Sydney Metro Tunnels

Presentation to Engineers Australia
Southern Highlands Branch

Geoff Bateman
Design Manager, Tunnels

Overview

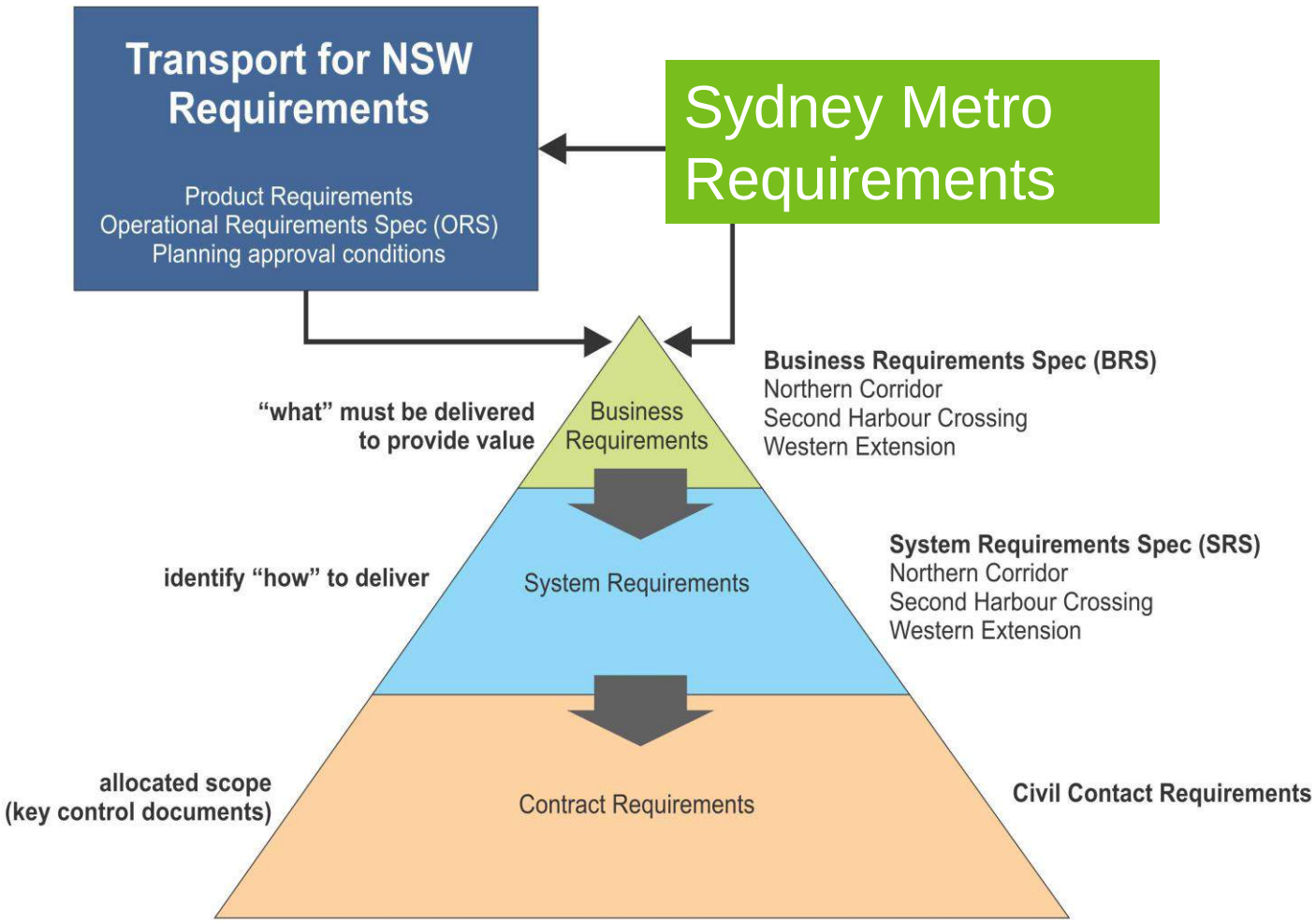
1. Project Overview
2. Sydney Metro Product
3. Tunnel Strategy
4. Sydney Metro Northwest
5. Sydney Metro City & Southwest

More than 65 km

Two stages

31 metro railway stations

Requirements Structure



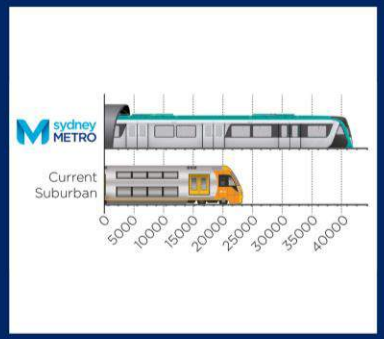
Customer Experience - Requirements

Safe and secure

Highly legible

Fully automated trains

Comfortable service



Move more people

Fast and reliable service

Accessible system

Connects jobs and people

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Product Requirements

- Station Locations
  - Transport Task
- Passenger Comfort
  - Accessibility
  - Experience
- Safe to build and operate
  - Fire & Life Safety
  - Maintenance
  - Constructability

Tunnel Strategy

- Configuration
  - How many tunnels?
  - Arrangement
- Geometry
  - Tunnel size – optimize
  - Tunnel alignment at stations – Shallow, straight and level
- Lining
  - Type - durable
  - Fire protection - 4 hours
  - Watertightness – drained or undrained

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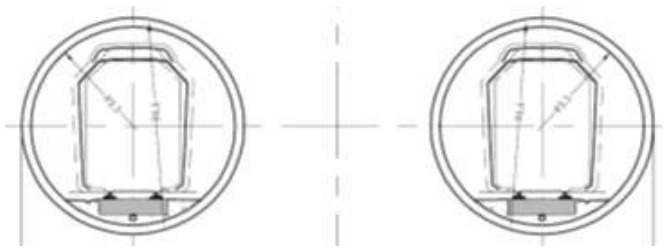
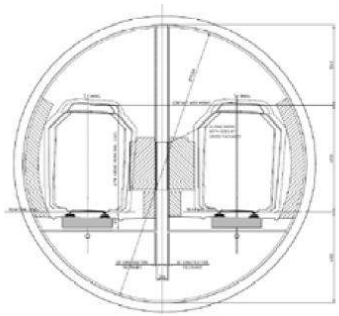
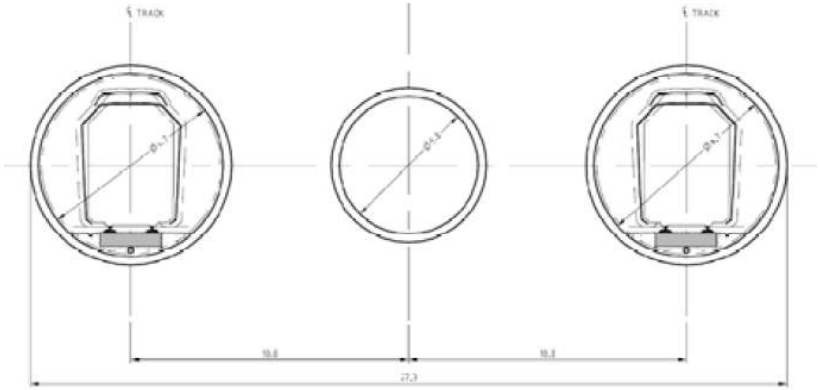
Tunnel Configuration – How Many?





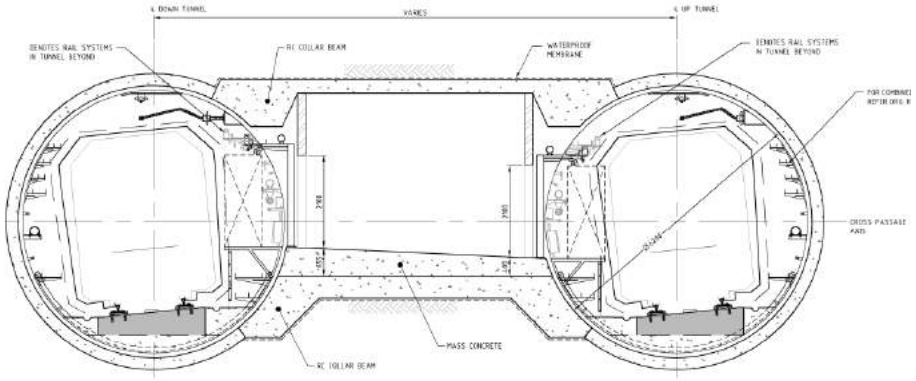


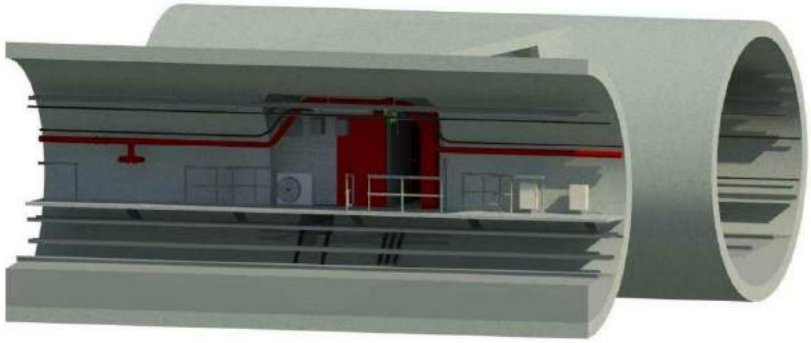
- Twin tube
- Single tube
- Single tube-stacked
- Triple tube

Tunnel Configuration - Arrangement

Emergency Egress

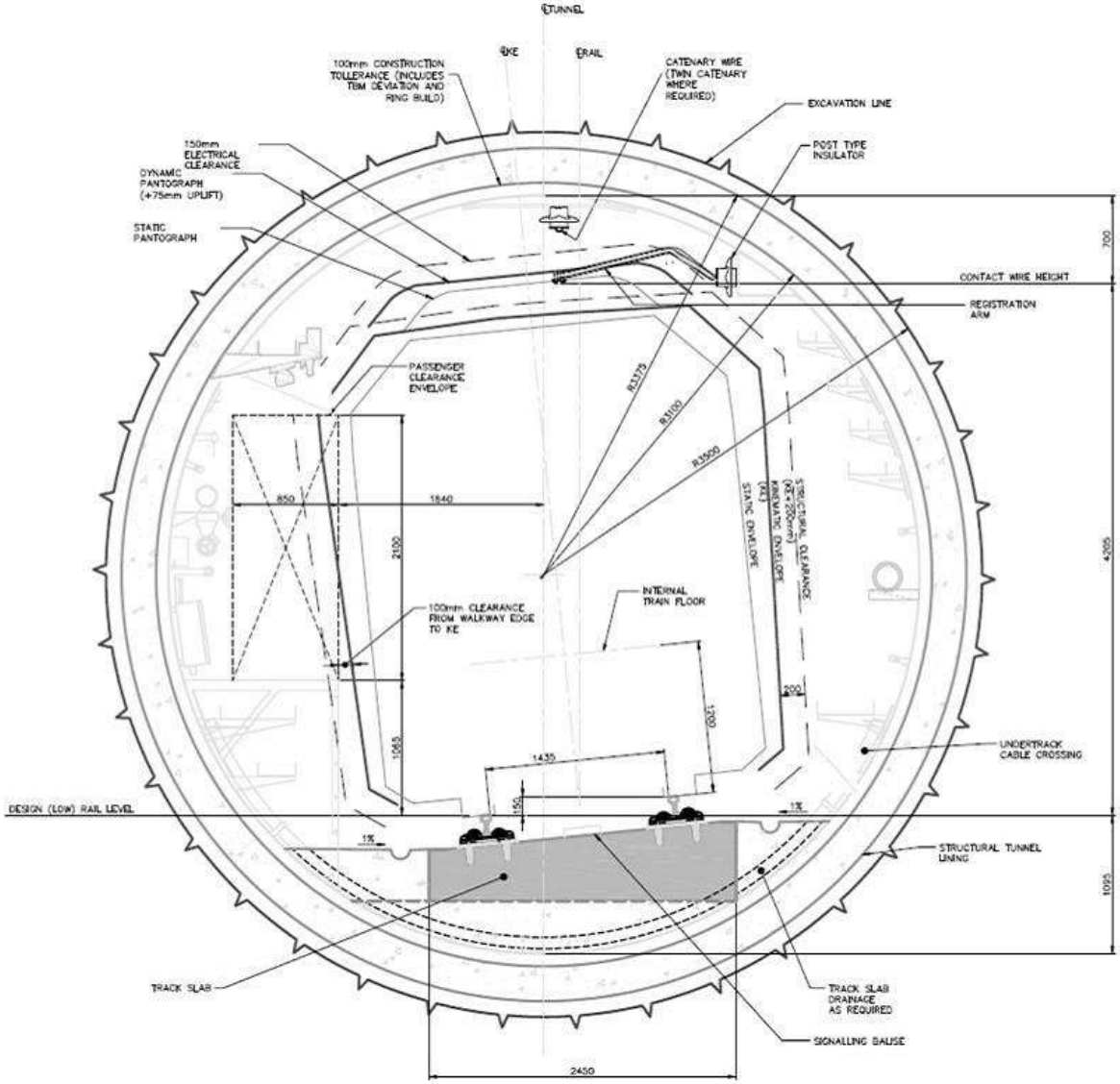
- Smoke Control/Ventilation – Intermediate Service Facility
- Walkways – Side egress from train
- Cross Passages – Maximum spacing 240m
- 4.5 m wide tunnel openings
- Plant Rooms

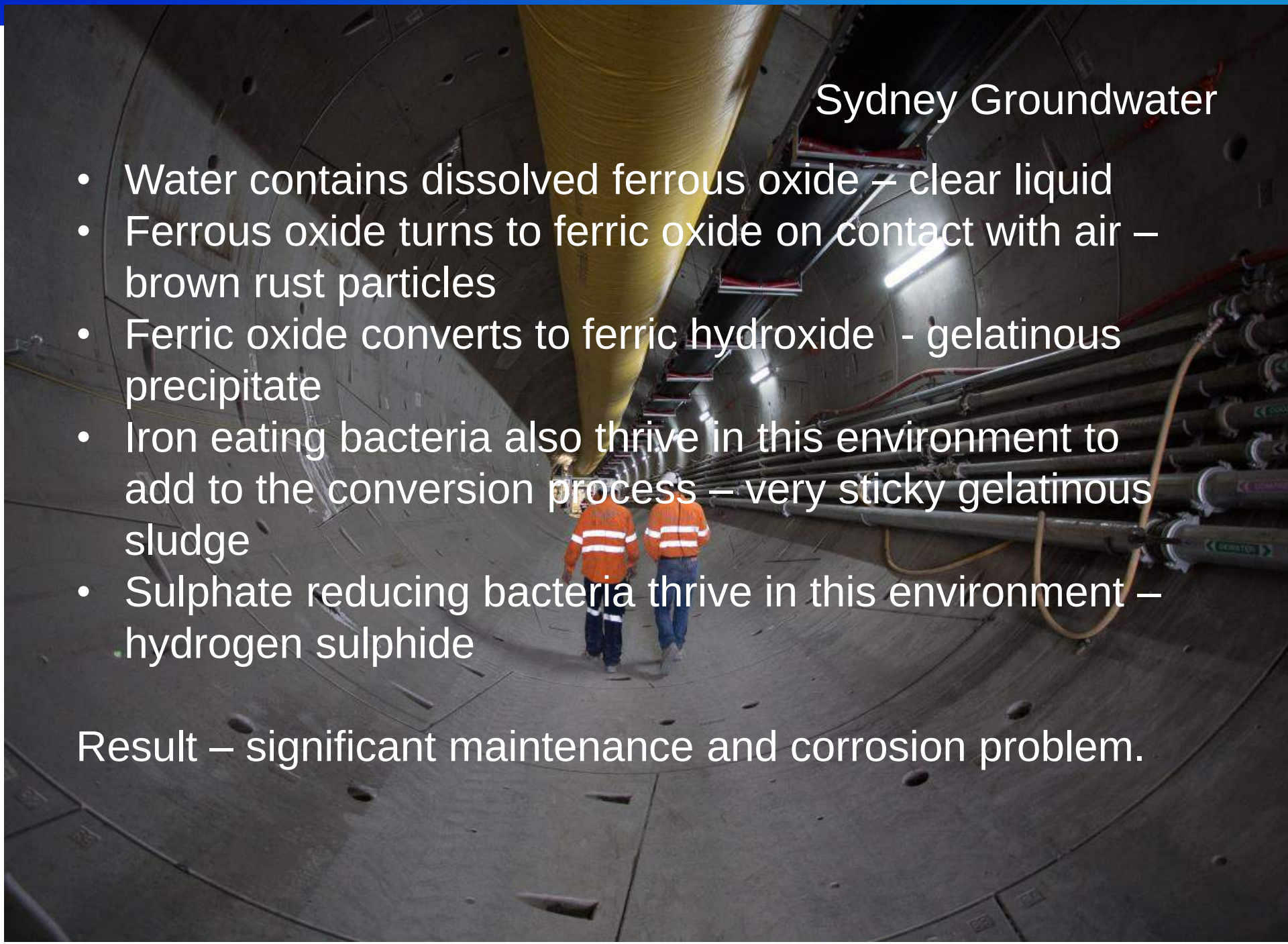




Geometry - Tunnel Size

- For Single Deck
- Side Evacuation
- Floating Track Slab
- Overhead Wiring
- Fire Main
- Cable Trays
- Smoke Management
  - OD: 6.7m
  - ID: 6.13m
  - Clear opening: 6.0m





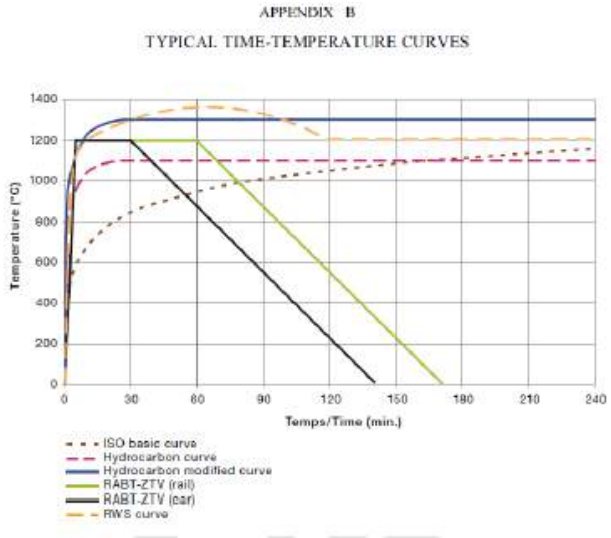
Sydney Groundwater

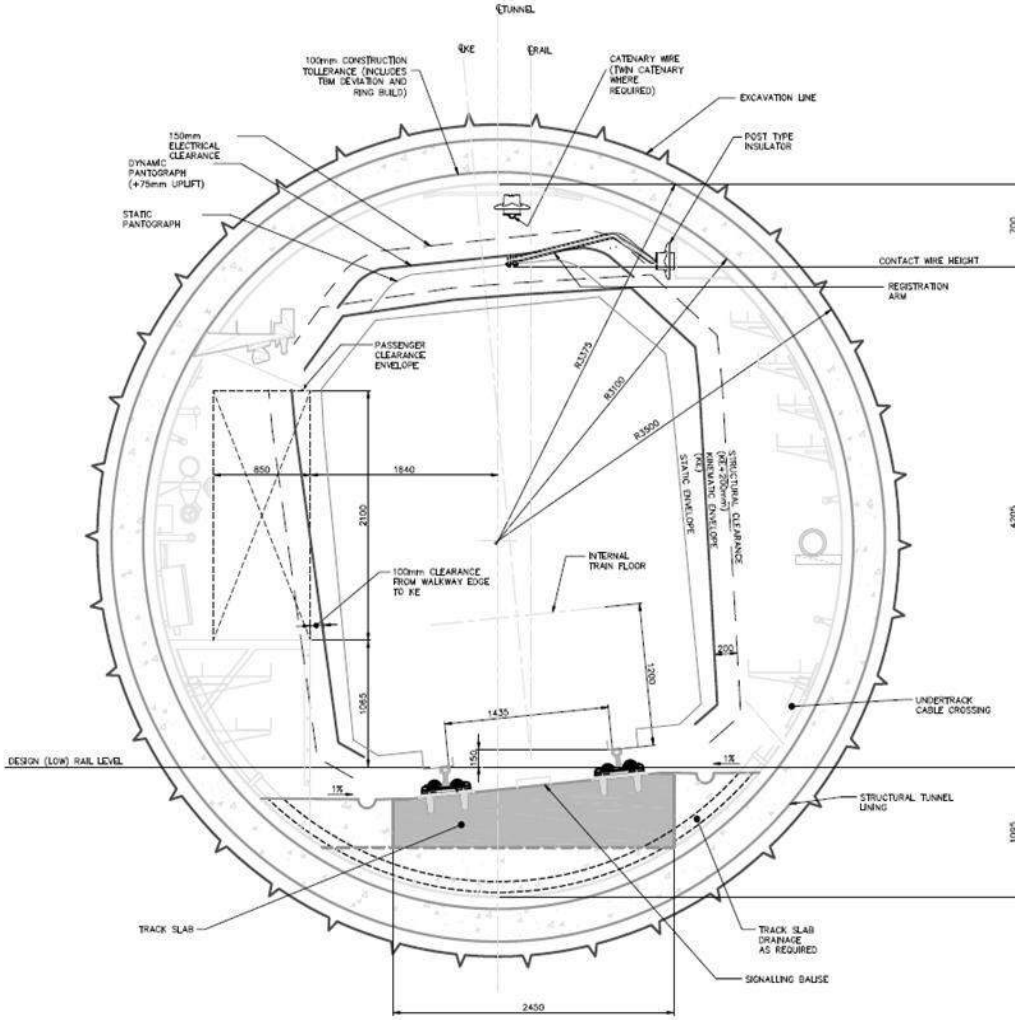
- Water contains dissolved ferrous oxide – clear liquid
- Ferrous oxide turns to ferric oxide on contact with air – brown rust particles
- Ferric oxide converts to ferric hydroxide - gelatinous precipitate
- Iron eating bacteria also thrive in this environment to add to the conversion process – very sticky gelatinous sludge
- Sulphate reducing bacteria thrive in this environment – hydrogen sulphide

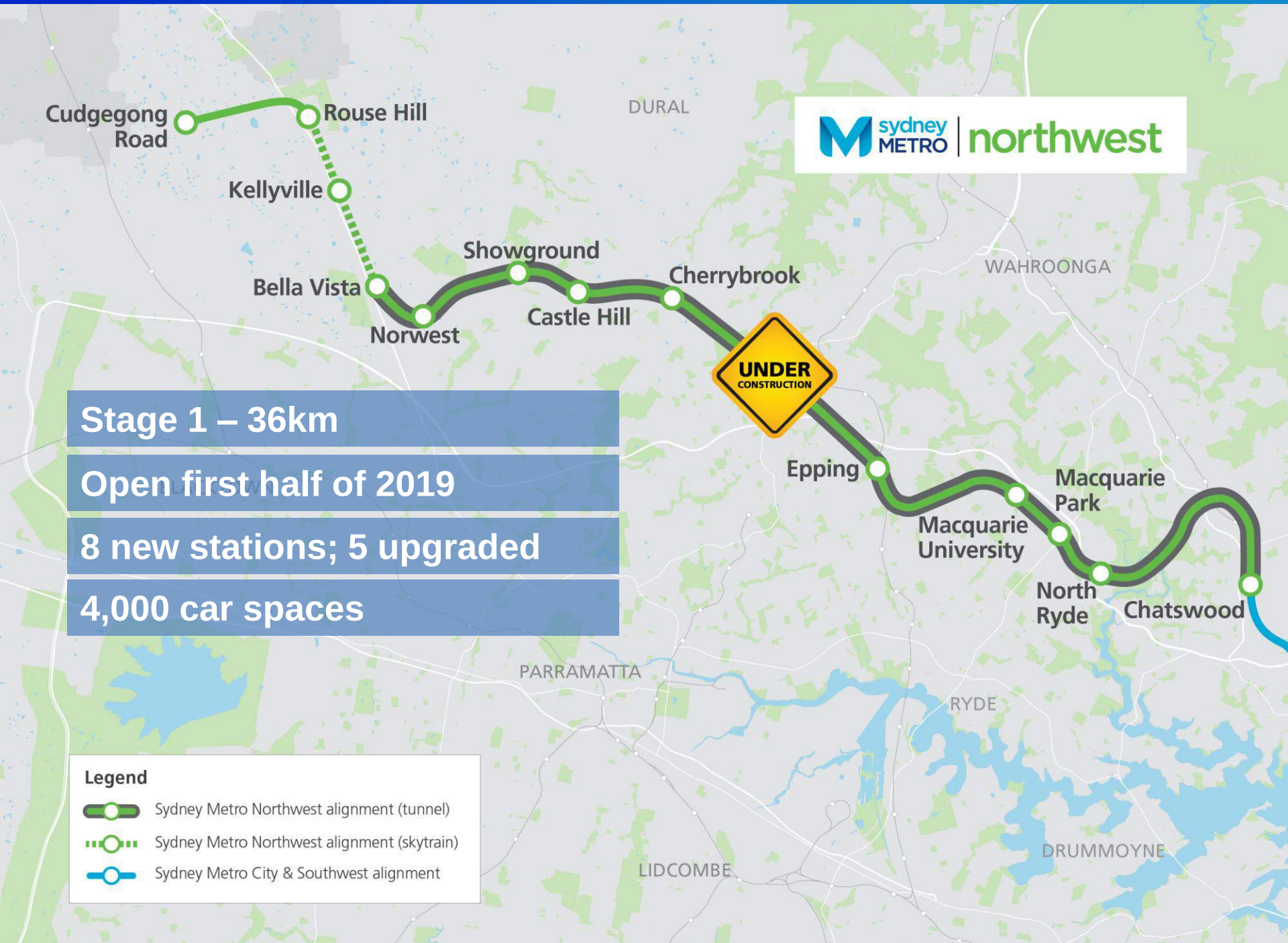
Result – significant maintenance and corrosion problem.

Tunnel Lining

- Durable Concrete lining
- Steel Fibre Reinforced
- Polypropeline Fibres
- Fire Curves
- Undrained –EPDM gaskets







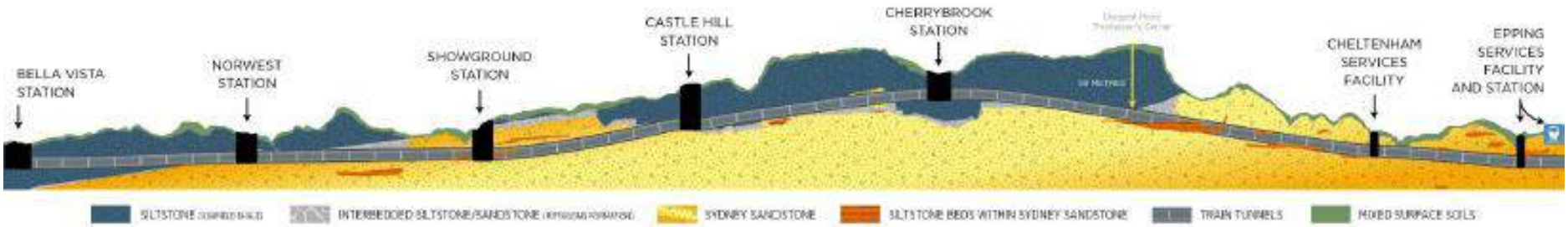
Stage 1 – 36km

Open first half of 2019

8 new stations; 5 upgraded

4,000 car spaces

Geology



Rock type	% of tunnel
Hawkesbury Sandstone	56%
Ashfield Shale	26%
Transition Zone (mixed conditions)	18%

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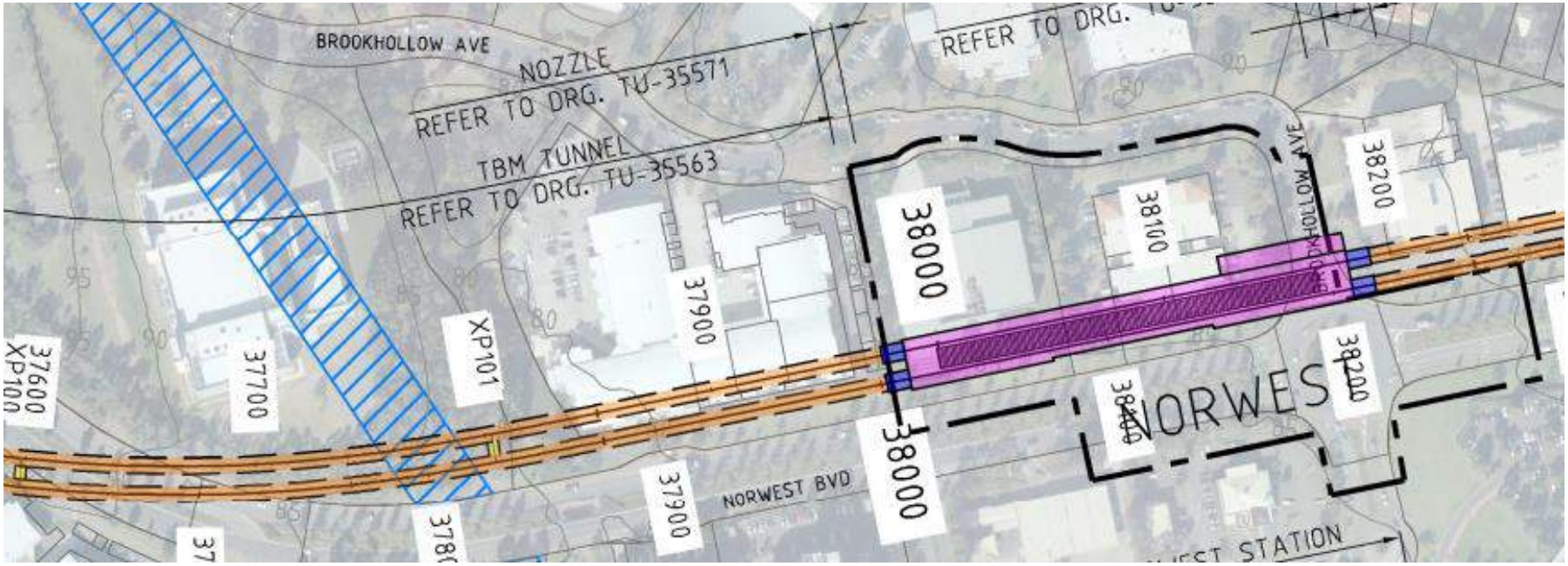
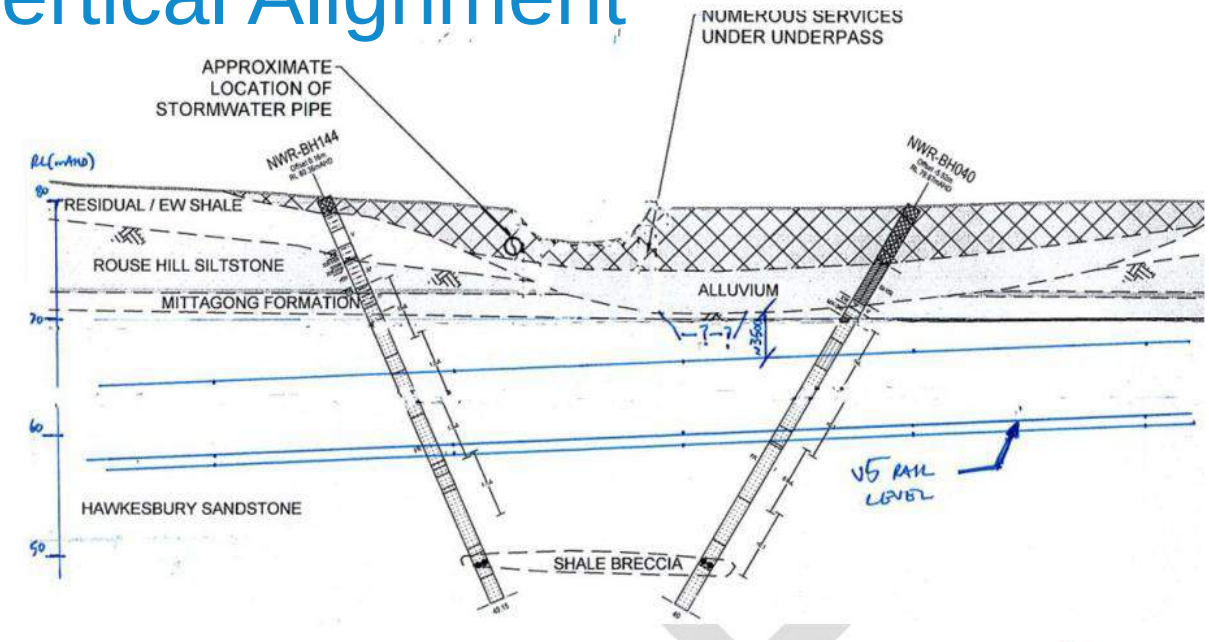
Geometry - Horizontal Alignment

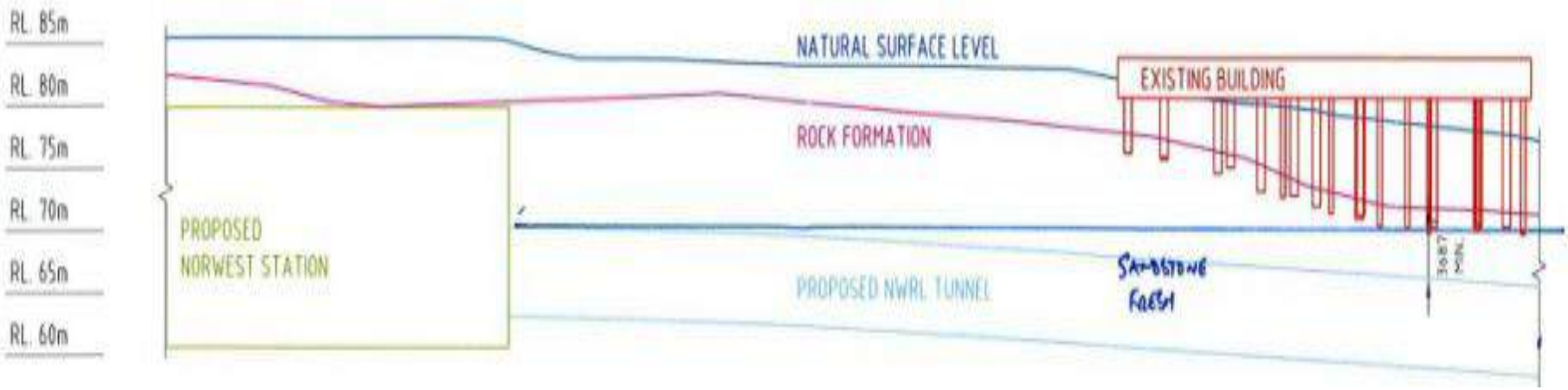
- Norwest Station – Brookhollow Avenue
- Bridge over excavation



Geometry - Vertical Alignment

- 3.5 m rock cover to creek





- Down Tunnel – 7 m clearance to pile

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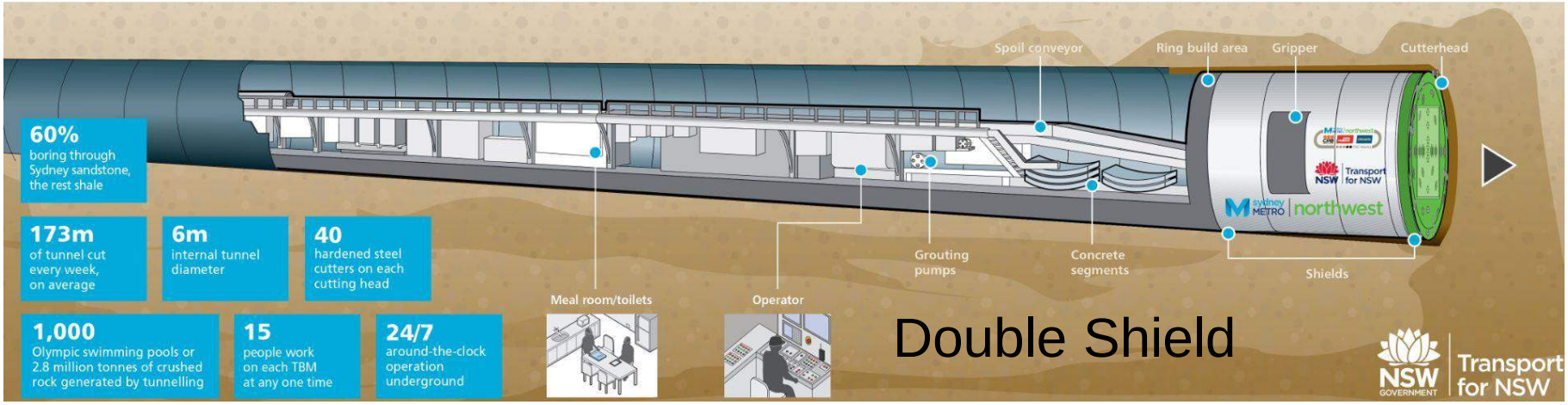
Rock – Preferred Tunnel Boring Machine

Construction



CPB Contractors: John Holland & Dragados

4 x Double Shield Tunnel Boring Machines (TBMs)

- 15 km of 6.13 m diameter lined twin bore tunnel
- Almost 100,000 fibre reinforced precast concrete segments
- More than 1.5 million tonnes of rock removed

Tunnelling

More than 2.5 million tonnes of rock excavated

100% crushed rock recycled

98,184 concrete segments

Pre-cast Facility

16,290 waterproof rings

99,000 concrete segments

More than 3,600 tonnes of cement

18 months, 635,000 working hours

Segment precast facility at Bella Vista

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Segments per ring - 6
Segment length 1.7 m

Weight per segment ~ 3.7 Tonne
Weight per ring~ 22 Tonne
Total segments ~ 99,000
Total rings ~ 16,500

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Cherrybrook 2015

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Norwest Station Box


Mined Tunnels - Epping


TBM Extraction – Epping


TBM Extraction – Epping

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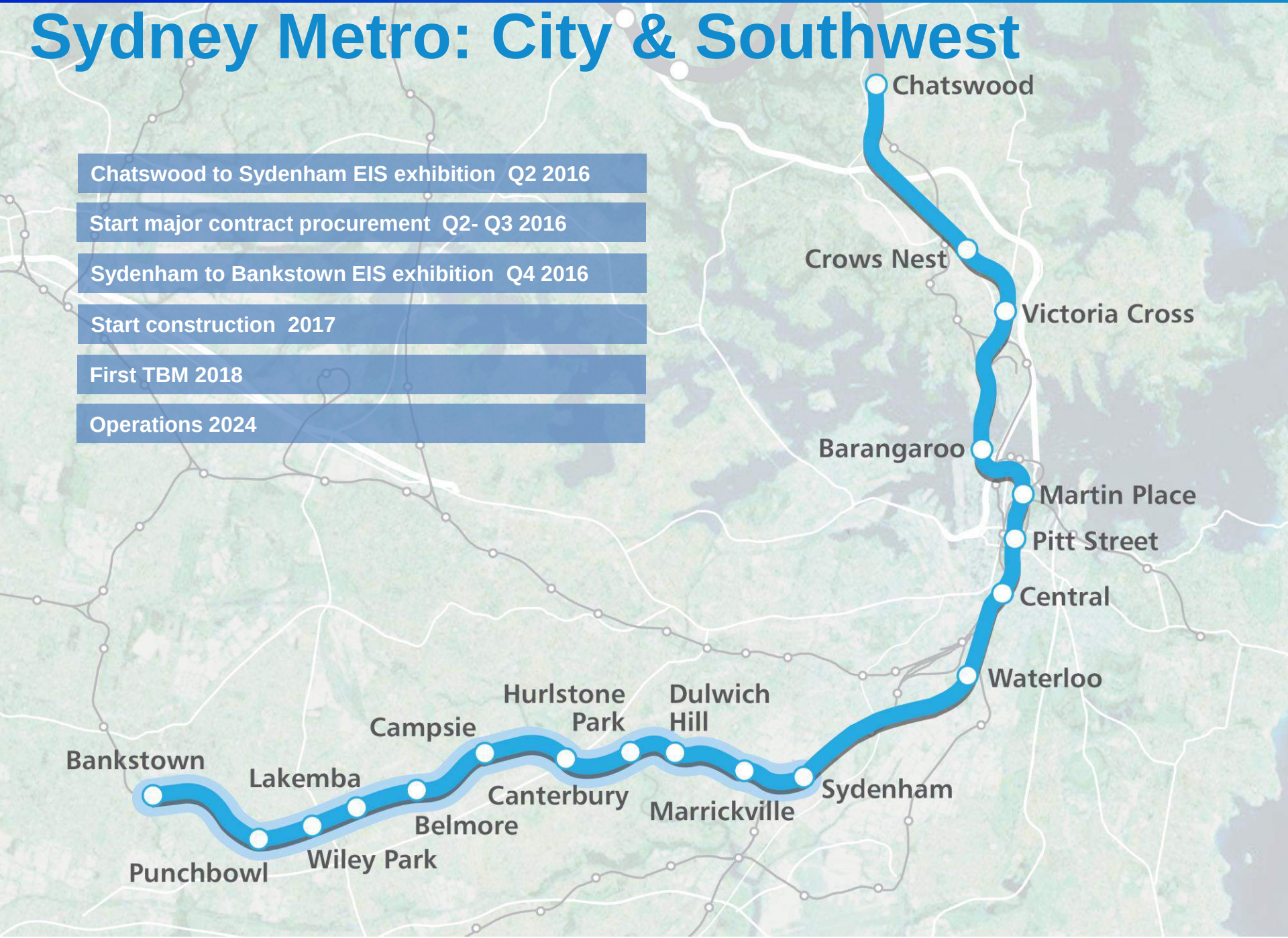
Sydney Metro: City & Southwest

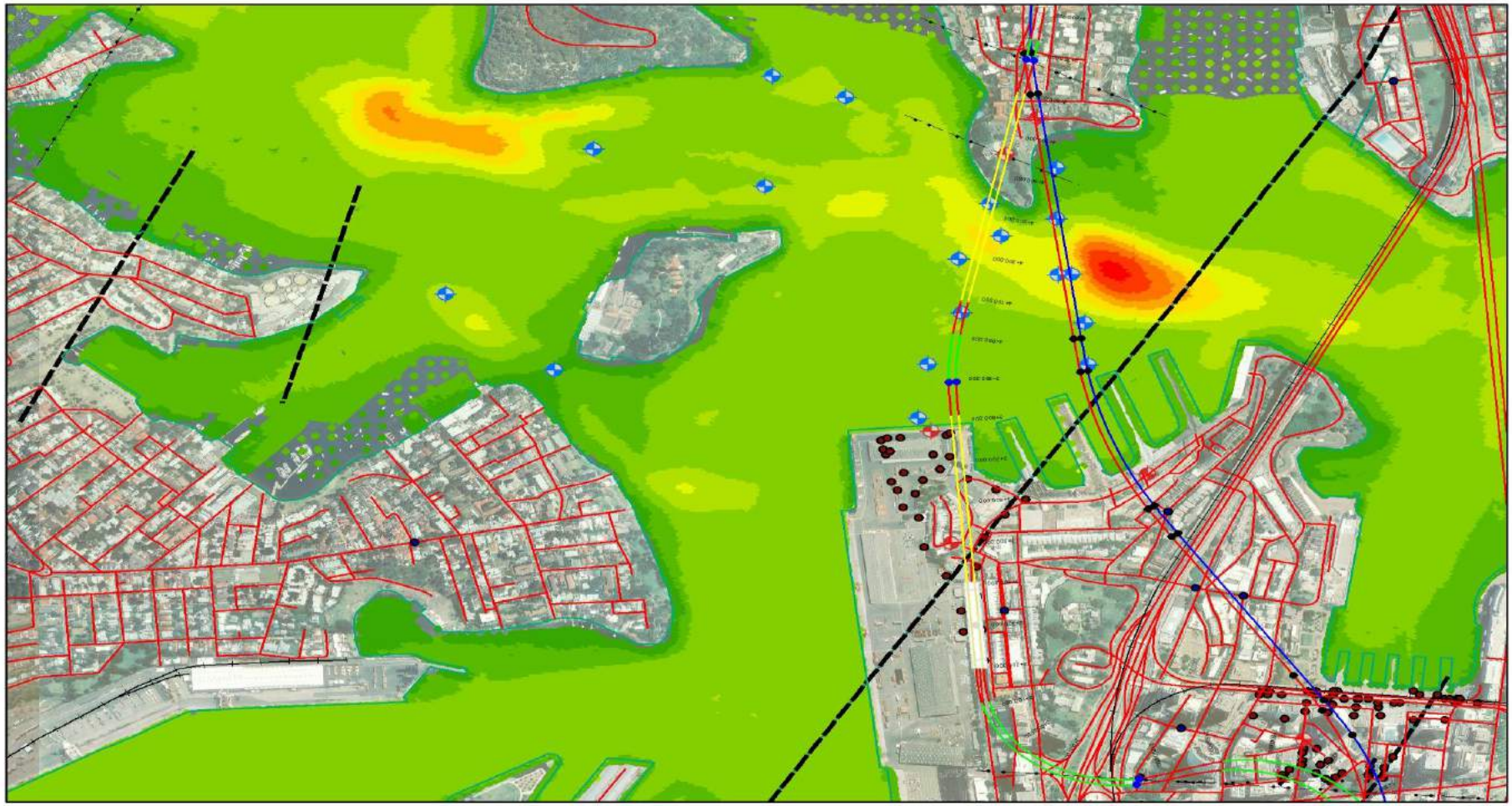
- Chatswood to Sydenham EIS exhibition Q2 2016
- Start major contract procurement Q2- Q3 2016
- Sydenham to Bankstown EIS exhibition Q4 2016
- Start construction 2017
- First TBM 2018
- Operations 2024



Key risks and mitigation

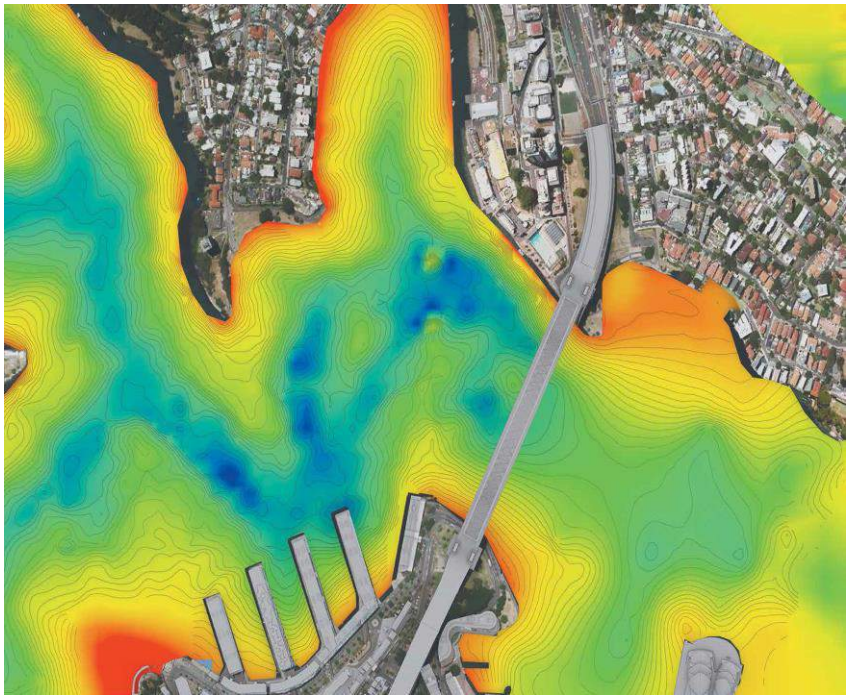
Risk	Mitigation
Sydney Harbour Crossing	
Harbour Crossing rock depth	• Geophysical investigations to be undertaken in December 2014 • Geotechnical borehole investigations to be undertaken in early 2015
Interface with existing buildings, basements & tunnels	• Investigation / surveys of adjacent properties • Existing buildings and structures assessment
Pitt Street Station transition cavern & Cross City Tunnel	• Alternative design options under consideration • Alignment over existing Cross City Tunnel transfer slab, with design & engineering investigations to confirm load design
Central Station constructability	• Investigations to determine construction impacts from SRT in parallel to other Central Station works • Design options considering minimising impacts
Central Station scope	• Consultation with Central Blueprint team • Constructability and pedestrian modelling investigations to confirm scope requirements for SRT (East/West concourse)
Martin Place	• Alternative design options / property under development
CBD construction site access constraints	• Property acquisition sufficient for station construction requirements • Constructability investigations to minimise impacts to adjacent sites and utilisation of sites outside of the CBD (and North Sydney)
‘Construction fatigue’ experienced in the CBD and other high impact areas forces changes to methodology and staging.	• Active stakeholder engagement, including RMS and City of Sydney • Approach to constructability to minimise impacts in highly congested areas • Assessment of other concurrent works to identify conflicts, interfaces, overlaps

Desk Study

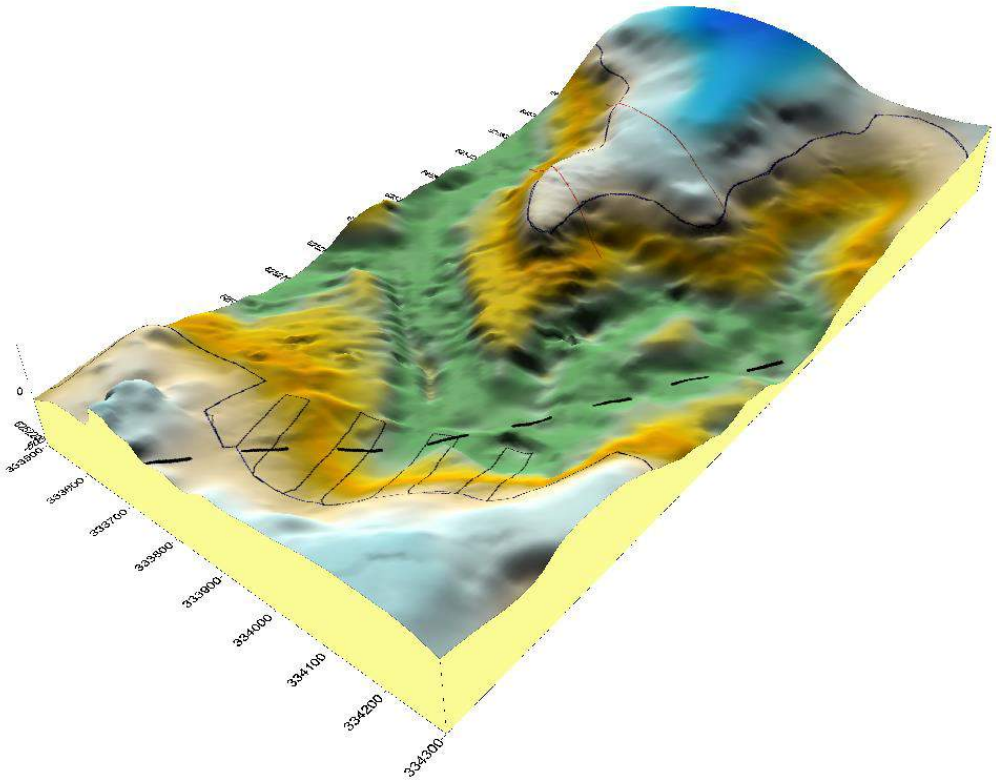


Ground Investigation - Geophysical

- Sonar Scan
- Seismic Reflection
- Seismic Refraction
- Magnetometer Scan



Sonar Scan



3D Image Top of Rock

Investigating The Harbour

Planned

- HQ coring + SPT
- In-situ stress testing
- Water pressure testing
- Downhole imaging

Additional

- Denison Sediment sampling
- CPT
- Cross-hole tomography
- Geomechanical testing
- Sedimentological analysis and testing
- Resistivity

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Harbour Crossing - Alignment

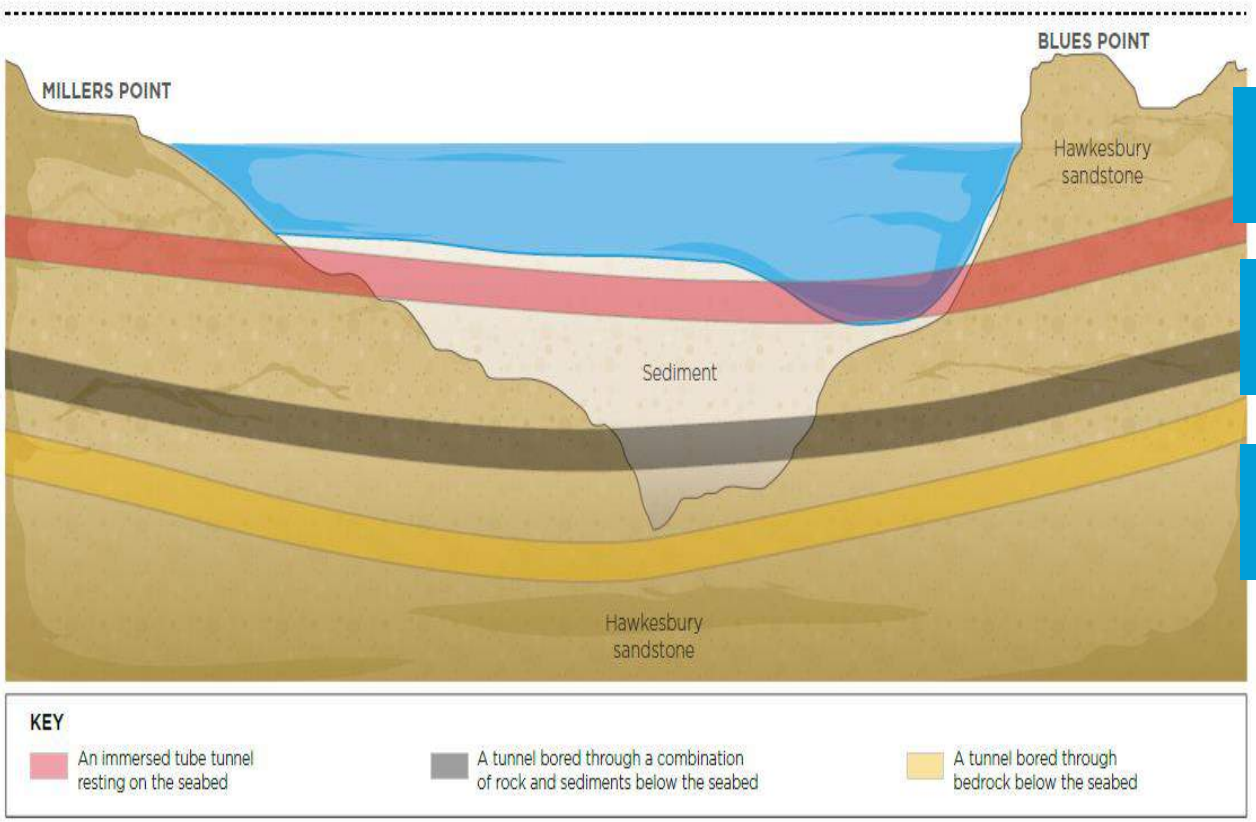

Figure 4.8 Sydney Harbour crossing vertical alignment options considered

Barangaroo 24m bgl
Vic Cross 28m bgl

Barangaroo 24m bgl
Vic Cross 30m bgl

Barangaroo 41m bgl
Vic Cross 42m bgl

Extract from State Significant Infrastructure Application Report

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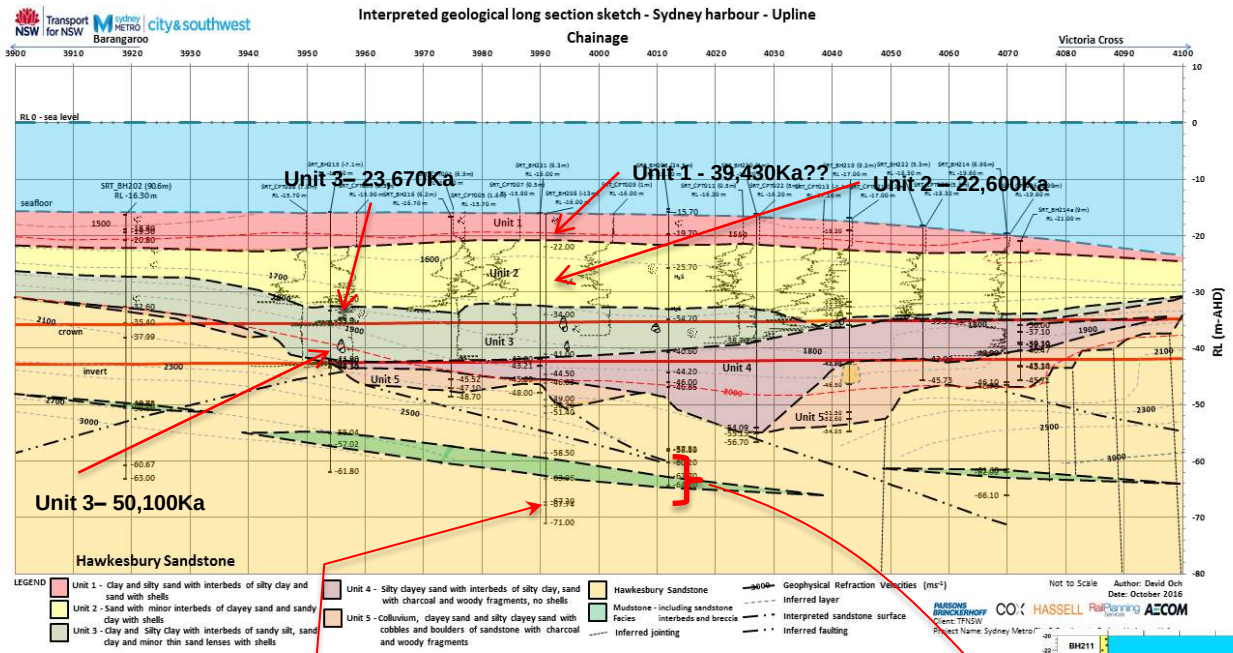
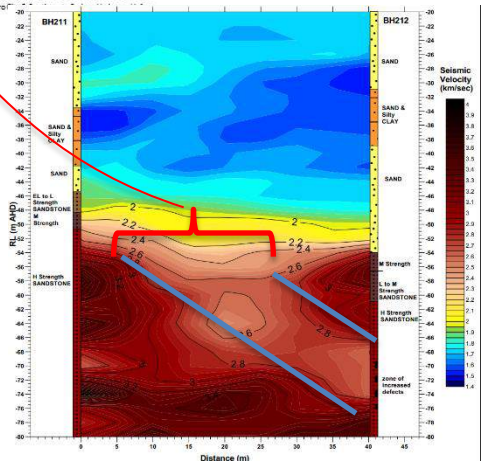
Harbour Investigation- the findings



Corresponding fault zone in Cross hole tomography highlighting the low angle fault zone

Hawkesbury Sandstone with low angle fault zone



PARSONS BRINCKERHOFF COX HASSELL AECOM

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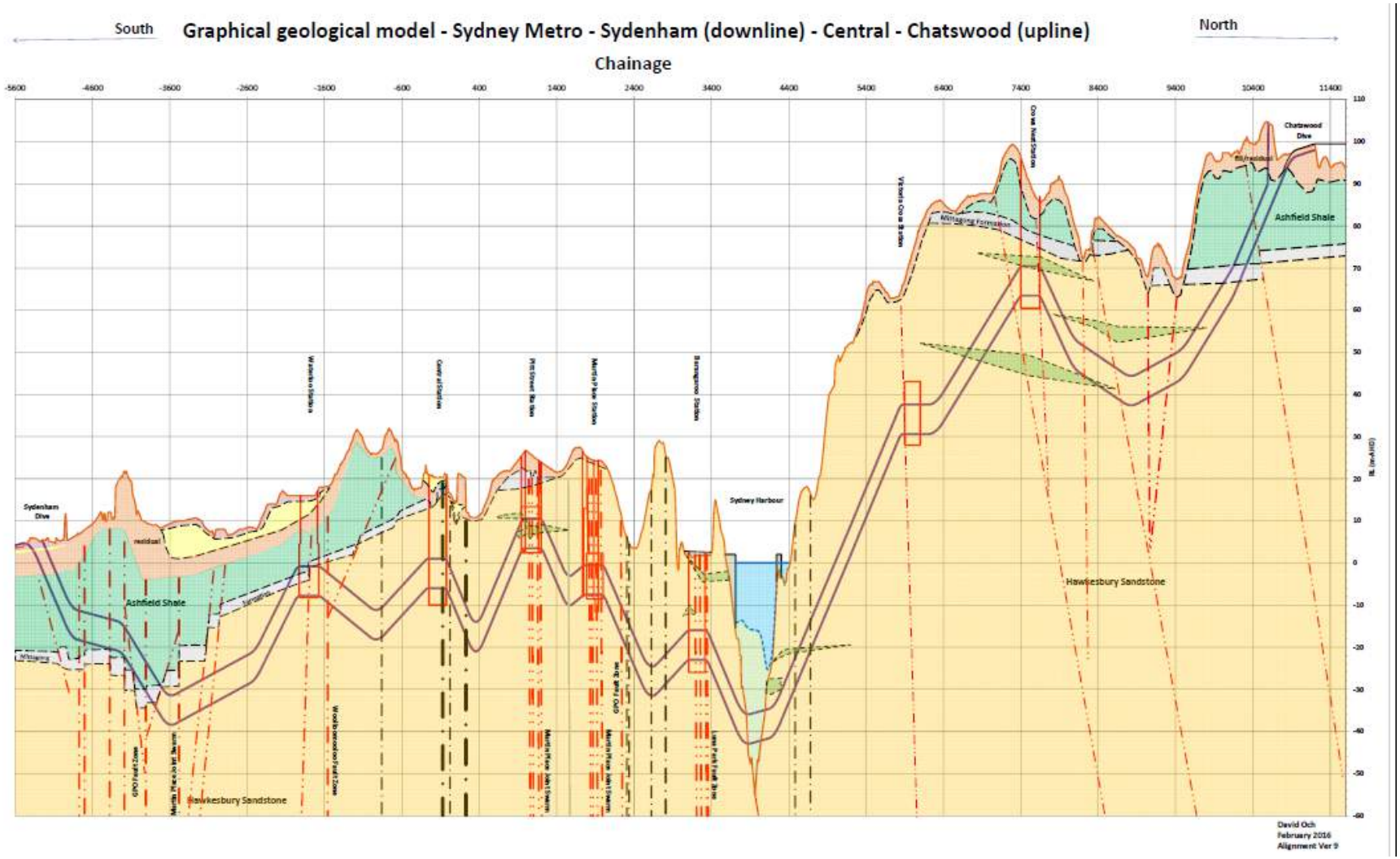
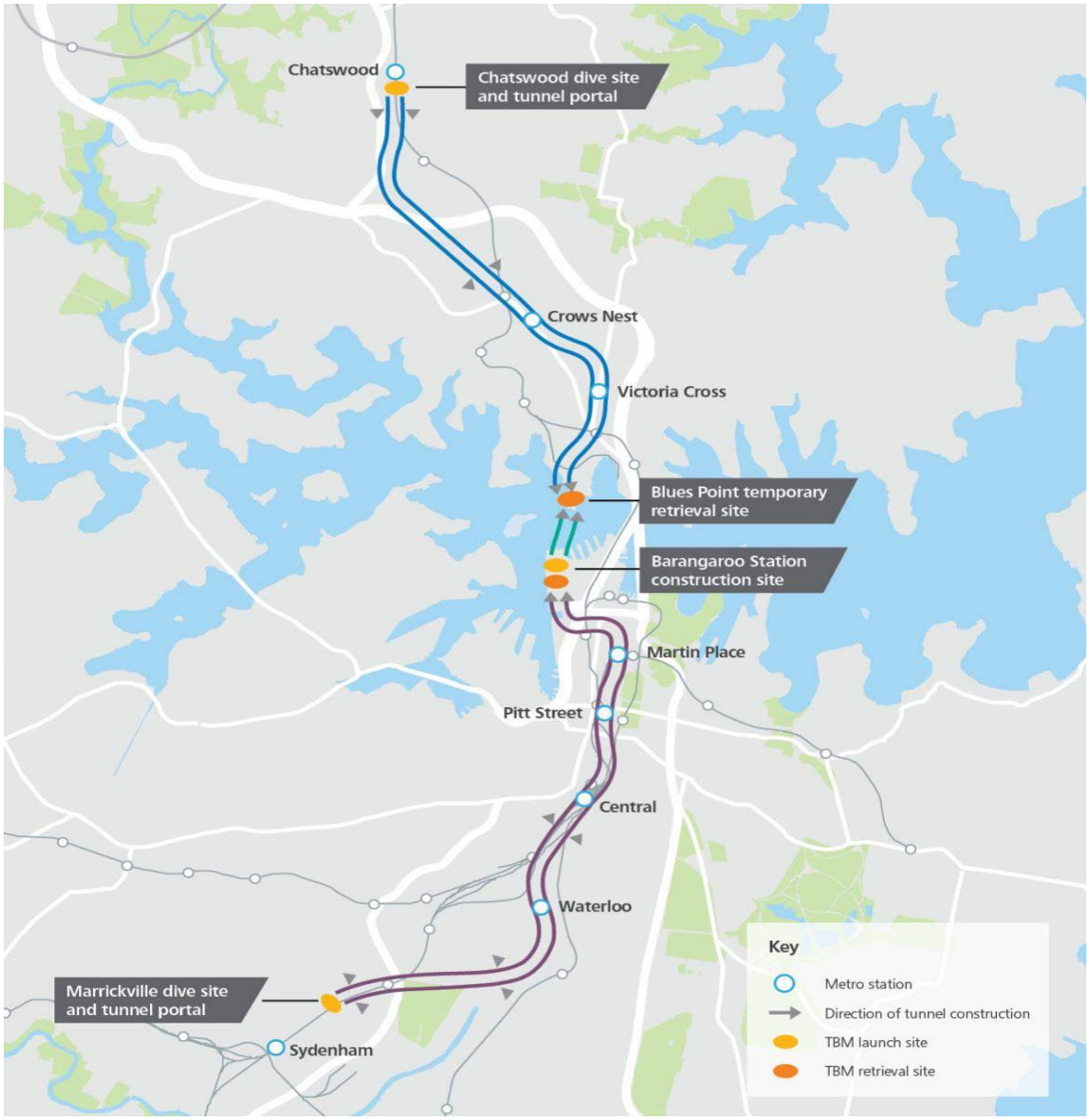
Geology


South
Graphical geological model - Sydney Metro - Sydenham (downline) - Central - Chatswood (upline)
North
Chainage
-5600
-4600
-3600
-2600
-1600
-600
400
1400
2400
3400
4400
5400
6400
7400
8400
9400
10400
11400
Sydenham Dive
Ashfield Shale
Hawkesbury Sandstone
Sydney Harbour
Chatswood Dive
Ashfield Shale
Hawkesbury Sandstone
David Och
February 2016
Alignment Ver 9



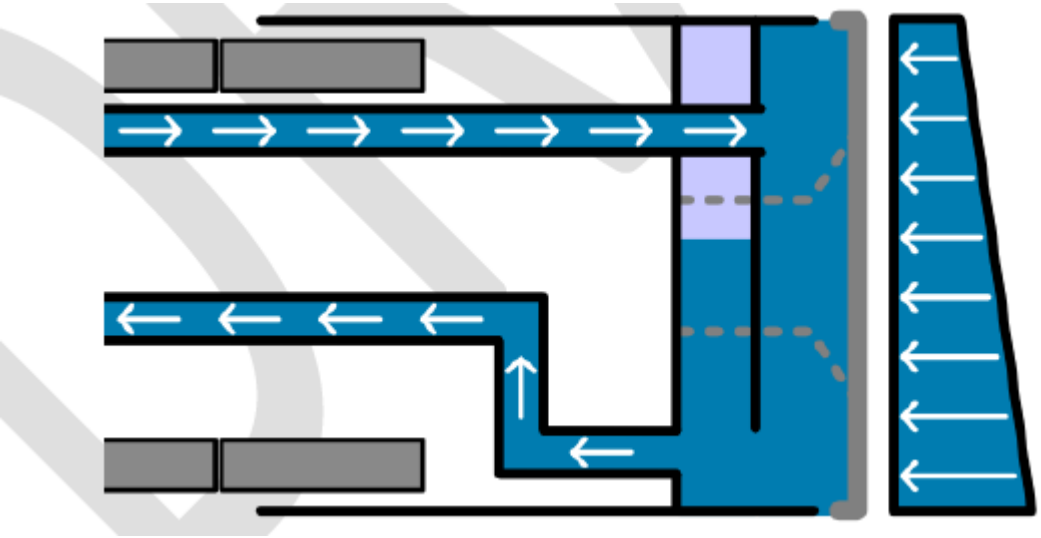
Tunnelling Strategy

TBM selection
- Mixed Ground
- Soft Ground
- Interventions

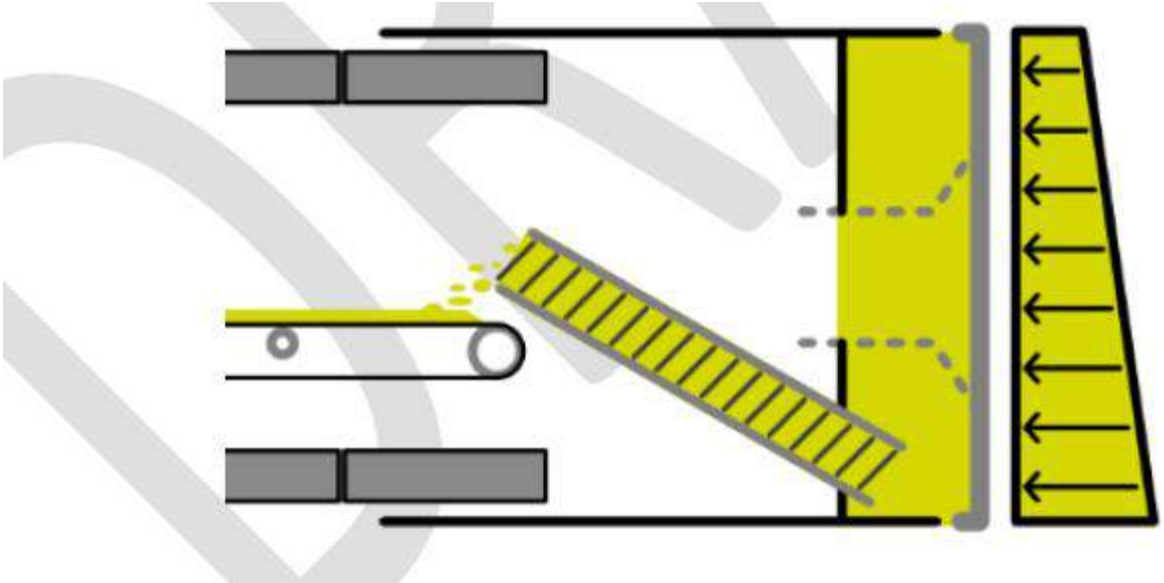
Geotechnical Processes
- Ground Treatment
- Ground Freezing

Access shaft at Blues Point

Harbour – Tunnel Boring Machines

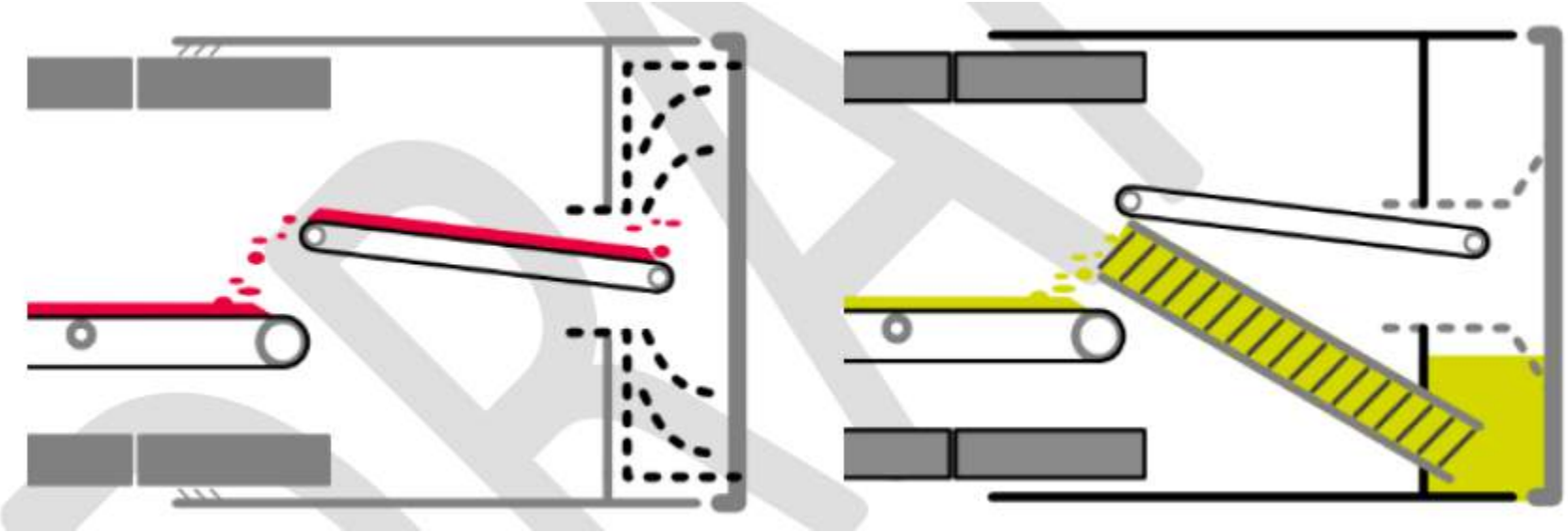


Slurry Machine

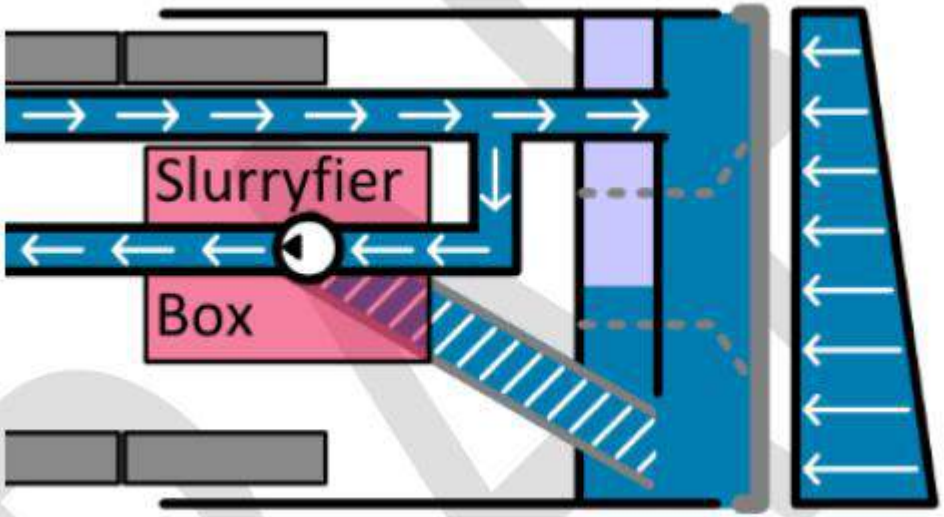


Earth Pressure Balance Machine

Harbour – Tunnel Boring Machines

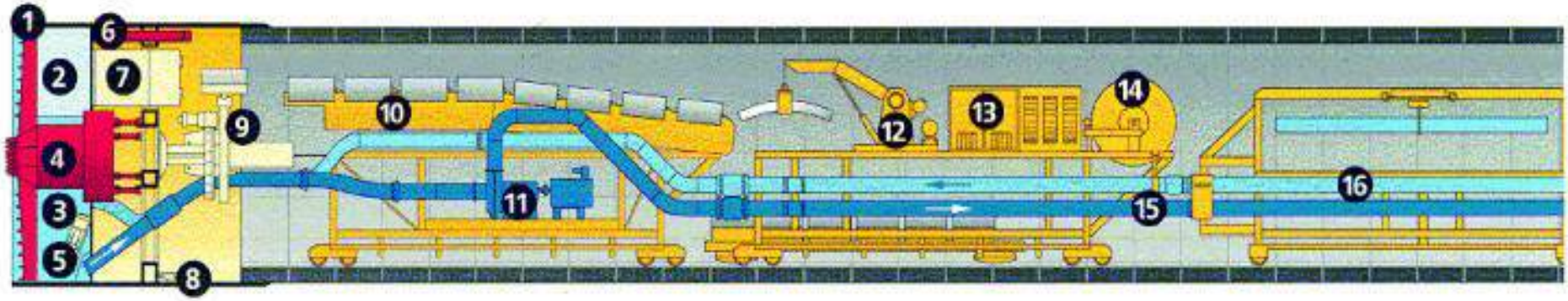


Convertible Earth Pressure Balance Machine

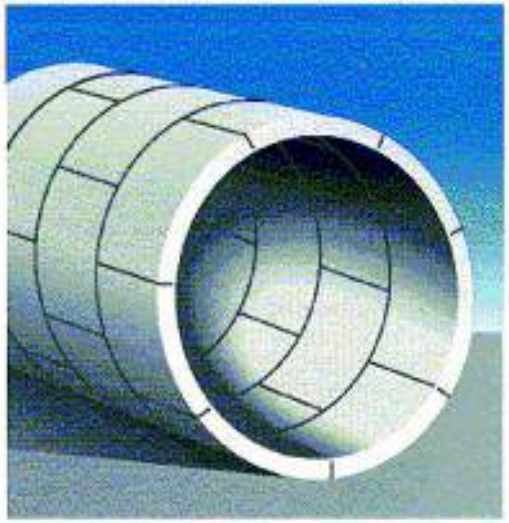


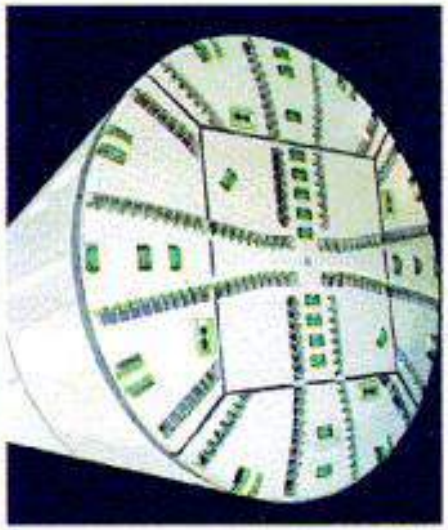
Hybrid Tunnel Boring Machine

Harbour – Preferred Tunnel Boring Machine



1 *Cutting wheel*
2 *Air bubble*
3 *Bentonite suspension*
4 *Drive unit*
5 *Stone crusher*
6 *Push cylinder*
7 *Air lock*
8 *Steer cylinder/ shield tail*
9 *Erector*
10 *Segment conveyor*
11 *Slurry pump*
12 *Segment crane*
13 *Main electric panel*
14 *Cable reeling drum*
15 *Discharge line*
16 *Feed line*





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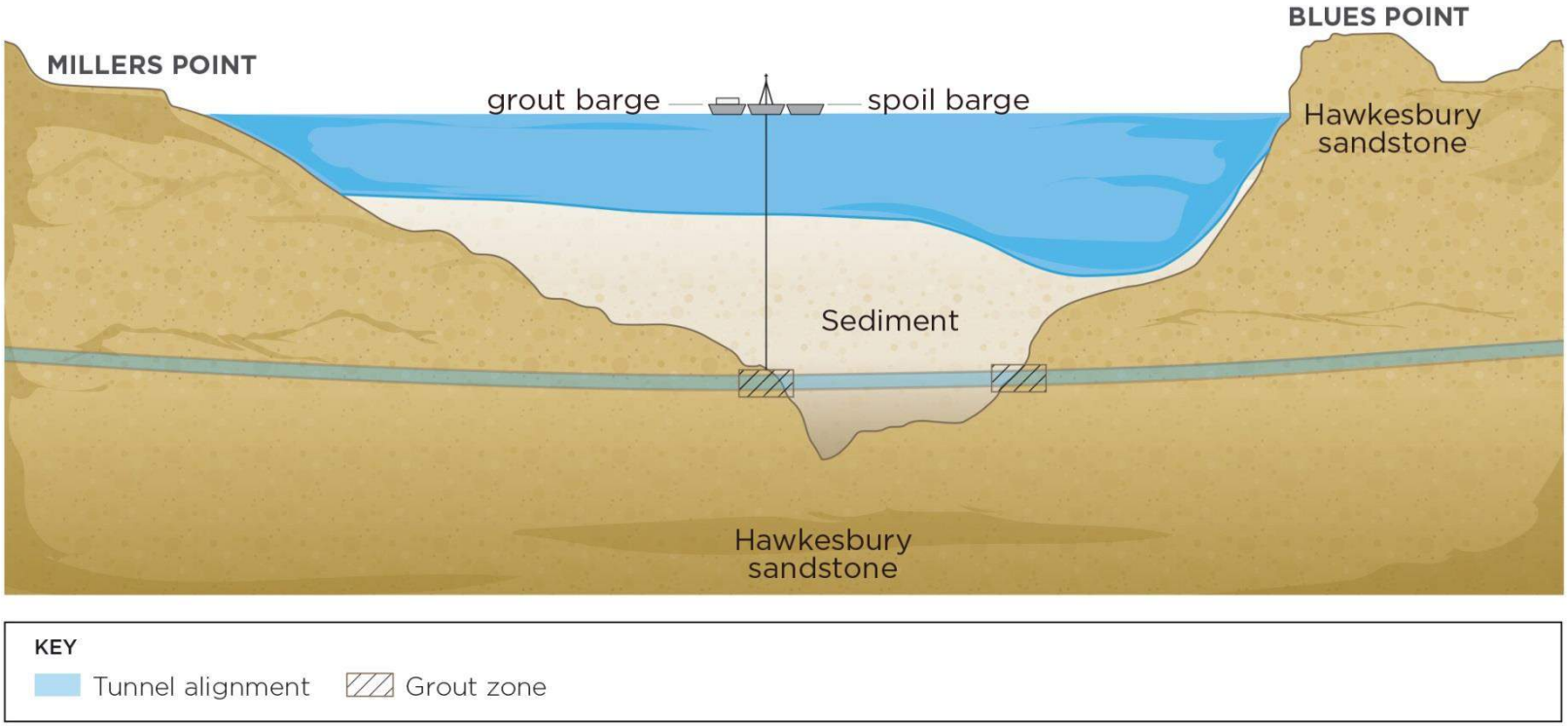
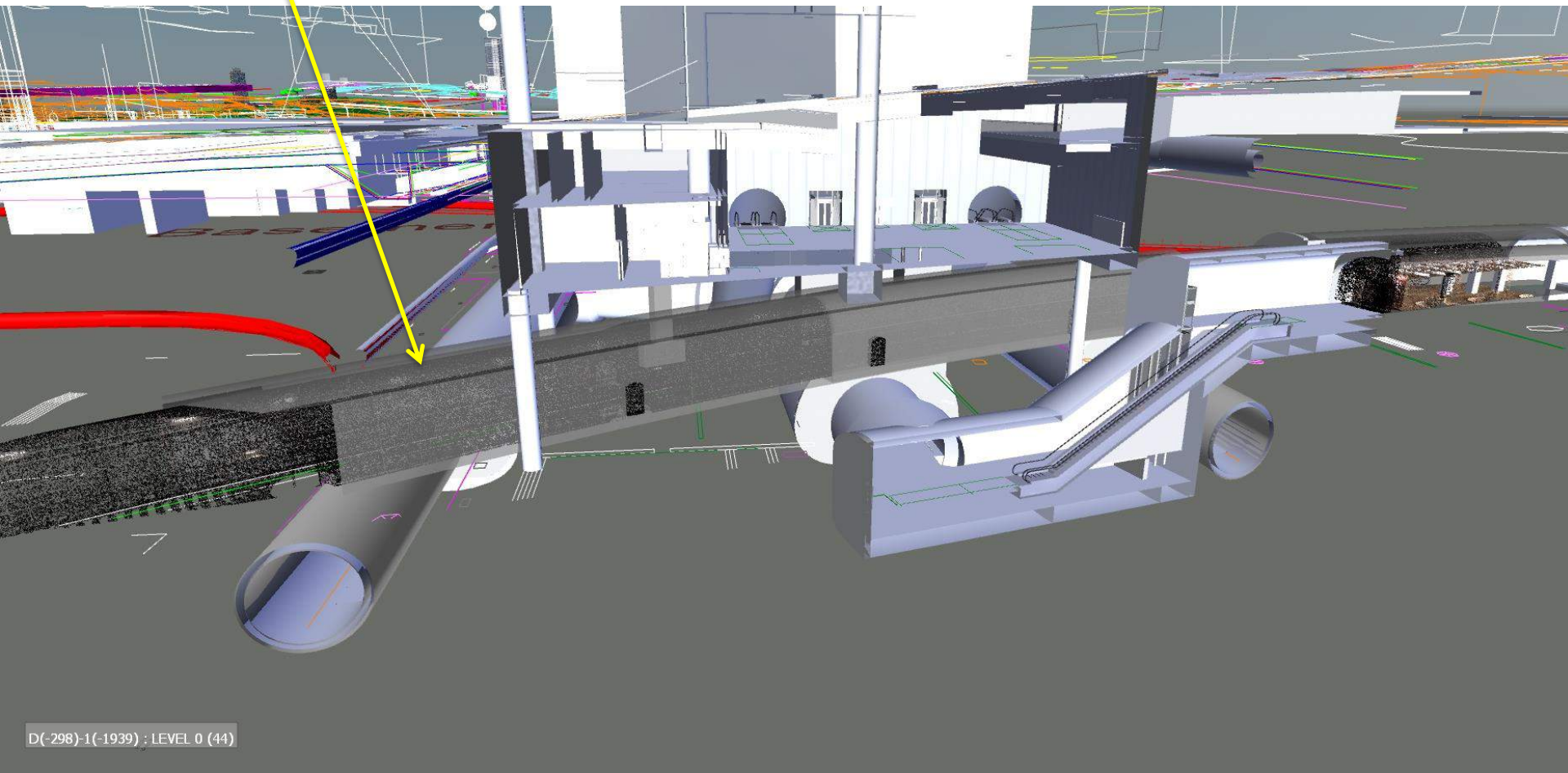
Harbour – Ground Treatment

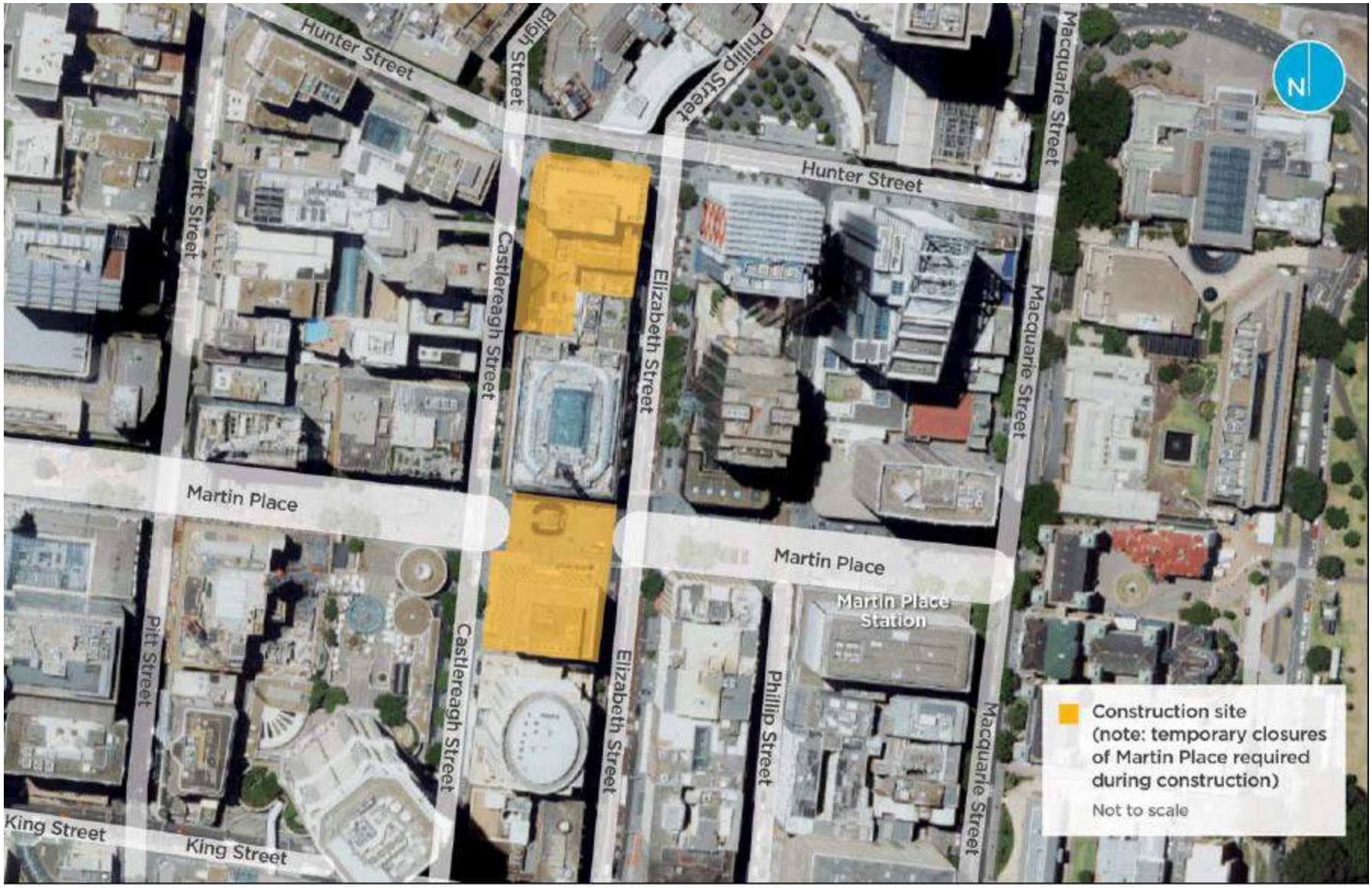


City Alignment

Underground constraints

Existing rail line





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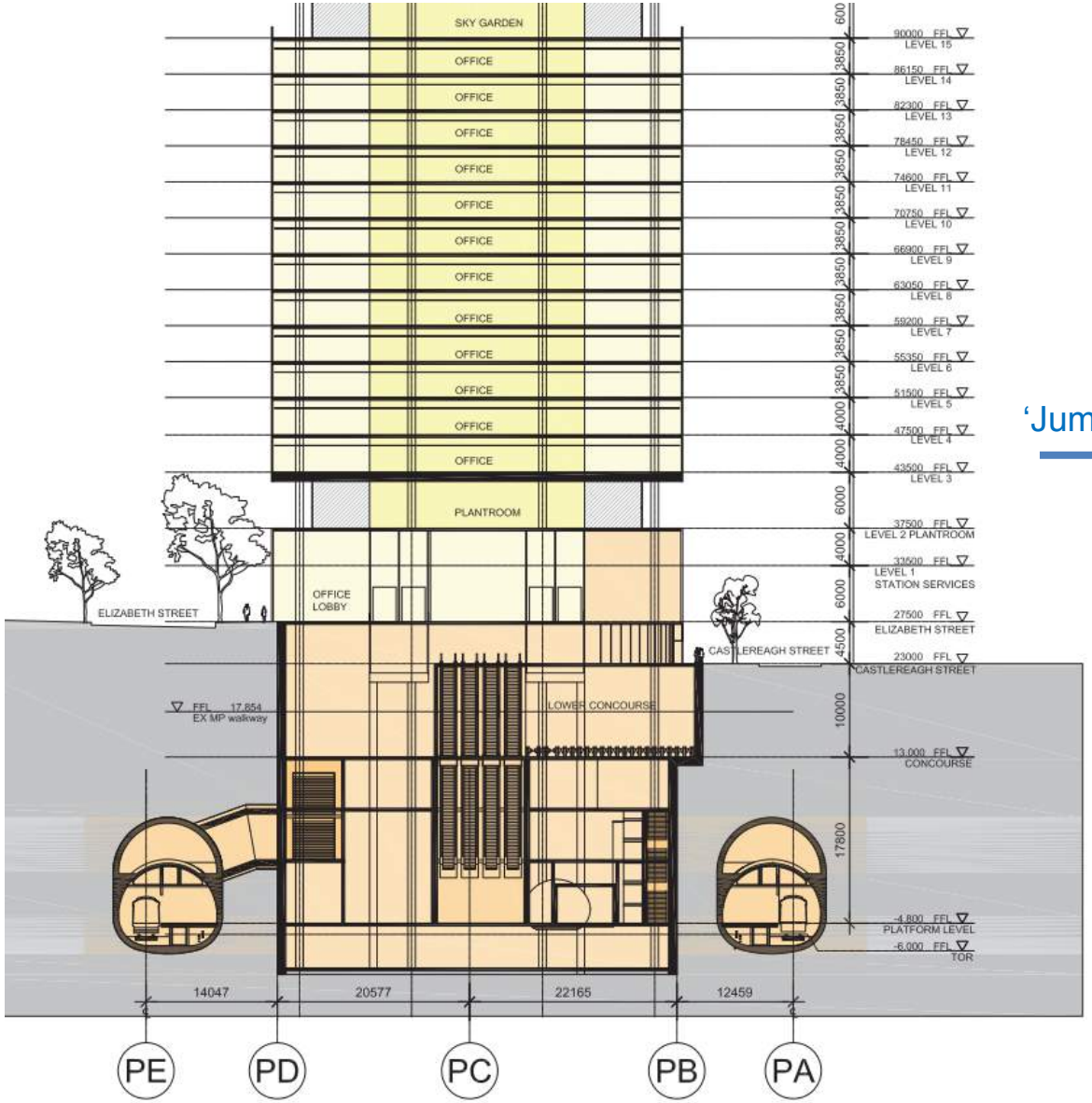
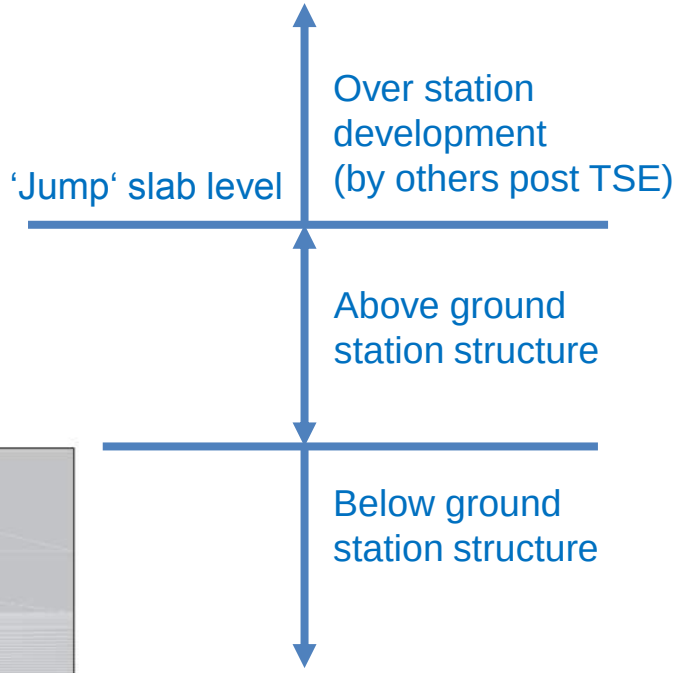
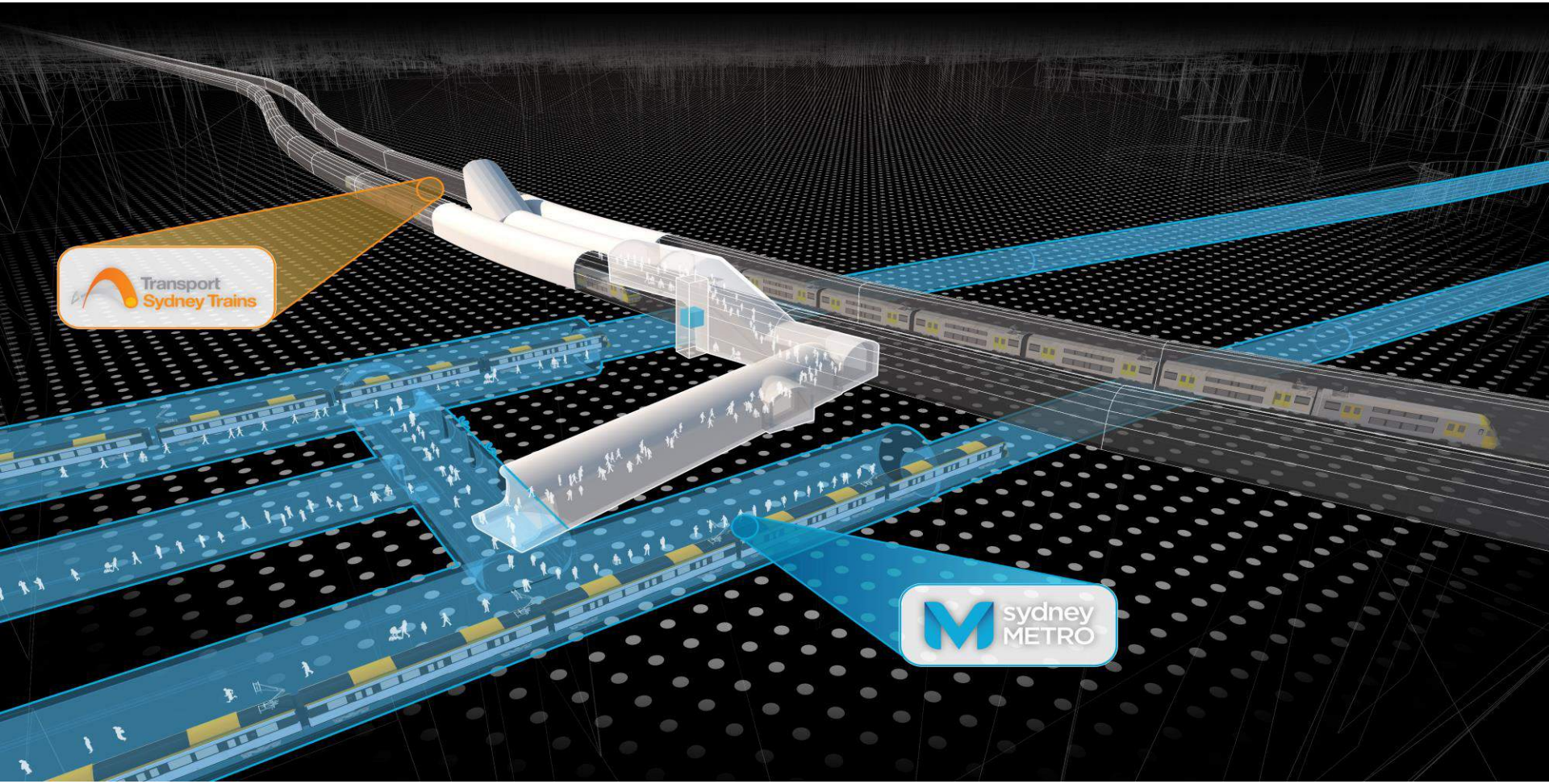
Development opportunities

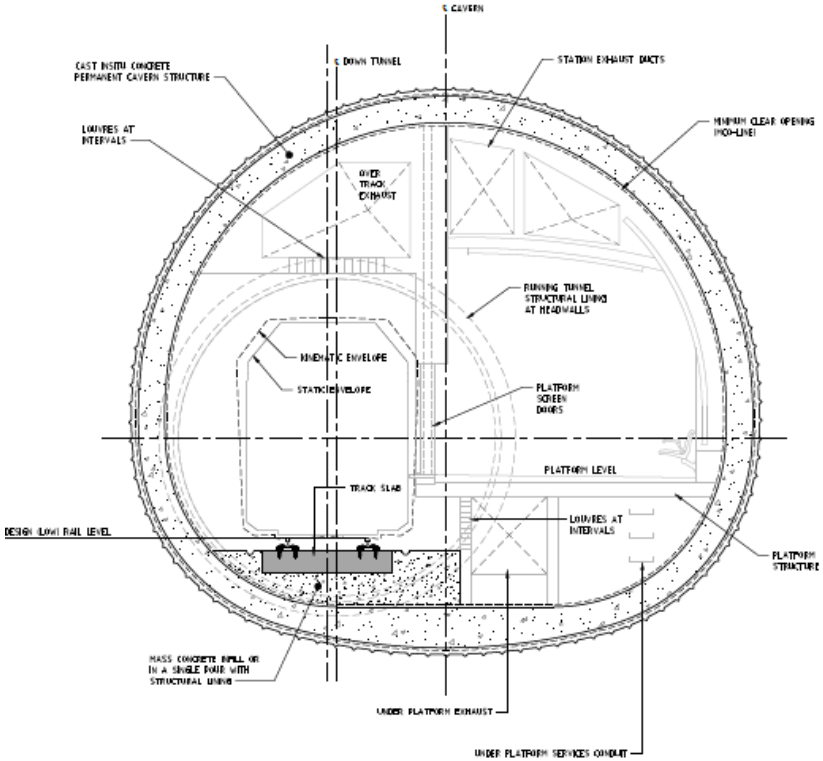




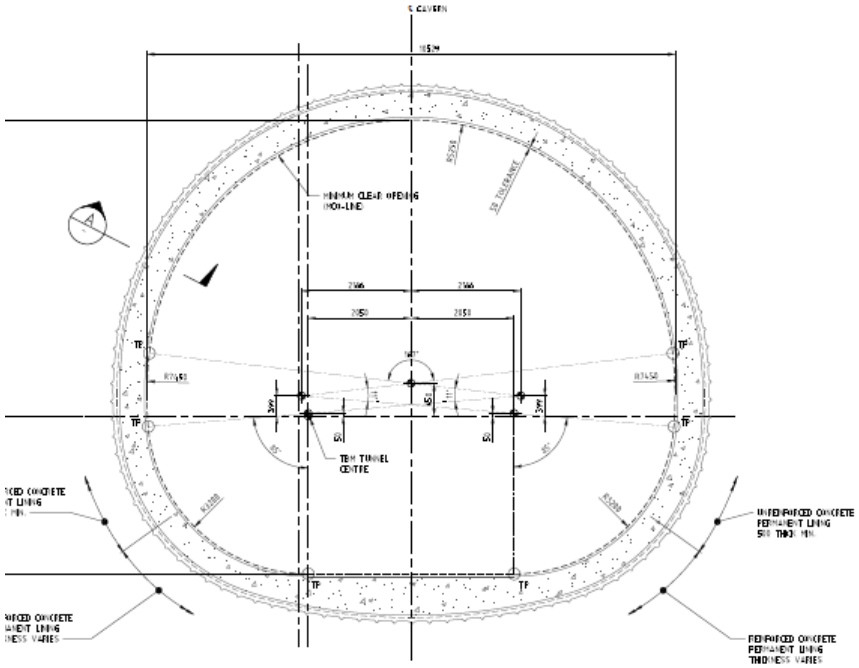
Martin Place Interchange



Binocular Platform Cavern

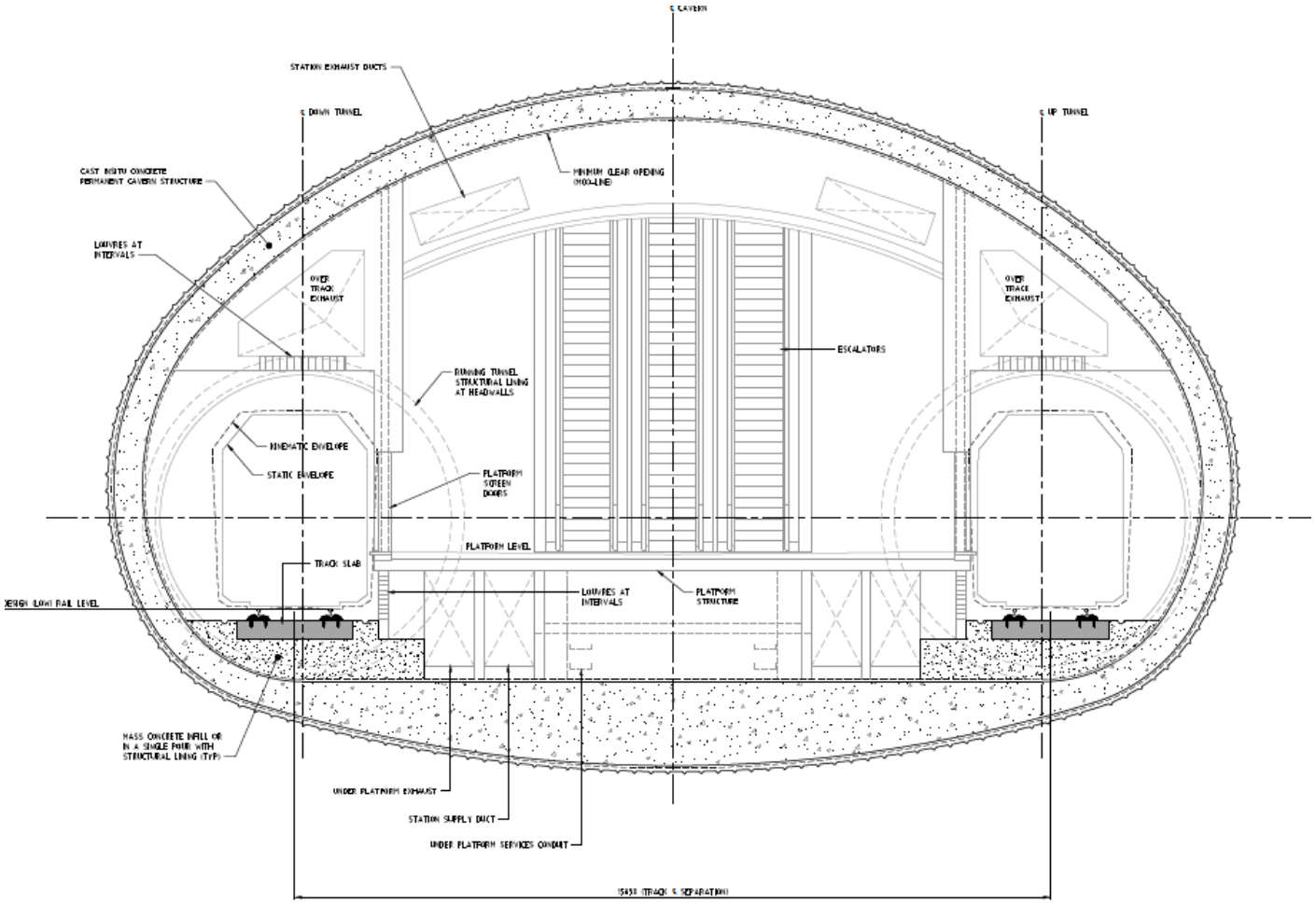


PITT STREET STATION/MARTIN PLACE STATION
TYPICAL BIONCULAR CAVERN
GENERAL ARRANGEMENT
SCALE 1:50



PITT STREET STATION/MARTIN PLACE STATION
TYPICAL BIONCULAR CAVERN
MCO SETOUT
SCALE 1:50

Single Platform Cavern



VICTORIA CROSS STATION
SINGLE SPAN STATION CAVERN
GENERAL ARRANGEMENT
SCALE 1:50

Thank you