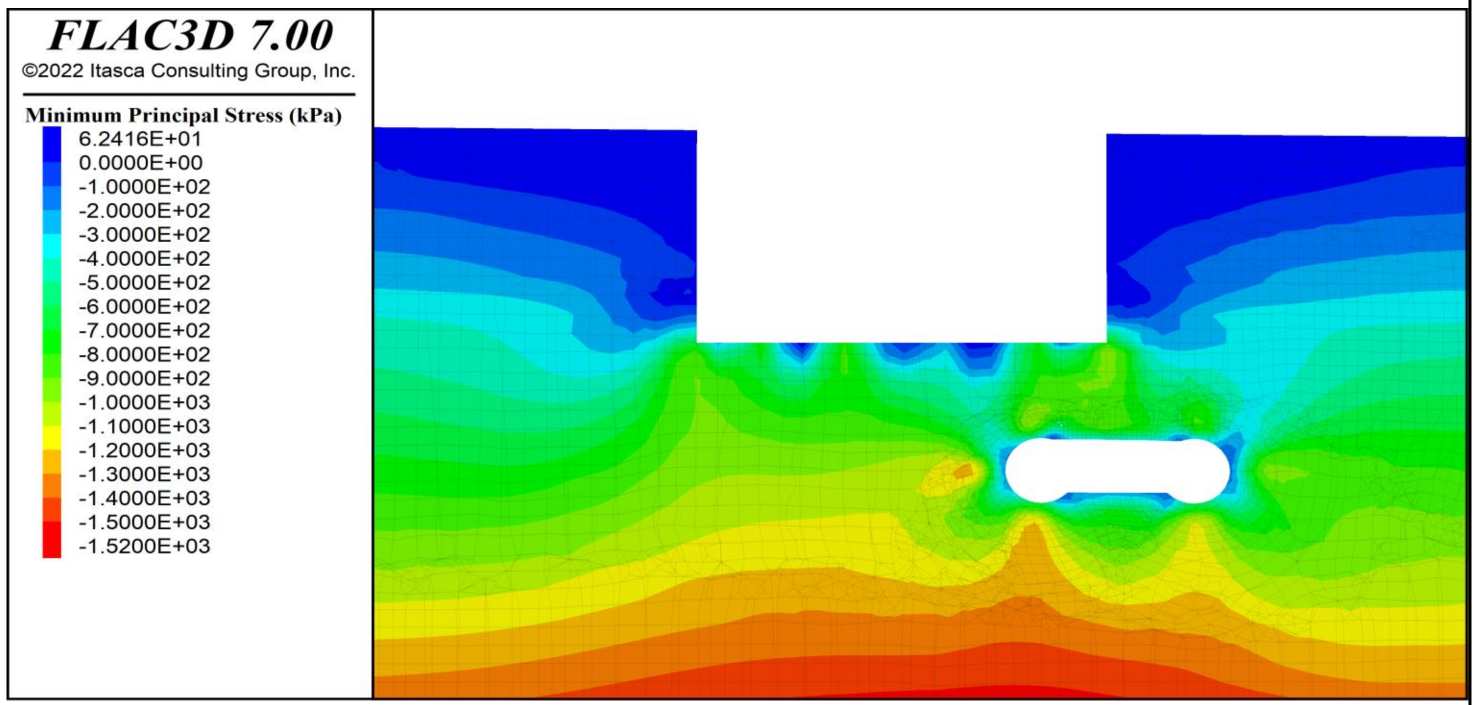
Case 1 - Stage 0 - Section 1



Case 1 - Stage 1 - Section 1



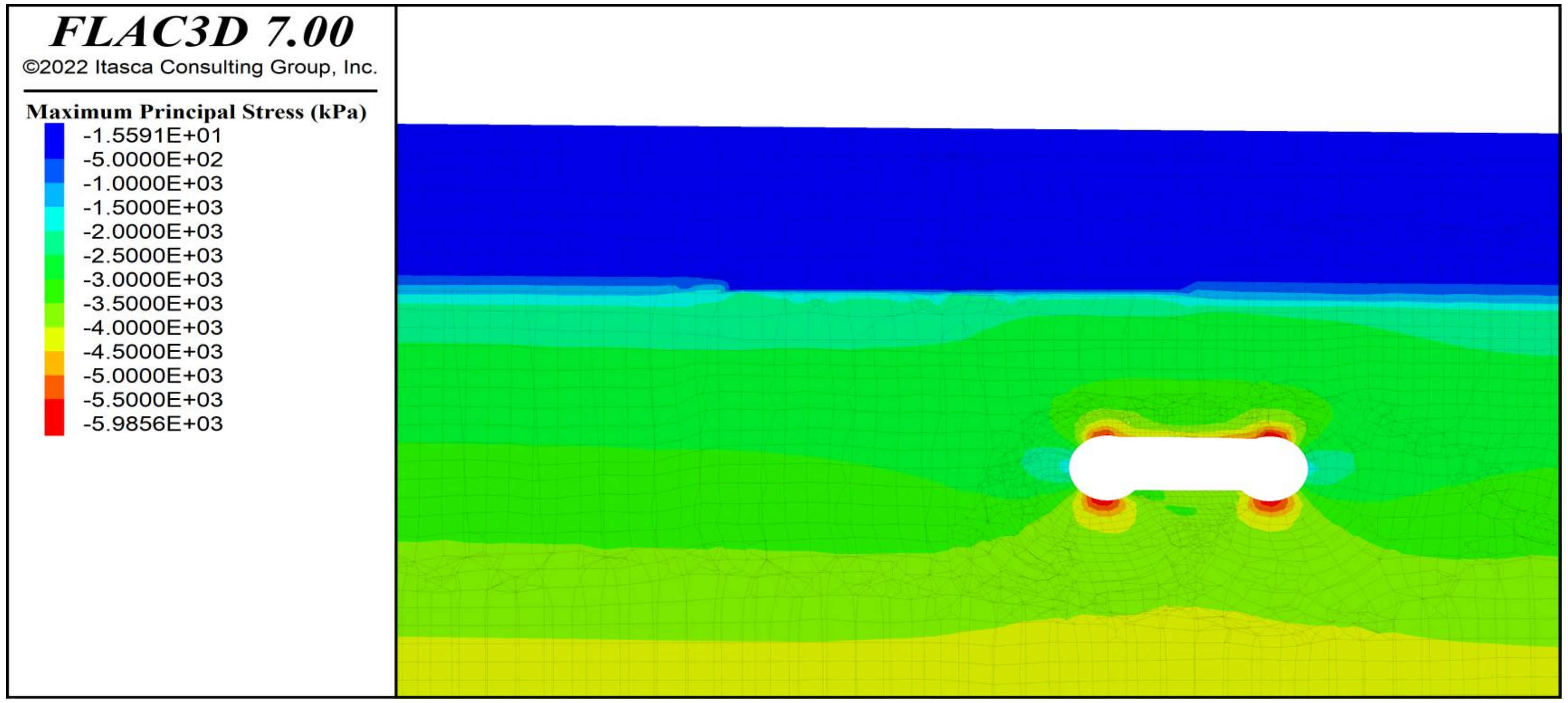
Case 1 - Stage 2 - Section 1



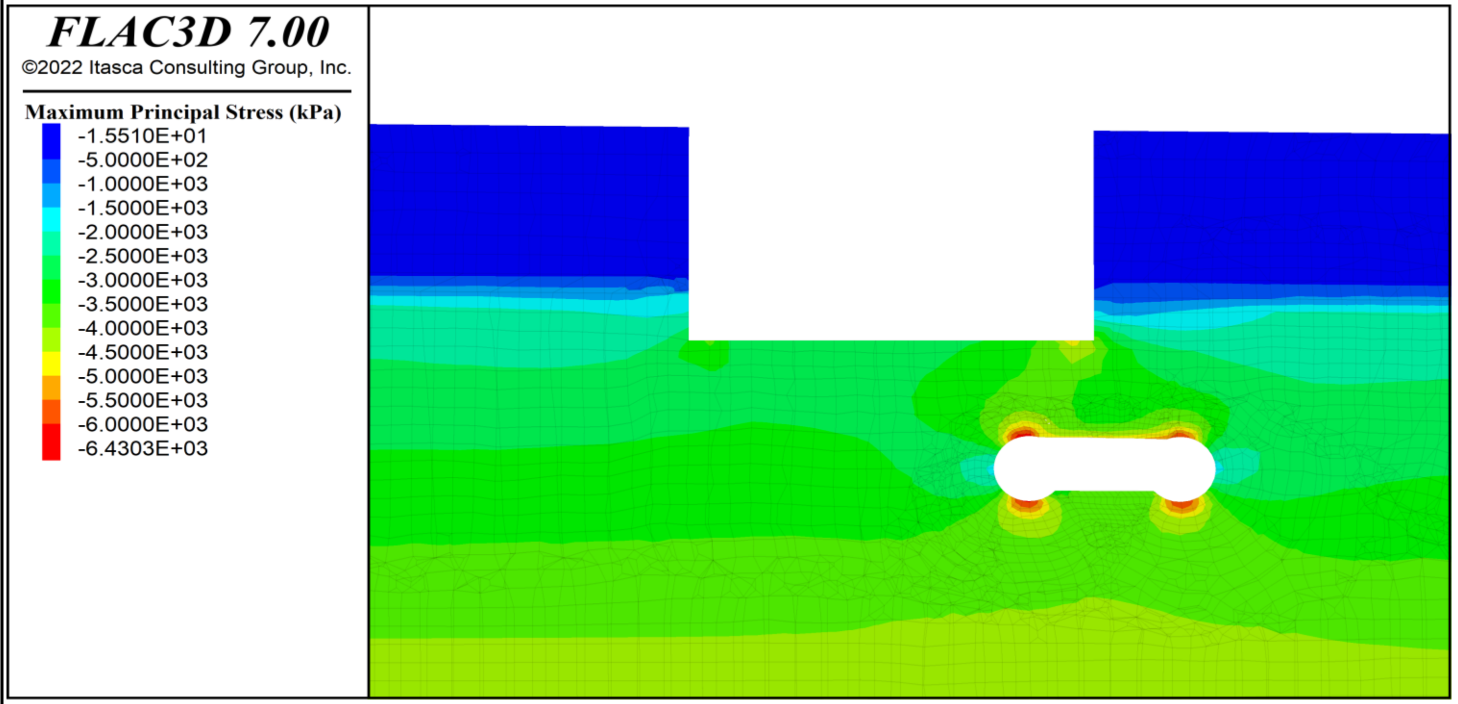
Douglas Partners
Geotechnics | Environment | Groundwater

CLIENT: Deicorp Pty Ltd	TITLE: **Minimum Principal Stress (kPa)**	PROJECT No:	86645.03
OFFICE: Sydney	**Case 1 - Stage 0, 1 & 2**	PLOT No:	6
DATE: 6 Sep 2023	**Fiveways Project, Crows Nest**	REVISION:	1

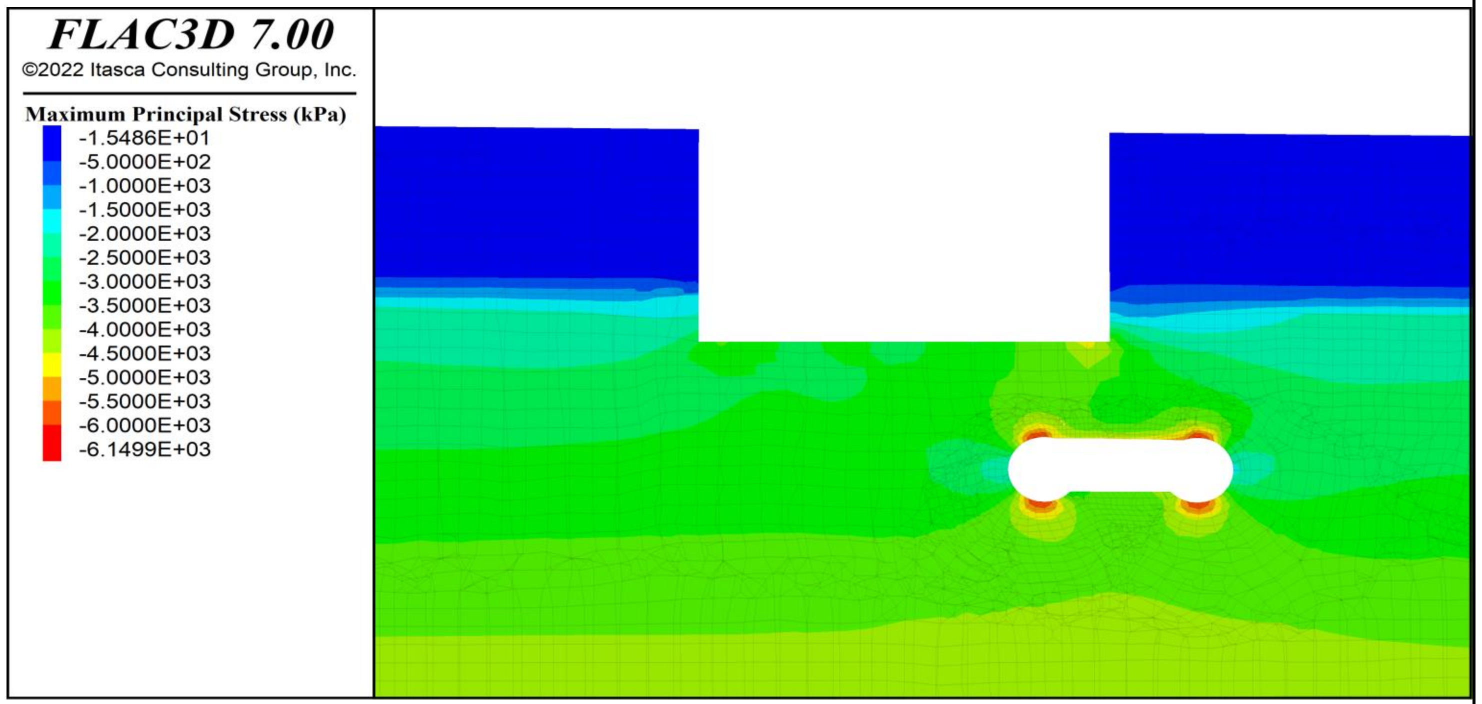
Case 1 - Stage 0 - Section 1



Case 1 - Stage 1 - Section 1

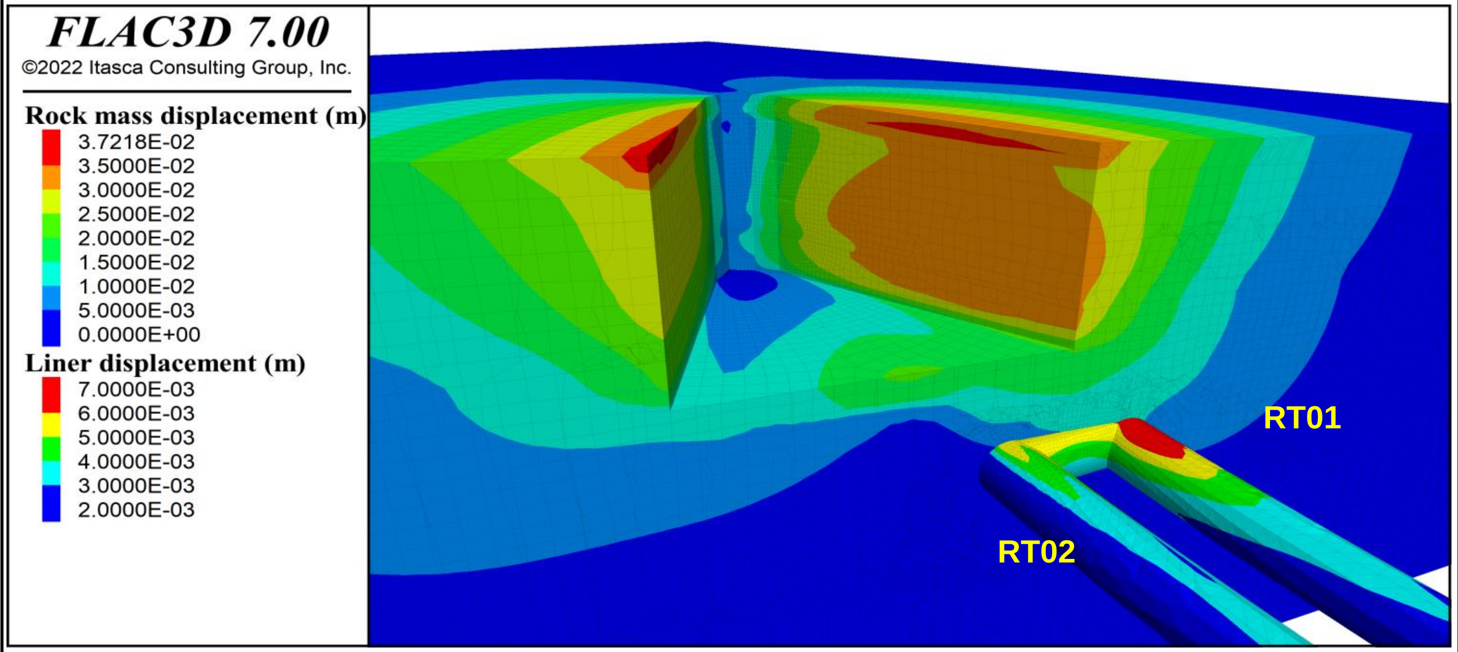


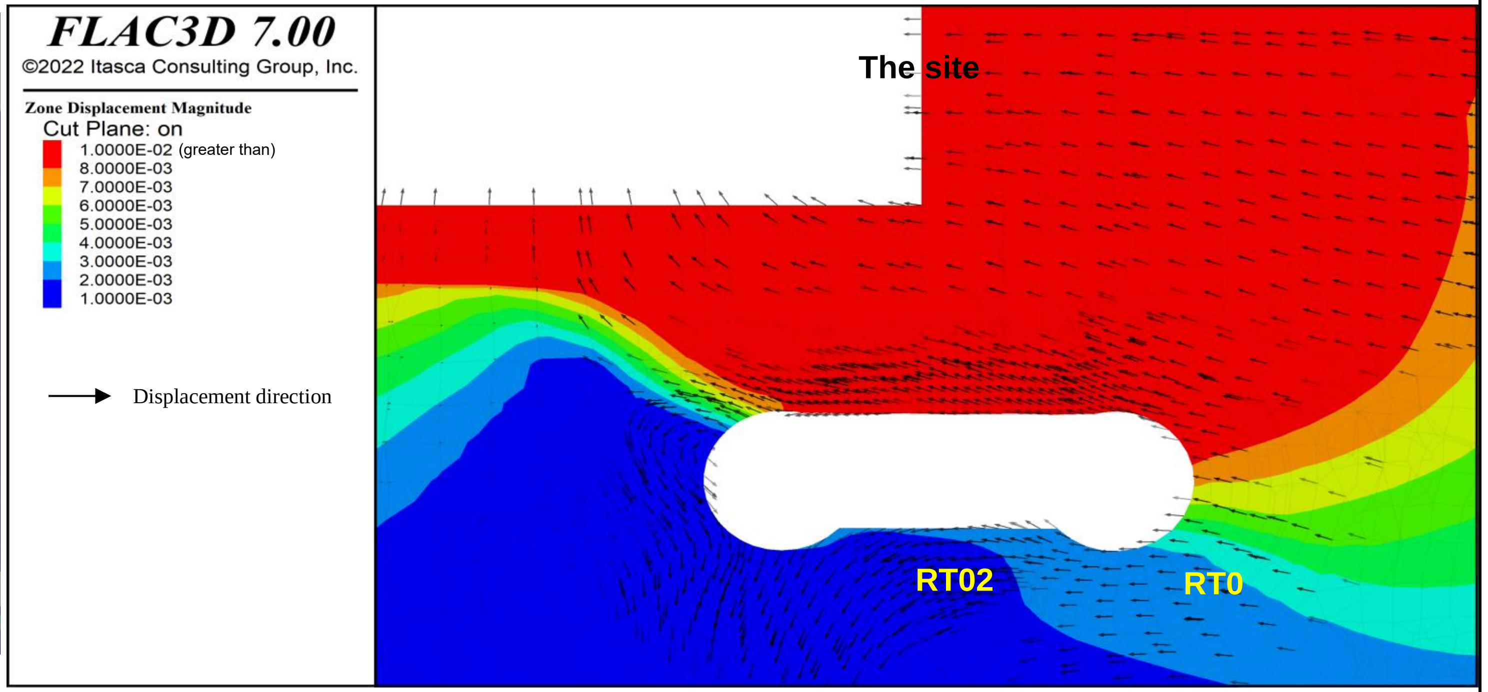
Case 1 - Stage 2 - Section 1



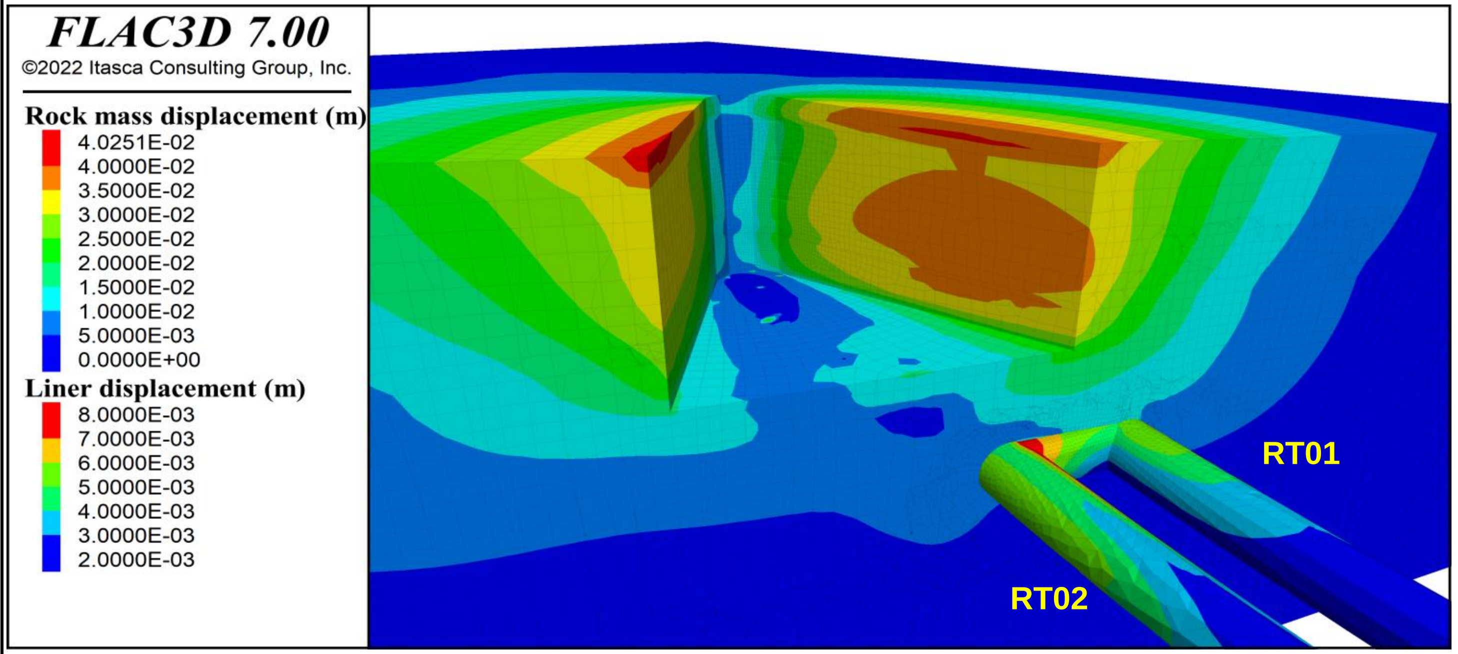
Douglas Partners Geotechnics / Environment / Groundwater	CLIENT: Deicorp Pty Ltd	TITLE: **Maximum Principal Stress (kPa)**	PROJECT No: 86645.03
	OFFICE: Sydney	**Case 1 - Stage 0, 1 & 2**	PLOT No: 7
	DATE: 6 Sep 2023	**Fiveways Project, Crows Nest**	REVISION: 1

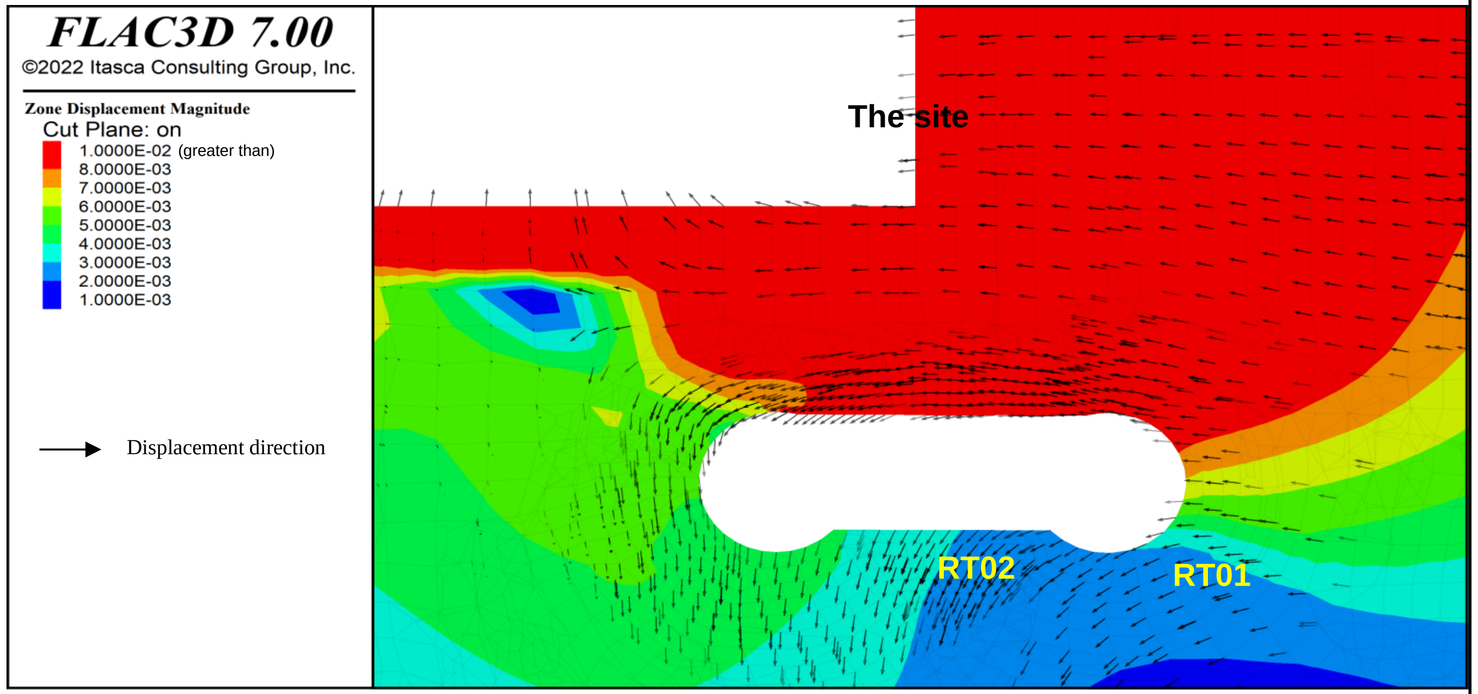
Case 2 - Stage 1 - Perspective View and Section 1 View





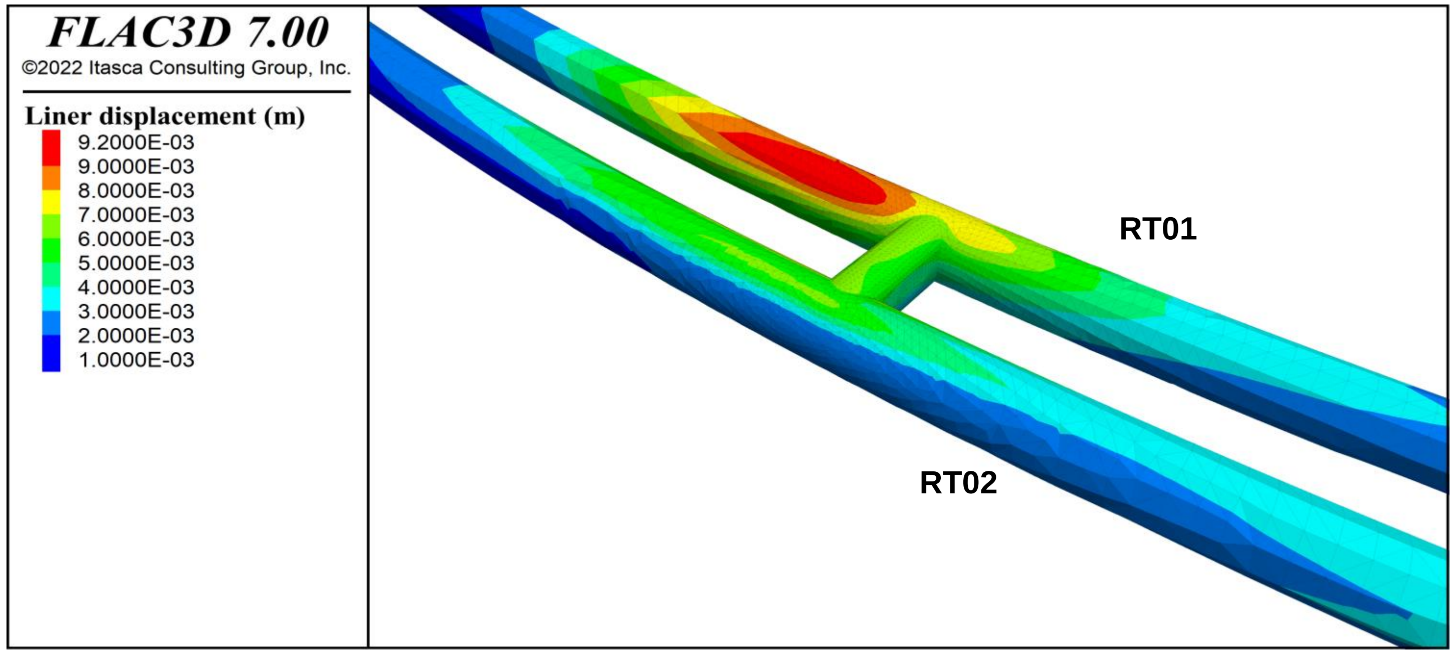
Case 2 - Stage 2 - Perspective View and Section 1 View

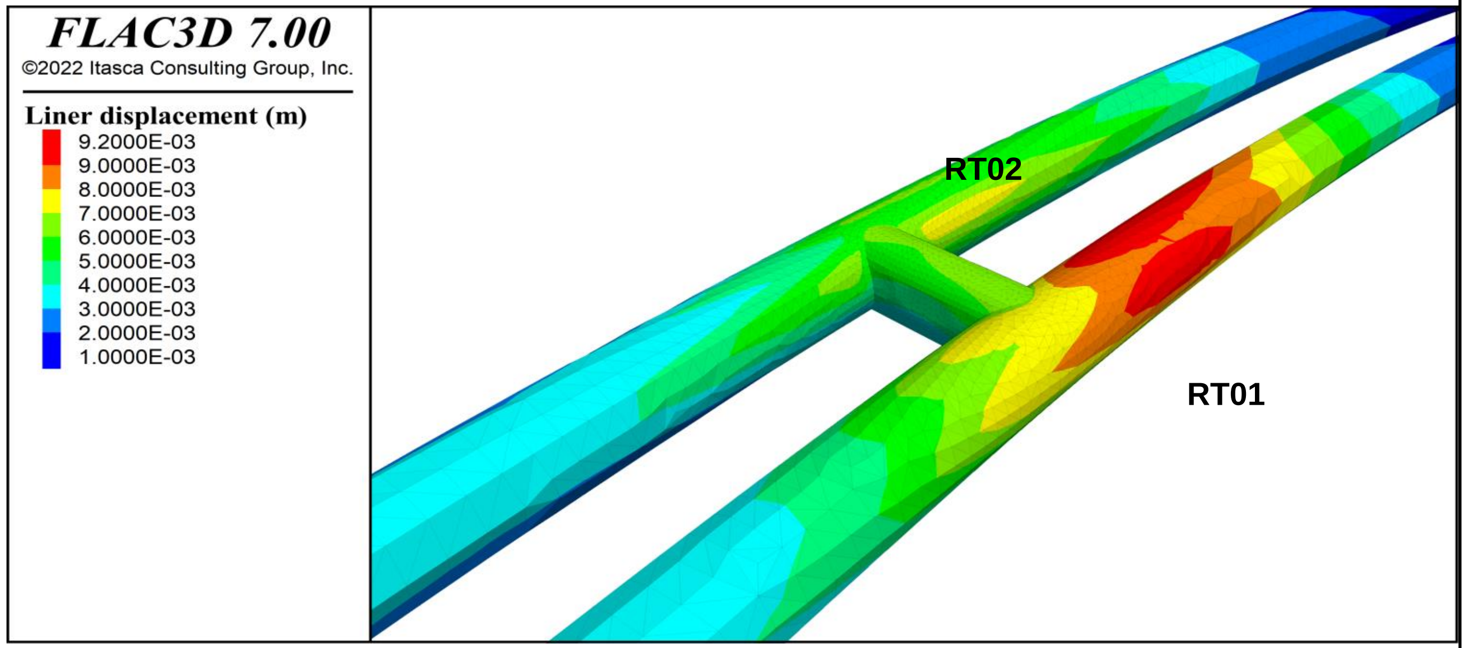




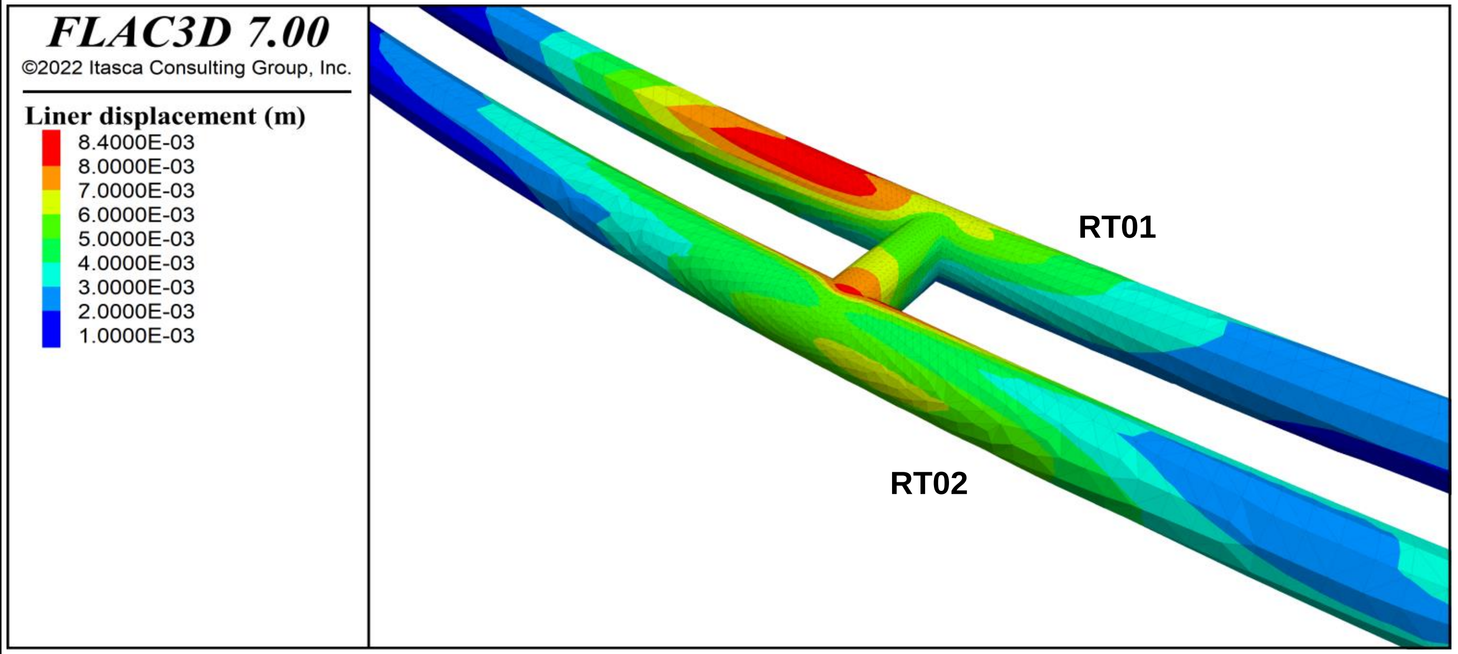
Douglas Partners Geotechnics / Environment / Groundwater	CLIENT: Deicorp Pty Ltd	TITLE: **Total Displacement (m)**	PROJECT No: 86645.03
	OFFICE: Sydney	**Case 2 - Stage 1 & 2 - Section 1**	PLOT No: 8
	DATE: 6 Sep 2023	**Fiveways Project, Crows Nest**	REVISION: 1

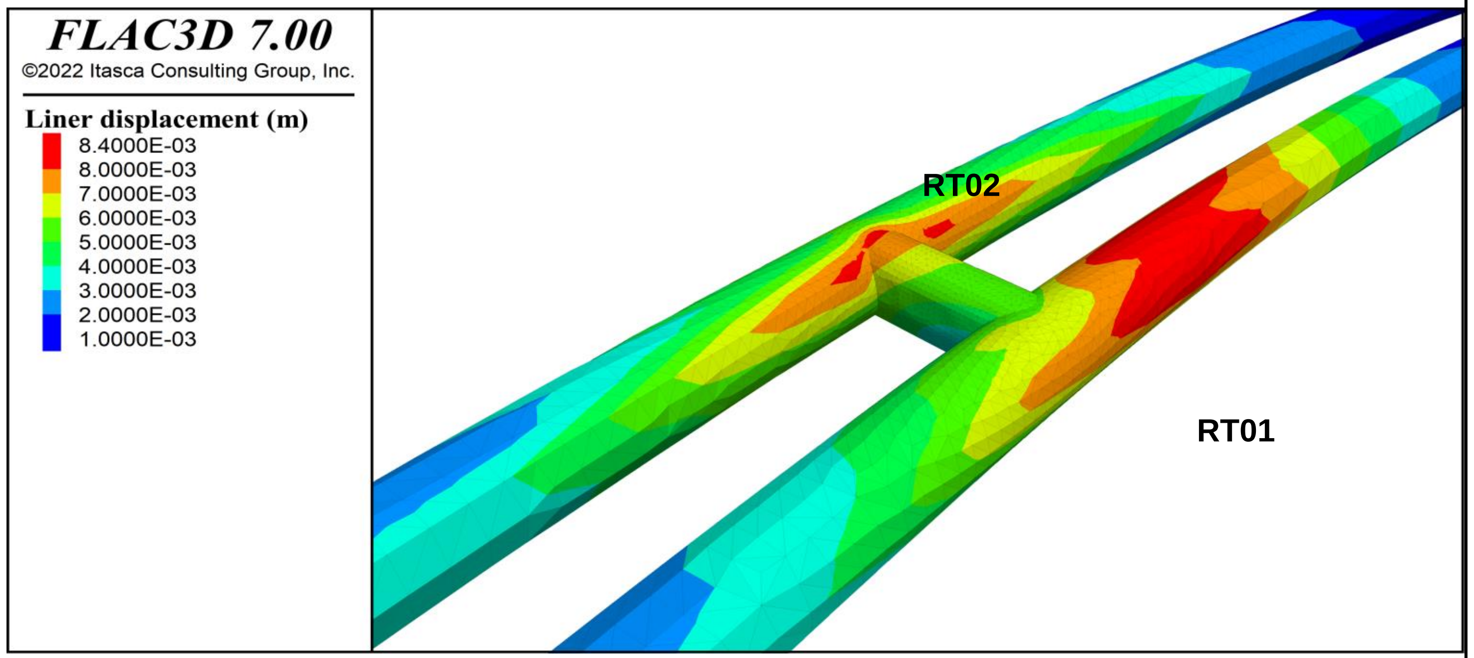
Case 2 - Stage 1 - Perspective Views





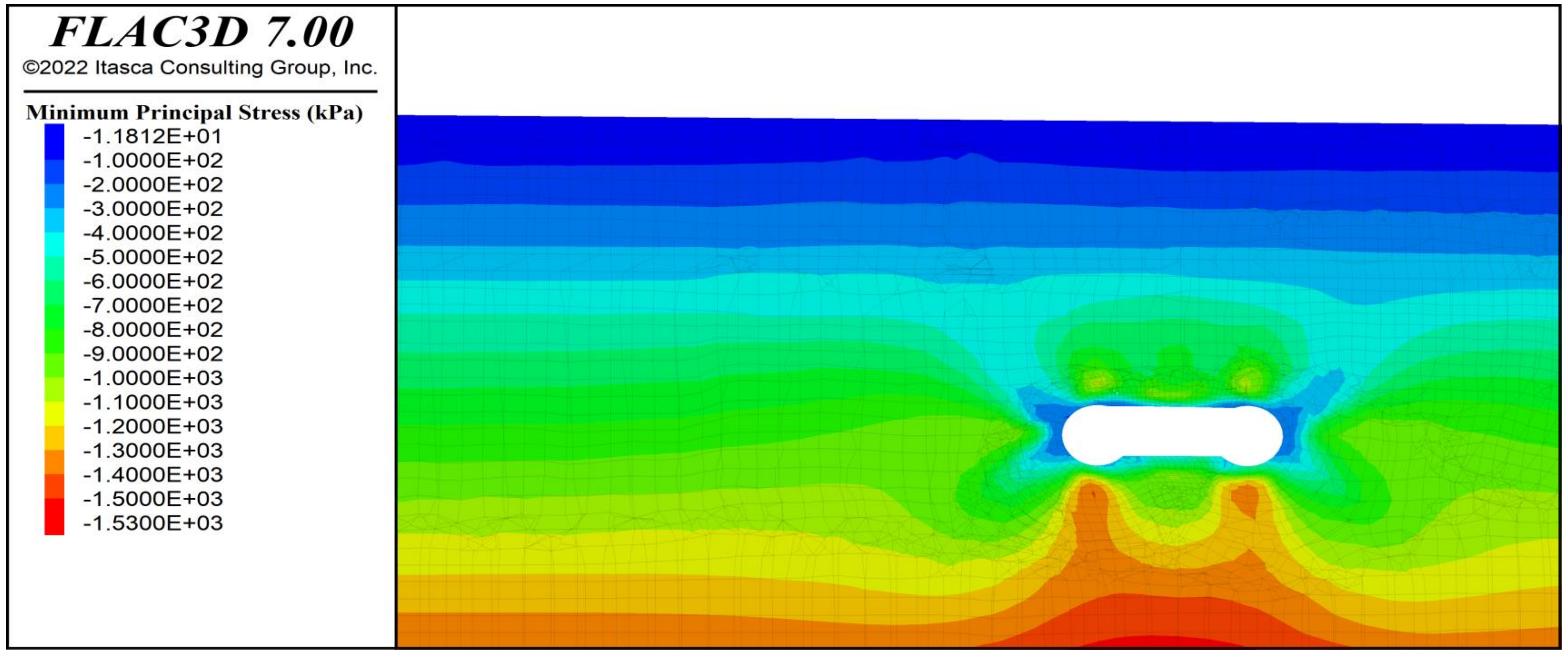
Case 2 - Stage 2 - Perspective Views



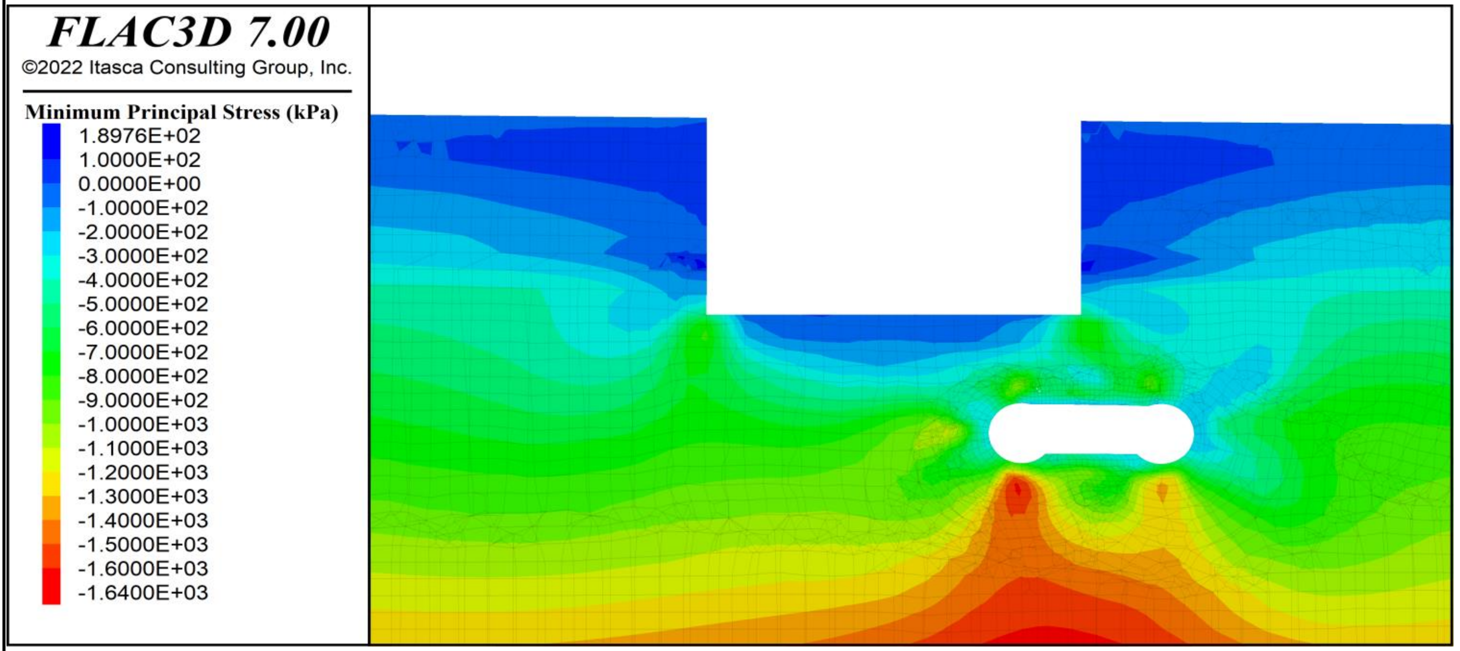


Douglas Partners Geotechnics / Environment / Groundwater	CLIENT: Deicorp Pty Ltd	TITLE:	**Total Displacement (m)**	PROJECT No:	86645.03
	OFFICE: Sydney		**Case 2 - Stage 1 & 2**	PLOT No:	9
	DATE: 6 Sep 2023		**Fiveways Project, Crows Nest**	REVISION:	1

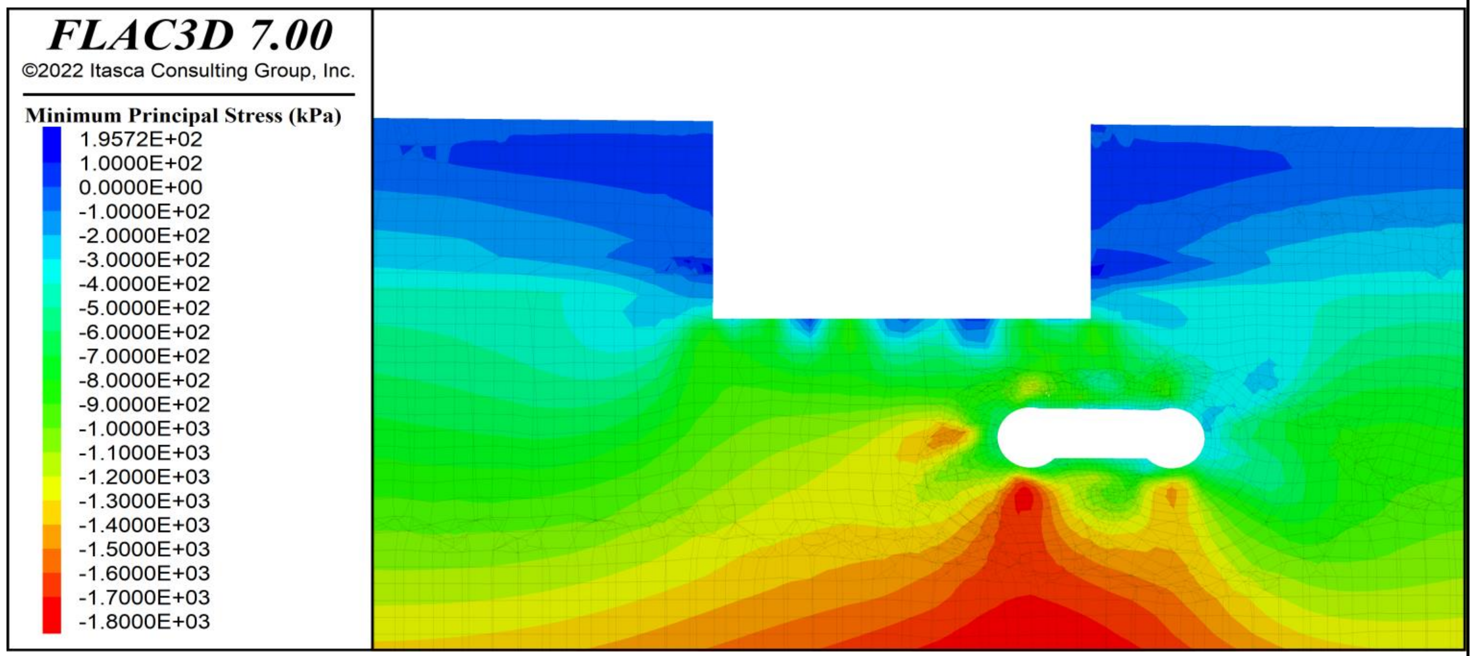
Case 2 - Stage 0 - Section 1



Case 2 - Stage 1 - Section 1



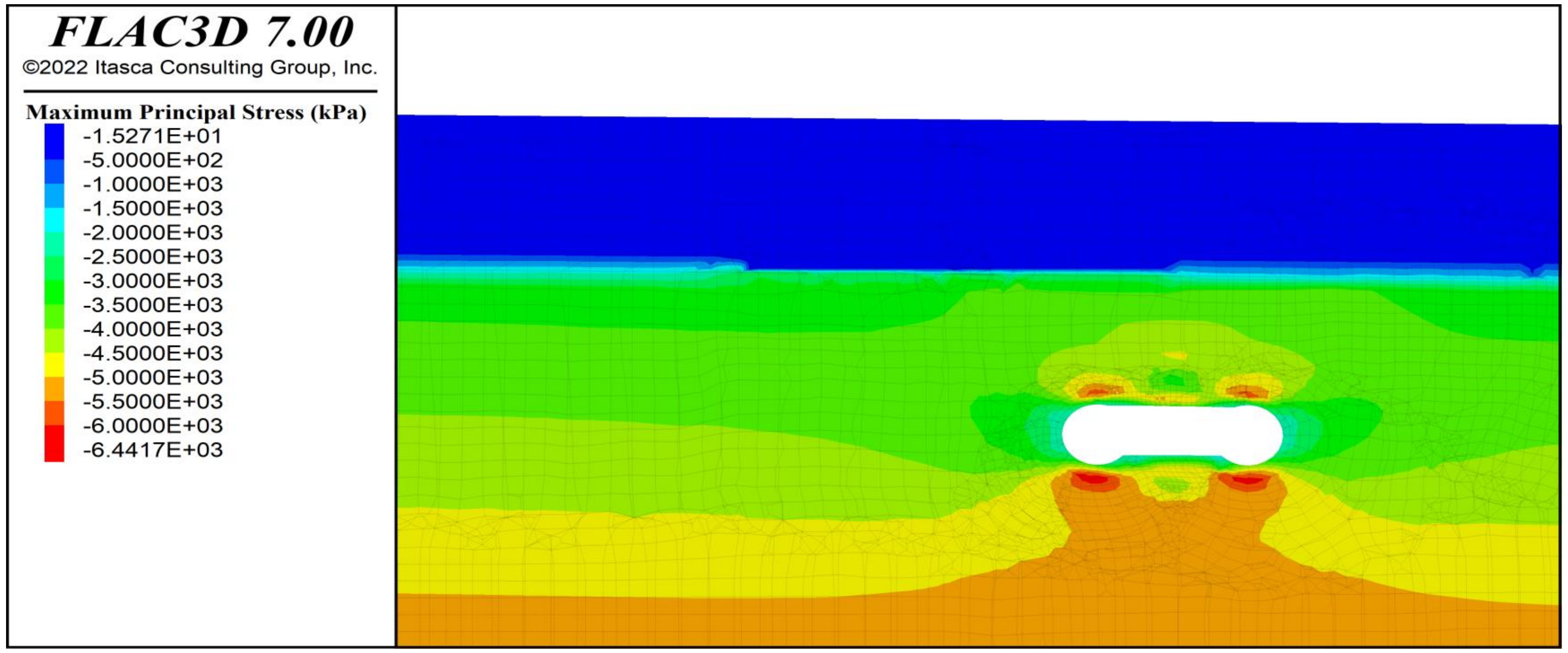
Case 2 - Stage 2 - Section 1



Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Deicorp Pty Ltd	TITLE: **Minimum Principal Stress (kPa)**	PROJECT No:	86645.03
OFFICE: Sydney	**Case 2 - Stage 0, 1 & 2**	PLOT No:	10
DATE: 6 Sep 2023	**Fiveways Project, Crows Nest**	REVISION:	1

Case 2 - Stage 0 - Section 1



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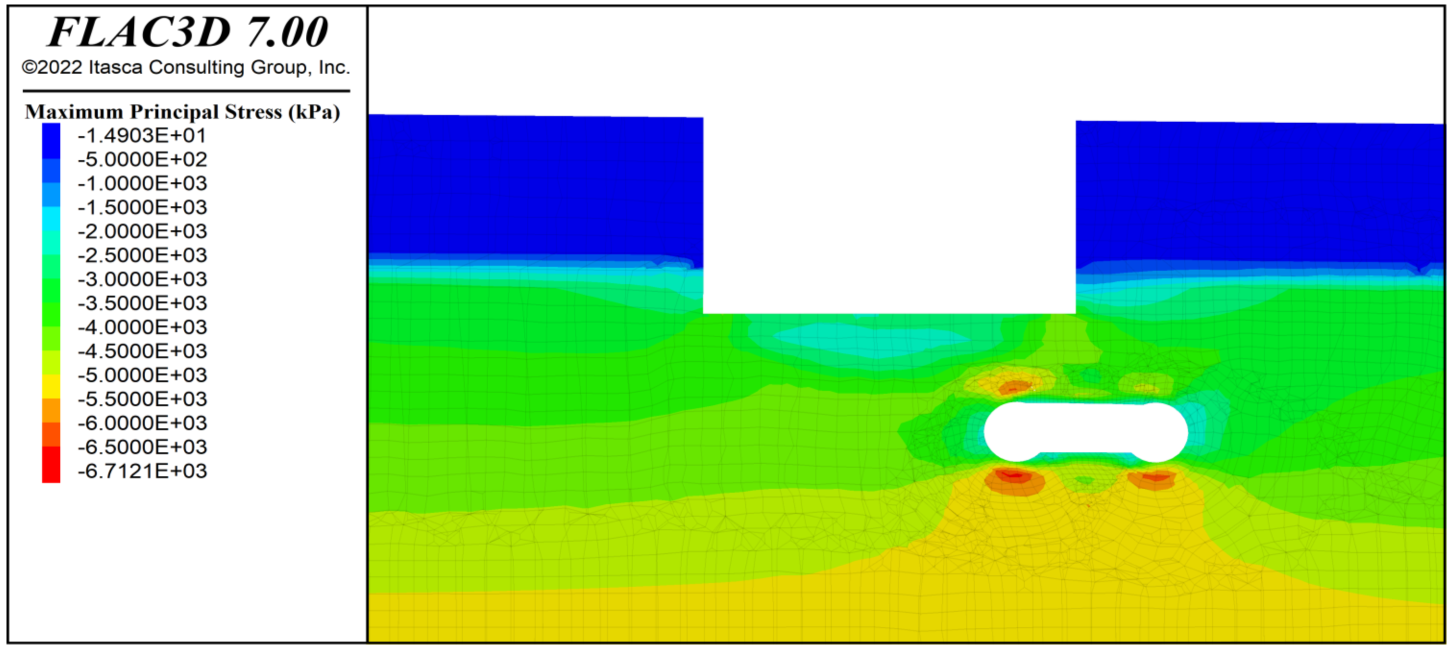

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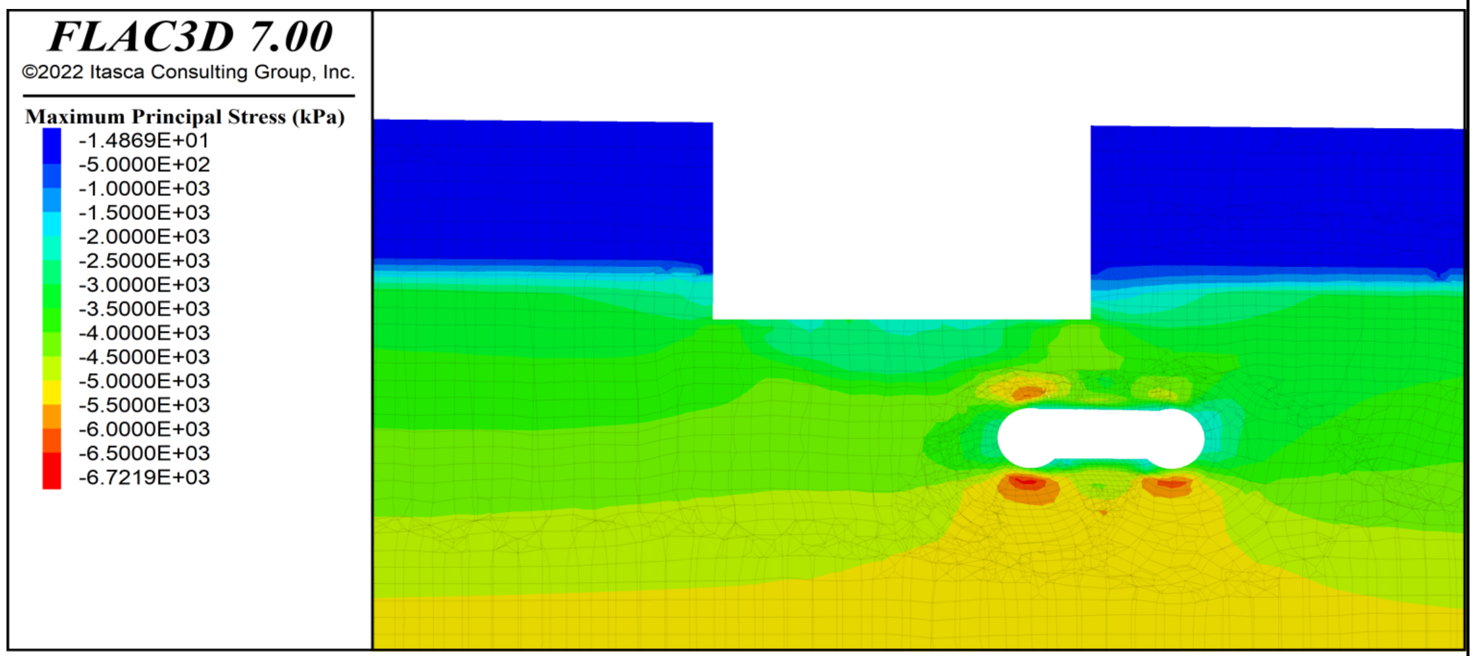

Douglas Partners Geotechnics / Environment / Groundwater	CLIENT: Deicorp Pty Ltd	TITLE:	**Maximum Principal Stress (kPa)**	PROJECT No: 86645.03
	OFFICE: Sydney		**Case 2 - Stage 0, 1 & 2**	PLOT No: 11
	DATE: 6 Sep 2023		**Fiveways Project, Crows Nest**	REVISION: 1