Building around existing tunnels

Seminar

Ground response due to deep excavations adjacent to underground infrastructure in Sydney

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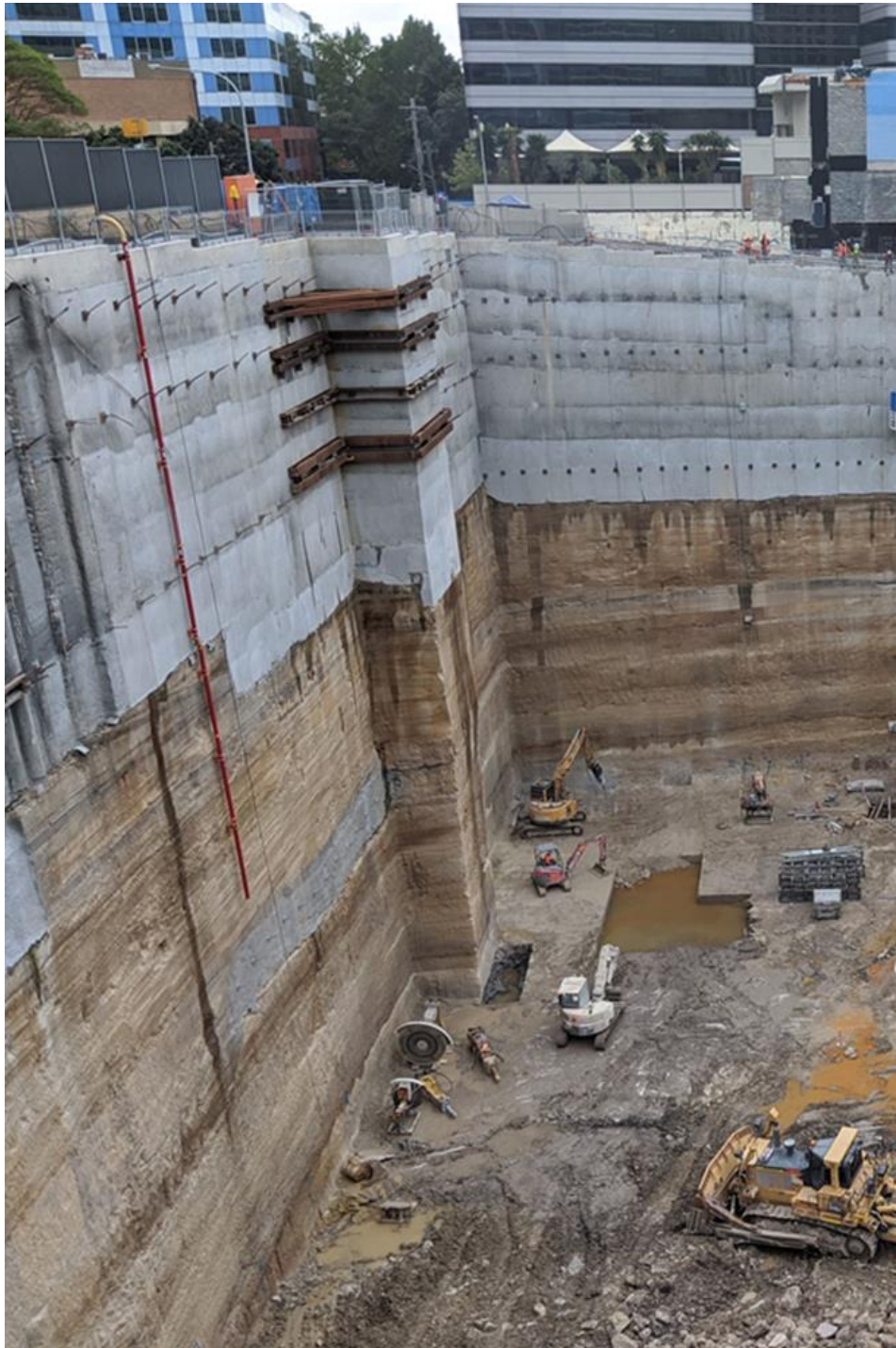
Sydney, 27 April 2023

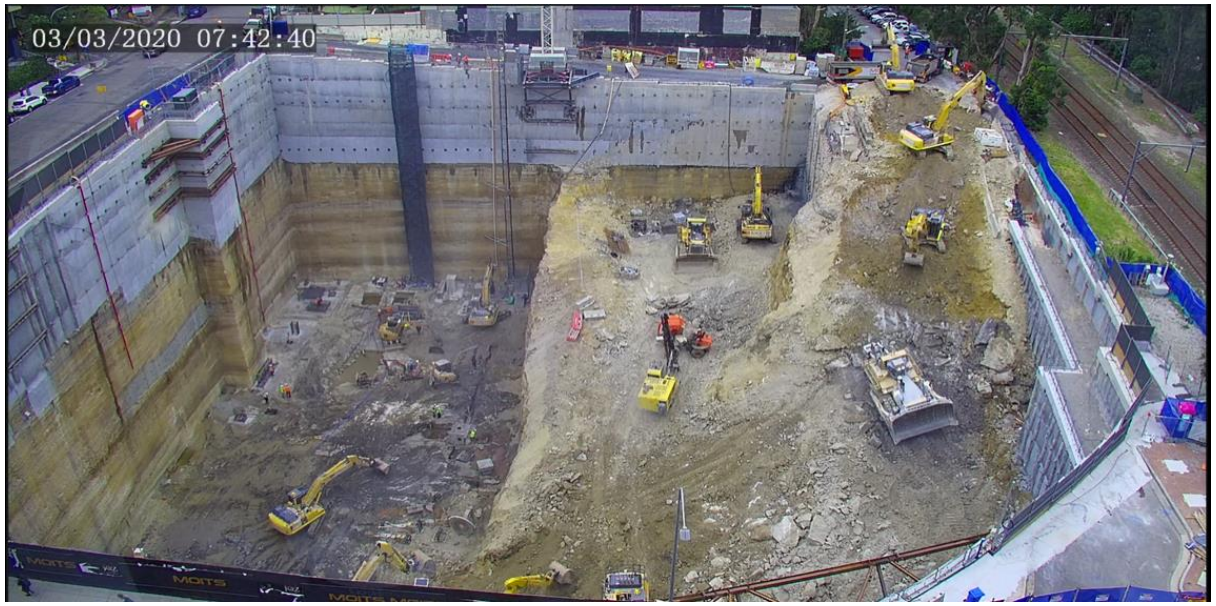
ENGINEERS AUSTRALIA | AUSTRALIAN TUNNELLING SOCIETY | 50 years 1972 - 2022 | AUSTRALIAN GEOMECHANICS SOCIETY

Overview

- Deep excavation design
- Case histories
- Impact assessment
- Construction performance
- Instrumentation and monitoring
- Lessons learned
- Summary and conclusions

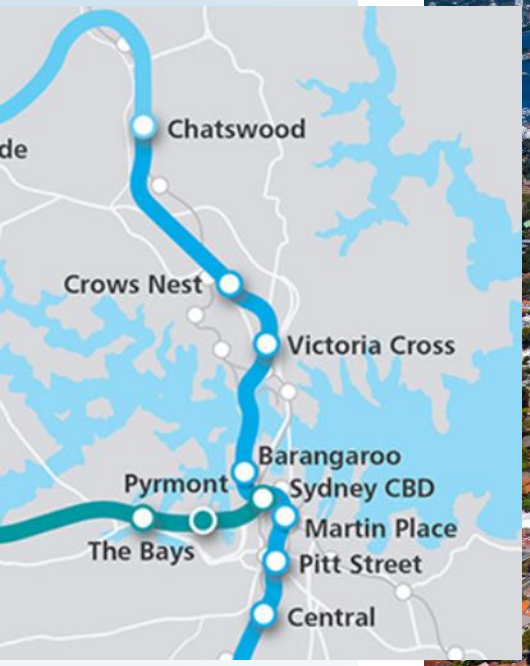


The project



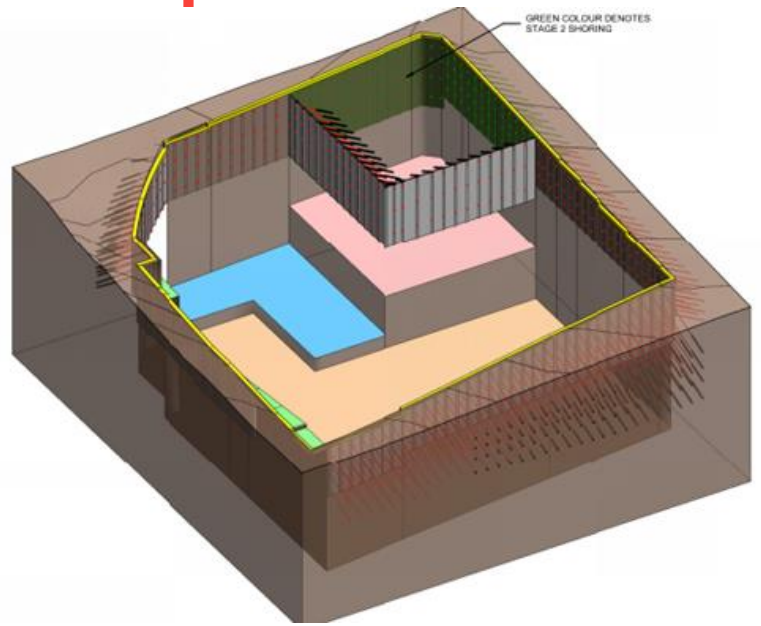
- $A1.6 billion multi-storey commercial development in Sydney's northern suburbs
- 47 and 26 storey towers
- 43m deep basement adjacent to transport infrastructure – world's deepest
- 340,000m^3 excavation
- Rigorous investigation and both 2D and 3D modelling used to gain rapid approval

Development location

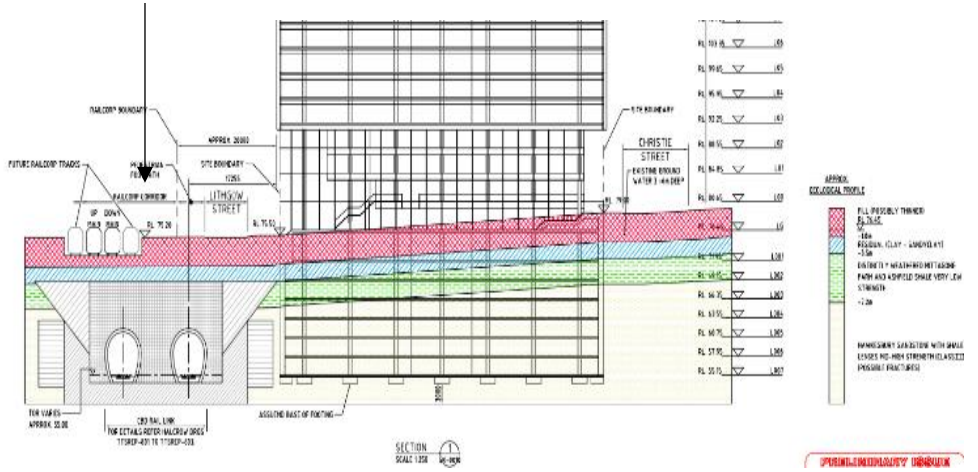



LANDMARK

Location plan showing adjacent transport infrastructure & isometric view

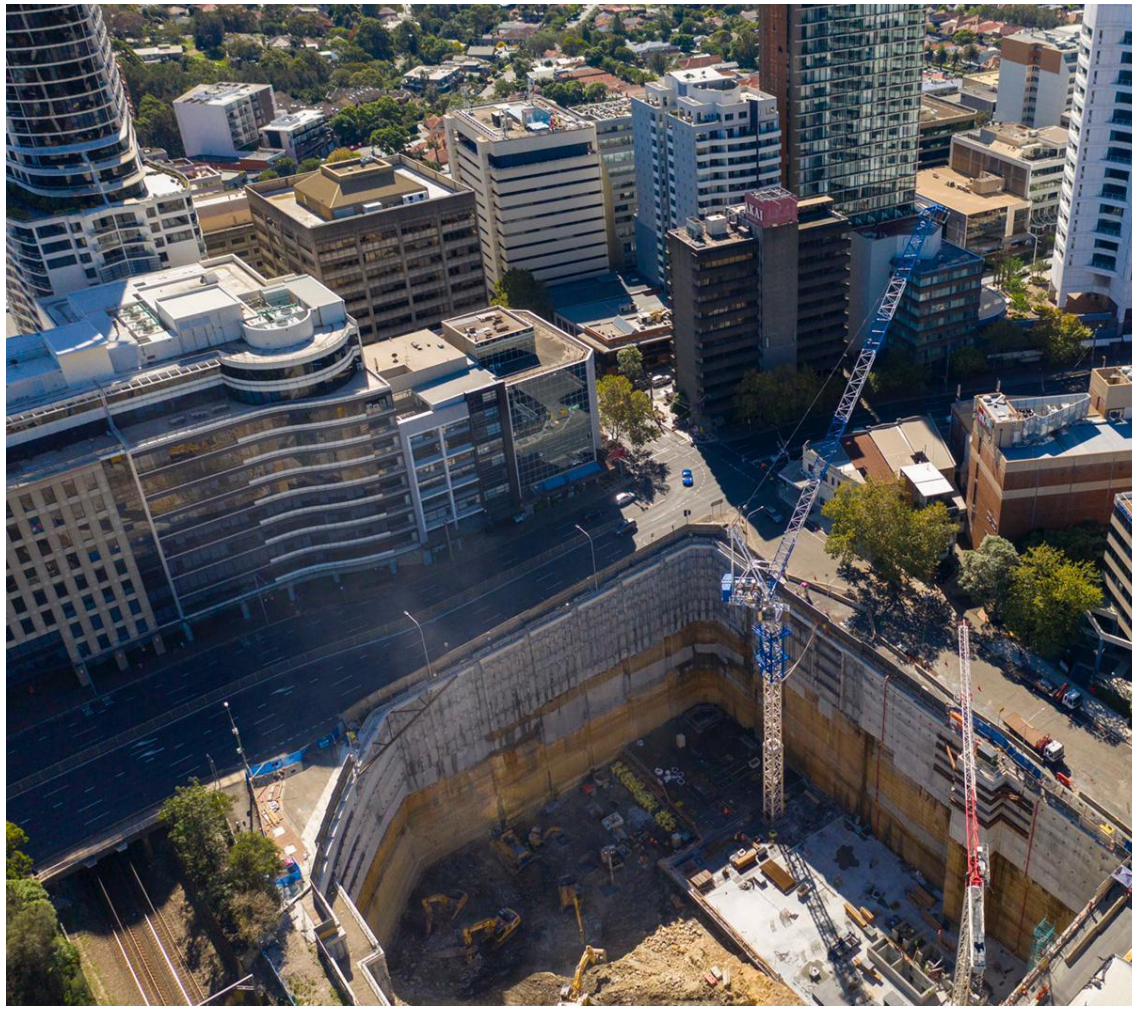


Rail corridor



Key geotechnical issues

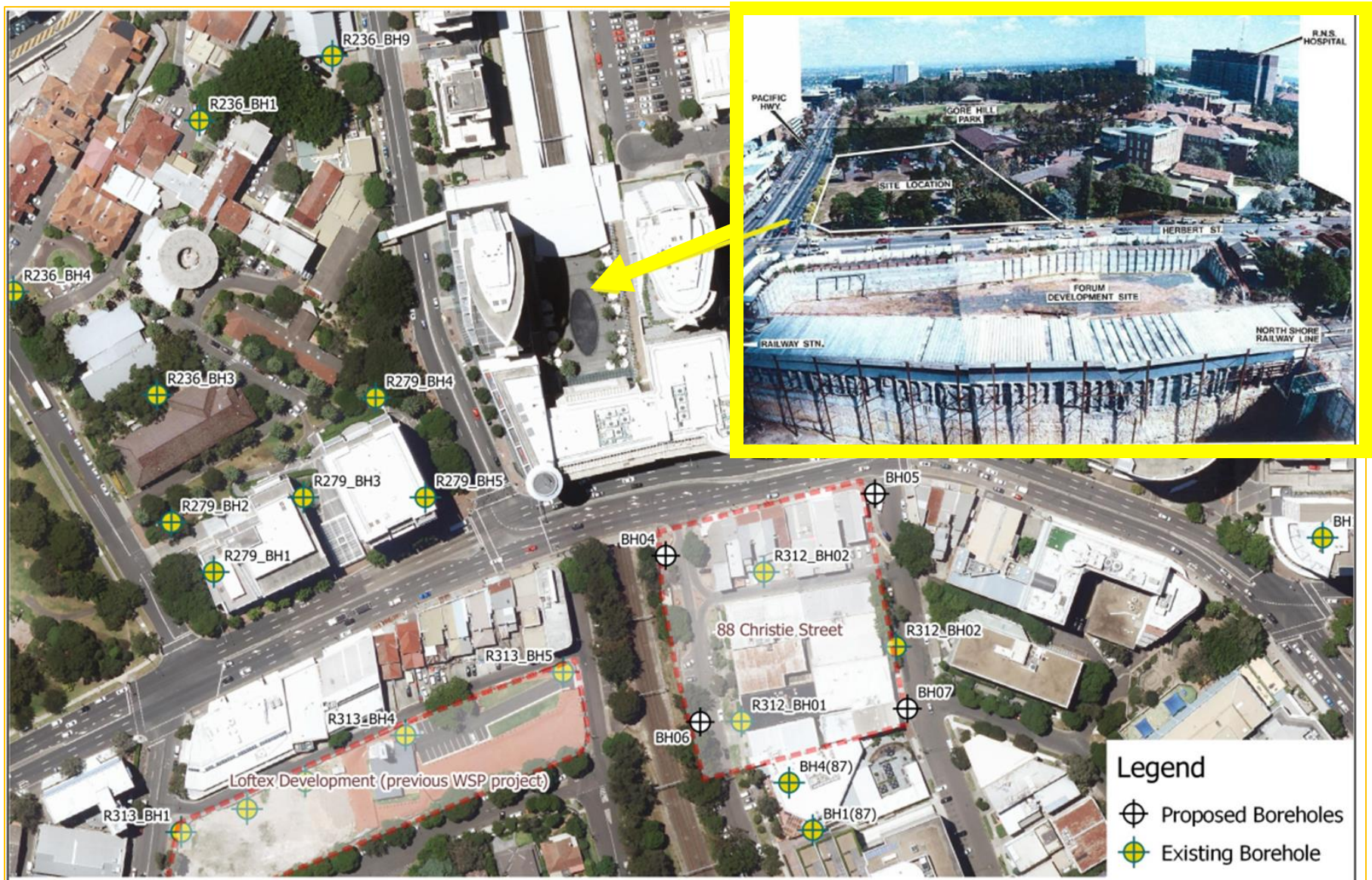
- Ground movement - protection of adjoining transport infrastructure – road and rail
- Impact assessment - Transport for NSW, Roads & Maritime Services & Council approvals
- Serviceability based design to optimise building footings
- Site retention
- Groundwater



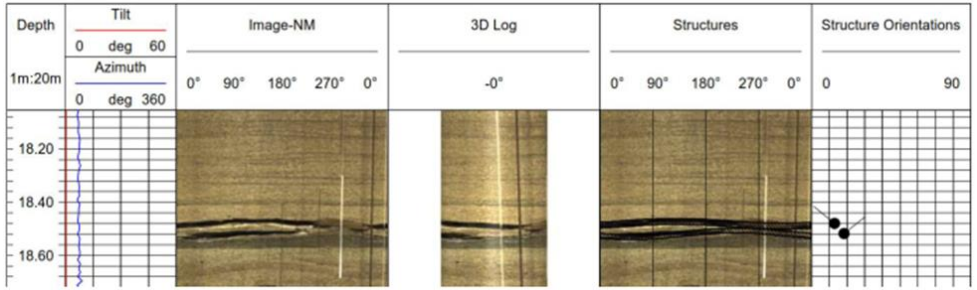
Geotechnical investigation

- Desk study
- Drilling of cored boreholes below proposed basement level
- Imaging to address defect details
- Geotechnical report presenting the investigation results and recommendations and geotechnical design parameters to support detailed design of project elements
- Impact assessment reports

Site investigation

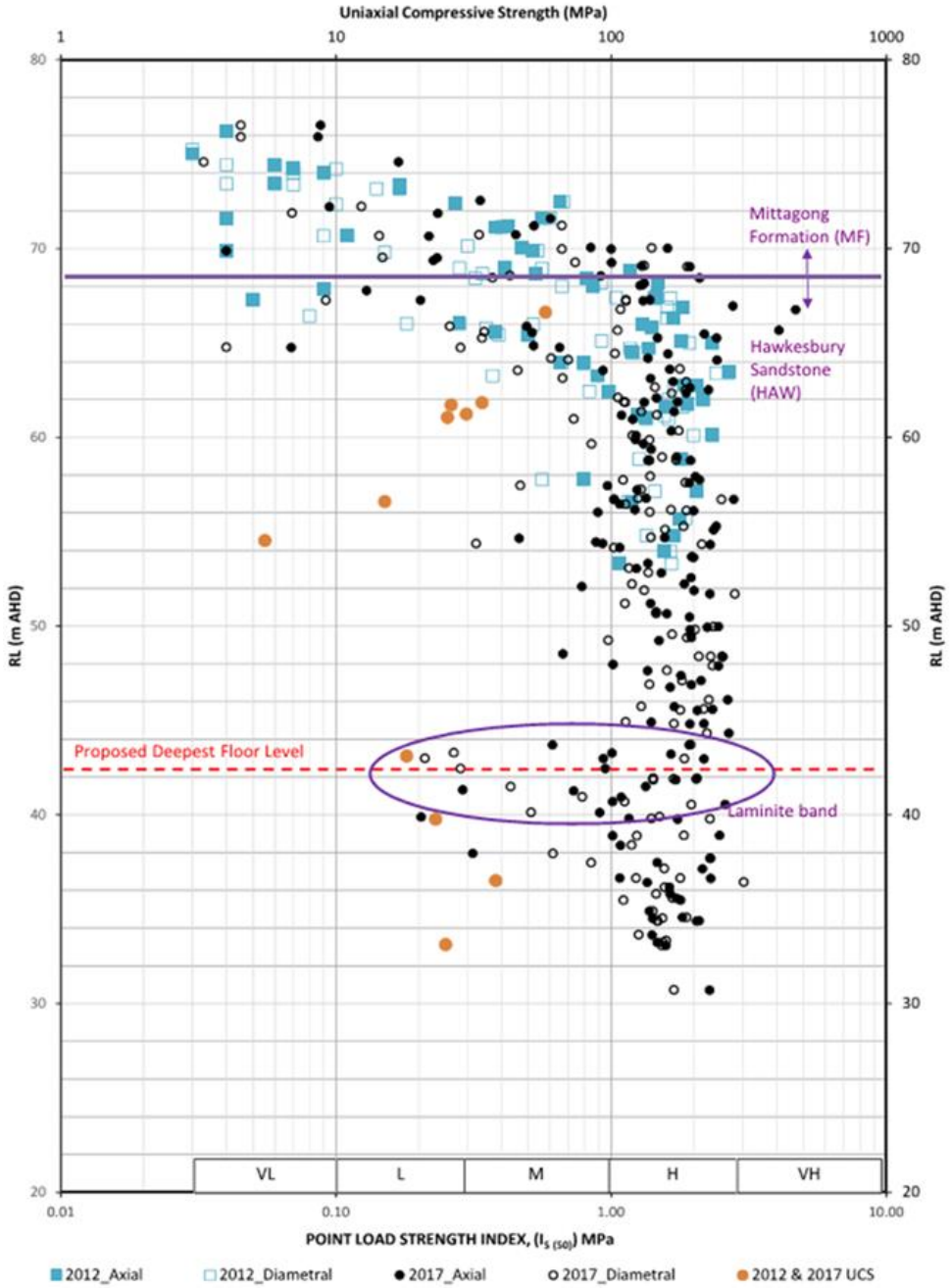


Ground profile

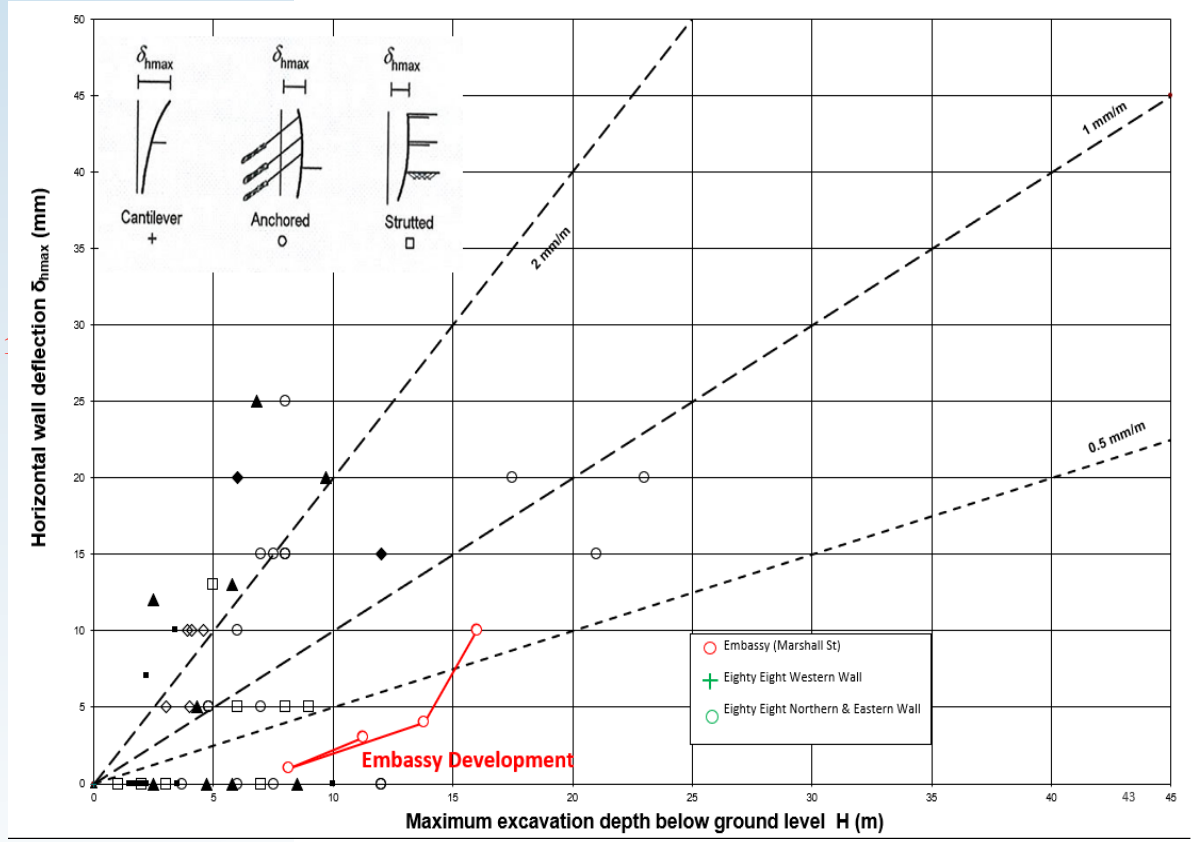


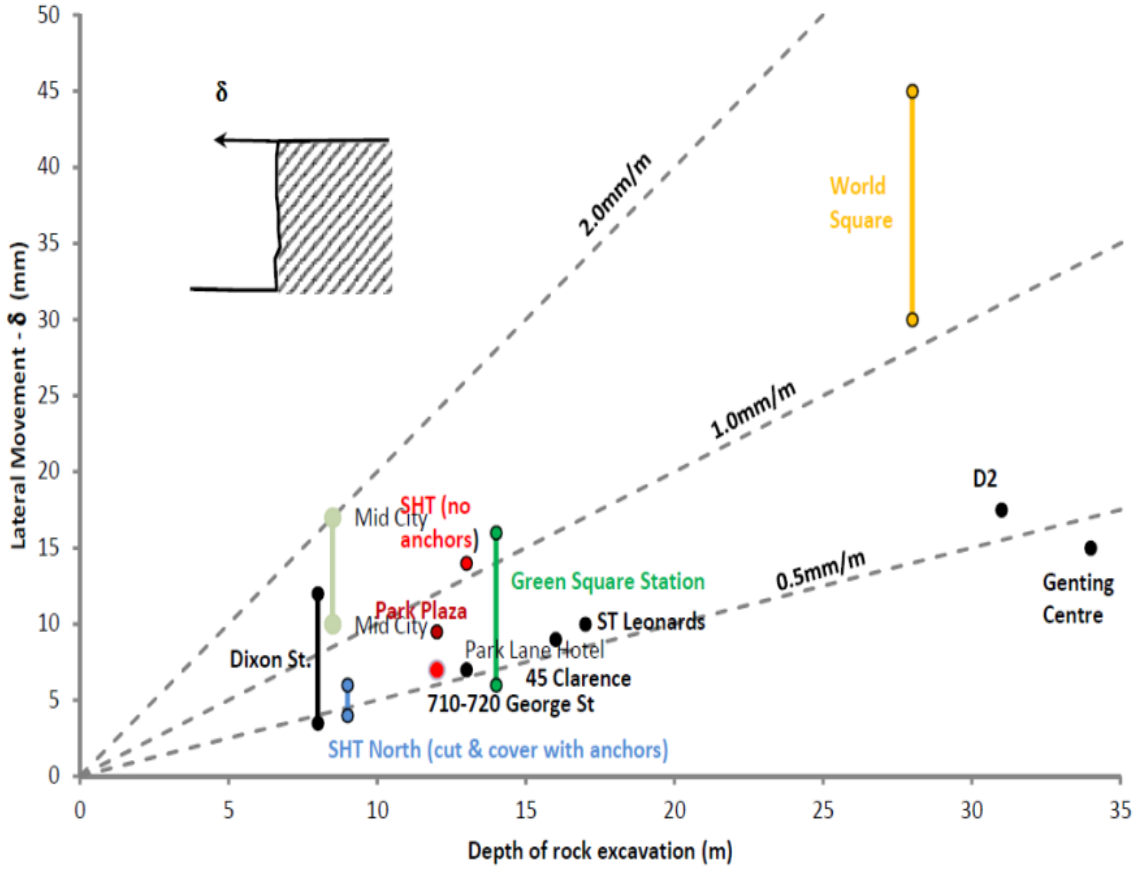
Structure Legend (Tadpole)

- Bedding Fabric
- Seam
- Bedding Parting
- Joint
- Joint (Healed)
- Joint (Fracture Zone)

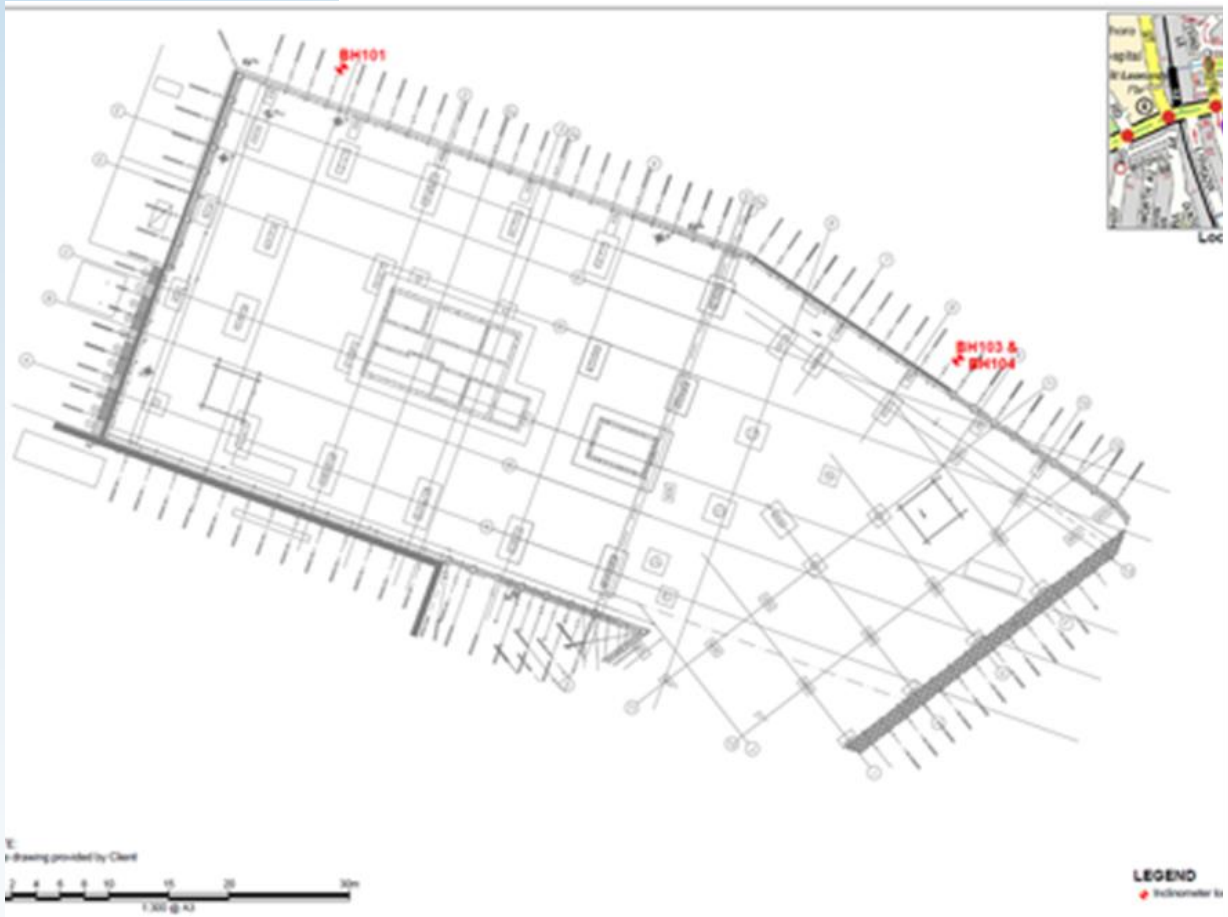


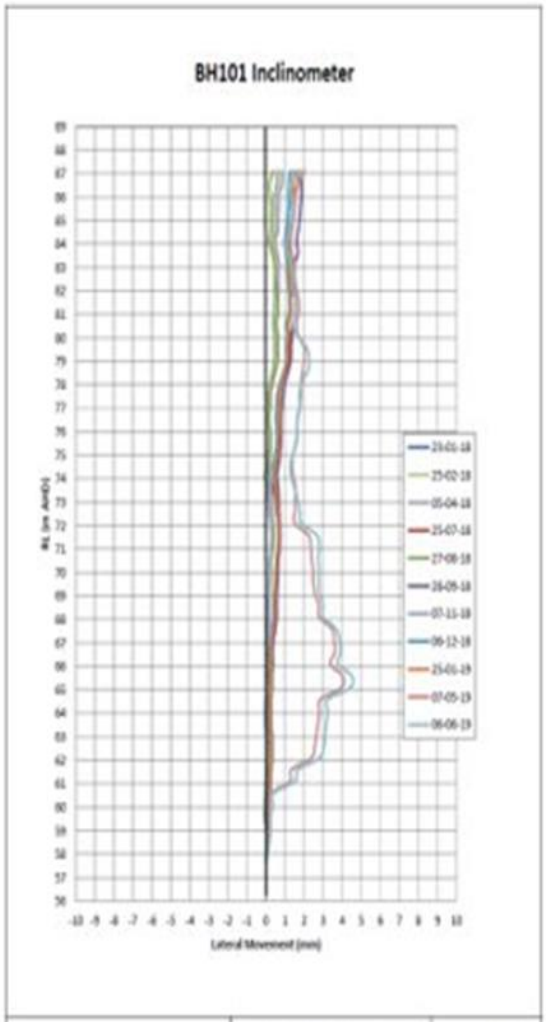
Excavation displacement - measured lateral movements at top of basement excavations in Sydney sandstone (Hewitt et al, 2008 & Wong, 2013)



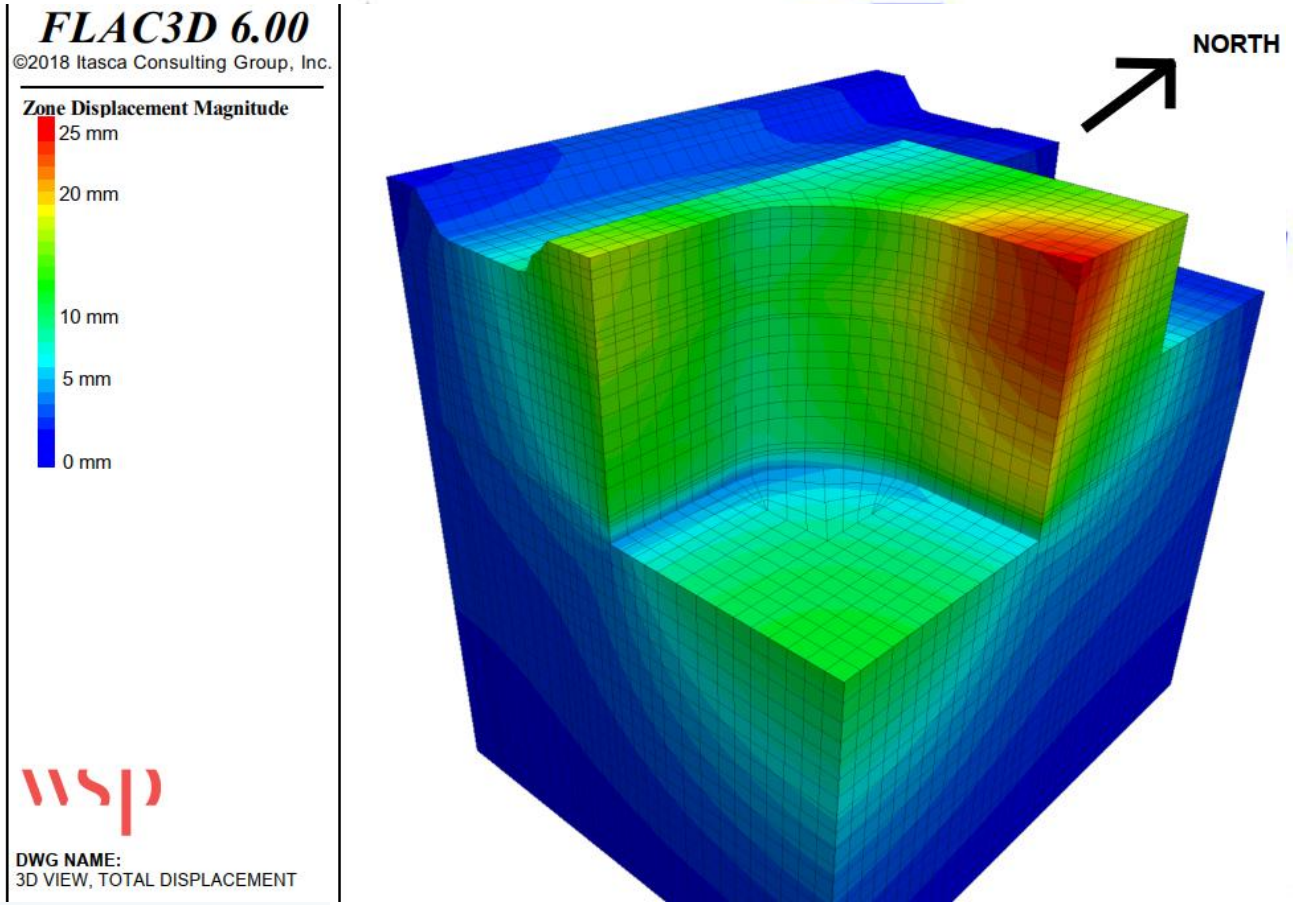


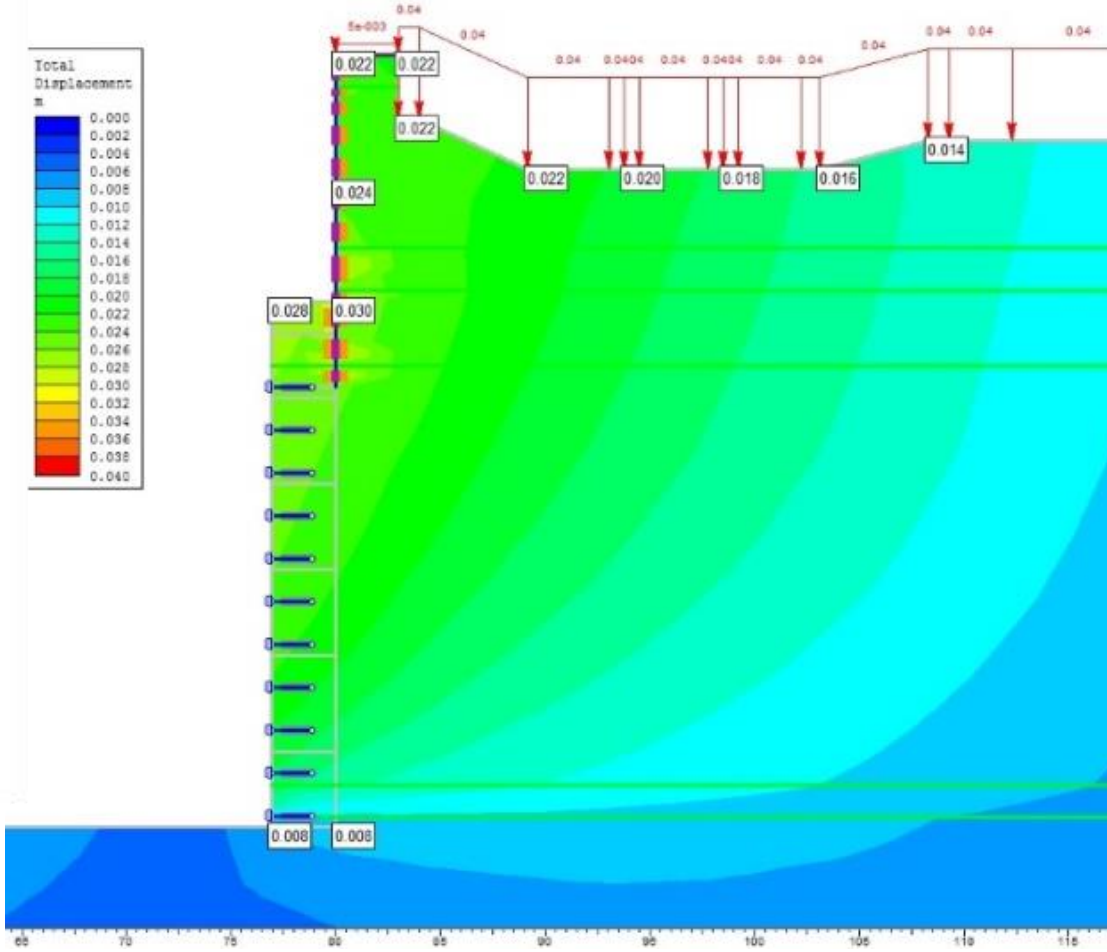
Adjacent project, St Leonards





Predicted 2D and 3D ground movements

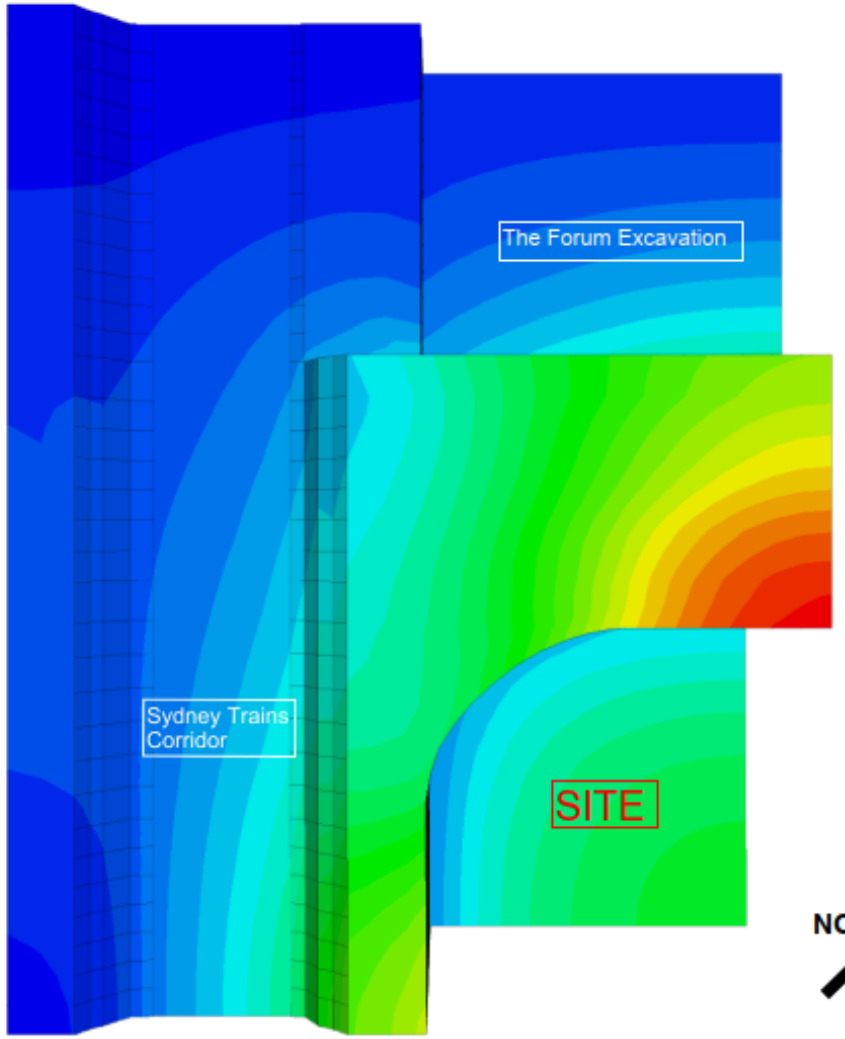




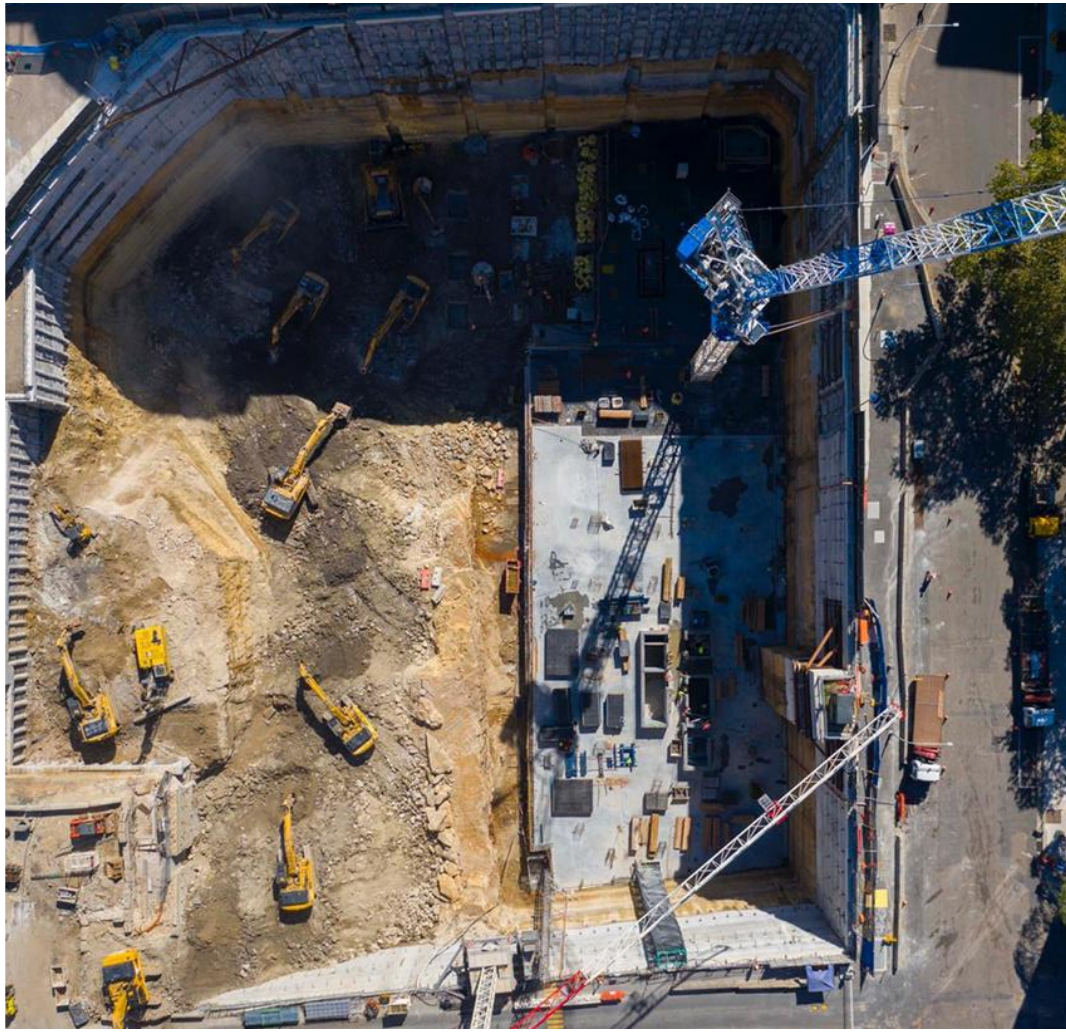
Displacement plan

FLAC3D 6.00

Zone Displacement Magnitude
25 mm
20 mm
10 mm
5 mm
0 mm



NORTH



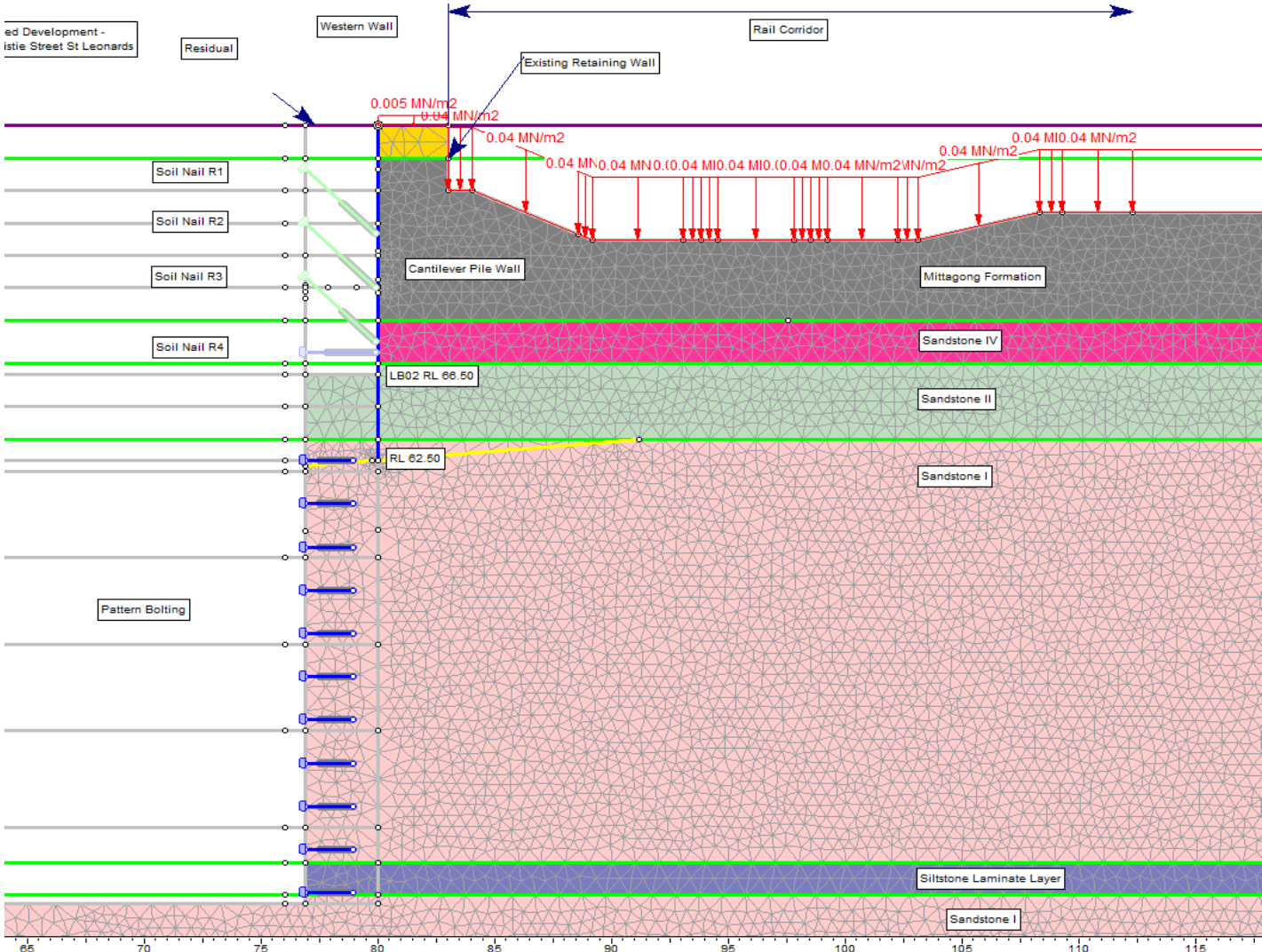
wsp

DWG NAME:
PLAN VIEW, TOTAL DISPLACEMENT

DWG REF:
PS106114-IMG- B2

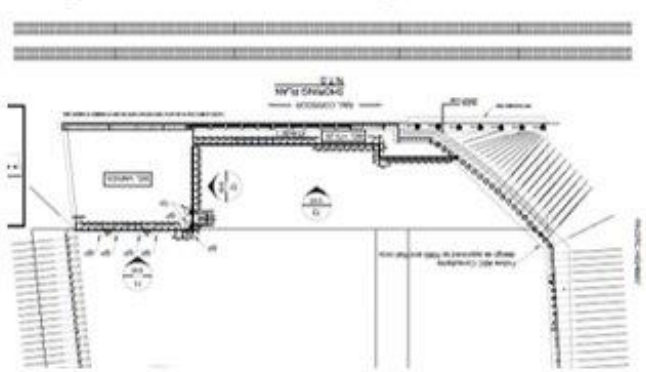
Construction sequence for cantilever pile wall – west (rail) boundary

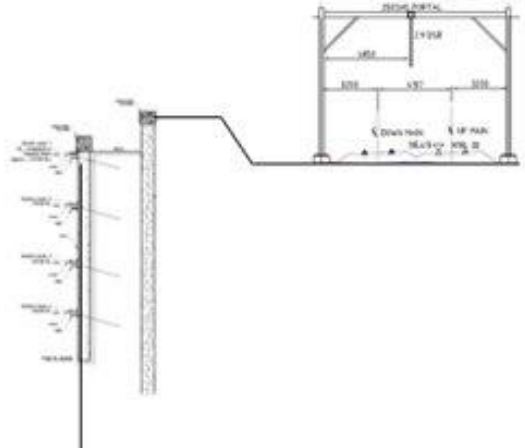
- Cantilever wall located entirely within development site (i.e. outside rail corridor) on west (rail) boundary
- Basement below RL69.5 m extends to 3.1 m outside the rail boundary to temporarily support cantilever pile wall.



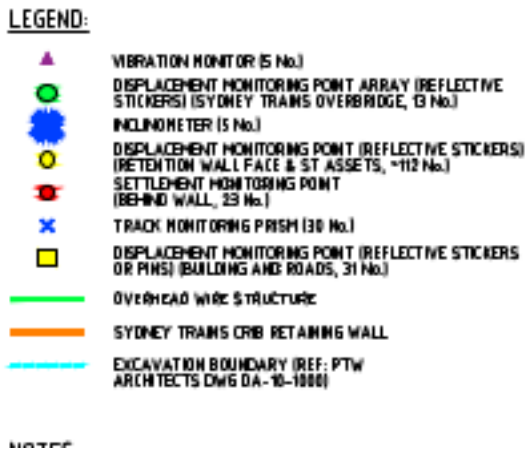
Railway wall retention

- 40m long middle section of retaining wall on railway side designed without long anchors under railway
- On either side long angled anchors used in permanent rock buttress in the corners
- A double piled retaining wall with a 3m wide step used over middle section
- Lower piled wall provided passive support to the upper wall



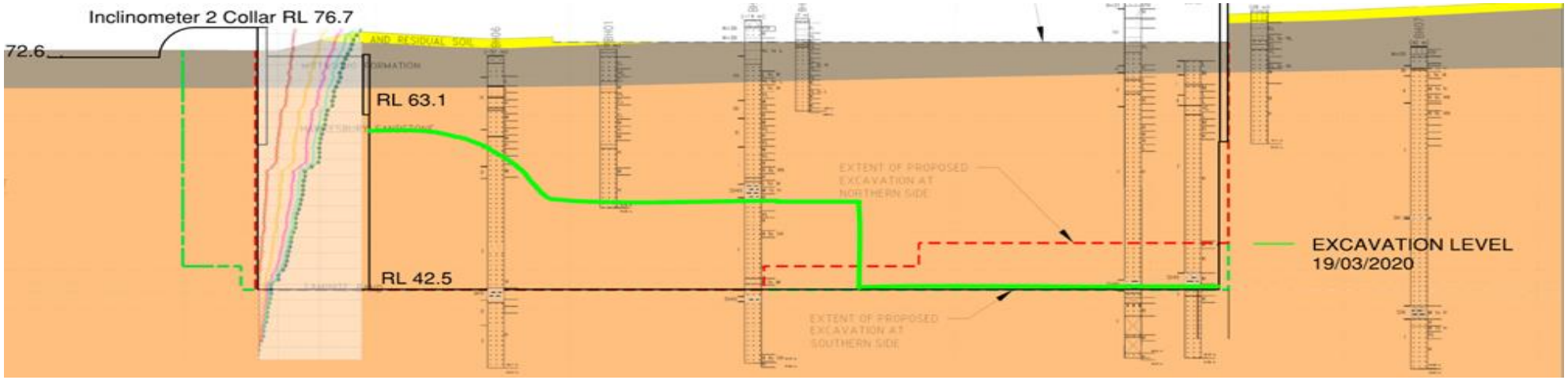


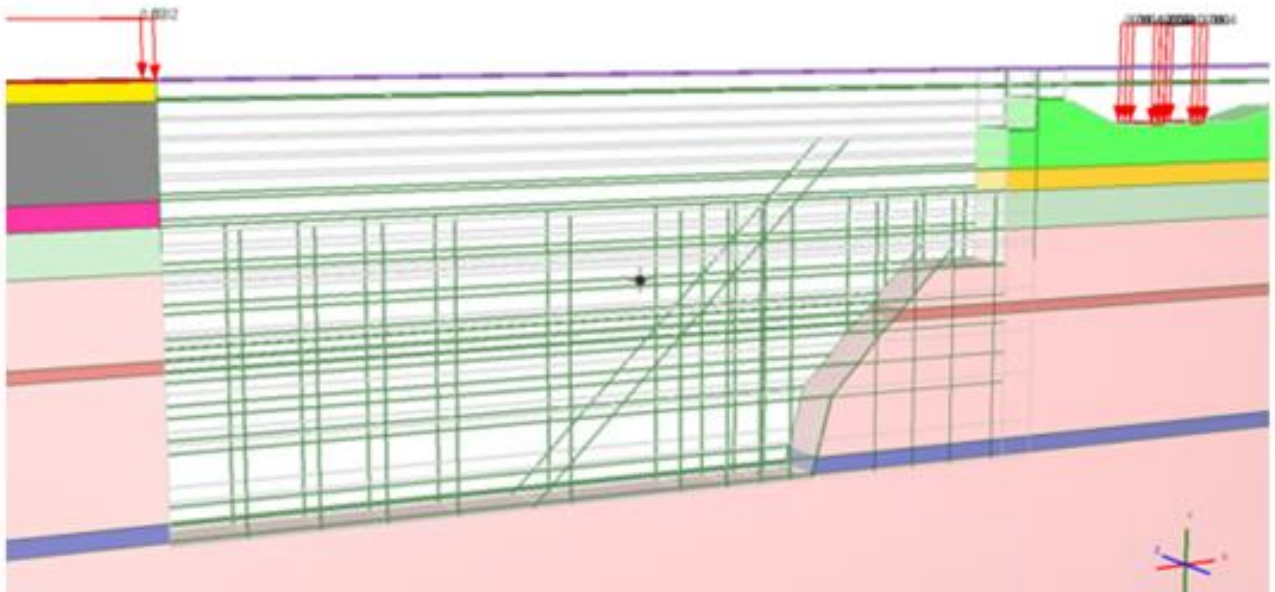
Instrumentation plan

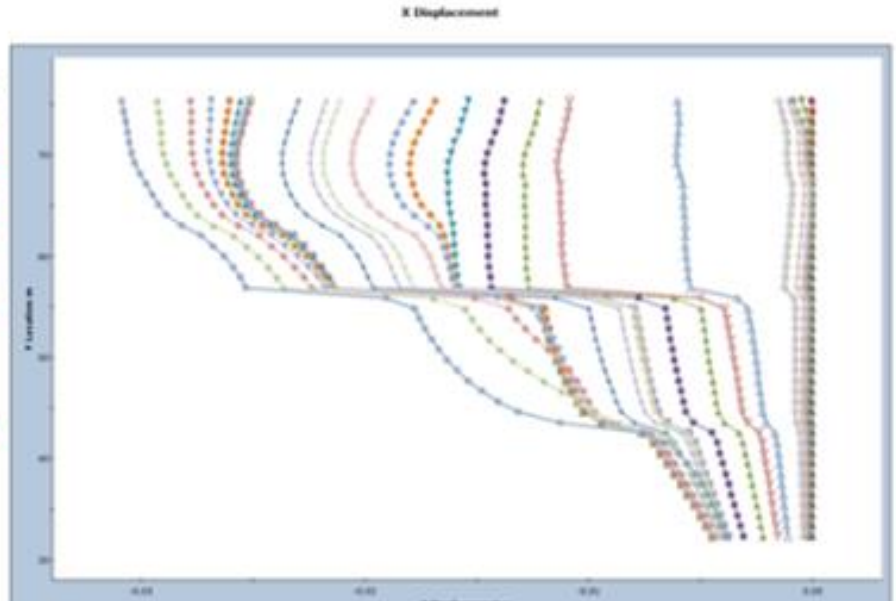


- Data-management system maximised value of site investigation data collected
- "Real-time" monitoring used to provide high information availability, transparency and reliability

Calibrated 3D model with inclinometer measurements – November 2019 to March 2020







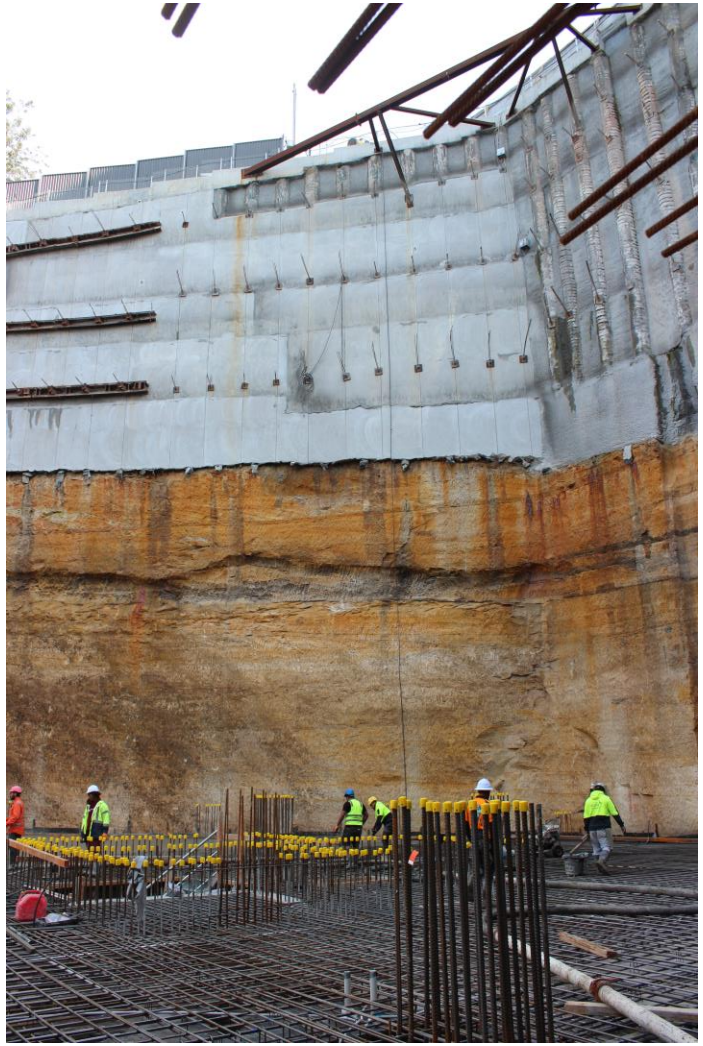
Excavation progress – February 2020

Excavation progress

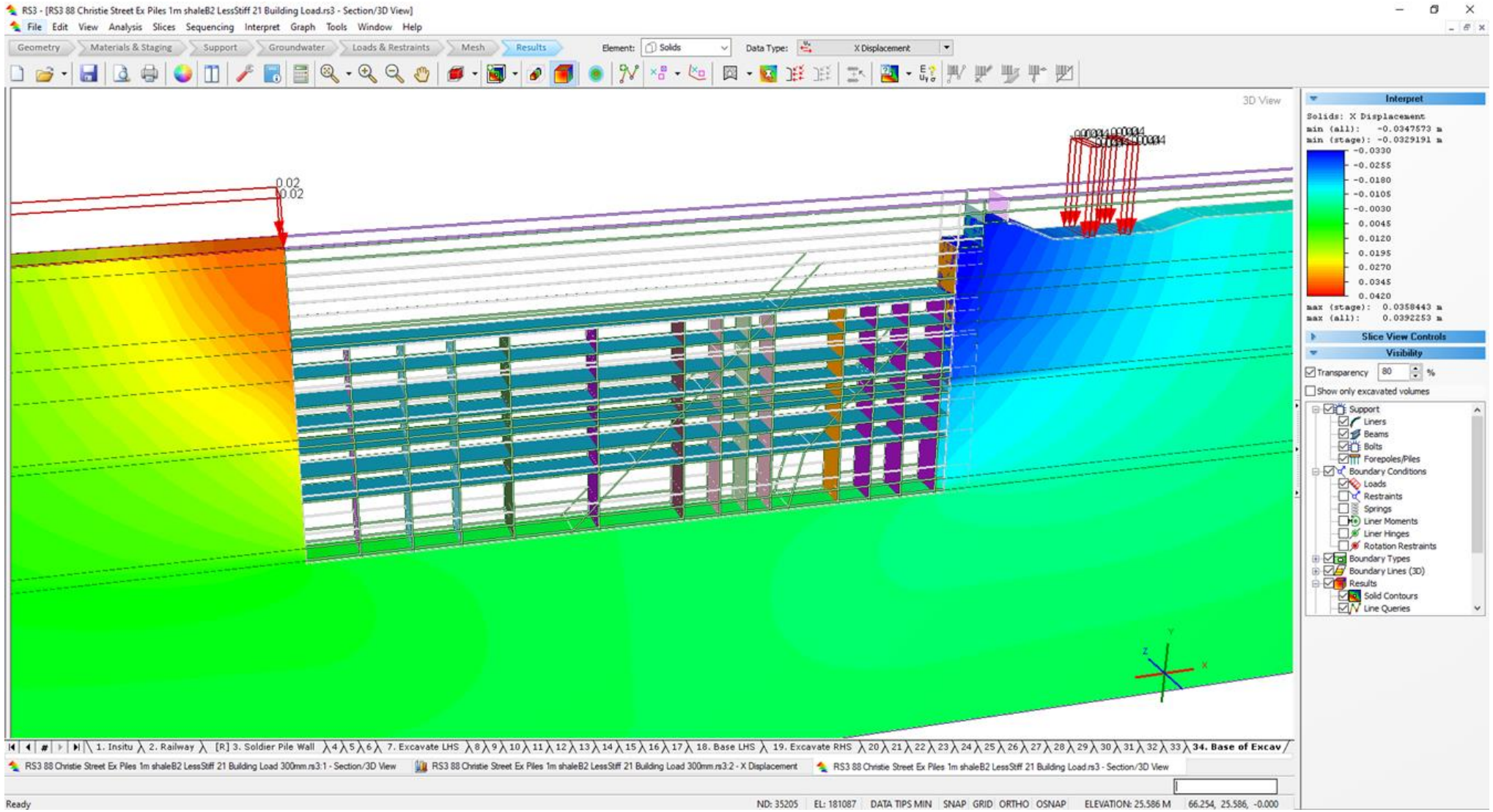
Excavation progress

Excavation progress – 7 April 2020

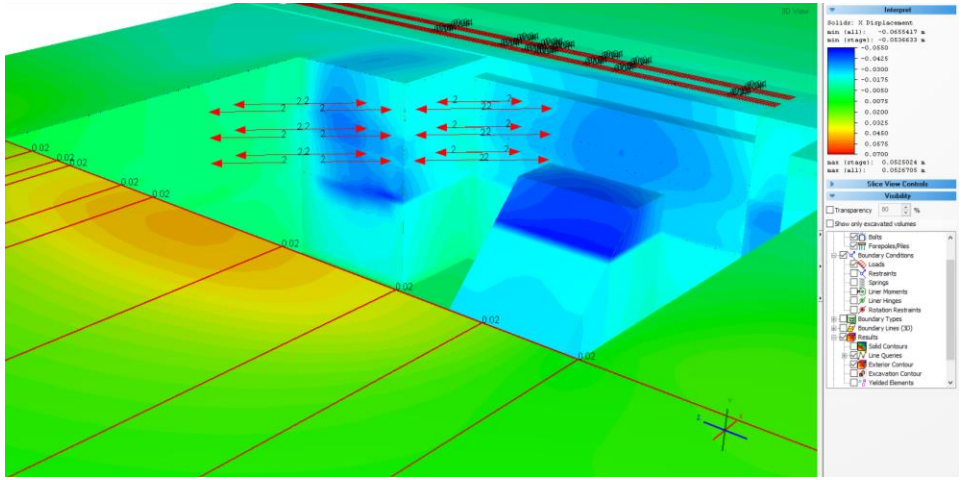
Groundwater control

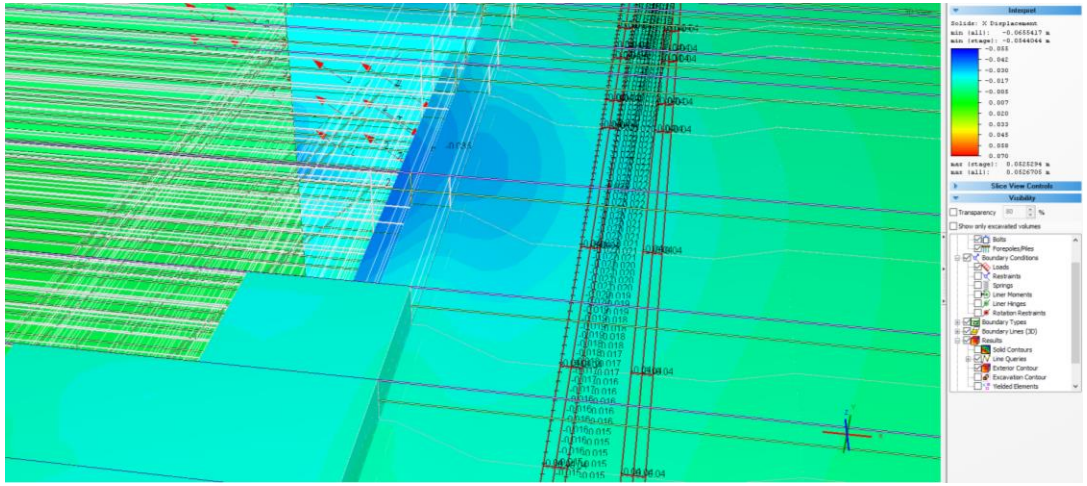


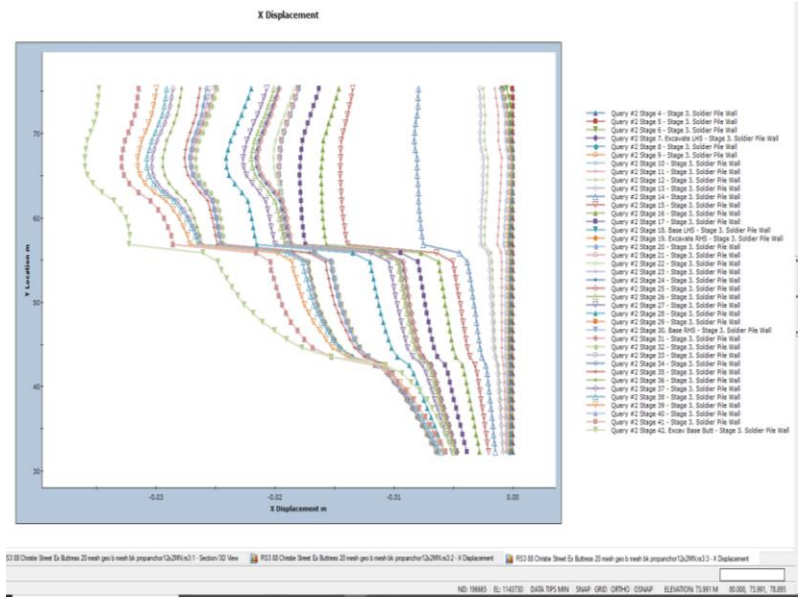
Revised excavation sequence

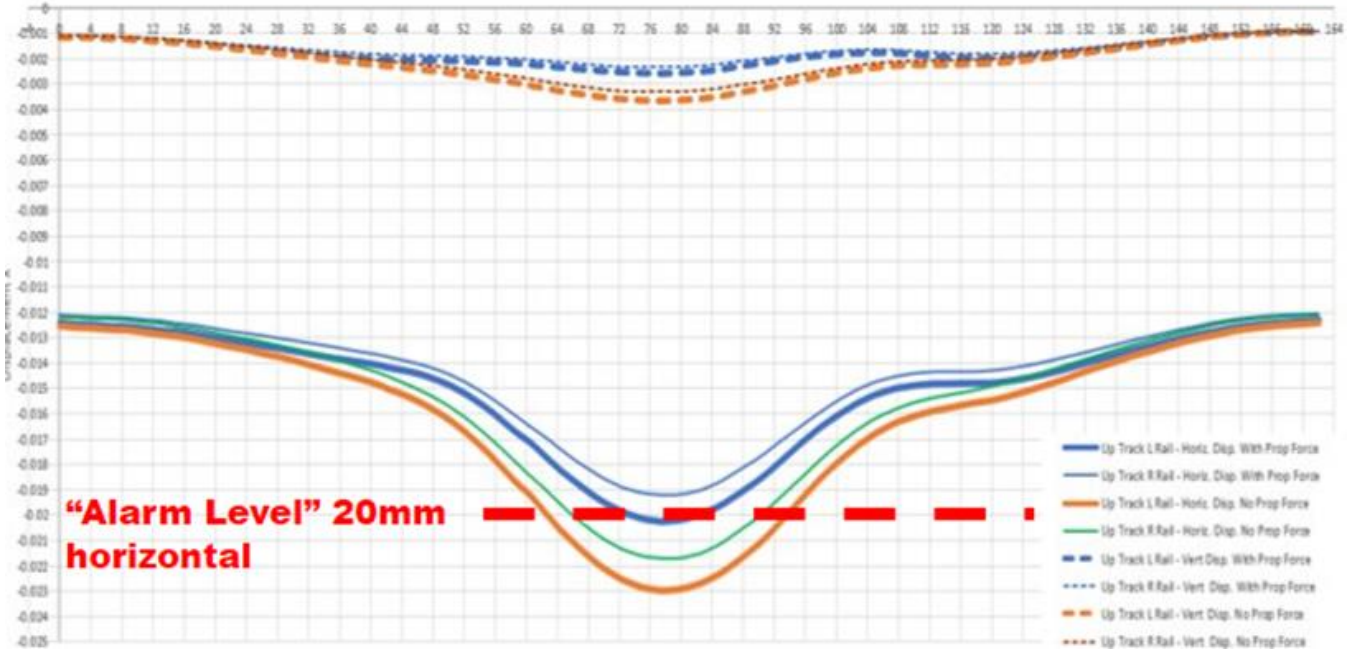


Predicted rail displacement – with/ without propping

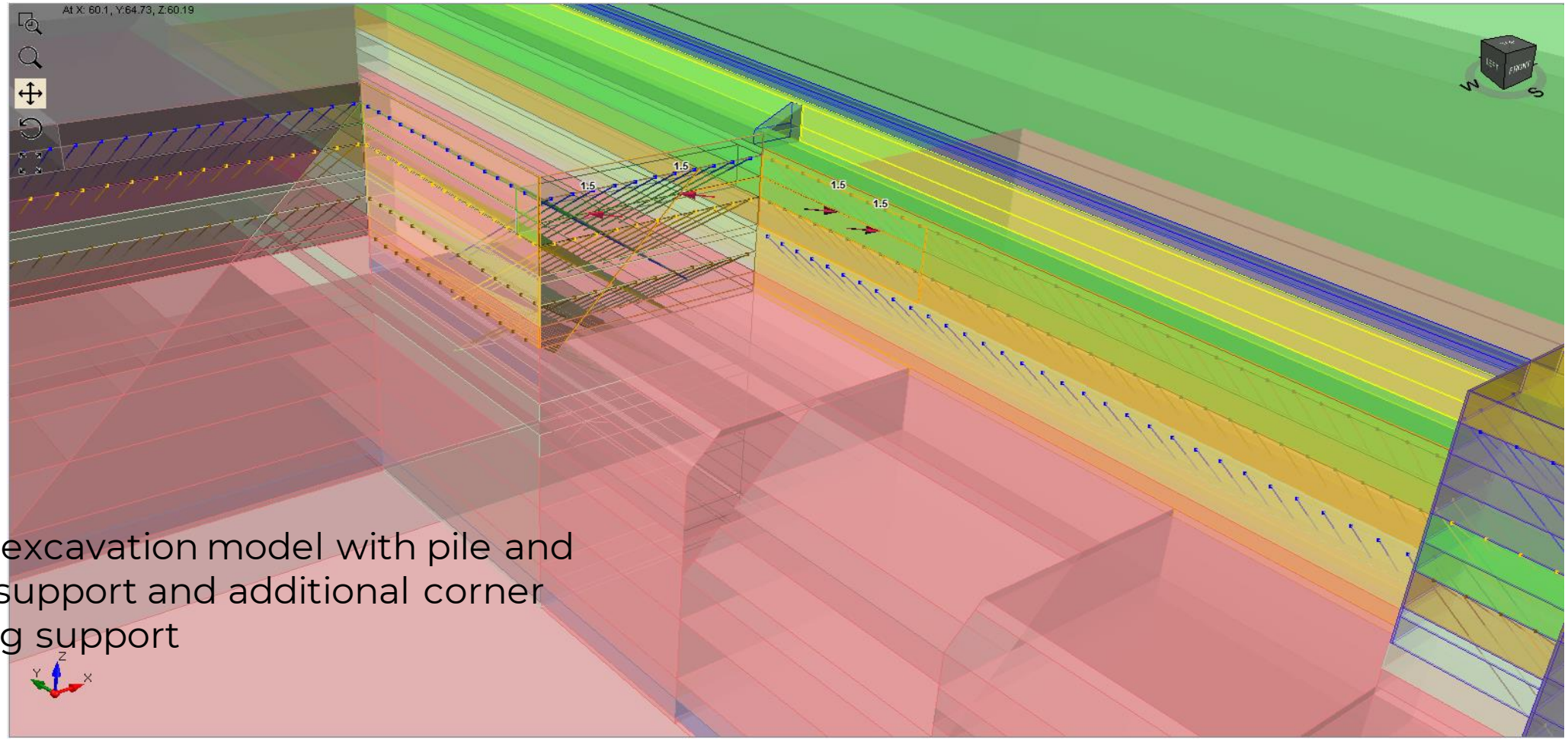






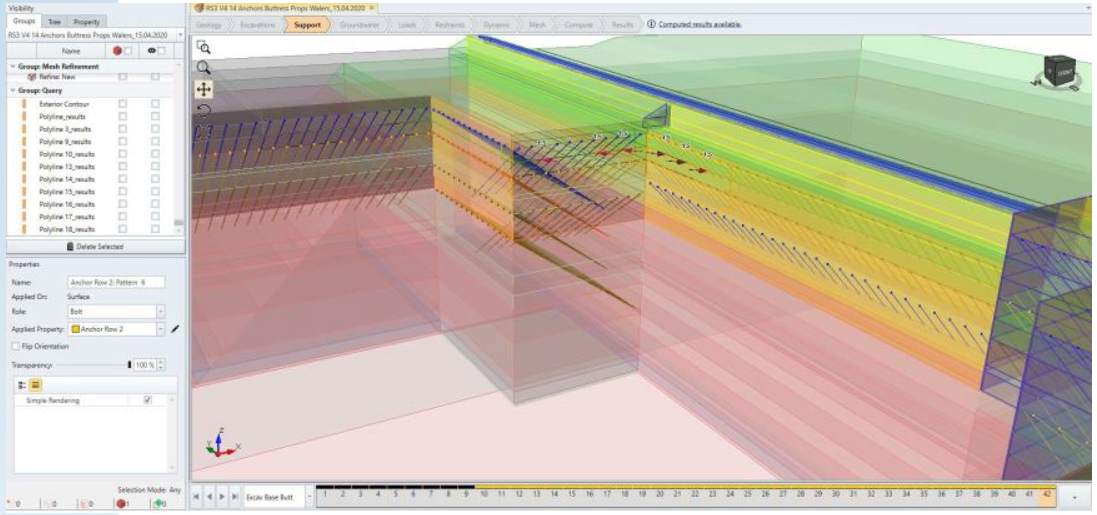


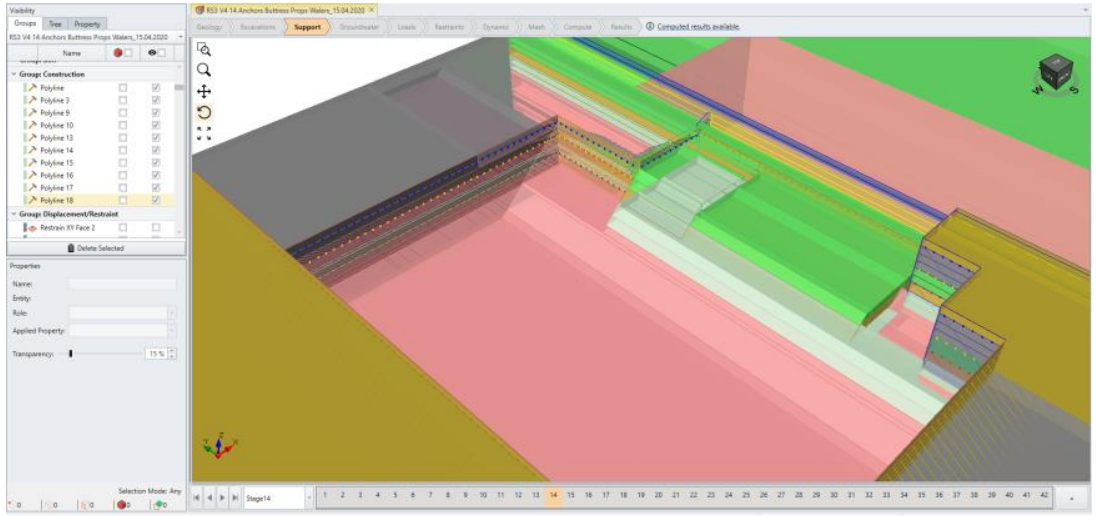
Excavation sequence

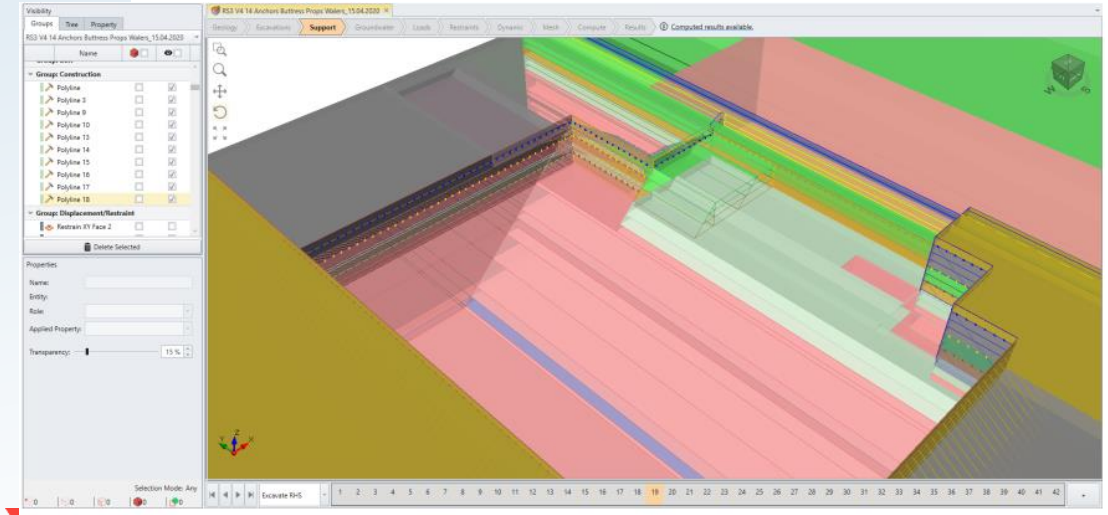


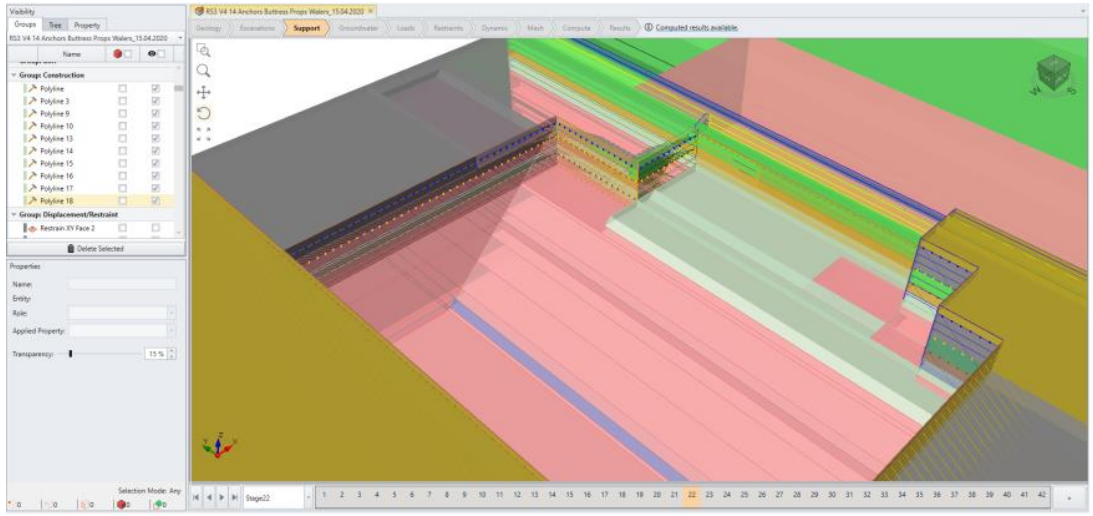
- RS3 full excavation model with pile and anchor support and additional corner propping support

Excavation sequence

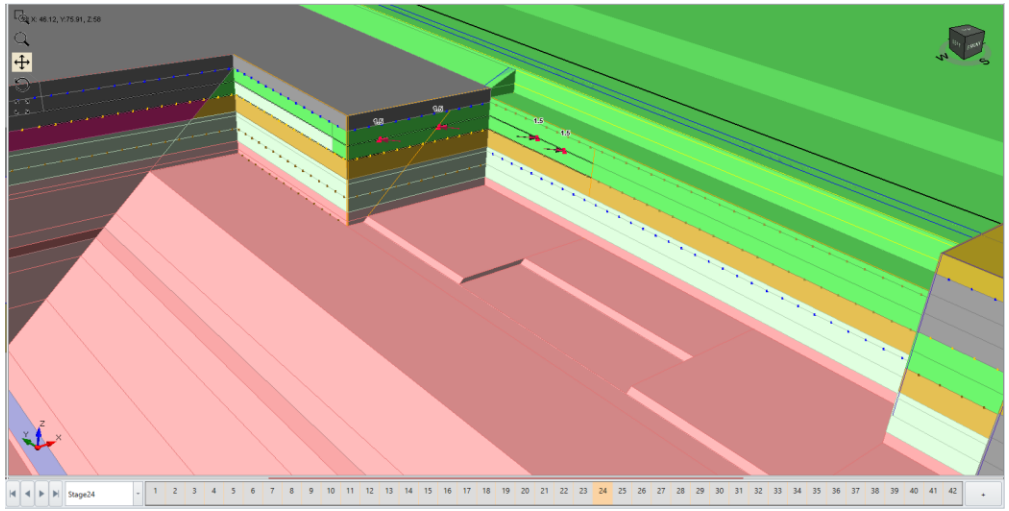


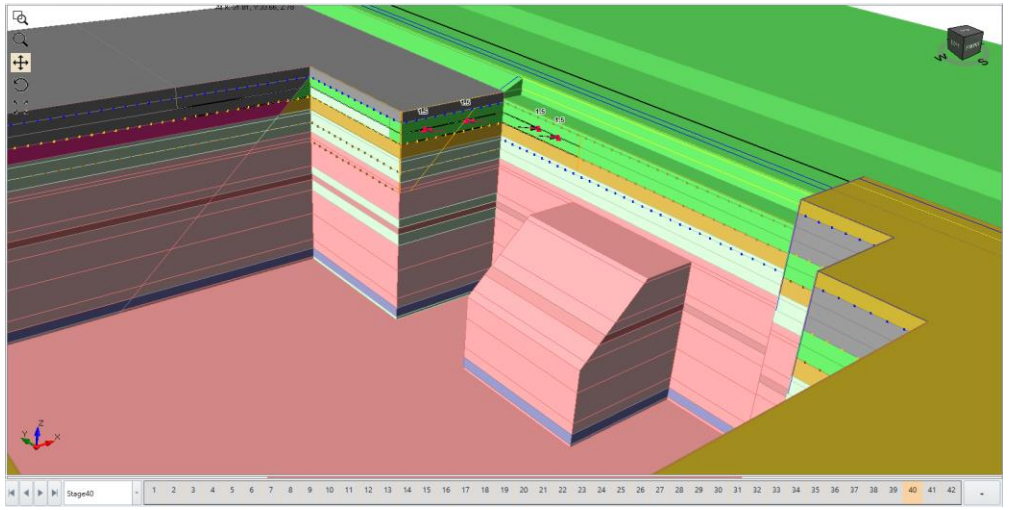


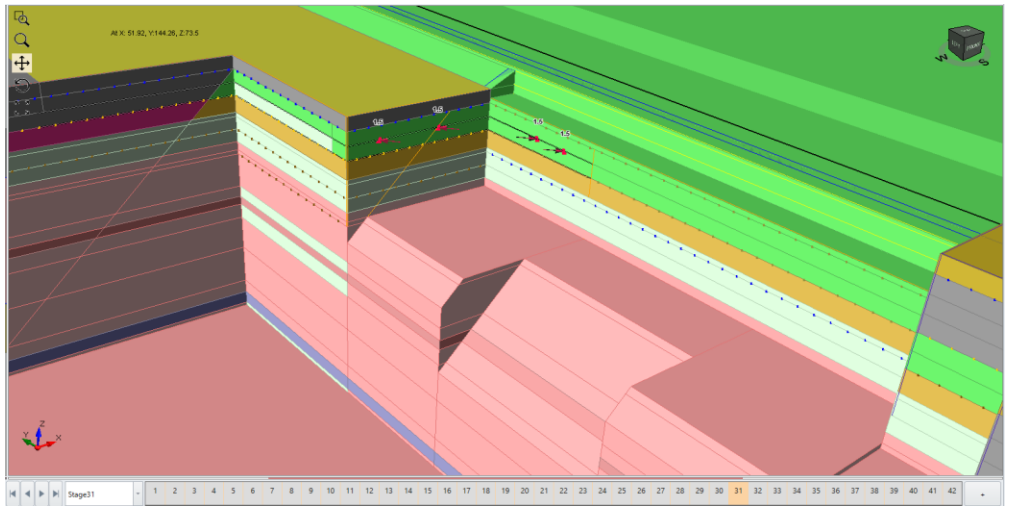


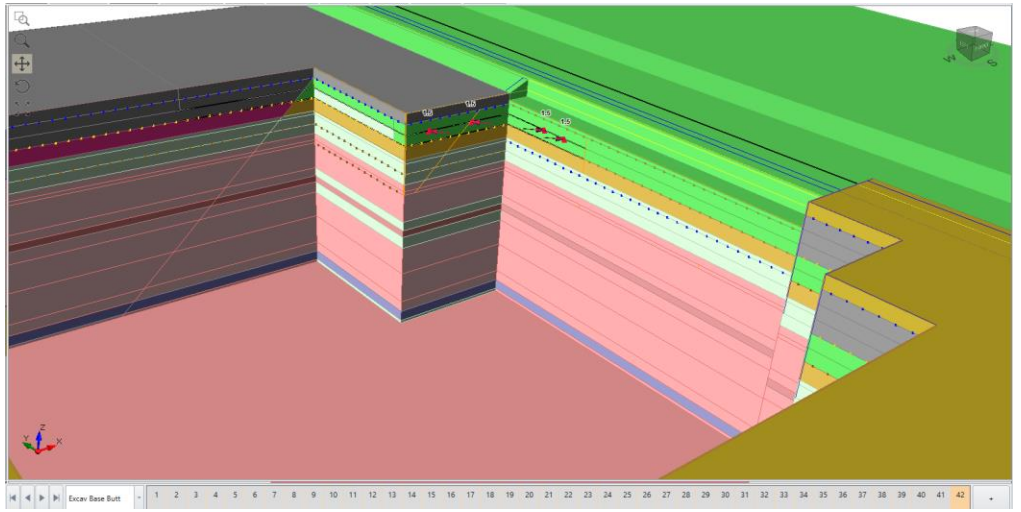


Excavation sequence









Excavation progress – July 2020


COSMO
MOITS
MOITS

Instrumentation schedule and displacement

- Manual Inclinometer
- Automatic Inclinometer
- Displacement monitoring points
- Wall Scanning Displacement (95% of the observations)
- Monitored
- Predicted

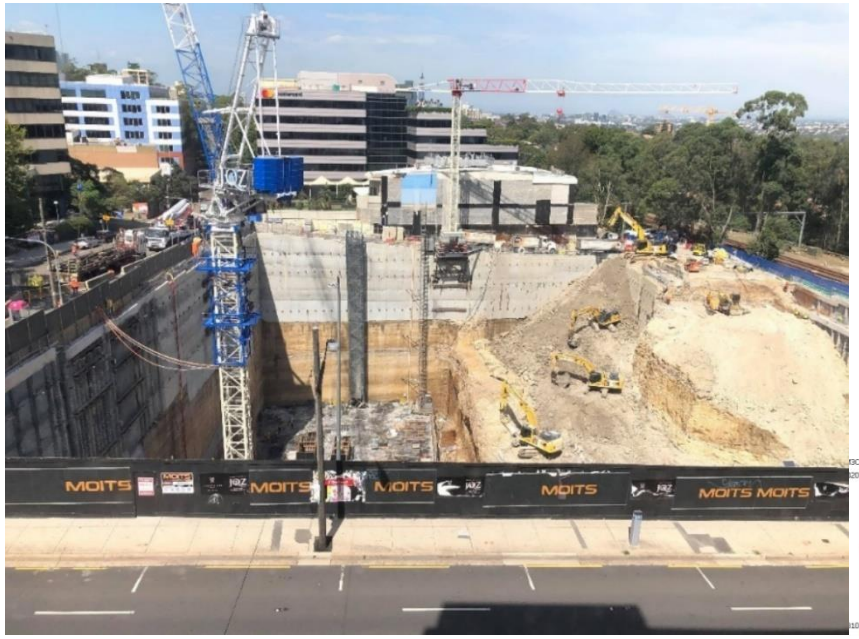
Rail Corridor

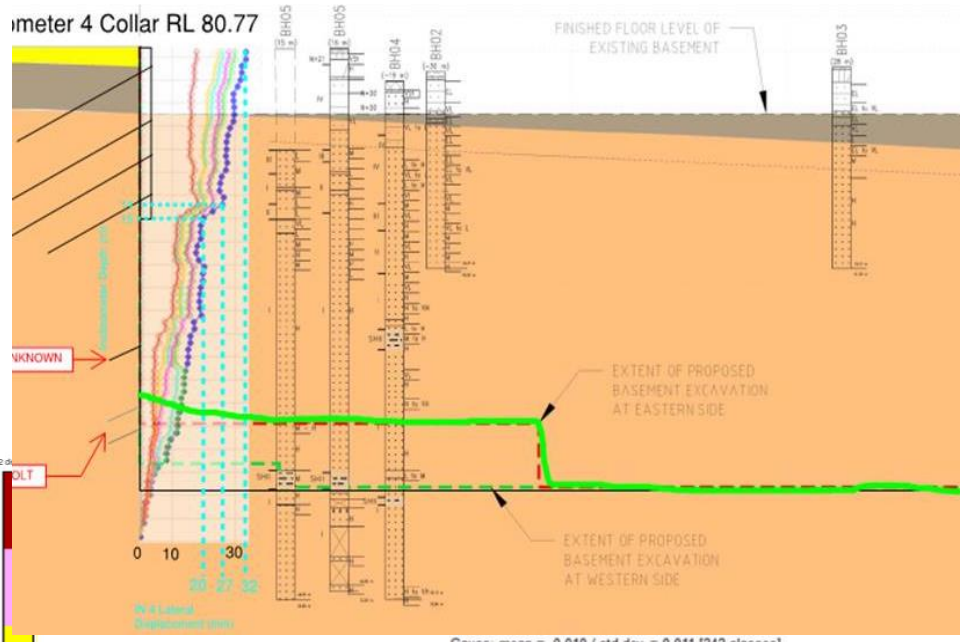
- Monitoring point (on track web)
- OHWS monitoring point
- Railway retaining wall

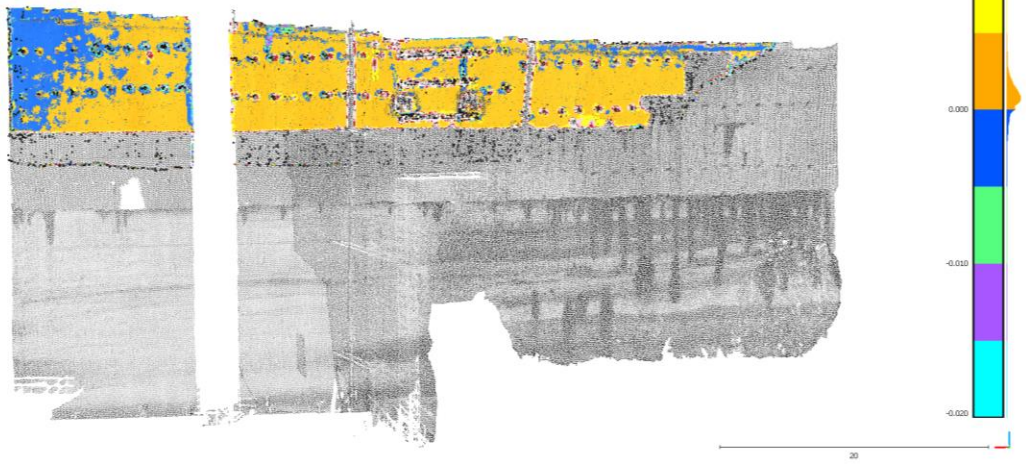
Instrument	Number
Inclinometer	5
Displacement point	112
Bridge displacement	3
Laser scan	
Track monitoring prism	30
Vibration	5
Crack gauge	~30
Overhead wiring structures	3

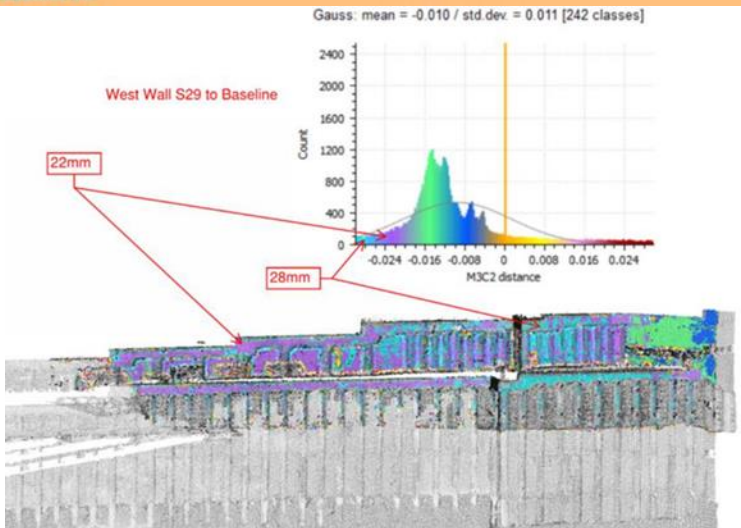
Remote monitoring & precise manual surveying

Excavation monitoring

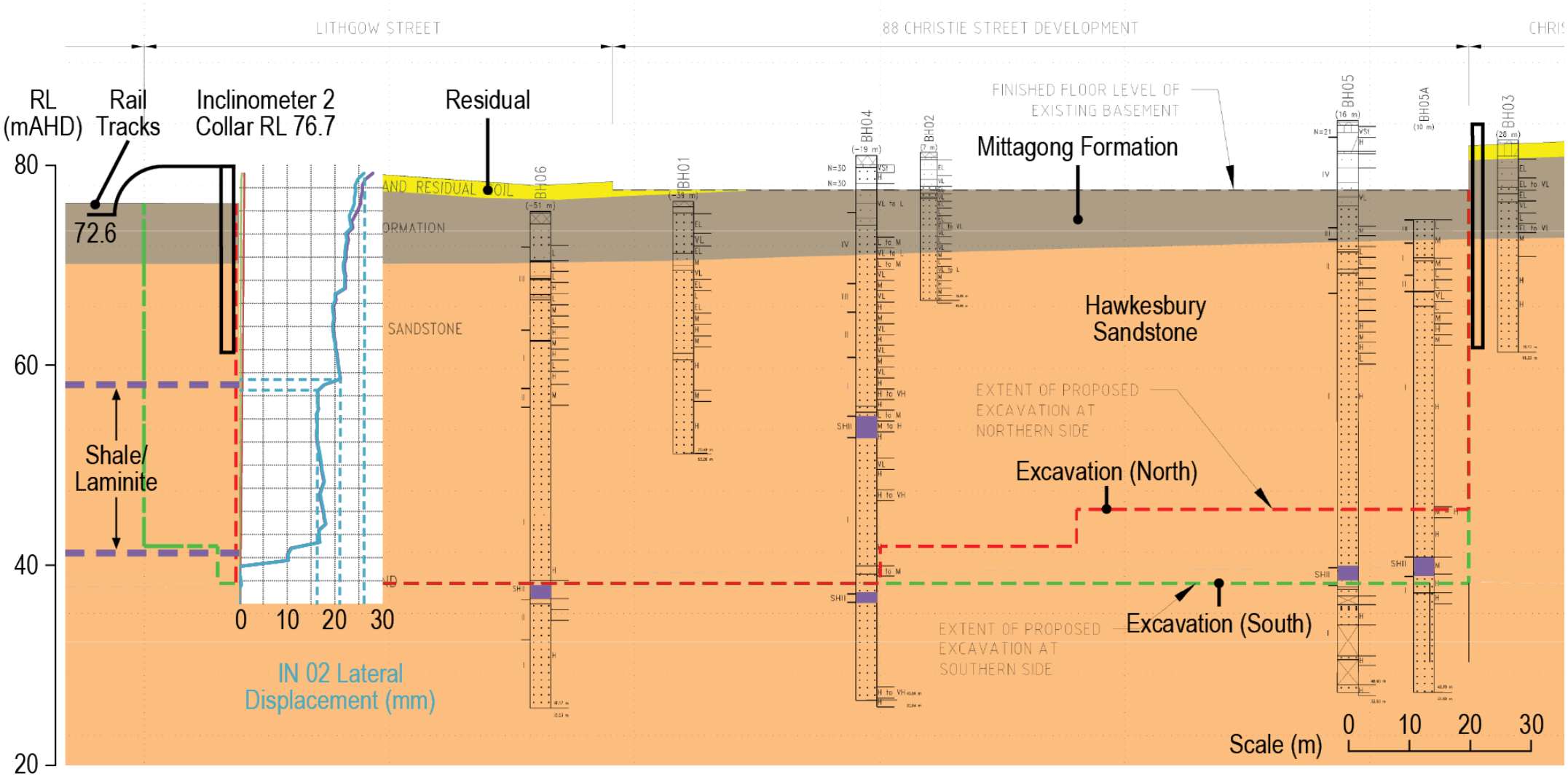






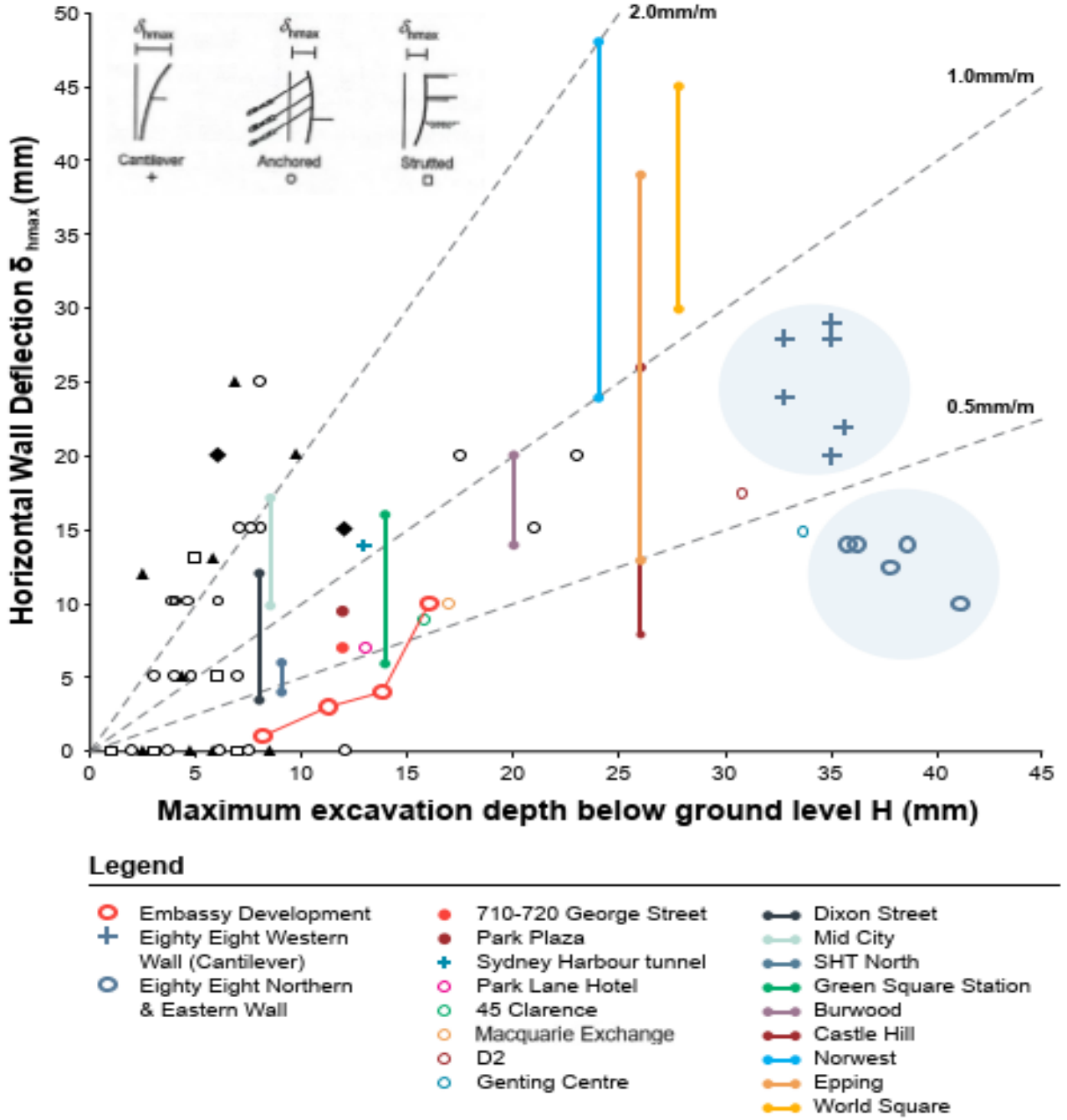


Measured ground movements – 3/10/19 to 22/10/20



Movement database and field performance

- Movement database – 0.5mm to 2mm per metre depth
- Cantilever wall- 0.7mm/m
- Anchored wall – 0.3mm/m



Conclusion

- Among world's deepest (known) basement excavations – 10 levels/ over 43 m deep
- Movement database and numerical analyses used to assess site retention system performance, and impacts on adjacent infrastructure
- Impact assessment enabled adjacent asset owners to establish baselines which reduced project cost and mitigated construction risk
- Advances in data management and visualisation allow progress towards performance-based design and resilience – changing how we process and make decisions
- Monitoring data indicates pre-construction geotechnical models and design parameters were appropriate
- Successful works construction and performance demonstrated that the adopted construction techniques were suitable for the site conditions
- https://youtu.be/Kj3aKPqiCPc

Thank you

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