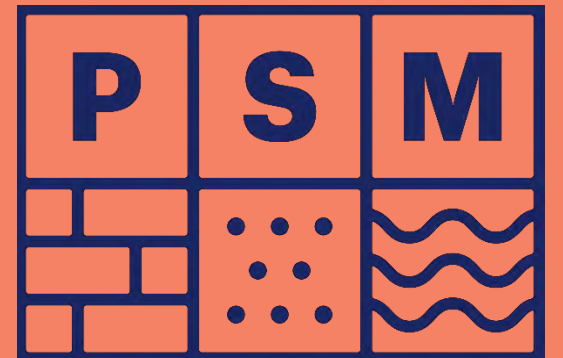


Exploring the crossover between tunnelling and mining

Robert Bertuzzi

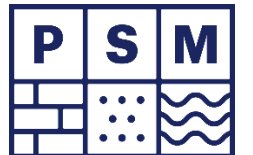
AusIMM Sydney Branch

16 October 2024



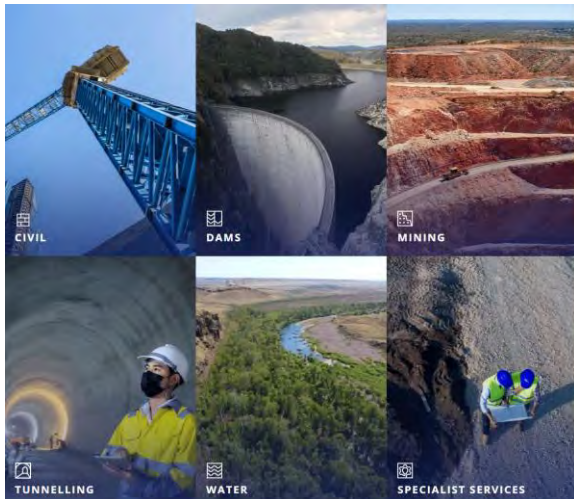
Dance card

- **PSM**
- **Recent examples of city tunnels**
- **What is a tunnelling project?**
- **Innovations**
- **Lessons for mining**



PSM

- Started in 1993
- 150 engineers, geologists, hydrogeologists and hydrologists
- Sydney, Brisbane, Perth, Melbourne





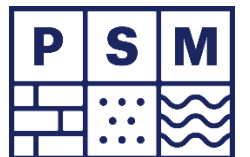
30 YEARS OF TUNNELLING FIRSTS



EASTERN DISTRIBUTOR • Largest Span – Hawkesbury Sandstone • Double Decker	1997
BURNLEY TUNNEL • Tunnel Remediation	2001
LANE COVE TUNNEL • Handlebar Plate	2002
BRISBANE AIRPORT LINK • Largest Span – Brisbane Tuff	2009
M2 WIDENING • Widening of Operational Tunnel	2012
NWRL • Largest Span – Ashfield Shale	2013
WYNARD WALK • Primary as Permanent Support	2015
M4 EAST • Largest Span – Hawkesbury Sandstone	2017
CROSS RIVER RAIL • Largest Span – Neranleigh Fernvale	2020
ROZELLE INTERCHANGE • Multi-level Tunnelling	2022
2023 SYDNEY METRO	
2024 WESTERN HARBOUR TUNNEL	
2024 METRO WEST	
2024 MELBOURNE SRL	

Rock-Soil-Water

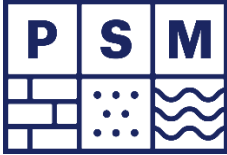
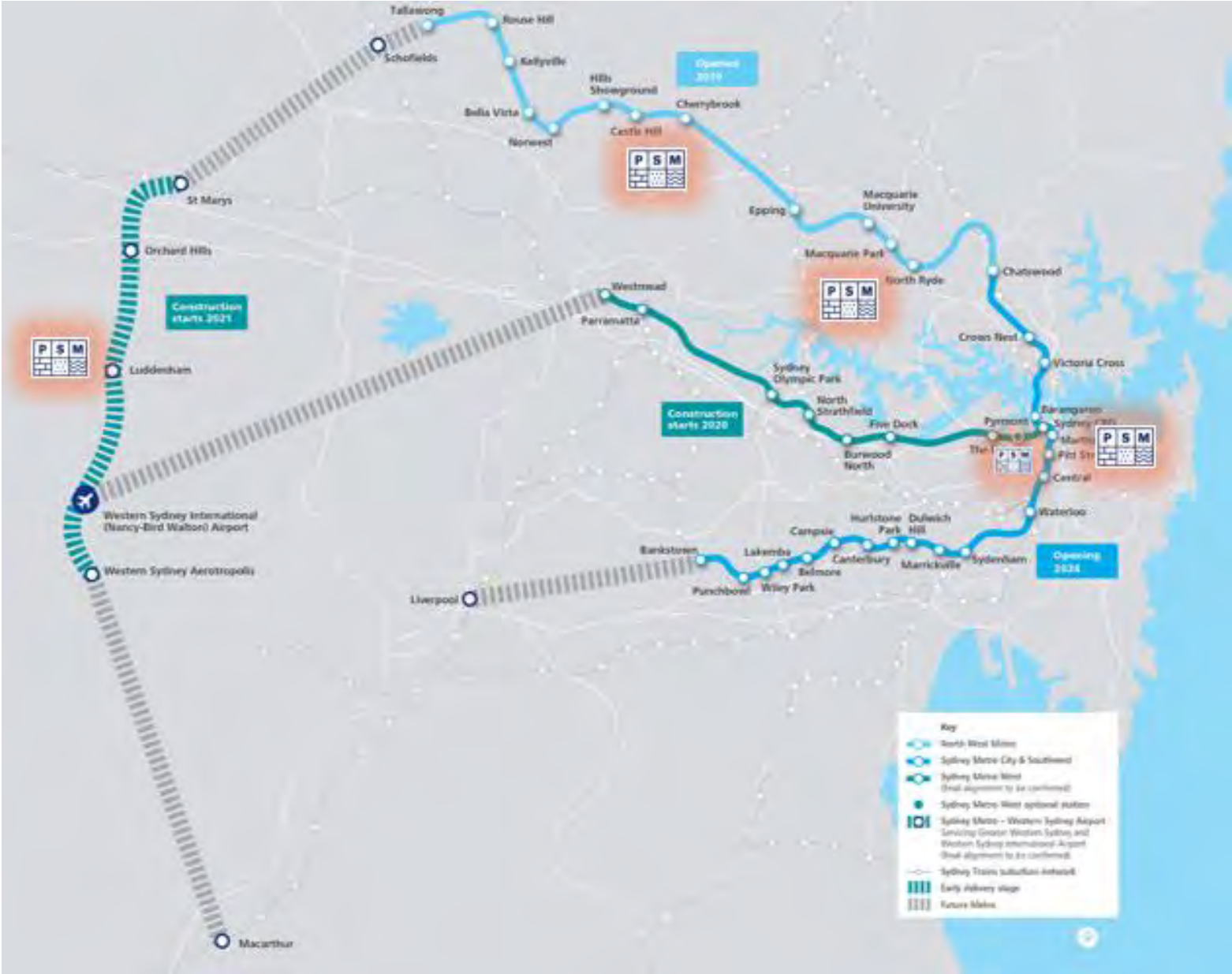
English Channel Tunnel



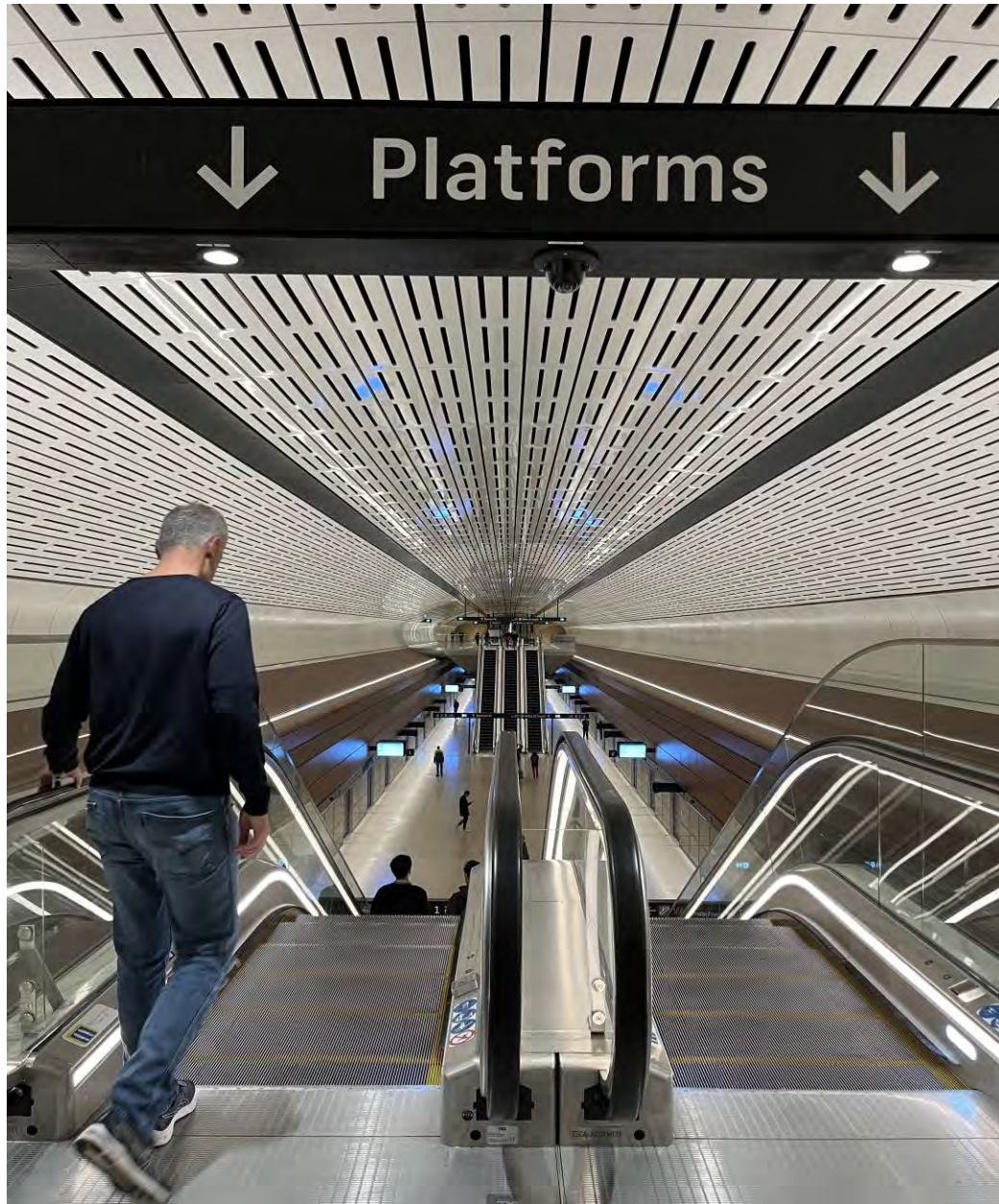
Recent examples of city tunnels



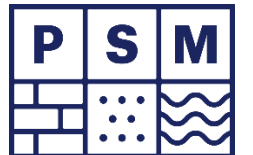
Sydney Metro



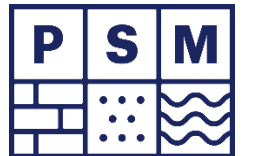
Sydney Metro – Victoria Cross Station



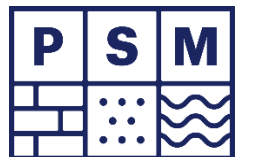
The “cathedrals of the 21st century”



Sydney Metro – Completed cavern (Dec 2020)



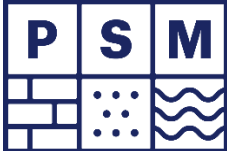
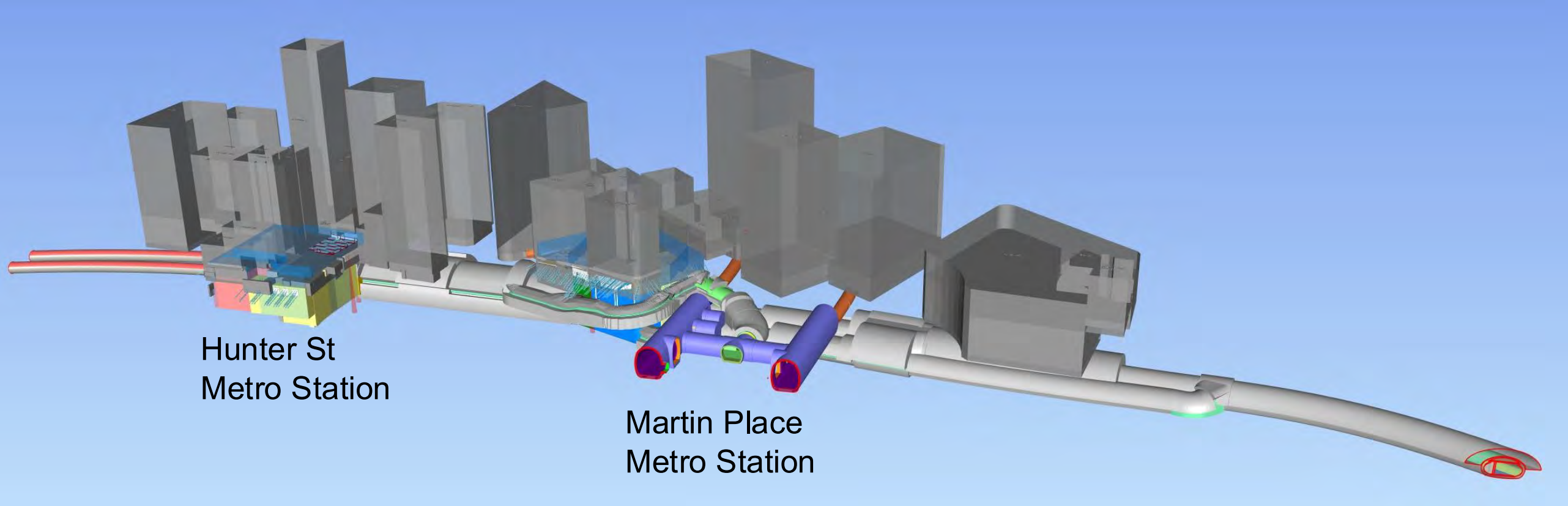
Sydney Metro – Cavern excavation (2019)



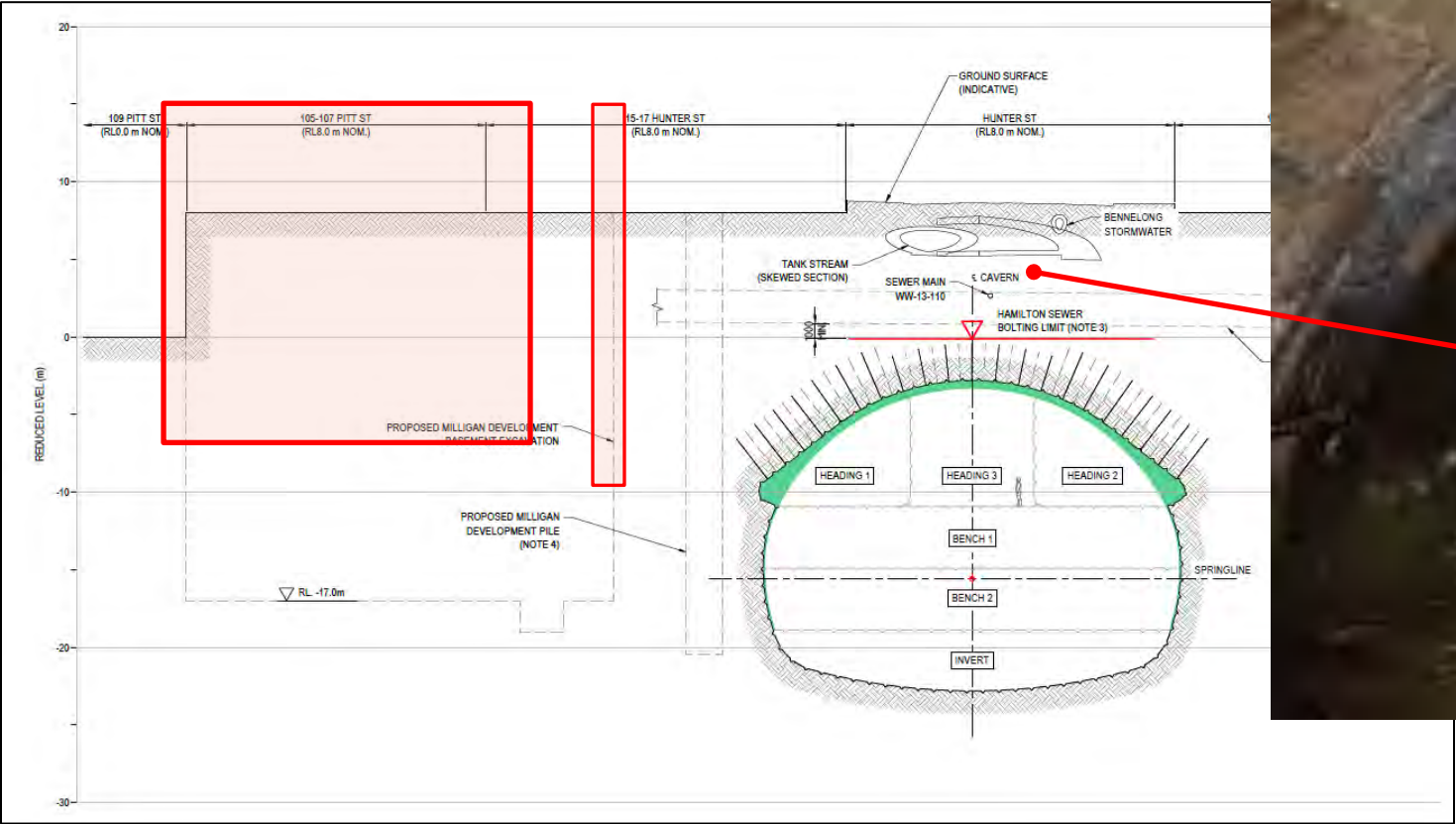
Sydney Metro West (under construction)



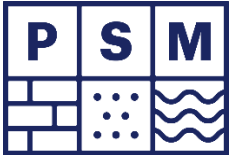
Metro West – Hunter St Station



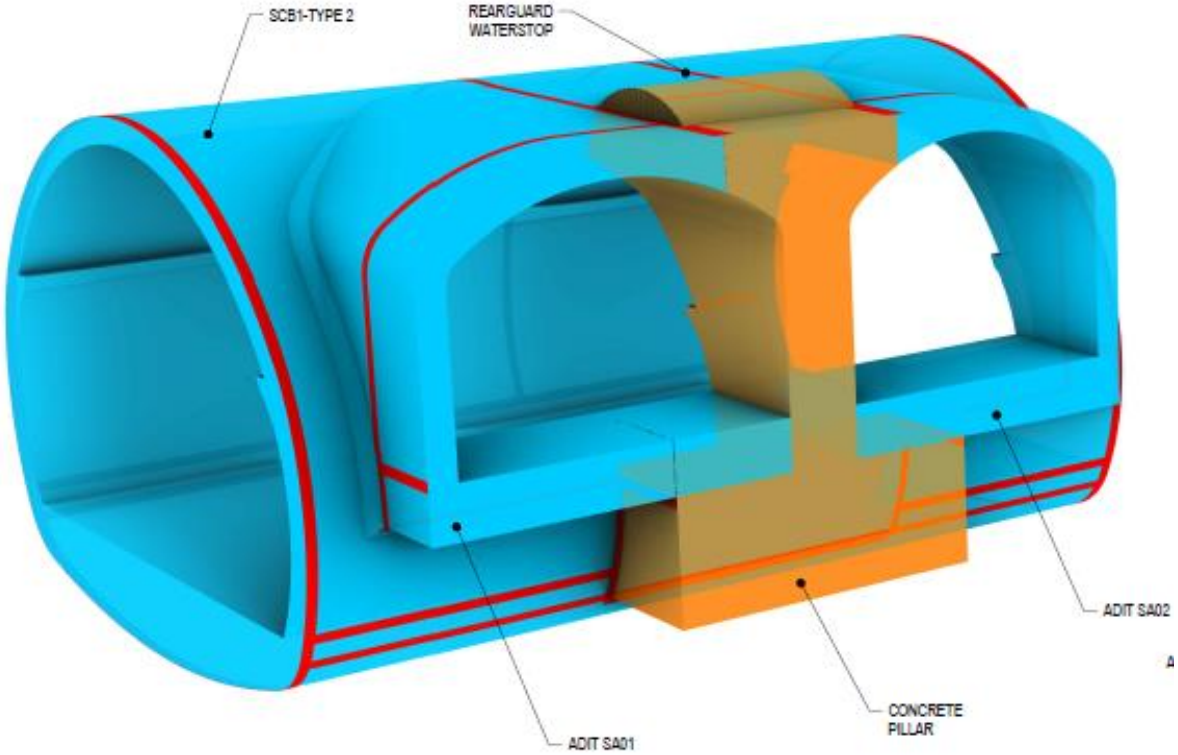
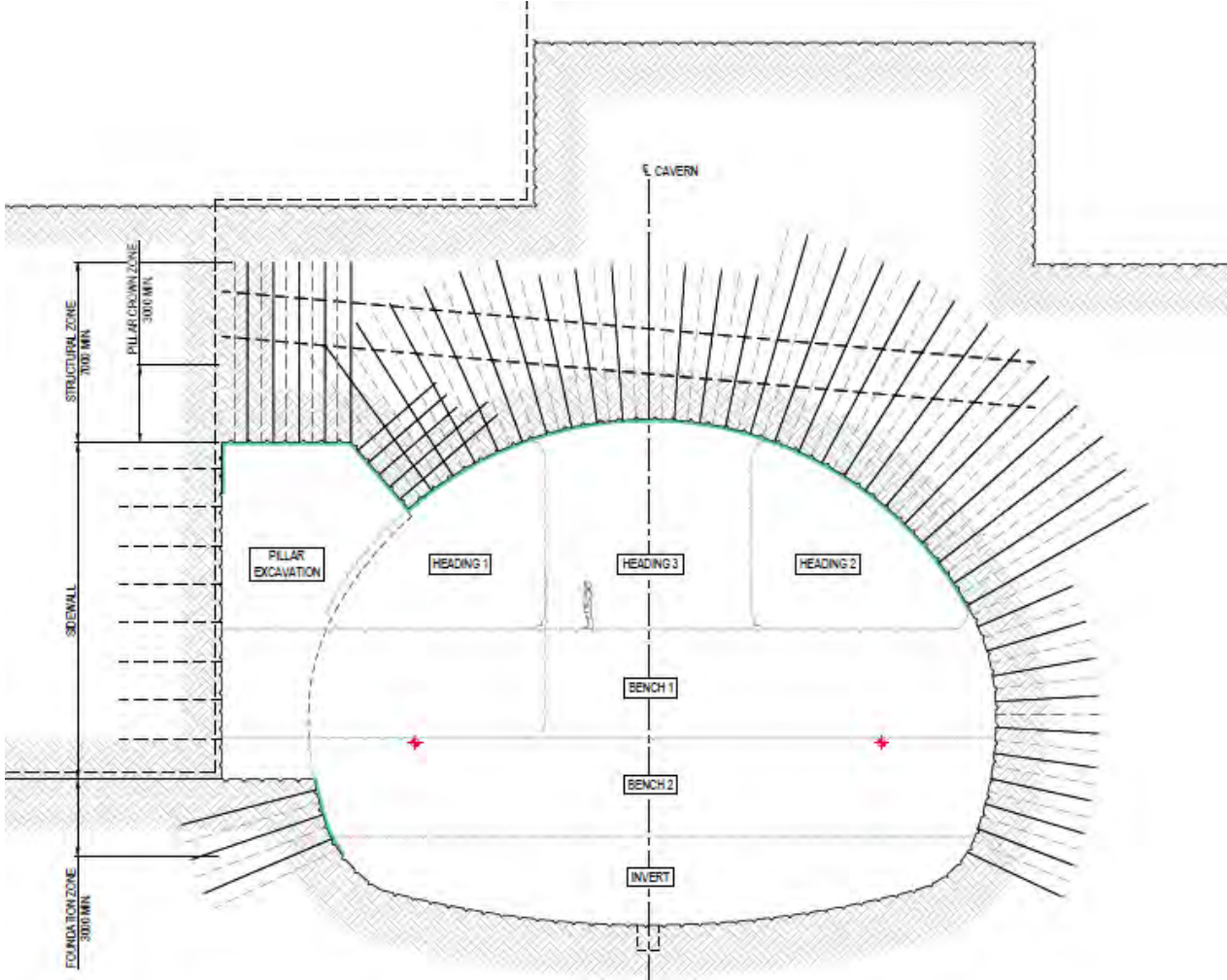
Hunter St Station – existing tunnels



Sydney Water Tank Stream heritage tunnel



Hunter St Station – future basements



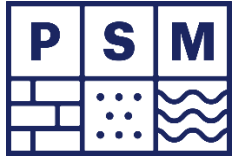
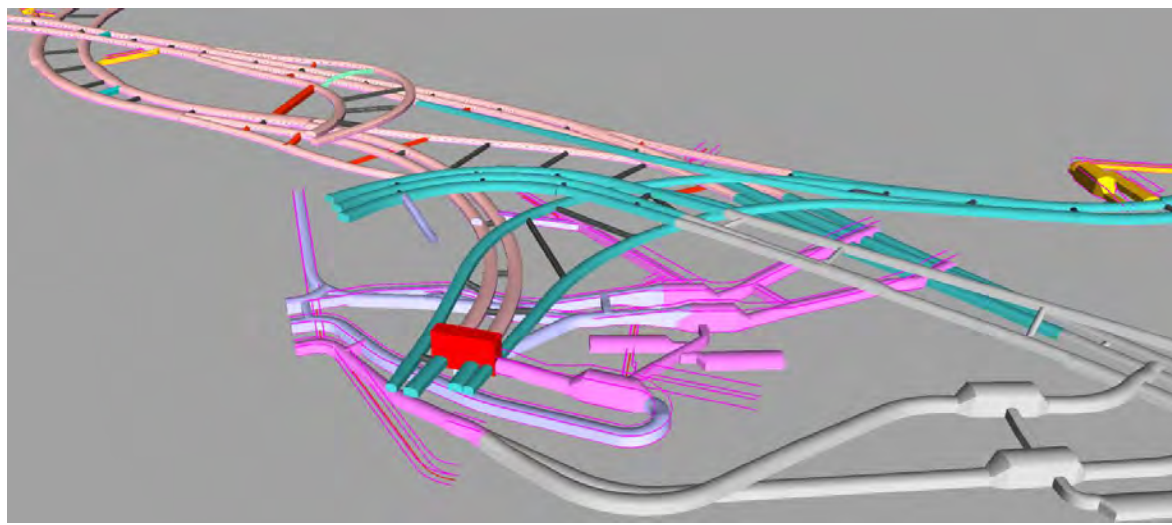
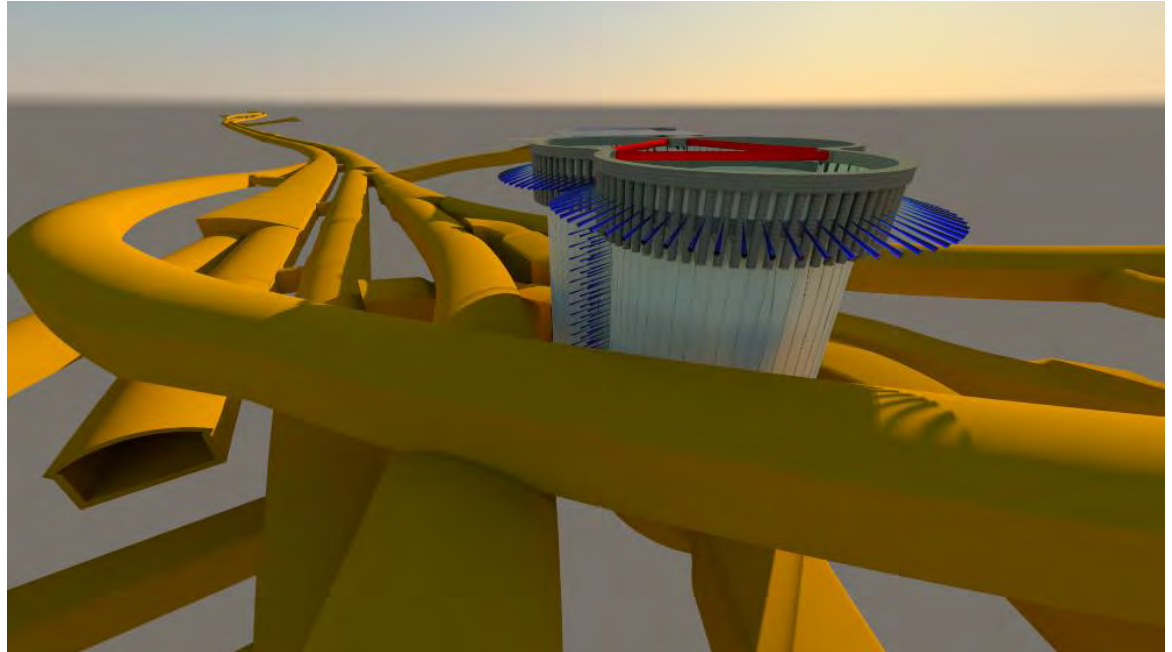
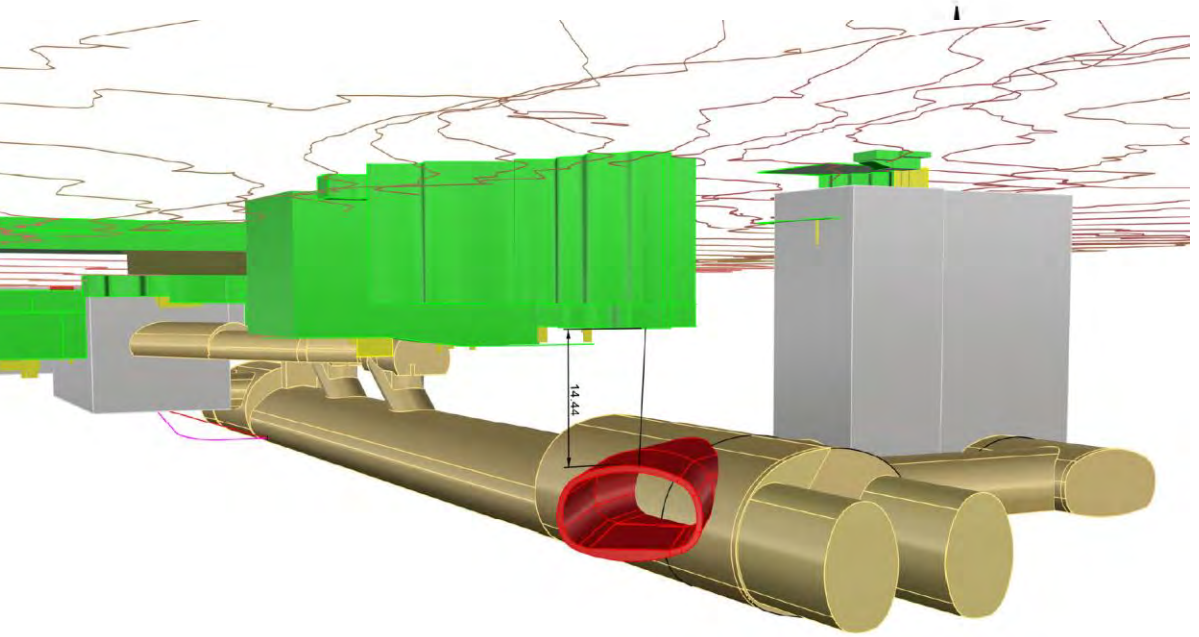
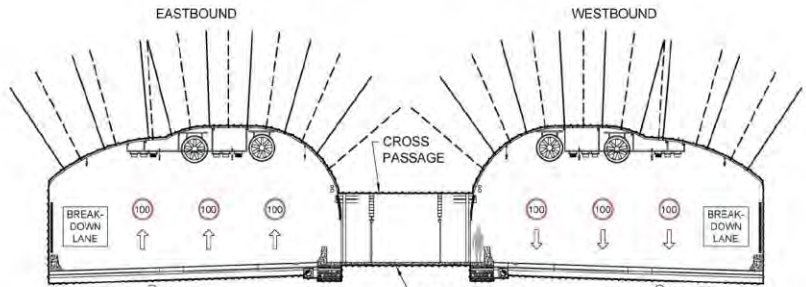
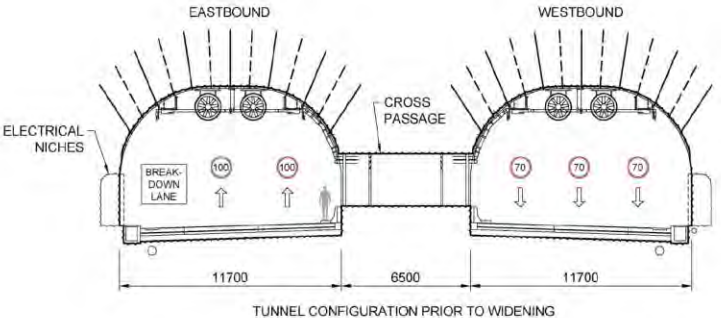
Hunter St Station – excavation



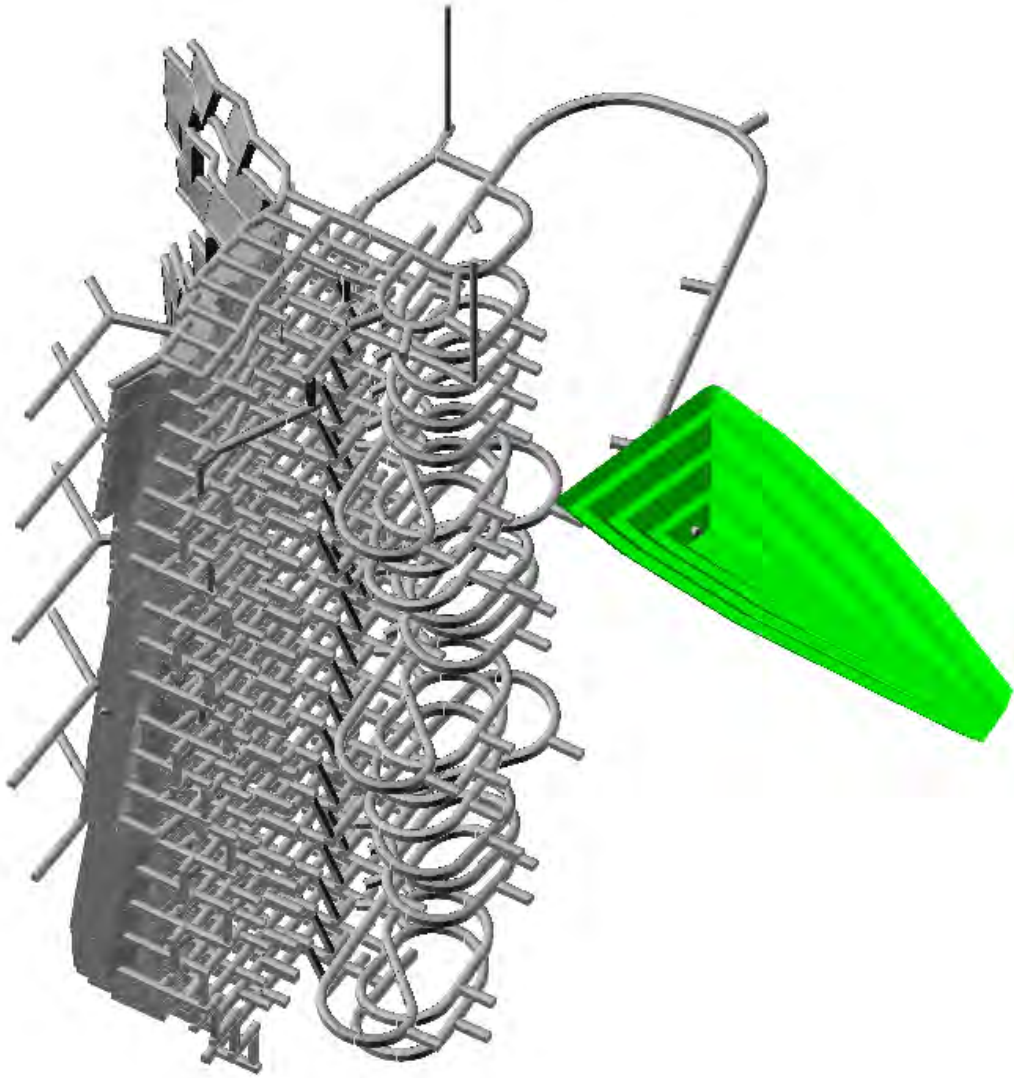
Hunter St Station – excavation



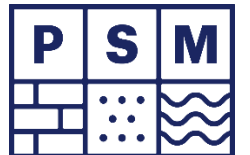
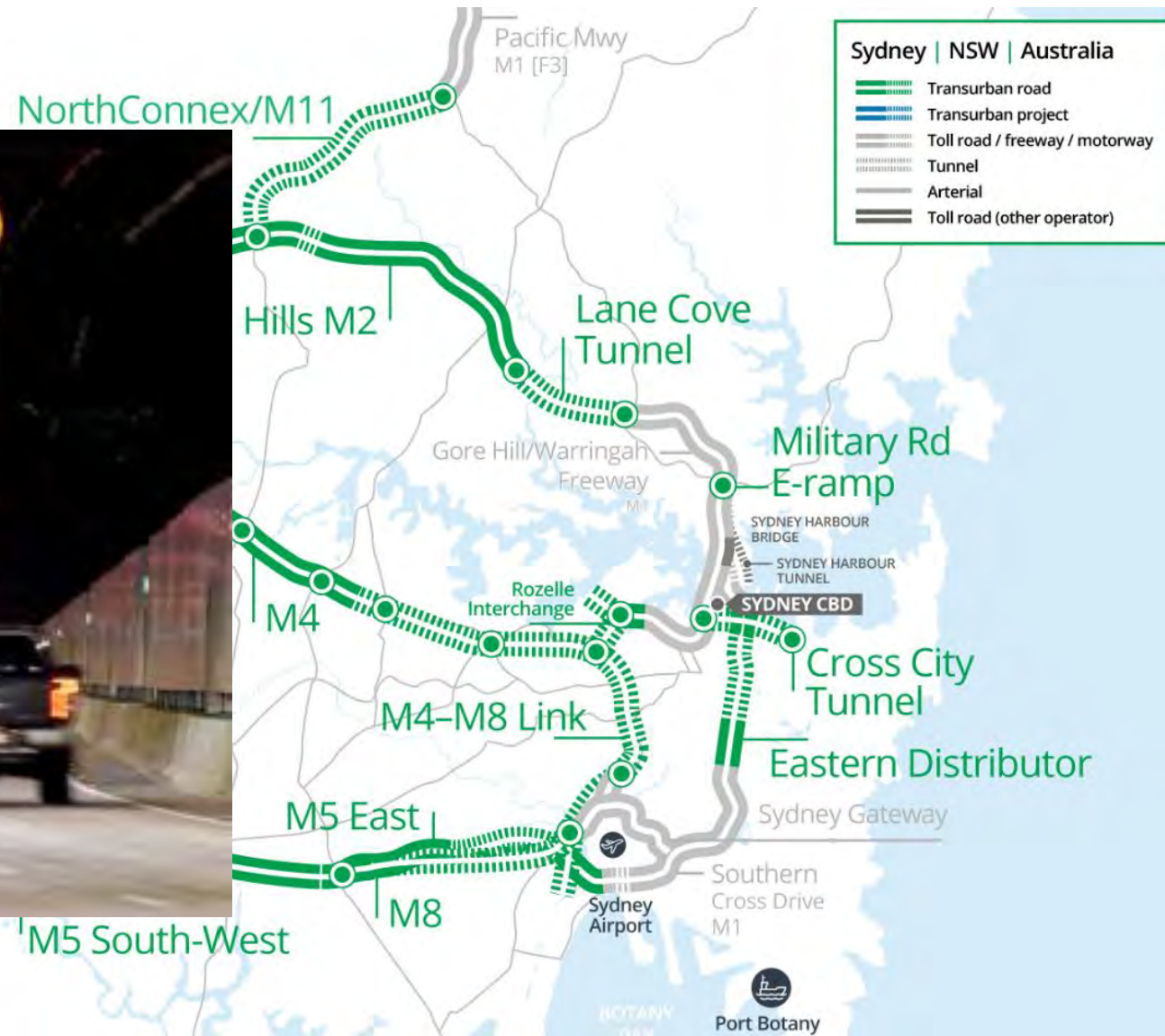
Increasingly complex geometry



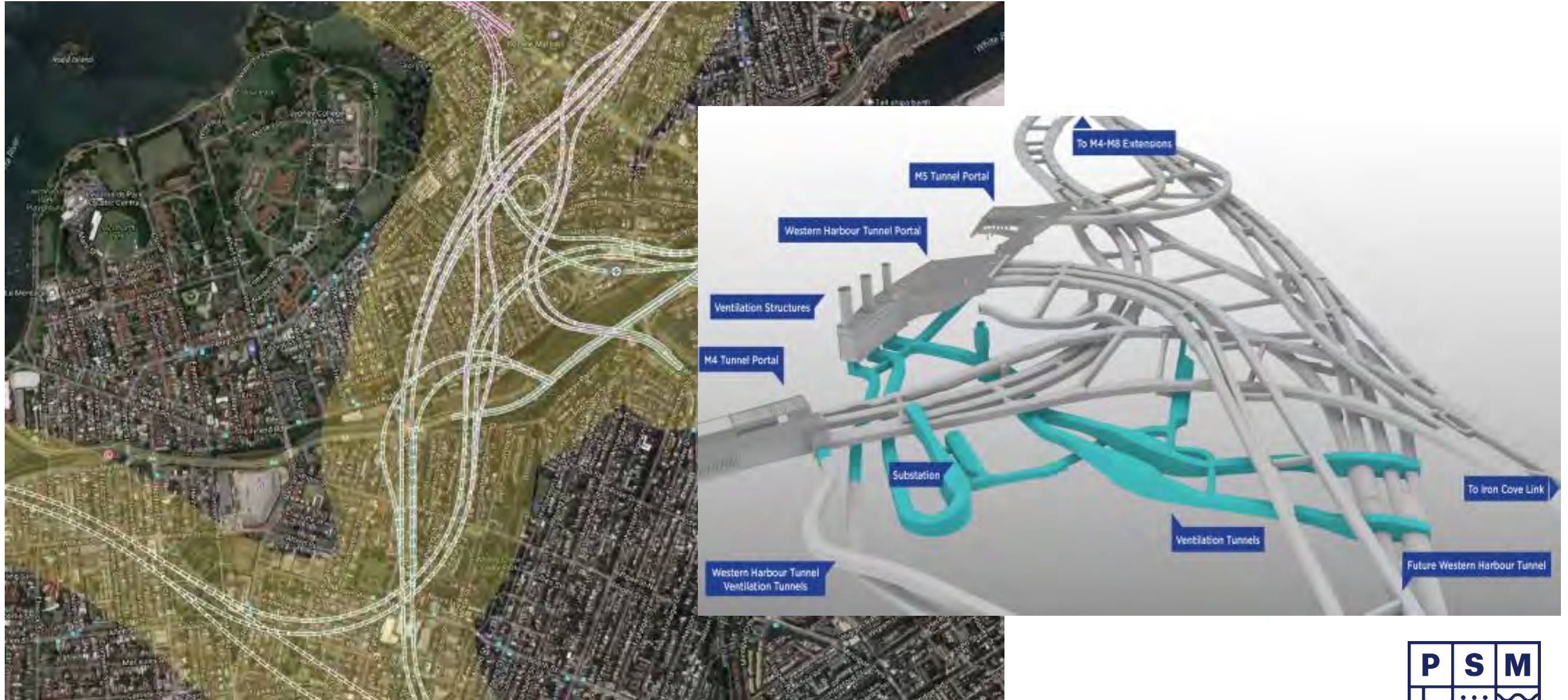
Complexity of a mine



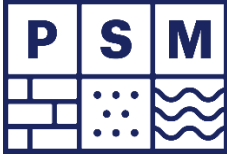
WestConnex – Rozelle Interchange



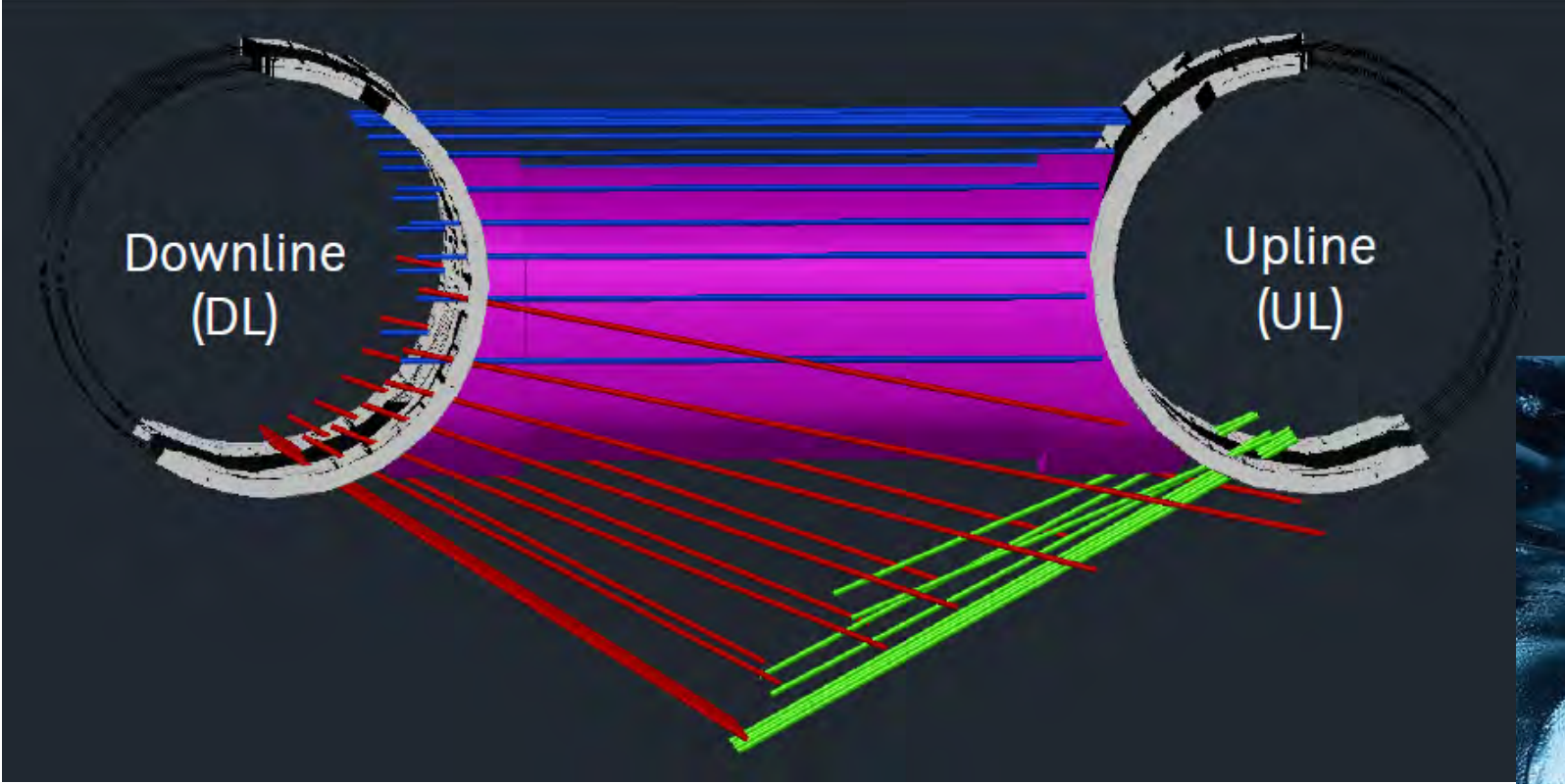
WestConnex – Rozelle Interchange



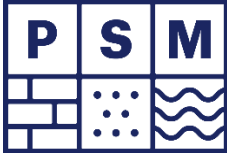
Rozelle Interchange



Melbourne – Suburban Rail Loop



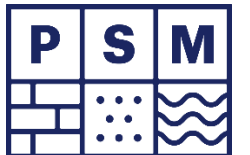
Ground Freezing to allow open excavation of saturated sands



Wynyard Walk



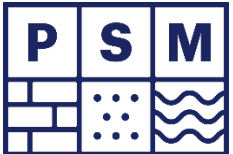
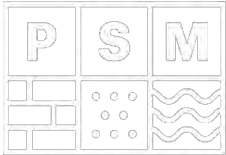
Complex Structures



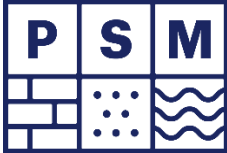
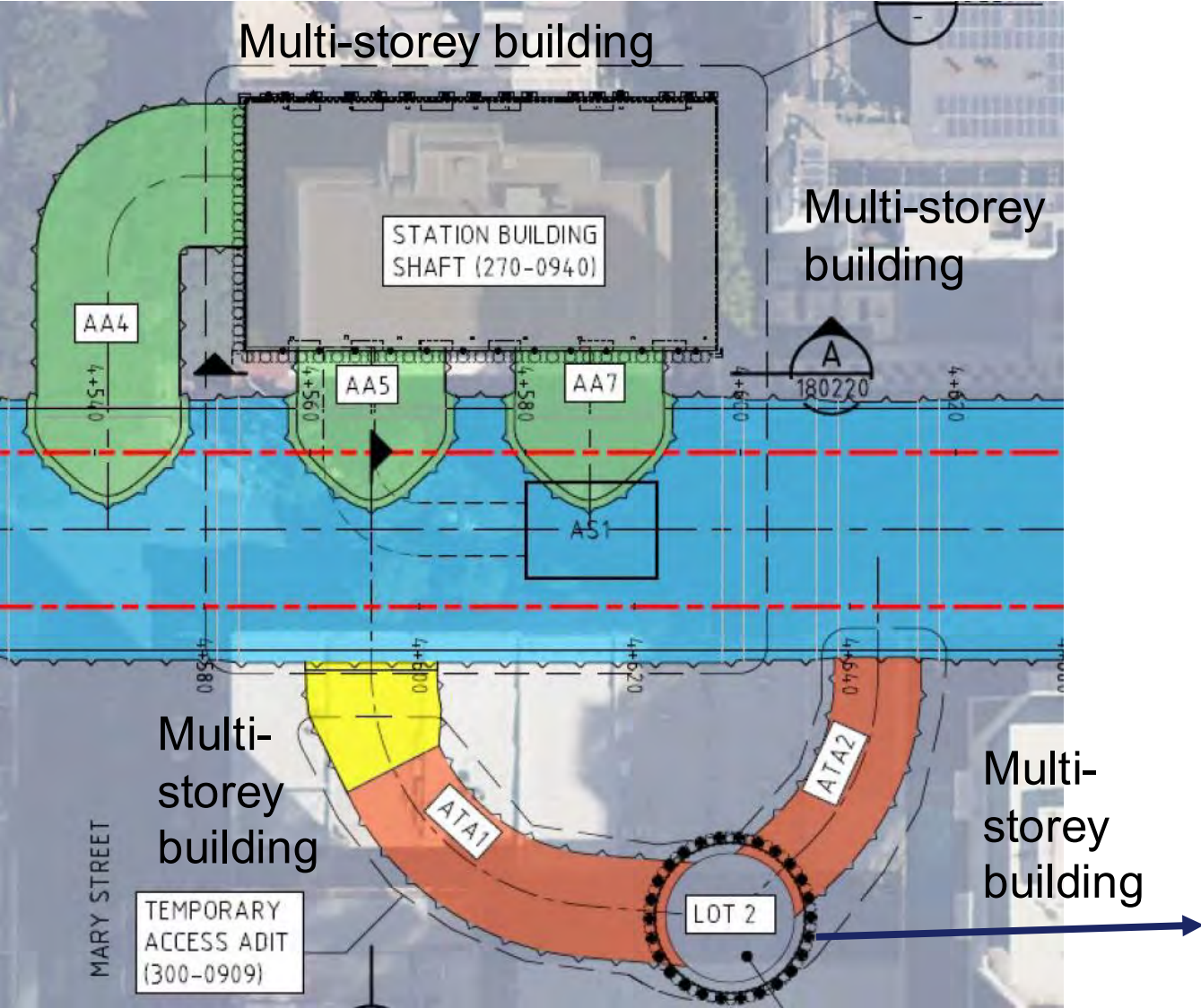
Brisbane – Cross River Rail Boggo Rd Station



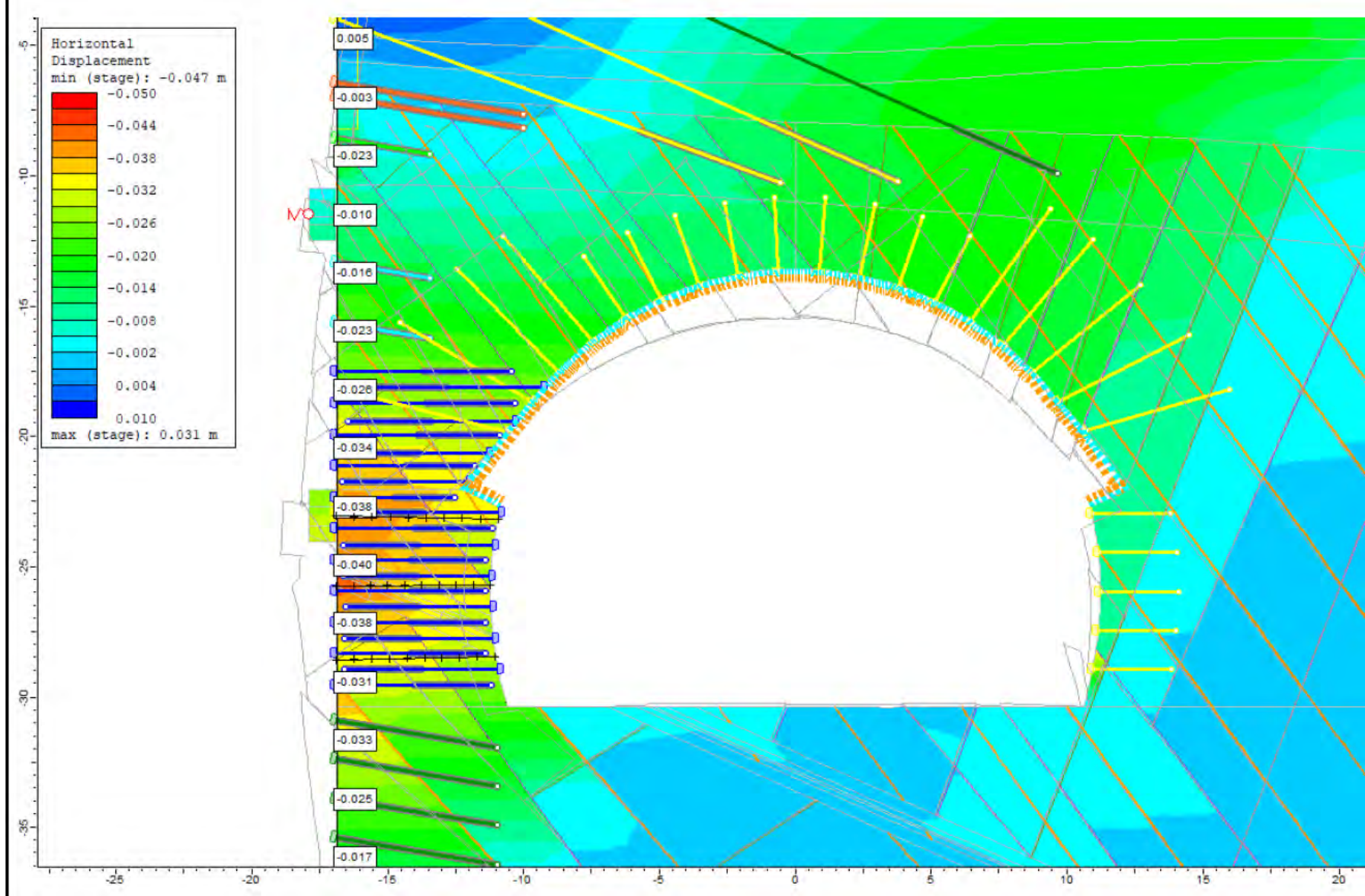
Big, shallow tunnels



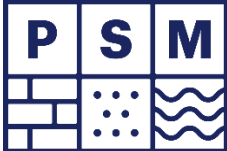
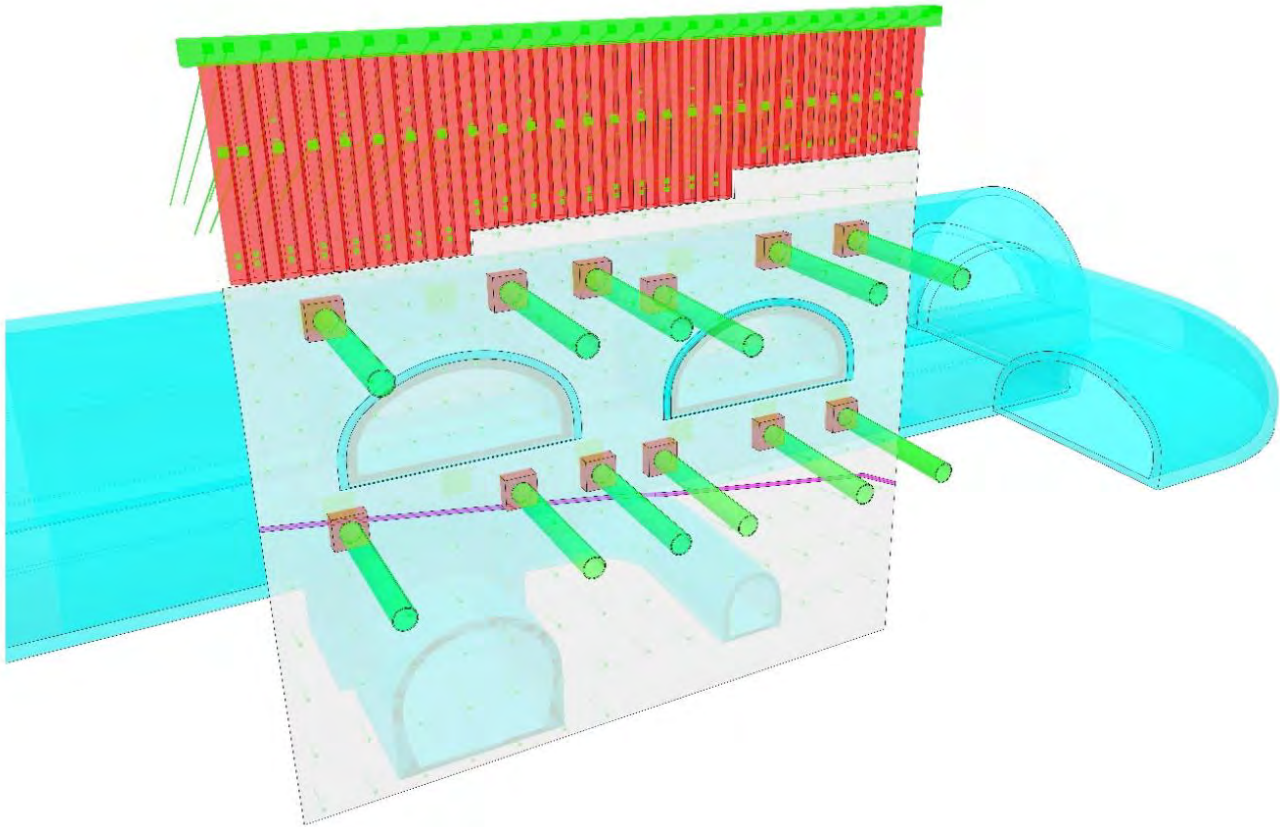
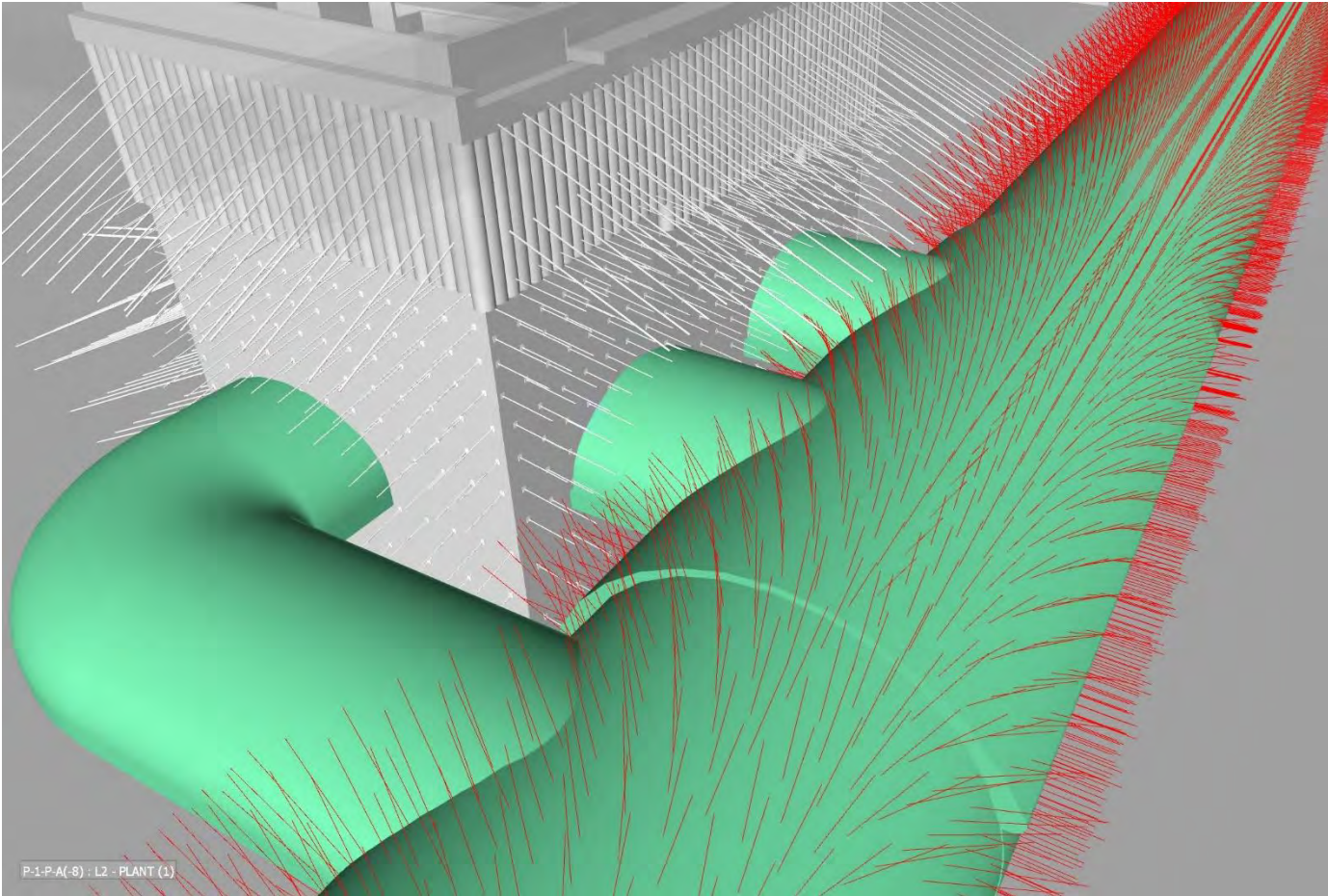
Brisbane - Cross River Rail



CRR – Albert St station building



CRR – connections



CRR – propping



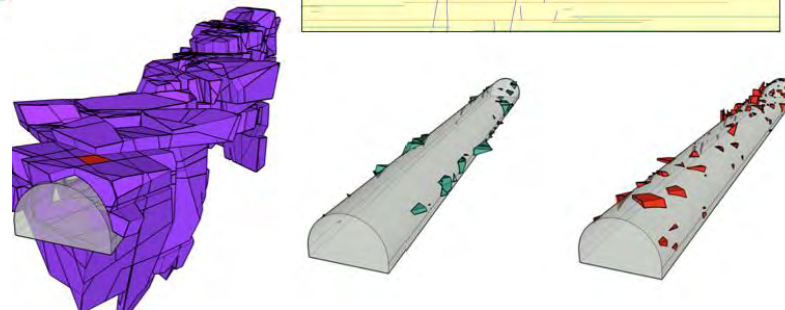
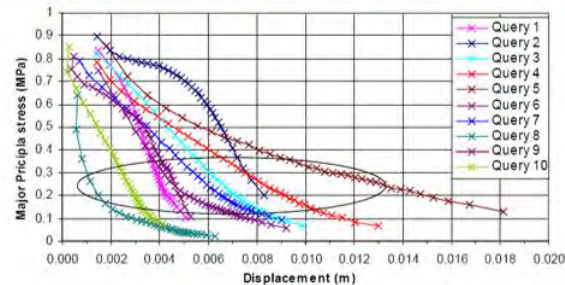
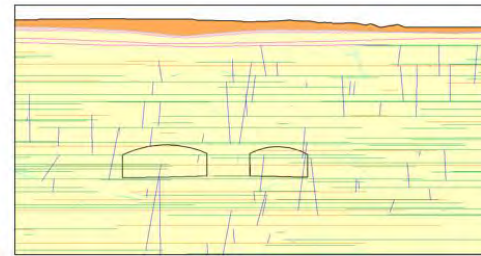
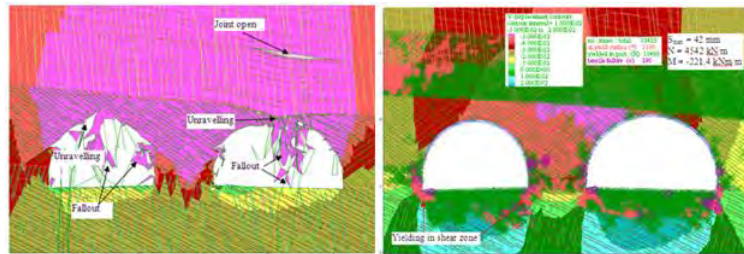
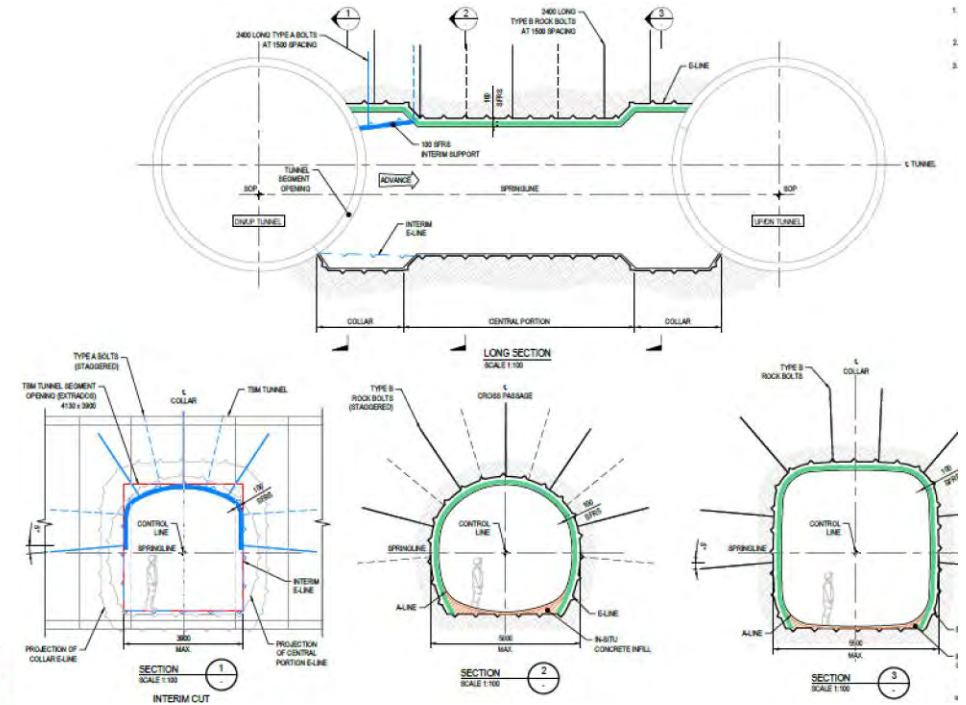
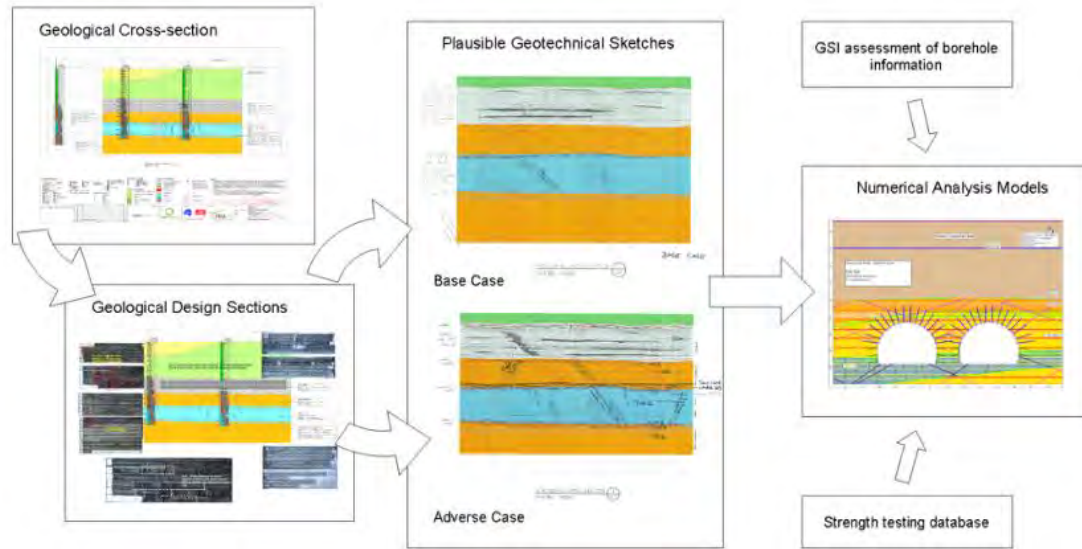
CRR – completed cavern



A Tunnelling Project



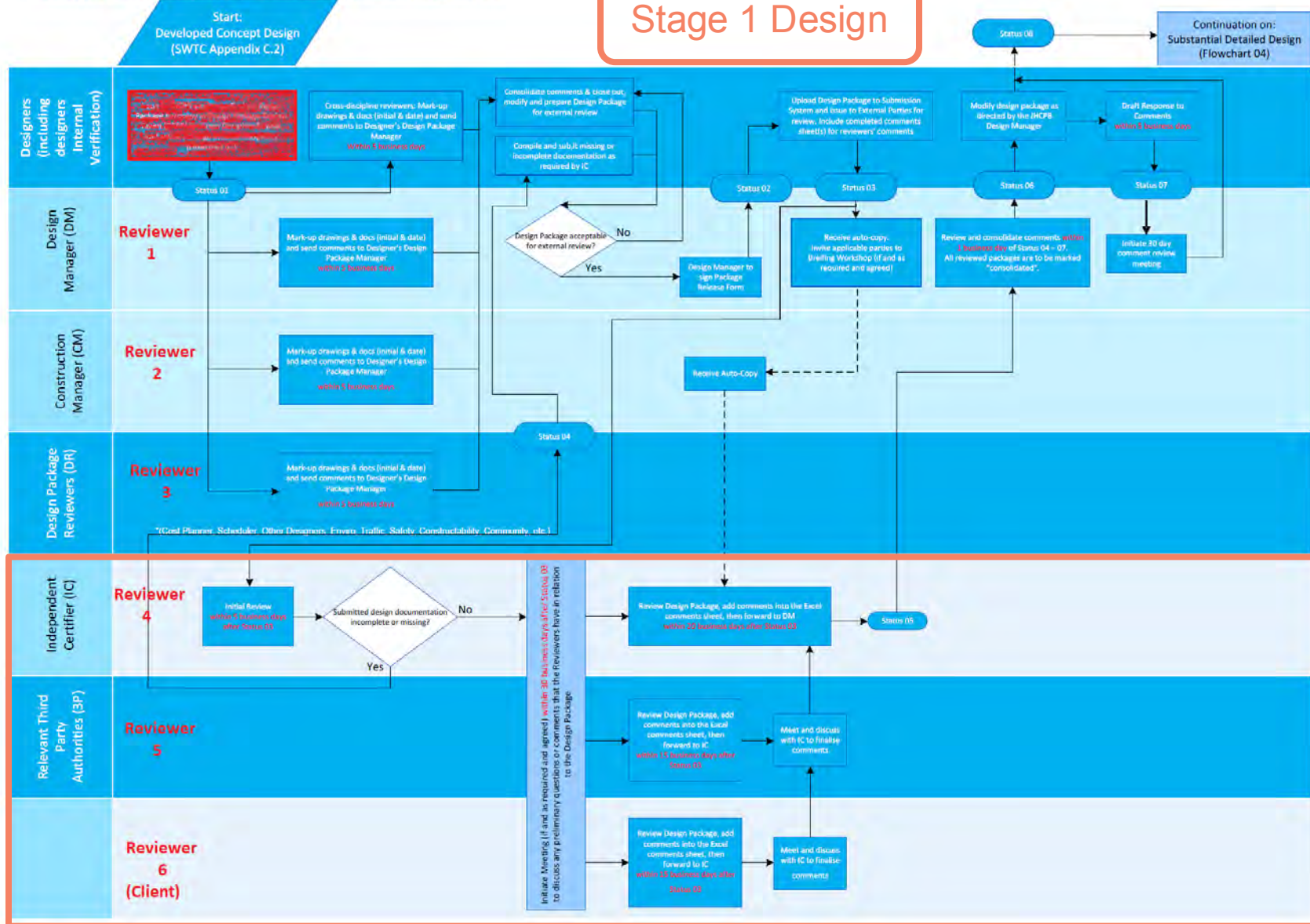
Engineering and Construction Project



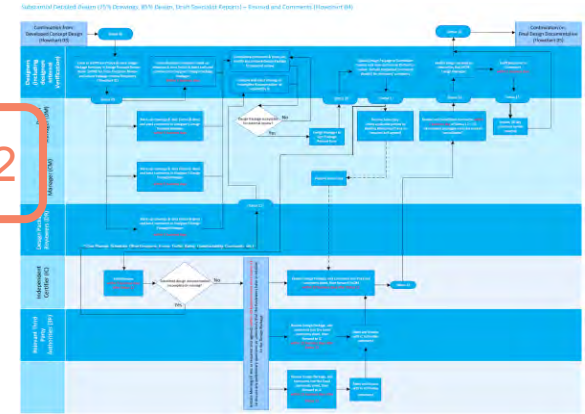
Design review

Developed Concept Design (15%) Review and Comments (Flowchart 03)

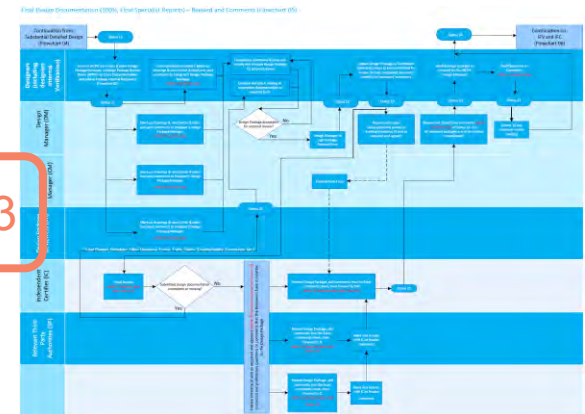
Stage 1 Design



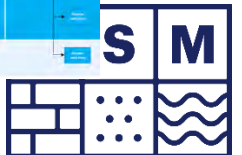
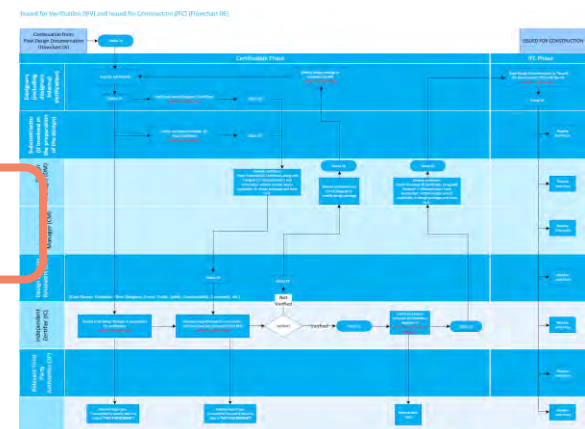
Stage 2



Stage 3



IFC

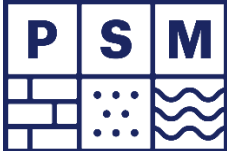
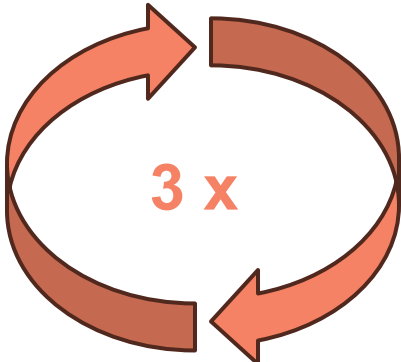
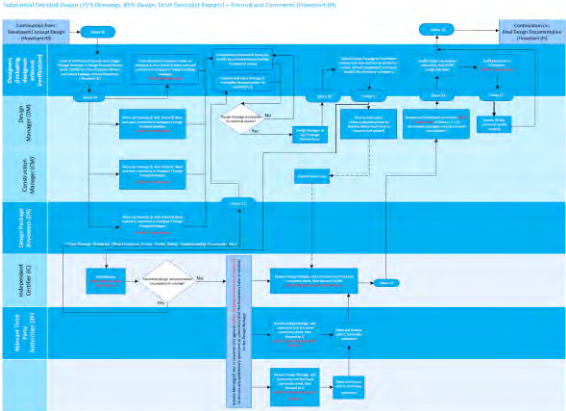


Design review

Designer

- 1. Internal review (ISO9001)
- 2. Design Project Manager
- 3. Construction Project Manager
- 4. Construction Team Reviewer(s)
- 5. Proof Engineer
- 6. Independent Certifier
- 7. Client's Engineer(s)
- 8. 3rd Party Stakeholders

Current project – 20 people are in the Reviewer's list



Timeframe and multiple reviewers

Standard
Slightly different
Unusual
'Out there'



Standard
Slightly different
Unusual



Standard
Slightly different

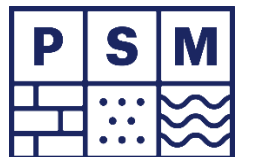


Standard



To ensure design delivery through multiple reviewers in the time needed by the project, it might be better to design “the standard”.

The pressure to do this increases with the number of reviewers and the shorter the timeframe



Result - 1

Eastern Distributor (1999)

Permanent

1700 m long

8 to 24.5 m spans

12 m high

About 1 km of road tunnels existed

Design + review \approx \$900k

\$5000 per km of tunnel

Access tunnel (2024)

Temporary

60 m long

8 m span

8 m high

About 150 km of road tunnels exist

Design + review \approx \$1,000k

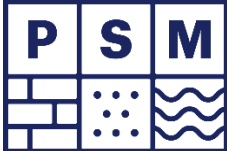
\$170,000 per km of tunnel

x 35

cf inflation x 1.9



Result - 2



INNOVATIVE TUNNEL ENGINEERING


normet
SmartDrive
NORMET.COM



INNOVATING FOR PERFORMANCE

SmartDrive product family provides high productivity with decreased operating costs. For more information, please contact your local Normet representative, visit www.normet.com for contact details.

Start your electrification journey with Normet SmartDrive today!

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Trusted INNOVATIVE SOLUTIONS



Crenshaw/LAX Transit Corridor

HNTB has a long history of winning work for some of the country's most complex projects. From small-diameter excavations to the largest machine-bored tunnels, our experts have the knowledge to provide innovative solutions to tunneling.

VOL. 5 | NO. 06 | JULY 2019

create

ENGINEERING IDEAS INTO REALITY

100 YEARS OF ENGINEERING IN AUSTRALIA

2019

A U S T R A L I A N M O S T I N N O V A T I V E E N G I N E E R S

UC of SME
North American Tunneling Journal



Cutting Edge Confer

Advances in Tunneling Technology
HOSTING THE ITA TUNNELING AWARDS

Where Innovation Meets Practical Experience

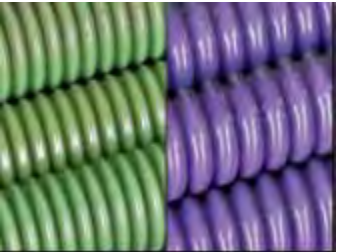
Increased design life of bolts



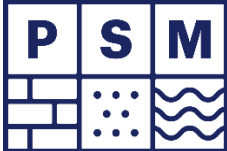
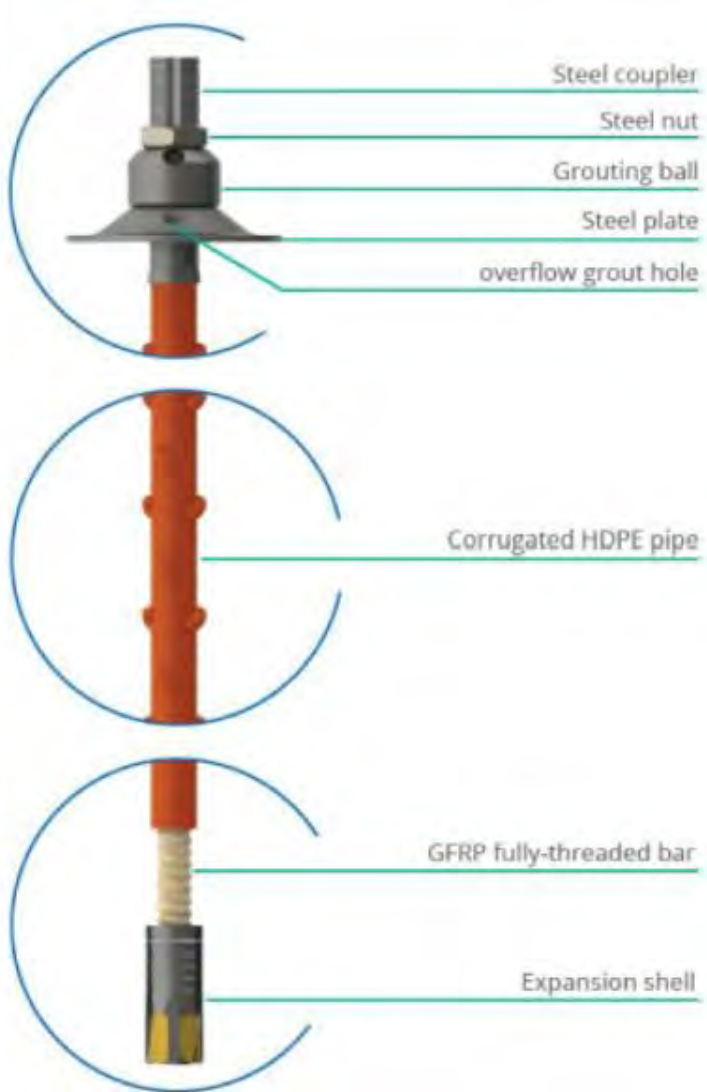
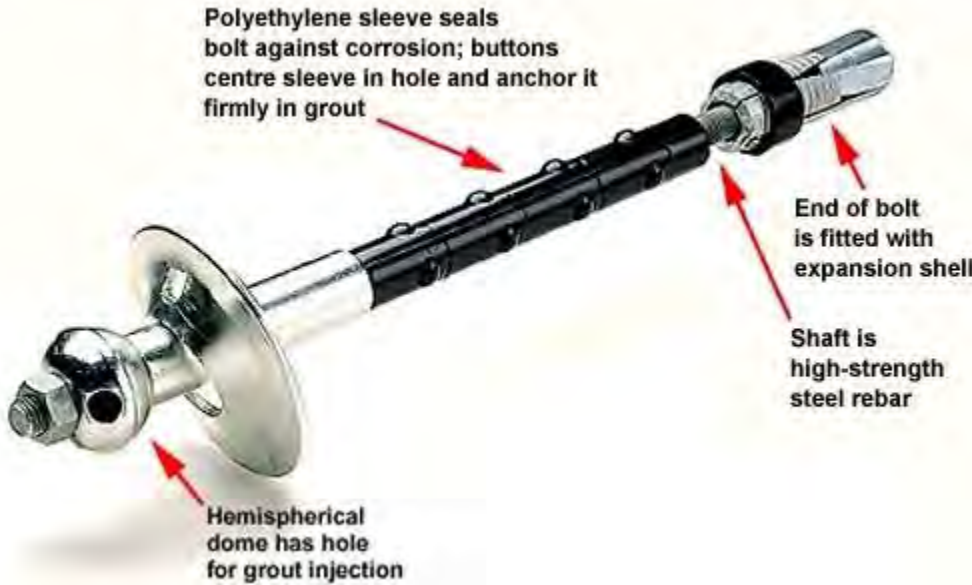
Black steel (M2, 1995)



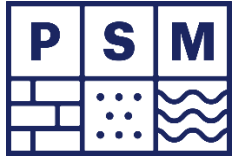
Galvanised



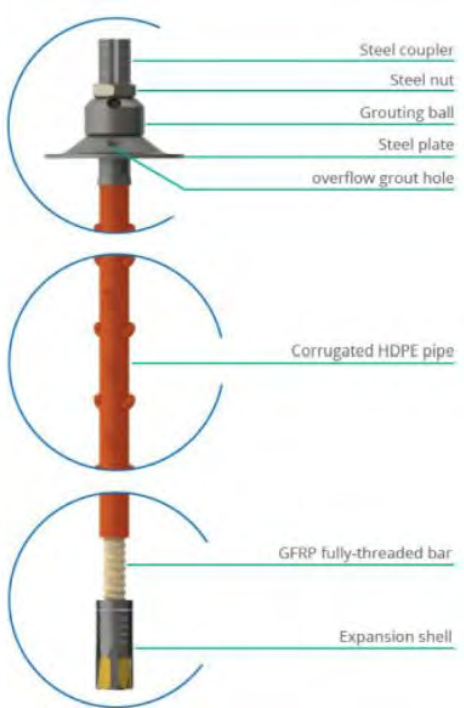
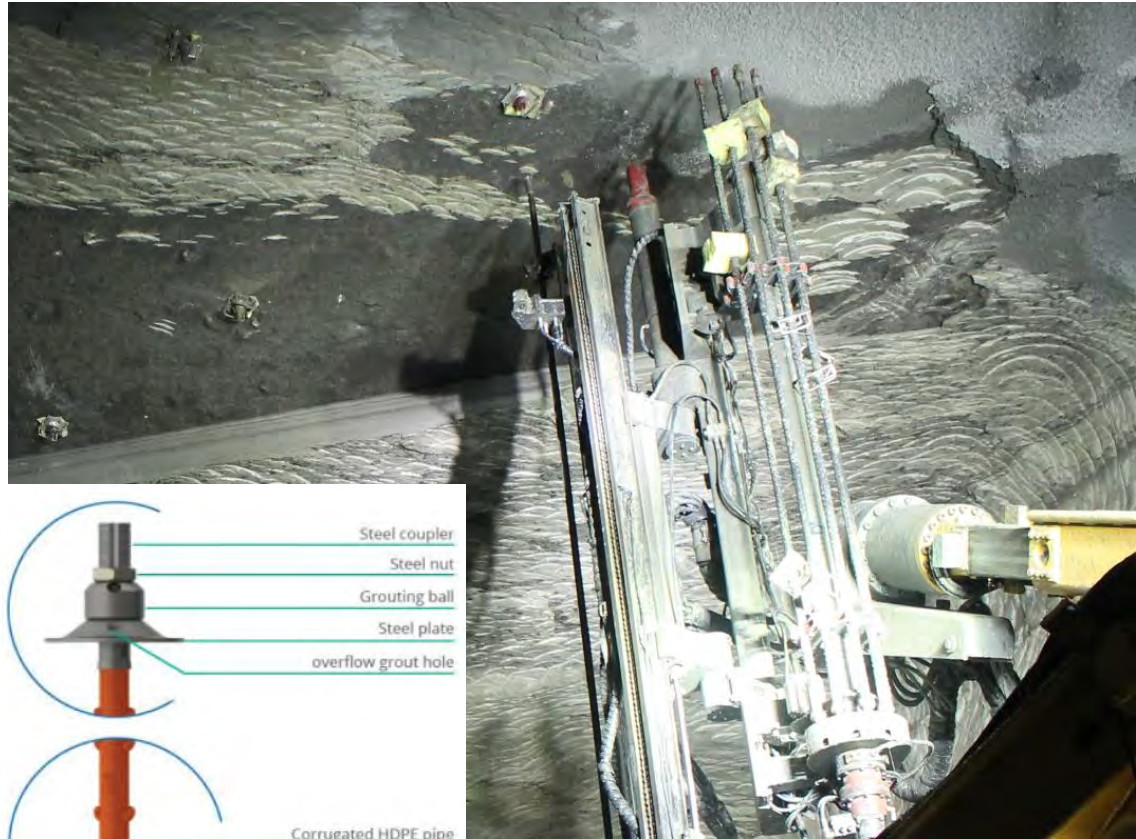
Epoxy coated (Opera House Carpark, 1991 & ED, 1999)



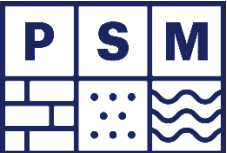
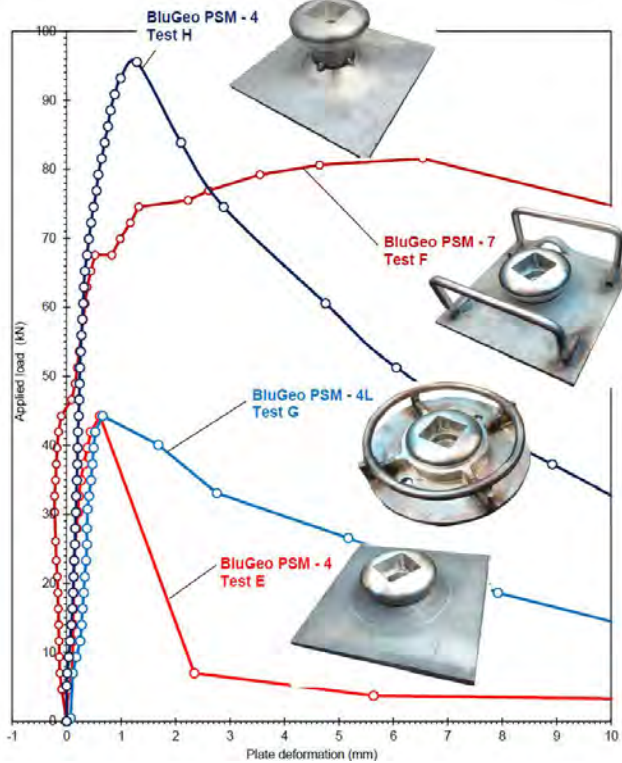
Installing bolts remotely



Remotely installed cuttable bolts and cables



Handle-bar plates



Multiple purpose

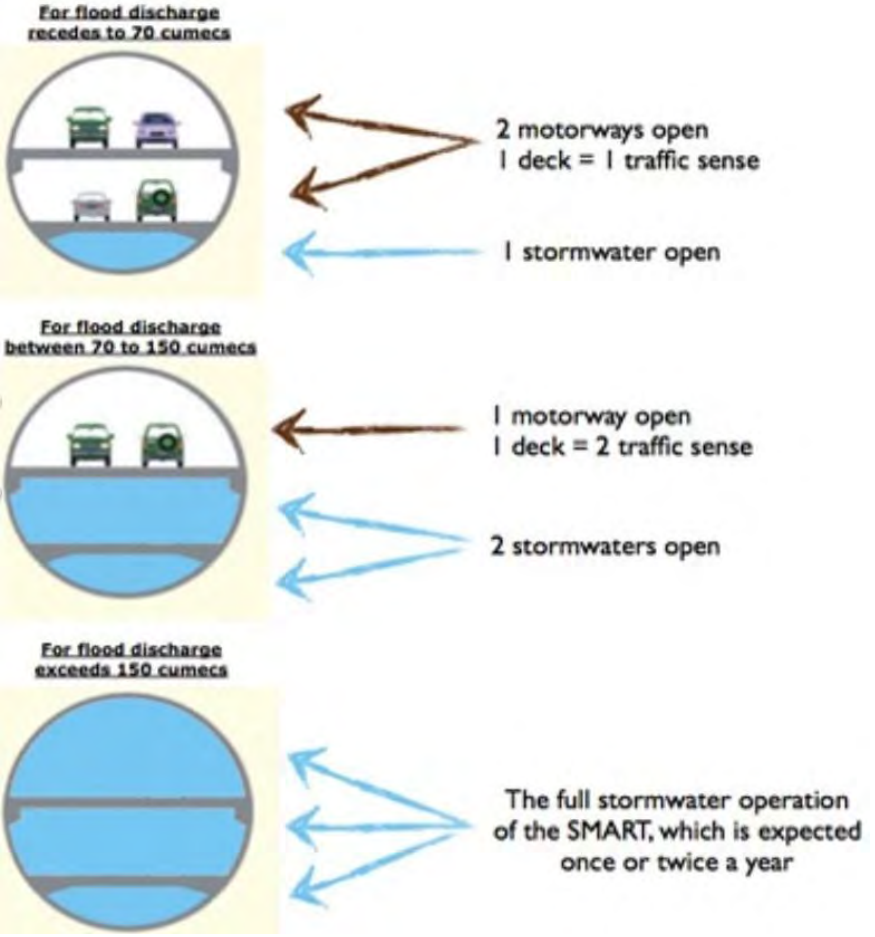
Eastern
Distributor
1.7 km long,
double-deck, 2
and 3-lane tunnel

Completed in
1999 with a span
of 24.5 m, it was
the widest road
tunnel in the
world.

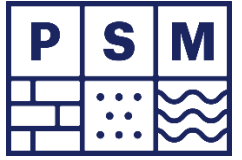


Multi-purpose tunnel

SMART, Kuala Lumpur, Malaysia
Completed in 2007
4 km long, 13.2m diameter, stormwater management and road tunnel (part of 9.5 km tunnel)



It's been used about 50 times



Faster excavation



Junction of two 5 m tunnels and 11 m cavern. Bank St, North Sydney, 1925



3-lane 12 m wide road tunnel. Lane Cove Tunnel, 2006



Convoy of trucks to service 18 roadheaders, RIC, 2022



2-lane 8 m wide ramp tunnel. Eastern Distributor, 1998



3-lane 15 m wide road tunnel. WestConnex 1B, Haberfield, 2018



TBM, Sydney Metro West, 2024



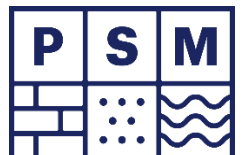
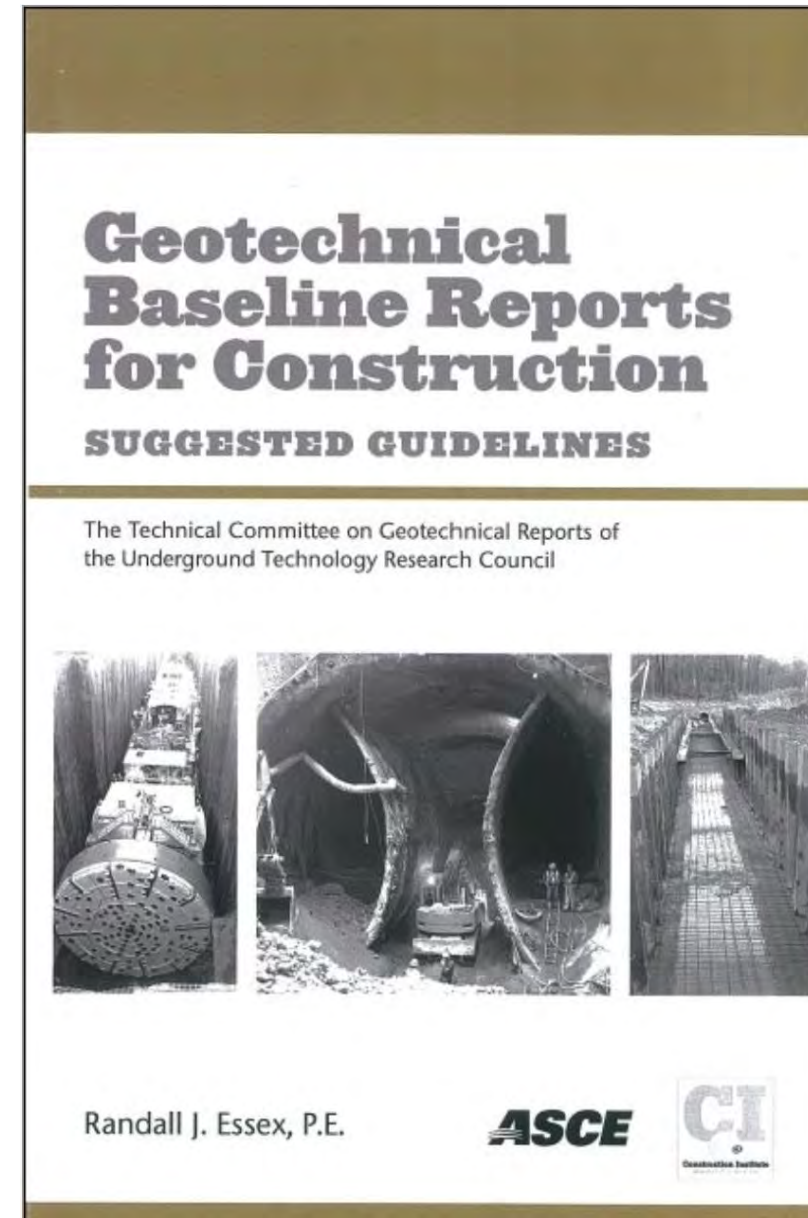
GBR

The Geotechnical Baseline Report sets out the subsurface conditions anticipated under the contract.

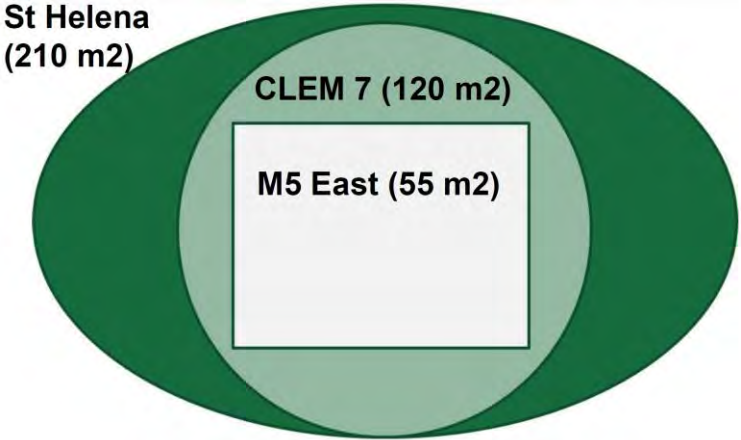
It is a means of allocating and managing subsurface risks associated with subsurface

Site conditions differing from those considered in the GBR are deemed to be 'unforeseen' under the contract and are carried out at the employer's risk.

Properly drafted GBRs reduce construction costs and set clear terms between the parties in the event of more adverse ground conditions, thus contributing to dispute avoidance.



Controlling seepage



Respirable dust



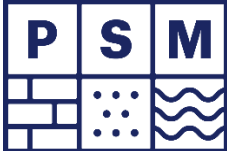
1990s



2010s



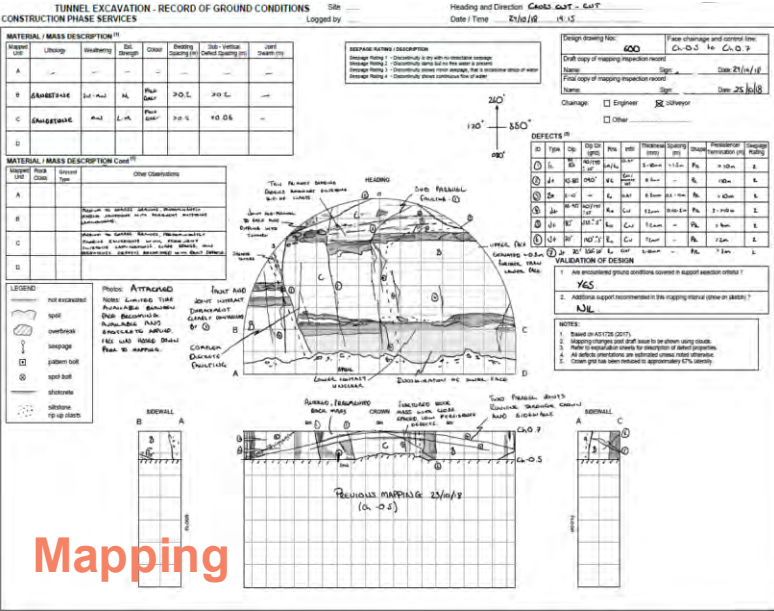
2023



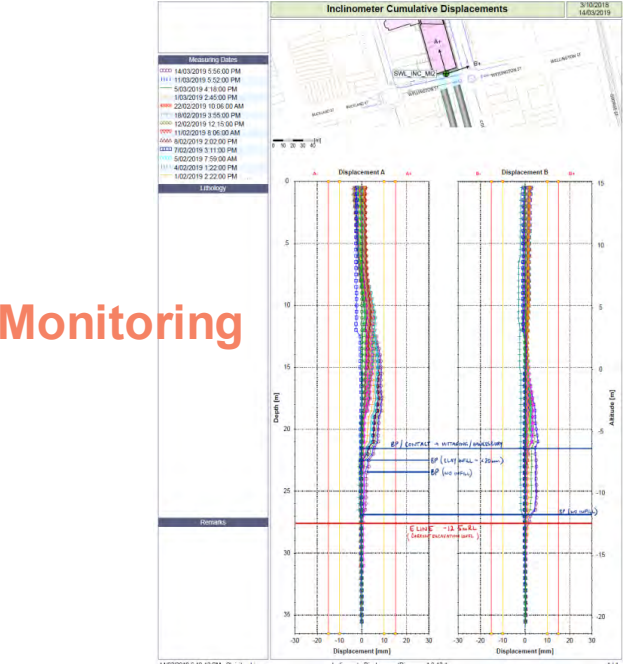
Risk procedures

Permit to Tunnel (PTT)

Permit to Excavate (PTE)

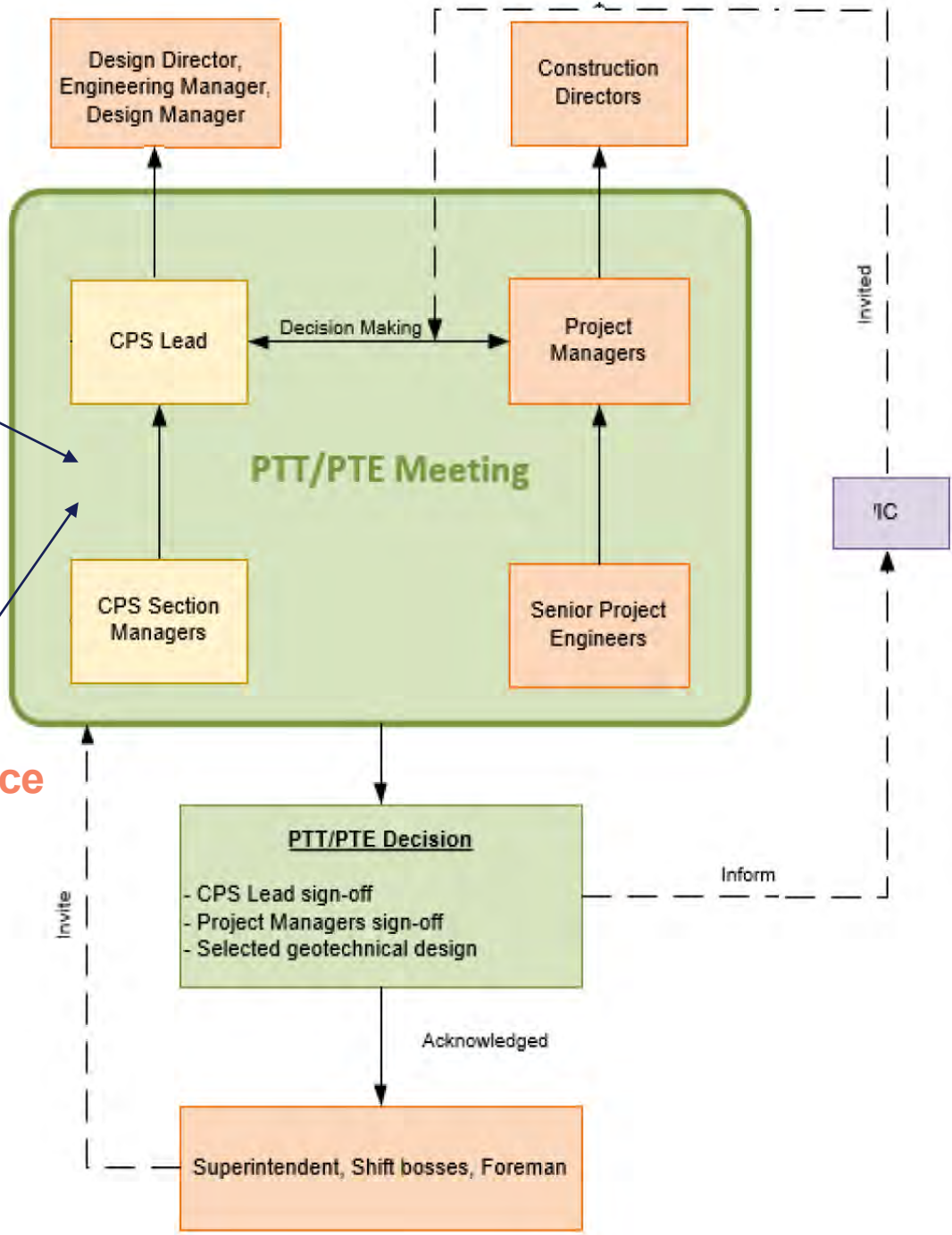


Mapping



Monitoring

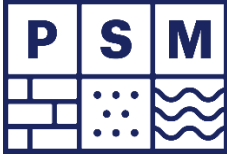
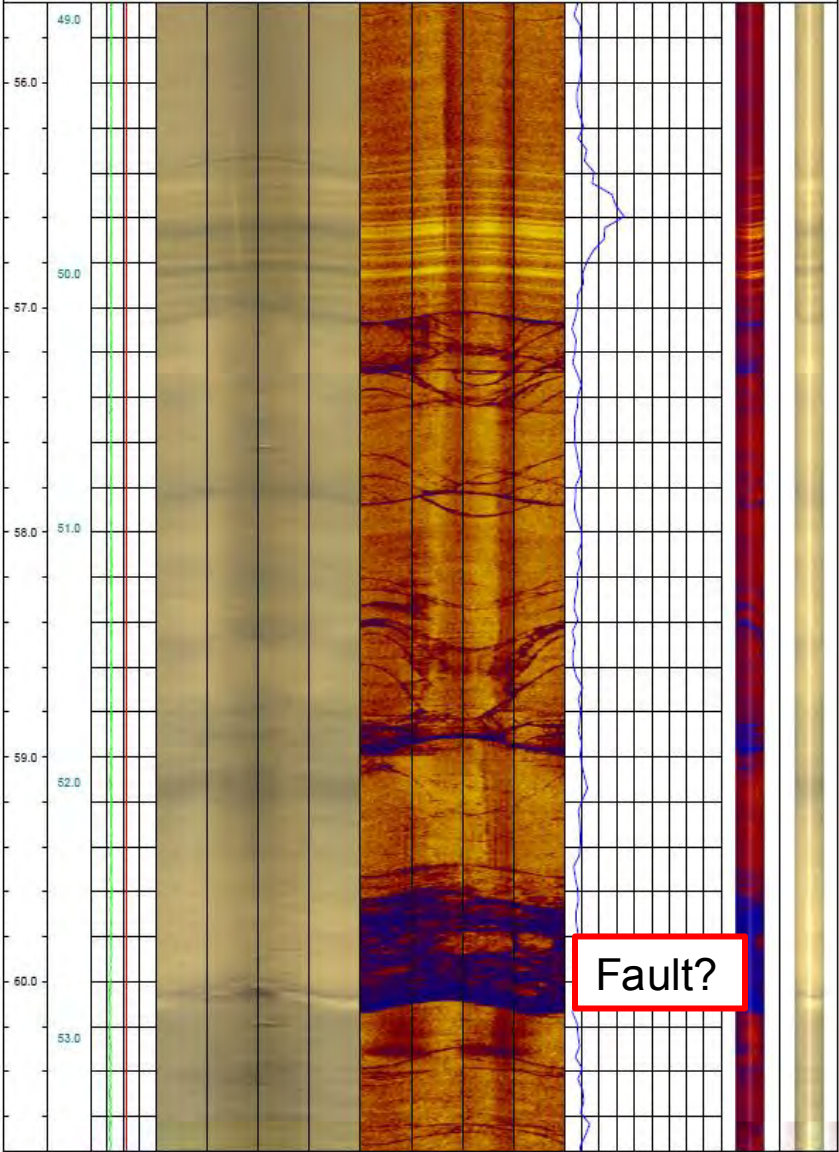
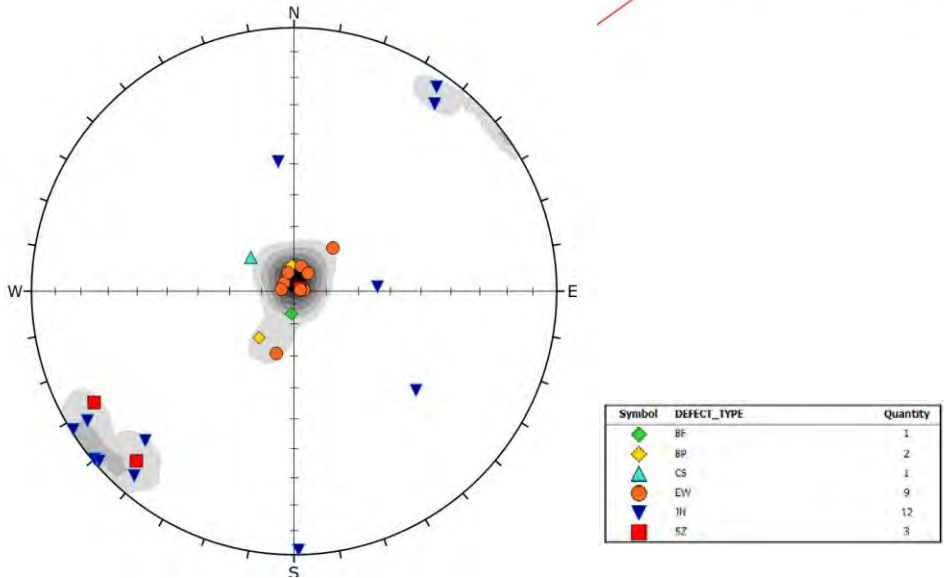
Performance



Crossover with mining



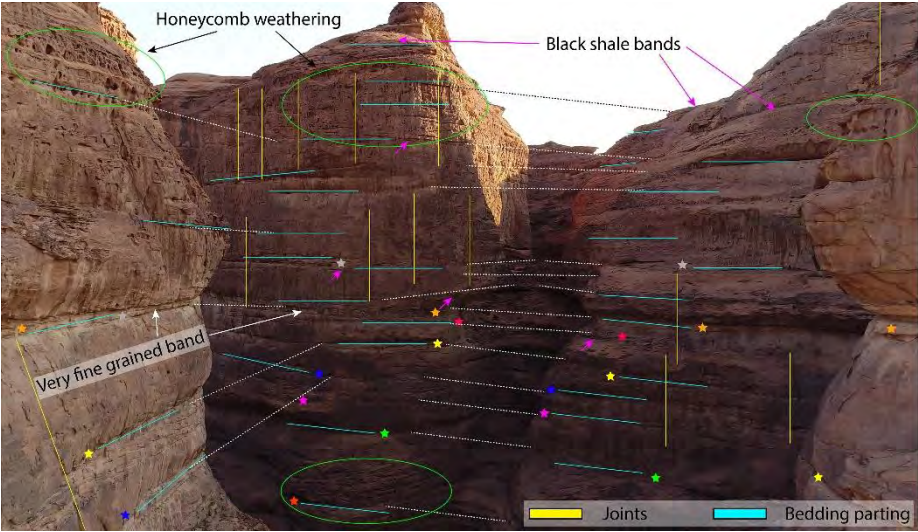
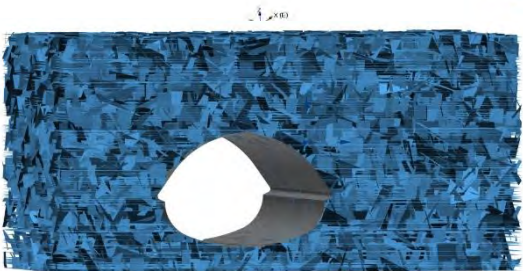
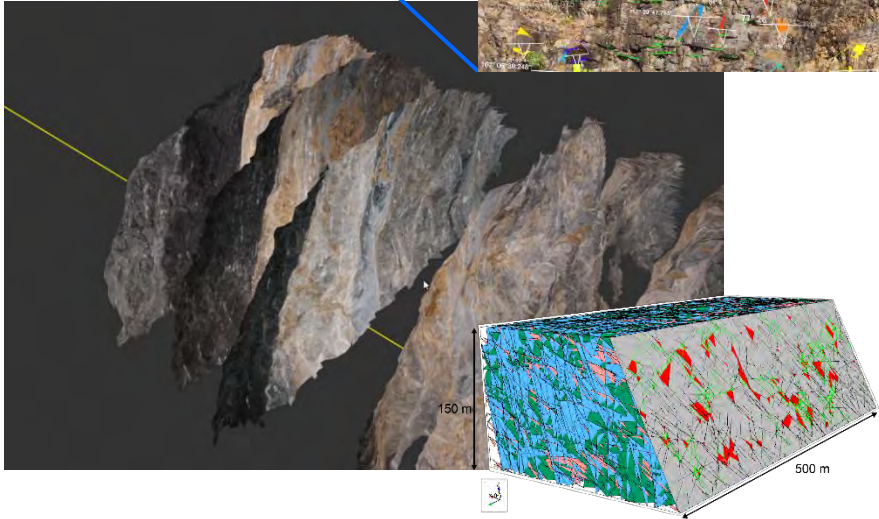
Geophysics



Scanning



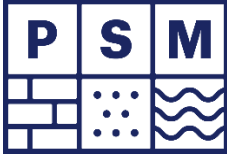
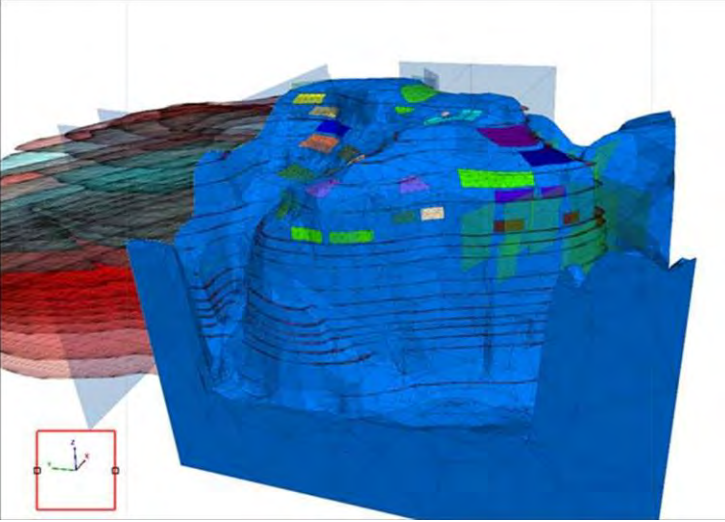
Mapping



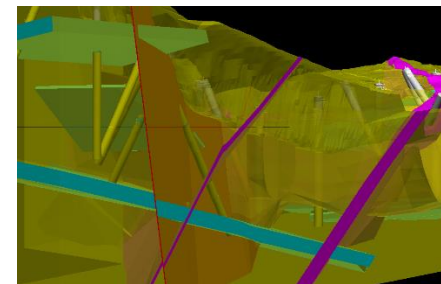
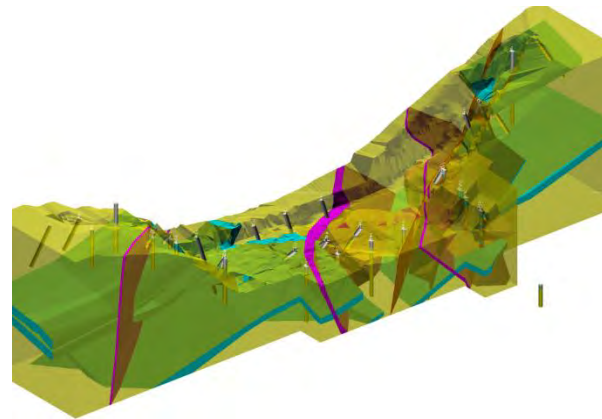
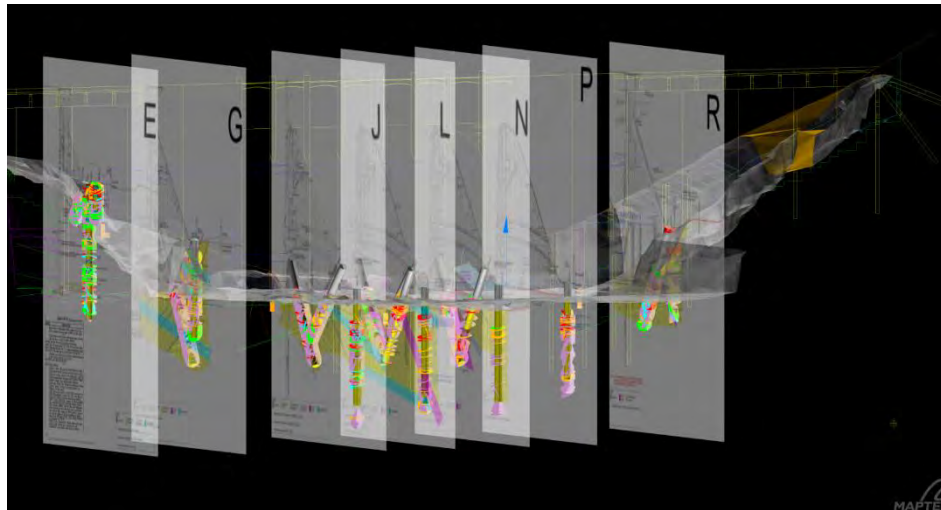
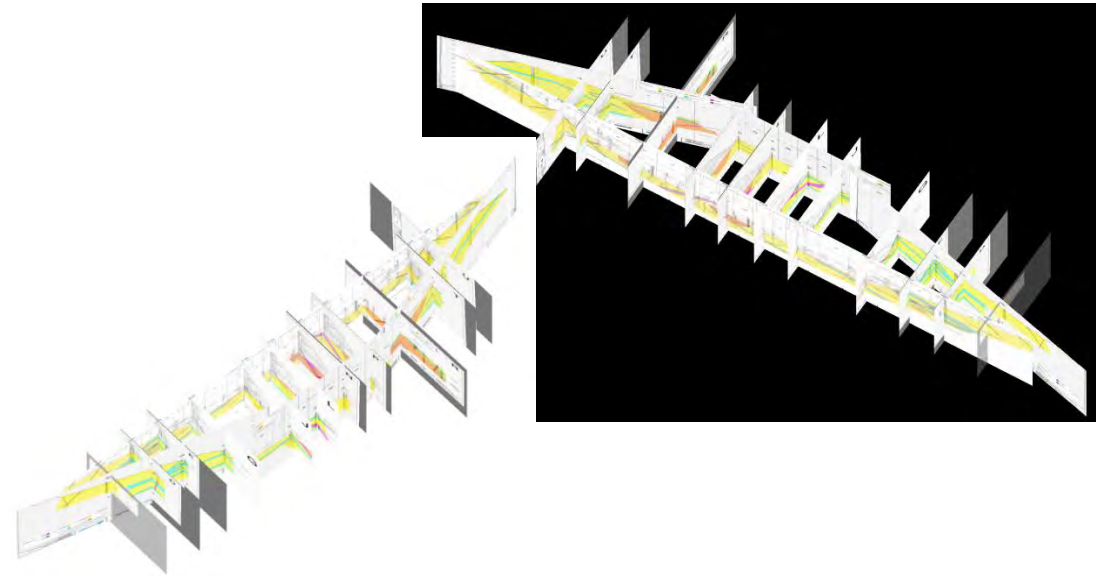
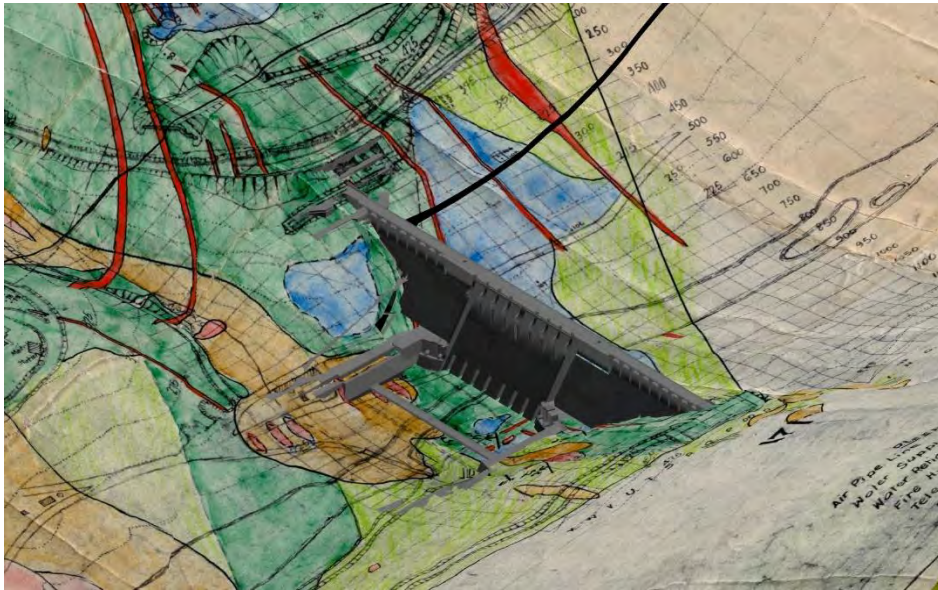
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 ©2017 Itasca Consulting Group, Inc.
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3D structural modelling



Monitoring

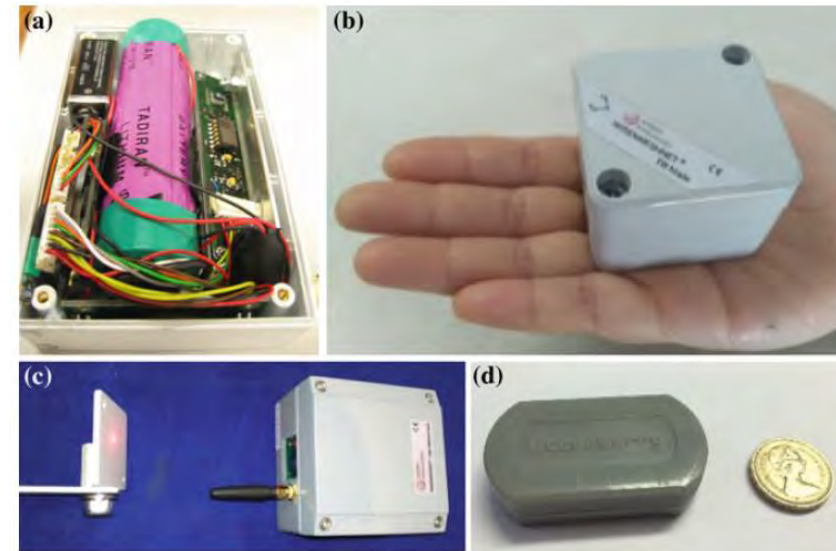
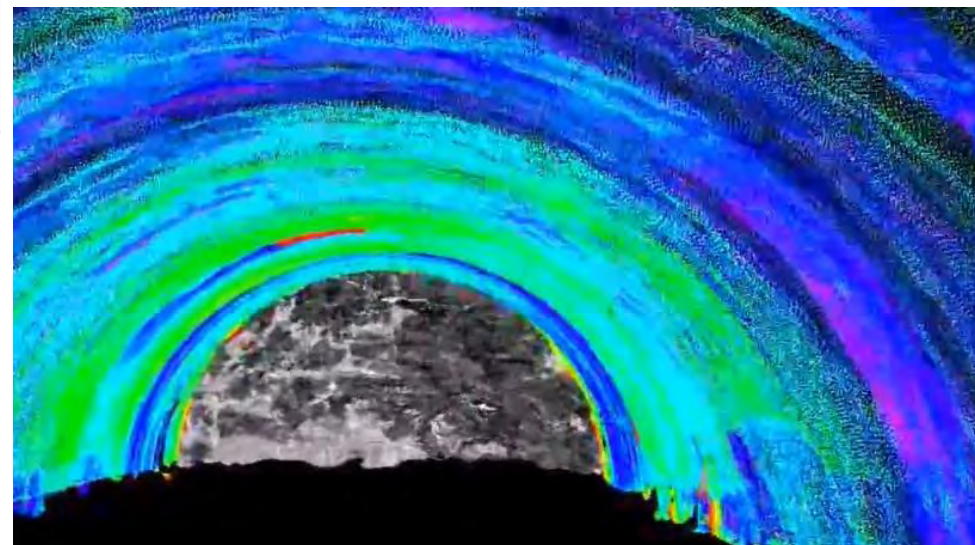
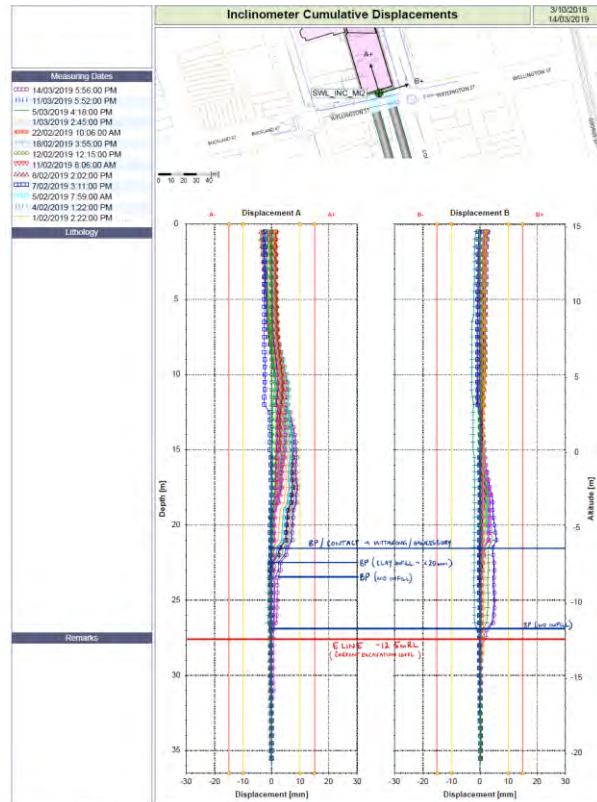
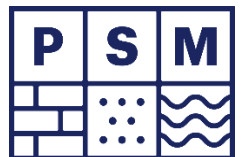


Fig. 27 a Original WSN system developed at the University of Cambridge in 2009, b tilt mote (Wisen innovation), c laser distance mote (Wisen innovation) and d displacement/acceleration mote (Utterberry)

Soga et al 2019, Advances in Geotechnical Sensors and Monitoring

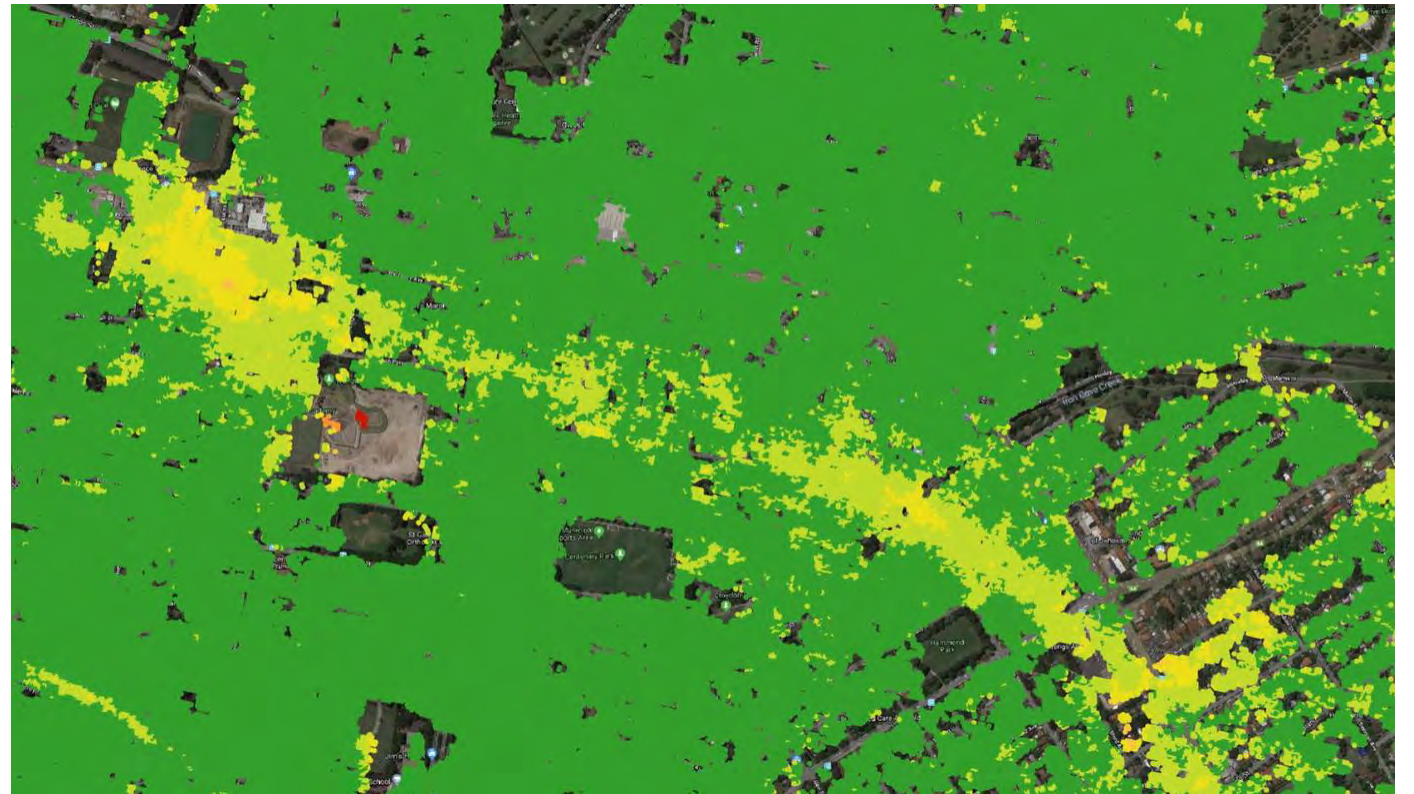
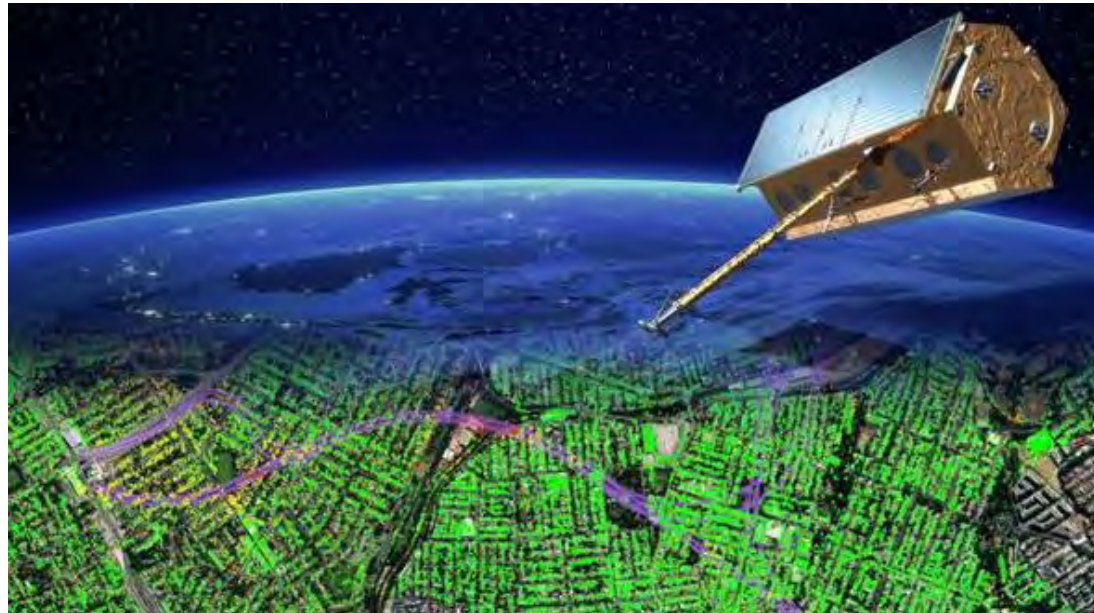


wireless sensor networks

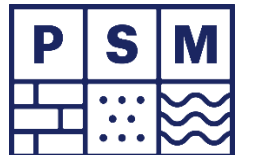


Monitoring

InSAR Interferometric Synthetic Aperture Radar



Tele-remote



TBM in Mining

TBM Use in Mine Development

R P Lovat, G I Zamel and L P Zenari

VIII Australian Tunnelling Conference

Sydney, 24 - 26 August 1993



Northparkes (NSW), 2013

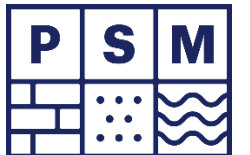


Grosvenor (Qld), 2013



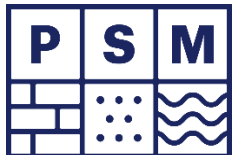
Drill and Blast tunnel viz. with Mobile Tunnel Bored tunnel

Mogalakwena (Sth Africa), 2024?



Civil tunnels have different requirements

- Acceptable performance particularly deformation
- Constrained geometry due to proximity of other assets
- The public, their homes and perceptions
- Consequence of failure
- Little or no opportunity to “try again”



Lessons for Mining

DOs

- Rigour
 - Geological data collection (televviewer interpretation, scanning / mapping)
 - Know the ground (geological / geotechnical / hydrogeological model)
 - Engineering (calculations are useful)
 - Permit to Tunnel / Excavate
- People
 - We learn the most when exposed to a range of experience

DON'Ts

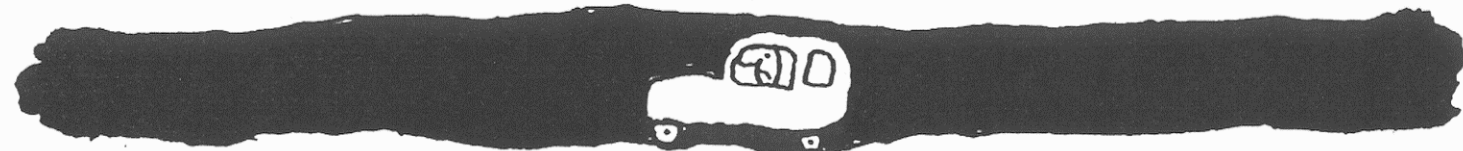
- Project management led engineering
- Review process
- Requirements traceability



Thank you

The Tunnel Wisdoms

- A DRIPPING TUNNEL OR A CROWING HEN IS NEITHER GOOD TO GOD NOR MEN • Drip Happens • BETTER LATE THAN TUNNEL • Better to have tunneled and lost than never to have tunneled at all • BREVITY IS THE SOUL OF TUNNEL • If it aint broke, don't tunnel it • FOOLS TUNNEL IN WHERE ANGELS FEAR TO GO • TUNNEL IN HASTE, REPENT AT LEISURE • You can't have too much of a good tunnel • TUNNEL, HEAL THYSELF • Spare the rod and spoil the tunnel • TOMORROW IS ANOTHER TUNNEL • Don't change horses in mid-tunnel • THE ROAD TO HELL IS TUNNELLED WITH GOOD INTENTIONS • ETC.



Leunig