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Deep Tunnel Sewerage System (DTSS) Phase 2

Tunnelling & Underground Construction Society (Singapore)

18 February 2016

Woo Lai Lynn
DTSS Phase 2 Project Unit
Deputy Project Director

Ganeshan
BV+AECOM Joint Venture
Manager (Tunnels)

PUB
Water for All: Conserve, Value, Enjoy

B&V AECOM
A joint venture of Black & Veatch and AECOM

<u>Commentary for Introduction slide</u>

The presentation attached was delivered at the Tunnelling and Underground Construction Society (Singapore) (TUCSS) Monthly Seminar on 18 Feb 2016. With focus on the DTSS Phase 2 Conveyance system, the intent of the presentation was to provide a brief introduction of the key features of our DTSS Phase 2 Deep Tunnels to TUCSS participants as well as contractors/consultants who might be interested in participating in our project.

The presentation was jointly presented by :

Ms Woo Lai Lynn – Deputy Project Director for DTSS Phase 2 Project Unit, PUB, the National Water Agency

Dr Ganeshan Vallipuram – Manager (Tunnels), BV&AECOM Joint Venture, PUB's appointed consultant for DTSS Phase 2 Project Unit

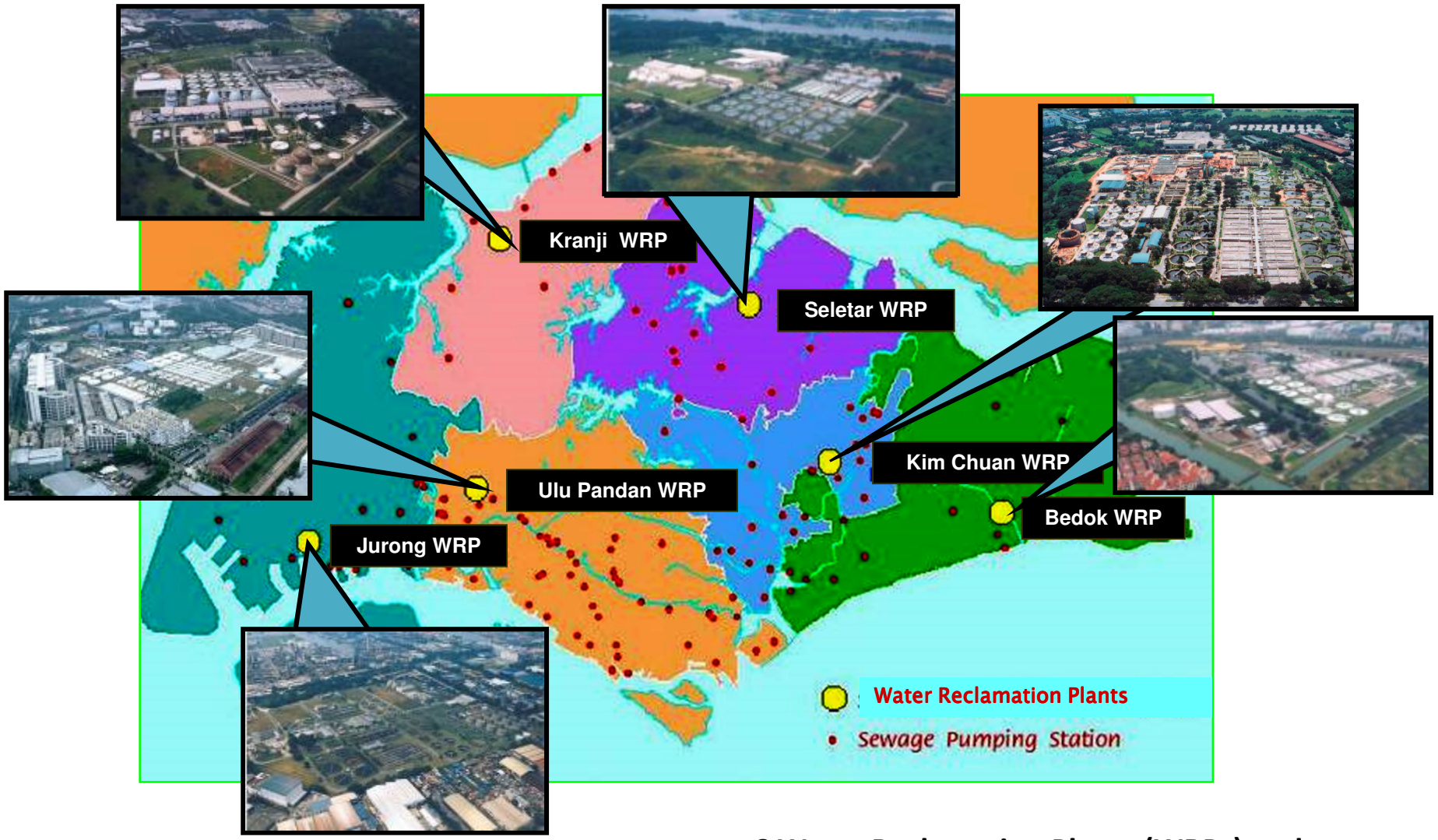
Outline

- Background of Singapore's Deep Tunnel Sewerage System (DTSS)
- Benefits of DTSS
- DTSS Phase 1
- DTSS Phase 2
- DTSS Phase 2 key features

<u>Commentary for Outline</u>

This slide provides the outline of the presentation by Ms Woo Lai Lynn.

Used Water System Before DTSS



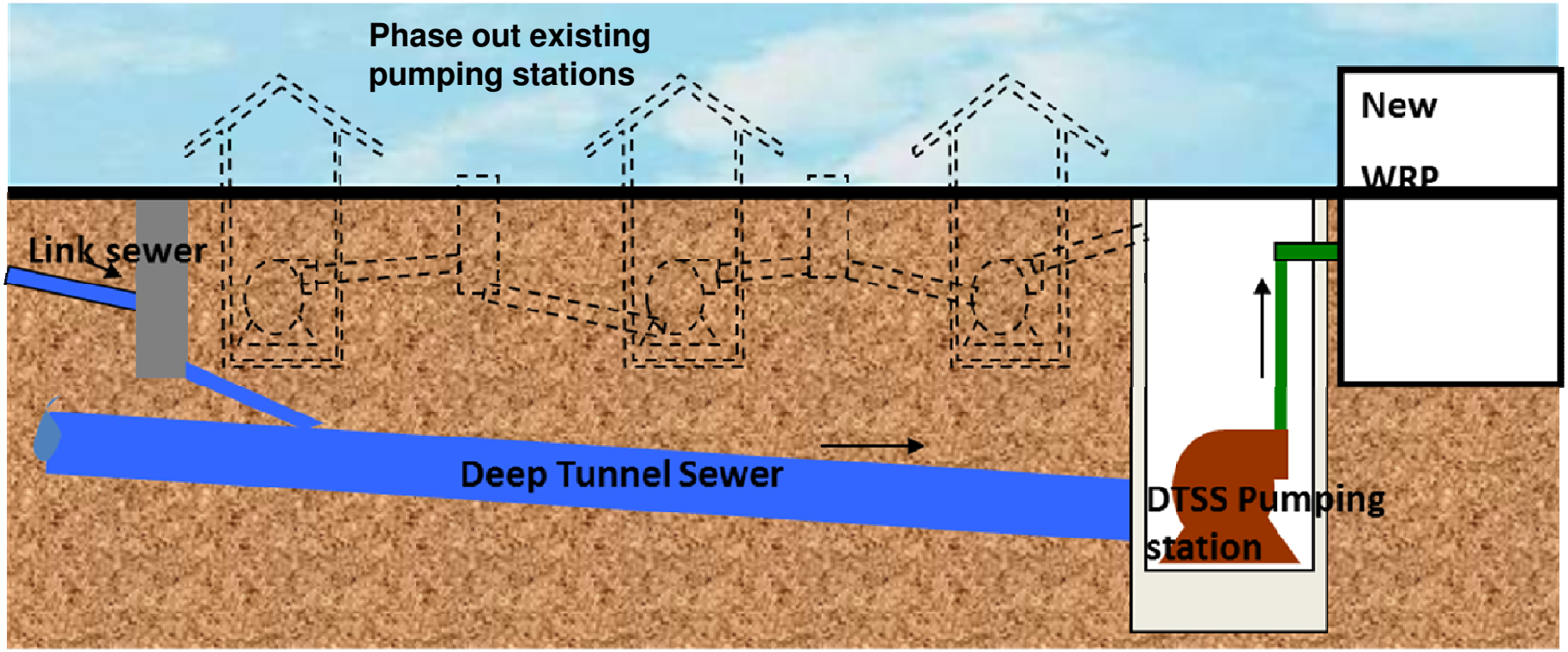
6 Water Reclamation Plants (WRPs) and

>130 Sewage Pumping Stations

<u>Commentary for Used Water System Before DTSS</u>

The used water system before DTSS consisted of 6 Water Reclamation Plants (WRPs) and more than 130 sewage pumping stations scattered throughout the island.

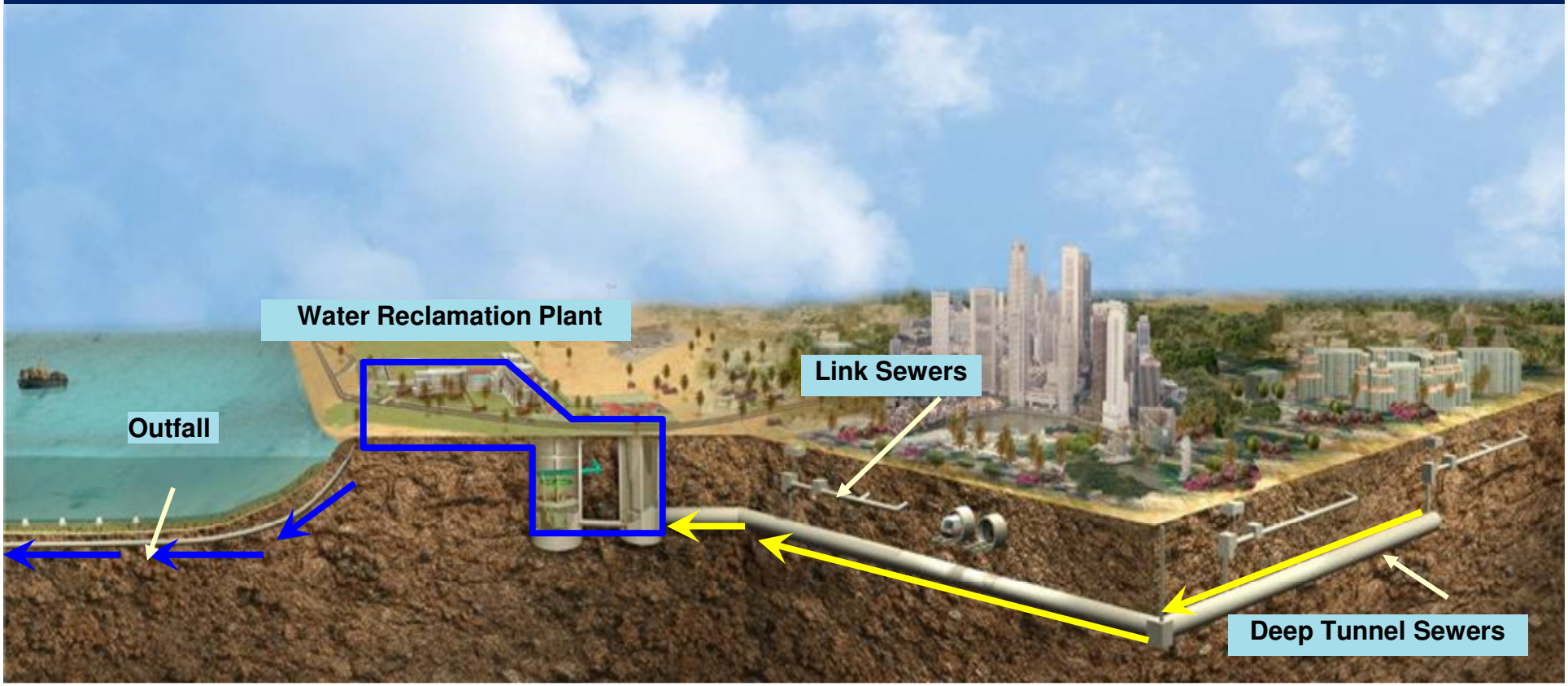
How DTSS Works



<u>Commentary for How DTSS Works</u>

Before DTSS, our sewerage system consisted of a network of gravity sewers conveying used water to the water reclamation plants via multiple intermediate pumping stations. With the introduction of DTSS, these intermediate pumping stations scattered all over the island can be phased out and be replaced with a single large diameter tunnel which conveys used water flow purely by gravity. The used water is pumped up only once at the centralized pumping station located at the WRP for treatment.

How DTSS Works



- **Link Sewers convey used water from existing sewerage network to the Deep Tunnels**
- **Used water flows by gravity through the deep sewer tunnels to centralised Water Reclamation Plants**
- **Treated used water will be channelled to the NEWater plant for further purification or discharged through the outfall**

<u>Commentary for How DTSS Works</u>

How does the DTSS works

- **Link Sewers convey used water from existing sewerage network to the Deep Tunnels**
- **Used water flows by gravity through the deep sewer tunnels to centralised Water Reclamation Plants**
- **Treated used water will be channelled to the NEWater plant for further purification or discharged through the outfall**

Benefits of DTSS

Benefits:

- More cost effective
- Free up valuable land
- Ensures sustainability of NEWater
- Robust, Reliable and Resilient

Existing WRPs & Pumping Stations – 300 ha

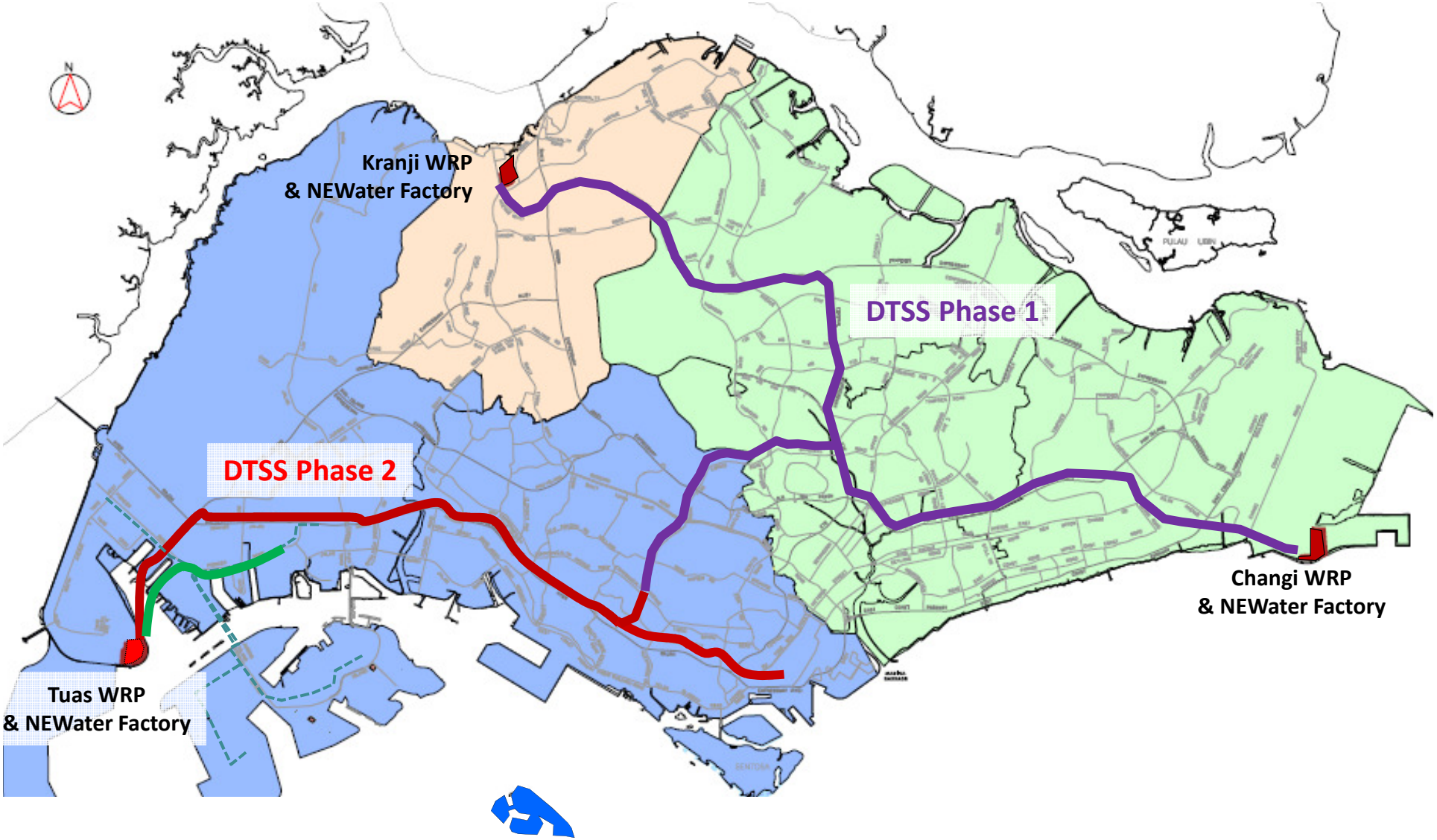
<u>Commentary for Benefits of DTSS</u>

The DTSS brings about many benefits:

- **It is more cost-effective than continually renewing and expanding existing used water infrastructure;**
- **It frees up valuable land for other high value development;**
- **It ensures adequate conveyance and treatment capacity to meet Singapore's long term water needs**
- **It provides a more robust, reliable and resilient used water system.**

Deep Tunnel Sewerage System (DTSS)

Long-Term Used Water System (Phase 1 & 2)



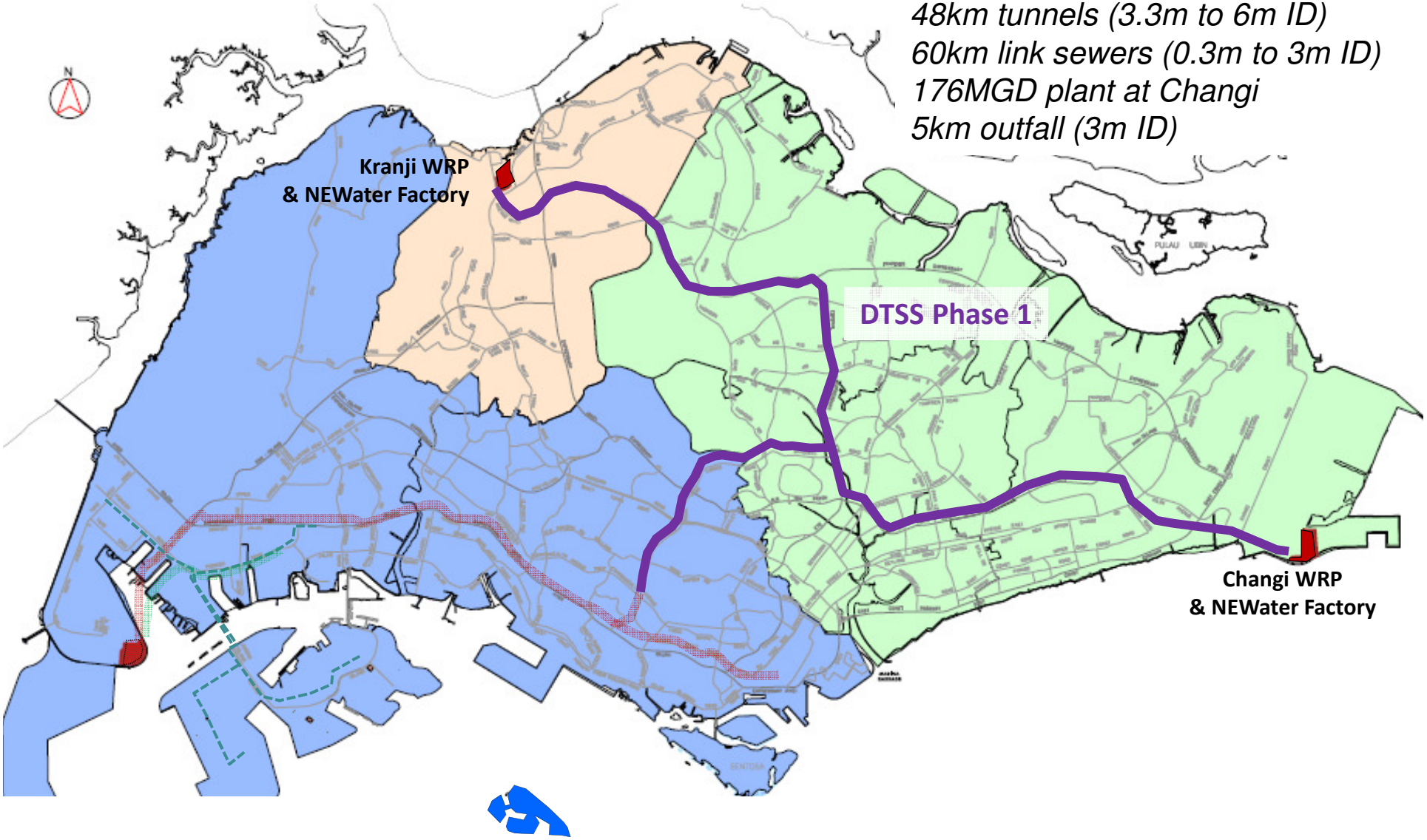
- **Used water superhighway to meet Singapore's long-term needs**

Commentary for Deep Tunnel Sewerage System (DTSS)

A superhighway for used water management, the Deep Tunnel Sewerage System (DTSS) is an efficient and cost-efficient solution conceived by PUB to meet Singapore's long-term needs for used water collection, treatment, reclamation and disposal. DTSS was envisaged to be implemented in two phases.

Deep Tunnel Sewerage System (DTSS)

DTSS Phase 1 (2000 – 2008)
48km tunnels (3.3m to 6m ID)
60km link sewers (0.3m to 3m ID)
176MGD plant at Changi
5km outfall (3m ID)



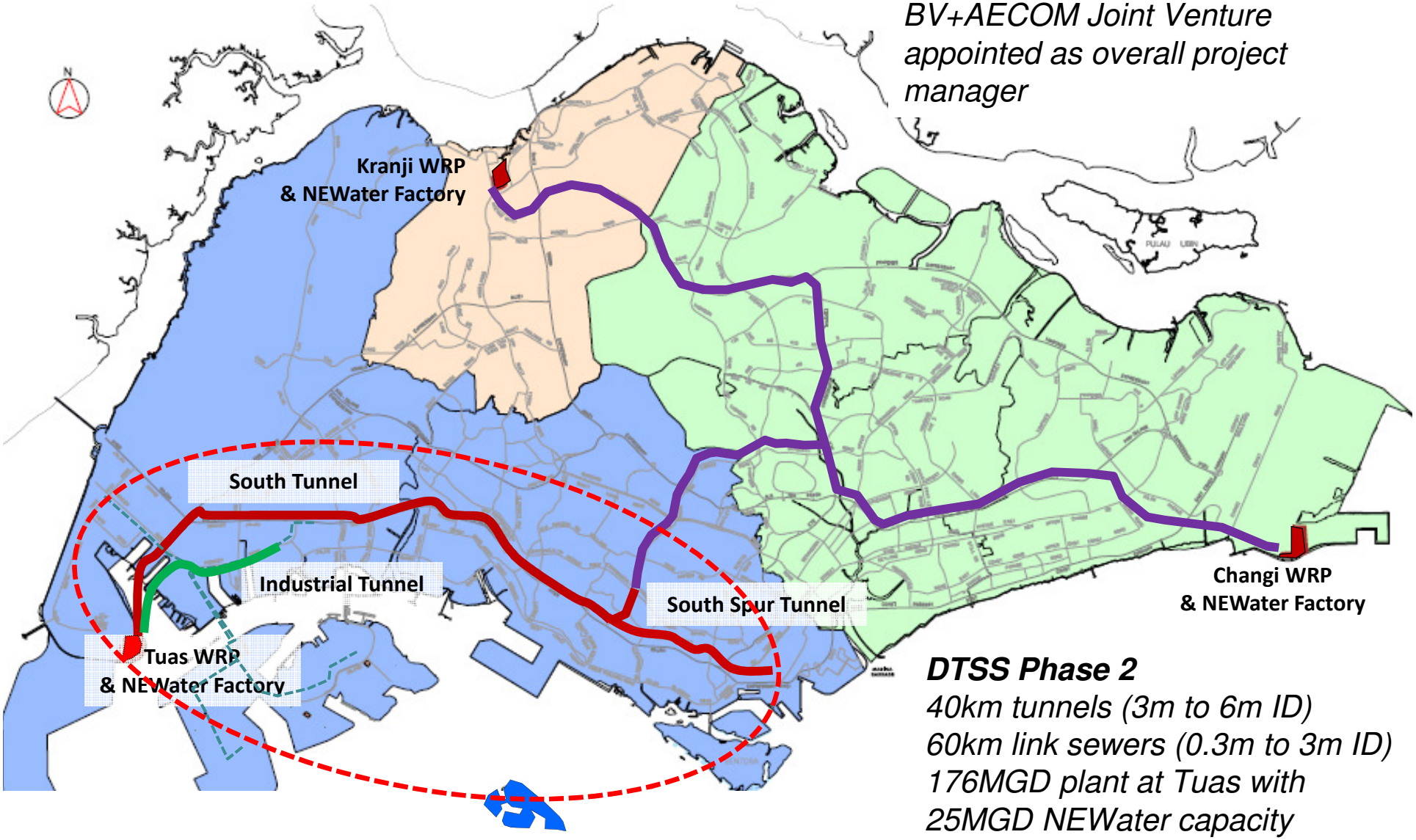
Commentary for Deep Tunnel Sewerage System (DTSS)

DTSS Phase 1 was completed in 2008 and consisted of

- **48km of tunnels**
- **60km link sewers, and**
- **A 176MGD plant at Changi with outfall**

Deep Tunnel Sewerage System (DTSS)

Project started in 2014
BV+AECOM Joint Venture appointed as overall project manager



DTSS Phase 2

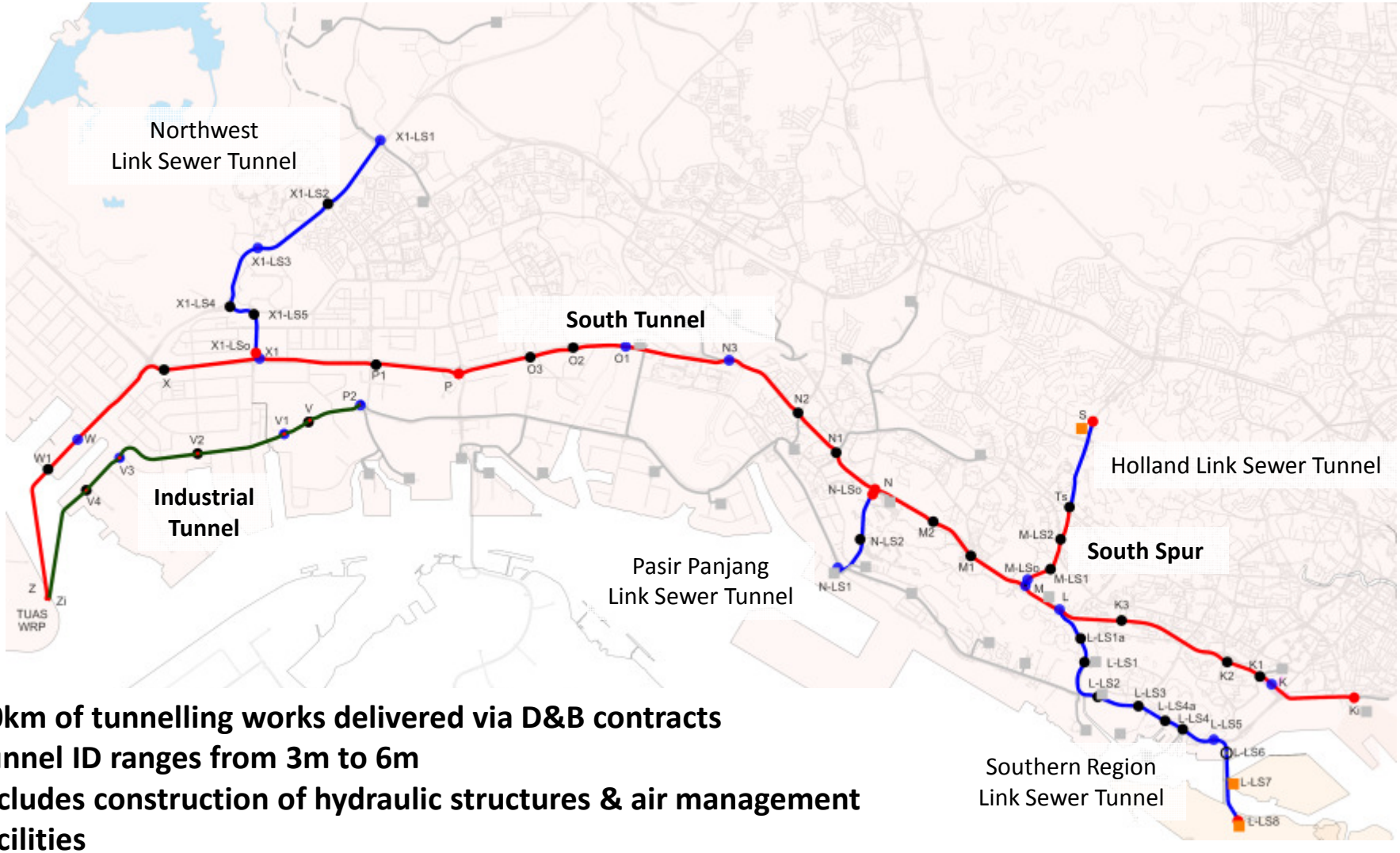
40km tunnels (3m to 6m ID)
60km link sewers (0.3m to 3m ID)
176MGD plant at Tuas with 25MGD NEWater capacity

Commentary for Deep Tunnel Sewerage System (DTSS)

- **DTSS Phase 2 consists of**
- **40km of tunnels with internal diameters of 3m to 6m;**
- **60km link sewers with internal diameters of 0.3m to 3m, and**
- **A 176MGD plant at Tuas with a 25MGD NEWater capacity.**

- **The DTSS Phase 2 project started in 2014 with the appointment of BV+AECOM Joint Venture as overall project manager.**

Scope of Tunnelling Works



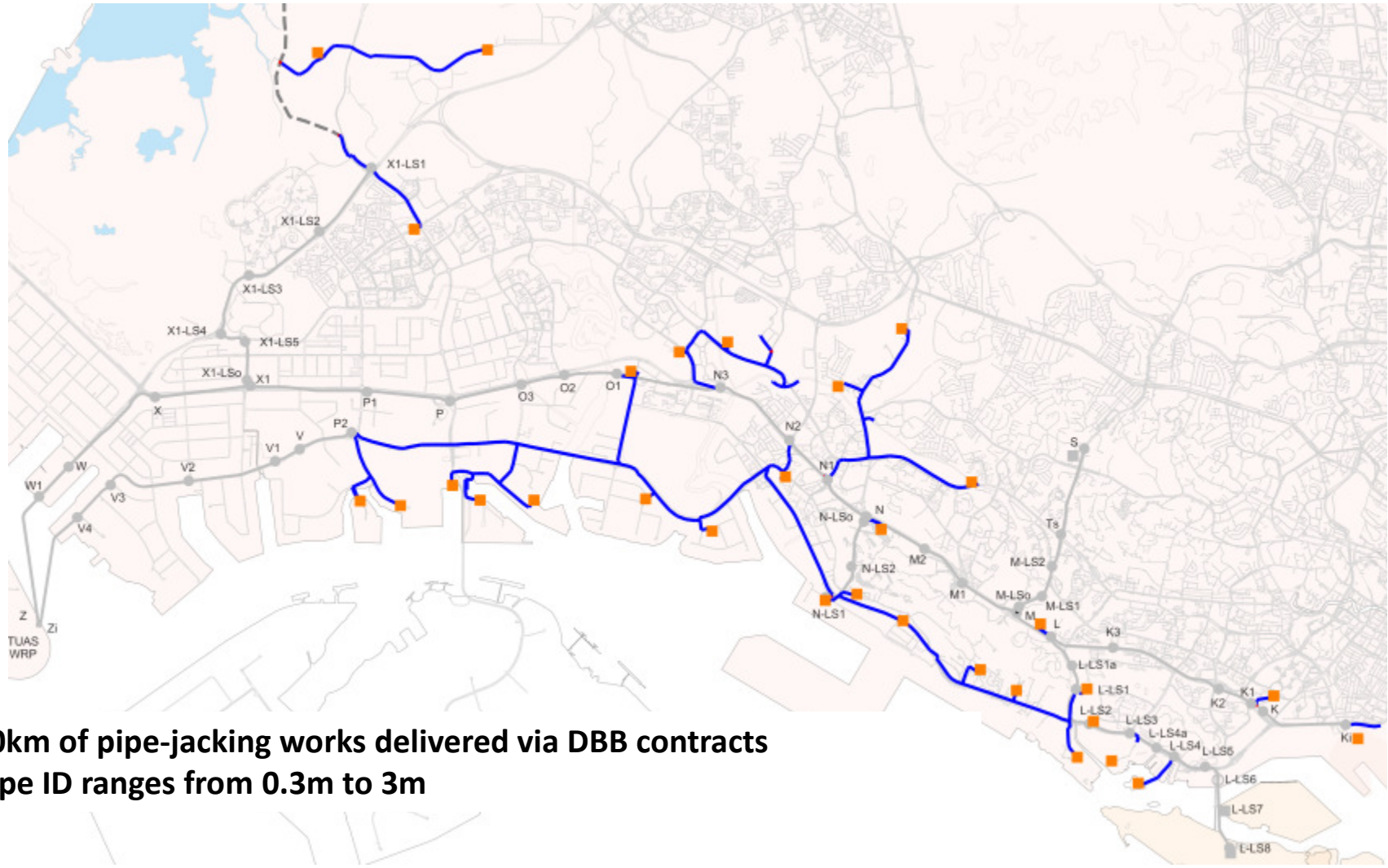
- **50km of tunnelling works delivered via D&B contracts**
- **Tunnel ID ranges from 3m to 6m**
- **Includes construction of hydraulic structures & air management facilities**

Commentary for Scope of Tunnelling Works

All 40km of Deep Tunnels and 10km of the larger diameter Link Sewers will be constructed using Tunnel Boring Machines (TBM) via Design & Build (D&B) contracts. The 50km of tunnelling works include:

- **South Tunnel;**
- **South Spur Tunnel;**
- **Industrial Tunnel;**
- **Northwest Link Sewer;**
- **Pasir Panjang Link Sewer;**
- **Holland Link Sewer, and**
- **Southern Region Link Sewer**
- **In addition to the TBM tunnelling works, the contracts will also include the construction of hydraulic structures and air management facilities.**

Scope of Pipe-jacking Works

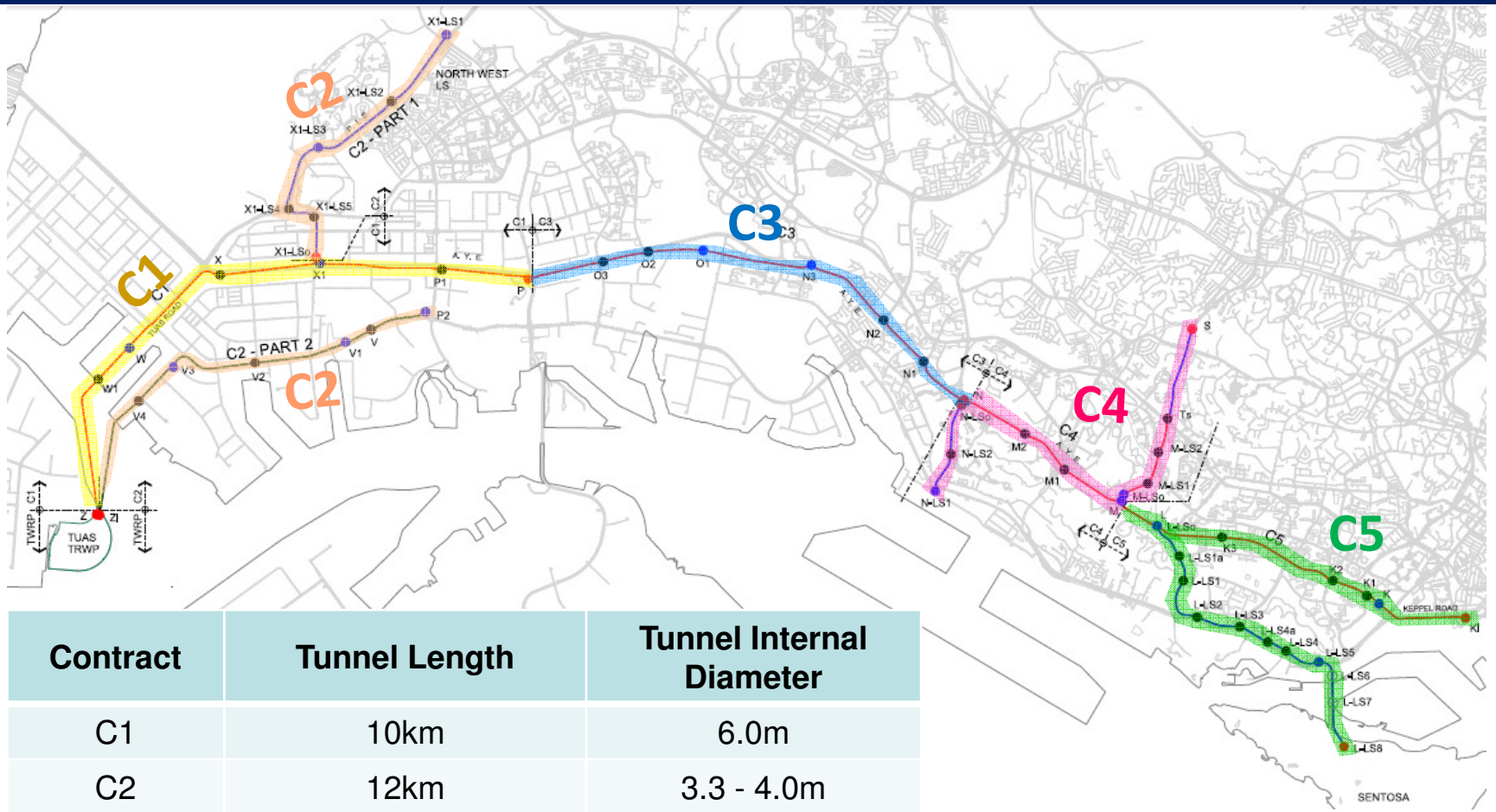


- **50km of pipe-jacking works delivered via DBB contracts**
- **Pipe ID ranges from 0.3m to 3m**

<u>Commentary for Scope of Pipe-Jacking Works</u>

The remaining 50km of smaller diameter Link Sewers will be constructed by pipe-jacking via conventional Design-Bid-Build (DBB) contracts.

Tunnel Contract Packaging

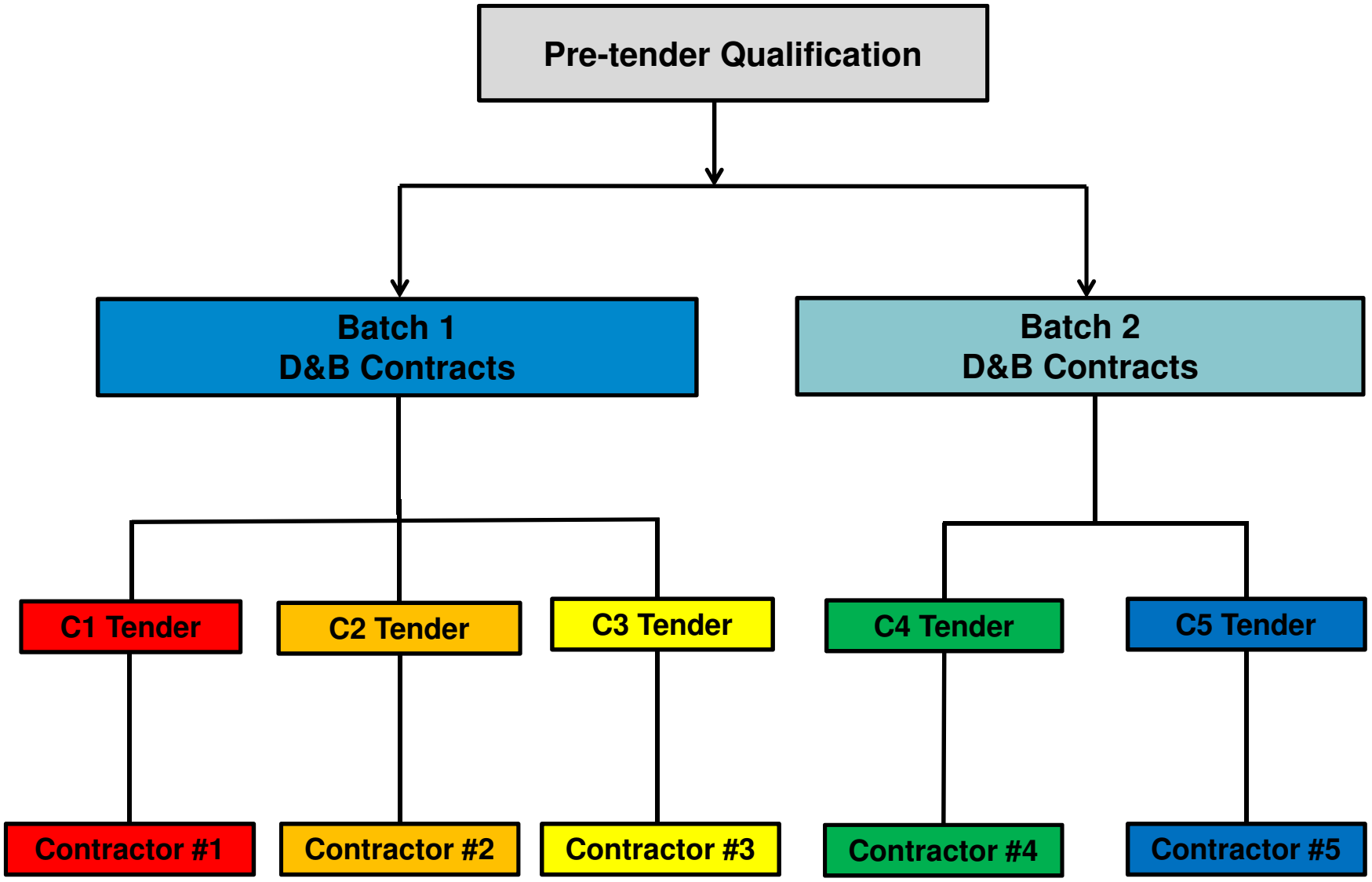


Contract	Tunnel Length	Tunnel Internal Diameter
C1	10km	6.0m
C2	12km	3.3 - 4.0m
C3	8km	6.0m
C4	8km	3.5 - 6.0m
C5	12km	3.0 - 3.3m
Total	50km	

Commentary for Tunnel Contract Packaging

The tunnel construction is expected to be let out in several contracts. This slide shows how the tunnel contracts may be packaged.

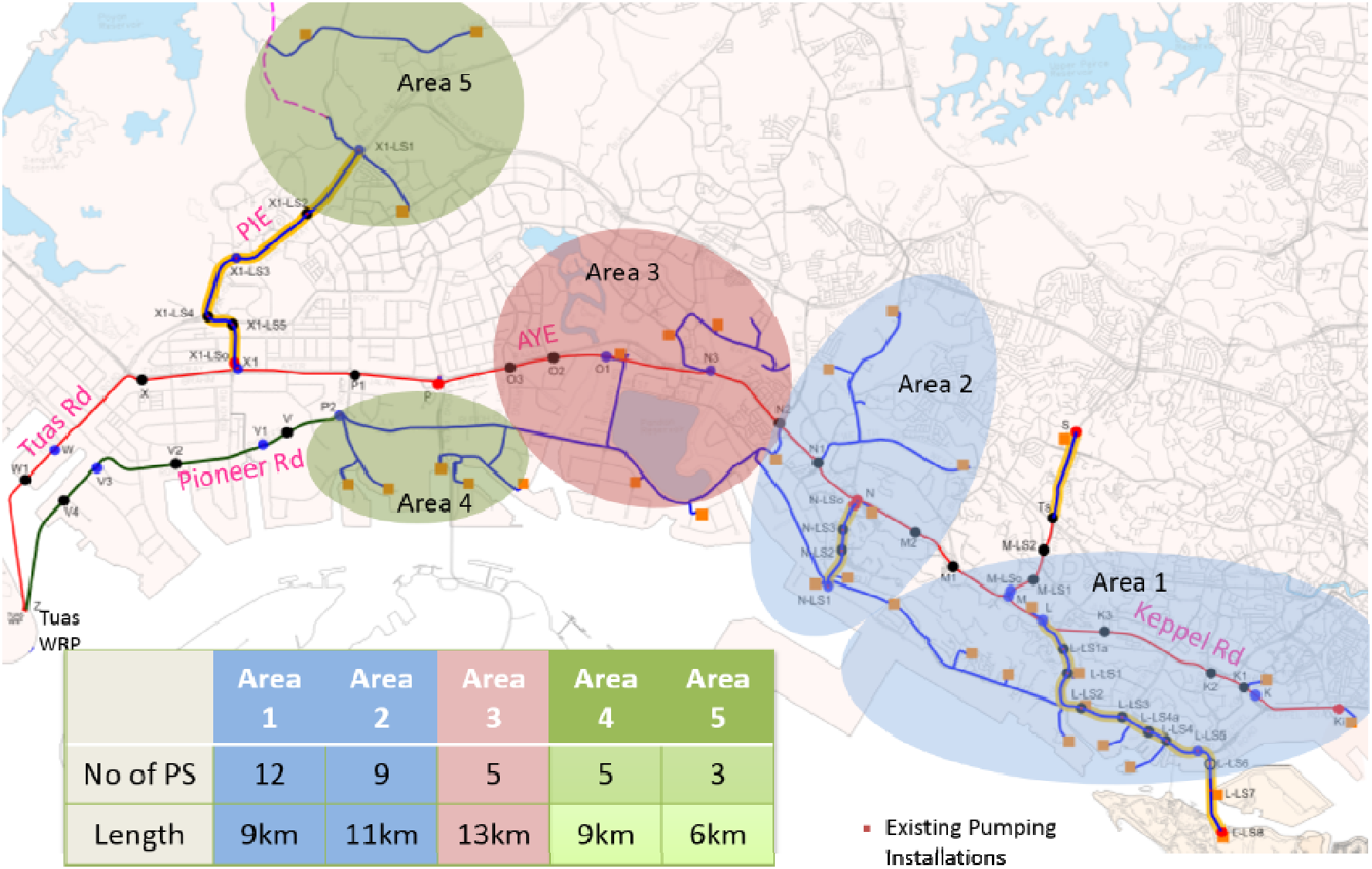
Tunnel Contract Packaging



<u>Commentary for Tunnel Contract Packaging</u>

There will be a pre-tender qualification exercise where interested contractors can apply to be pre-qualified to tender for the subsequent D&B construction tenders. These construction tenders will be let out in two batches

Link Sewer Contract Packaging

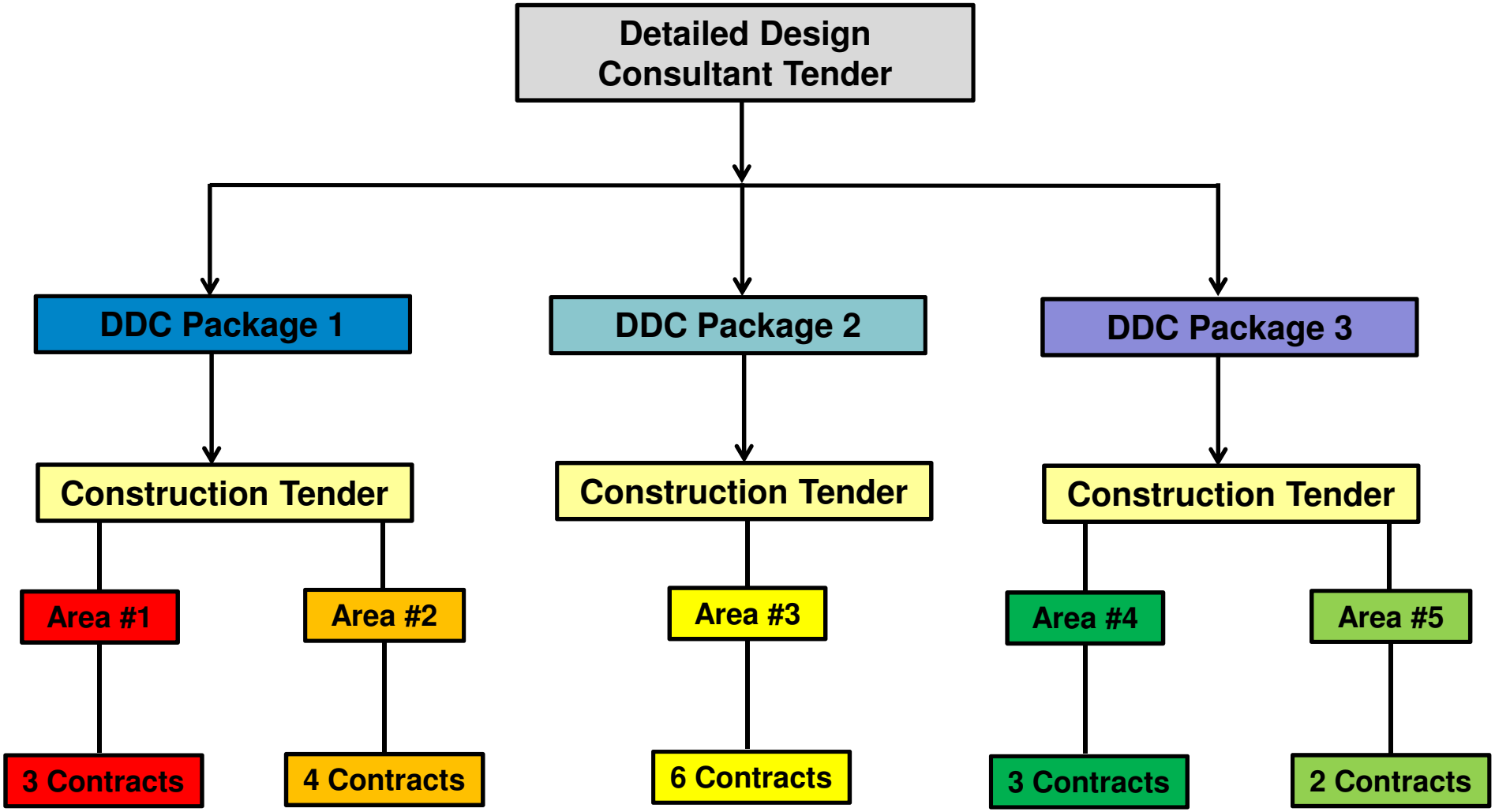


	Area 1	Area 2	Area 3	Area 4	Area 5
No of PS	12	9	5	5	3
Length	9km	11km	13km	9km	6km

<u>Commentary for Link Sewer Contract Packaging</u>

The pipe-jack Link Sewer contracts are divided by areas as shown on this slide.

Link Sewer Contract Packaging



Commentary for Link Sewer Contract Packaging

As these pipe-jack Link Sewer contracts are DBB contracts, detailed design consultants have to be first appointed before the construction tenders are let out. It is envisaged that about 3 detailed design consultants will be appointed. Subsequently, a number of construction contracts will be called. This slide shows an example of how the Link Sewer contracts may be packaged.

Deep Tunnel Sewerage System (DTSS) Phase 2

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Manager (Tunnels)

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<u>Commentary for Introduction Page for Dr Ganeshan's section</u>
This section is presented by Dr Ganeshan from BV+AECOM Joint Venture.

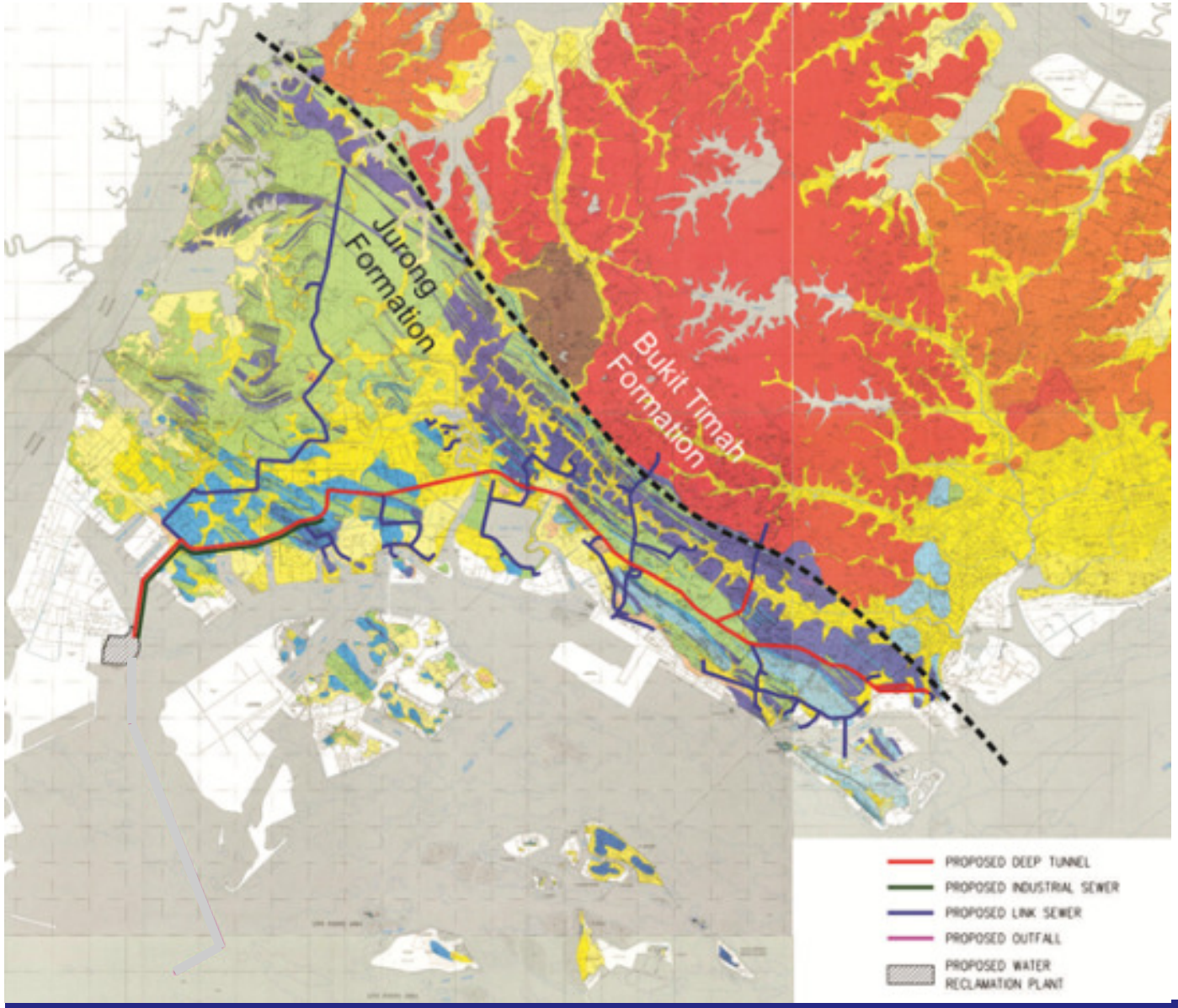
DTSS Phase-2 Key Features

- Geology
- Tunnel Inspection
- Tunnel Monitoring
- Air Management
- Tunnel Isolation
- BIM
- IDMS

<u>Commentary for Outline for DTSS Phase-2 Key Features</u>

This slide provide the outline of the presentation by Dr Ganeshan.

Geological Formation: DTSS Ph-1 & Ph-2

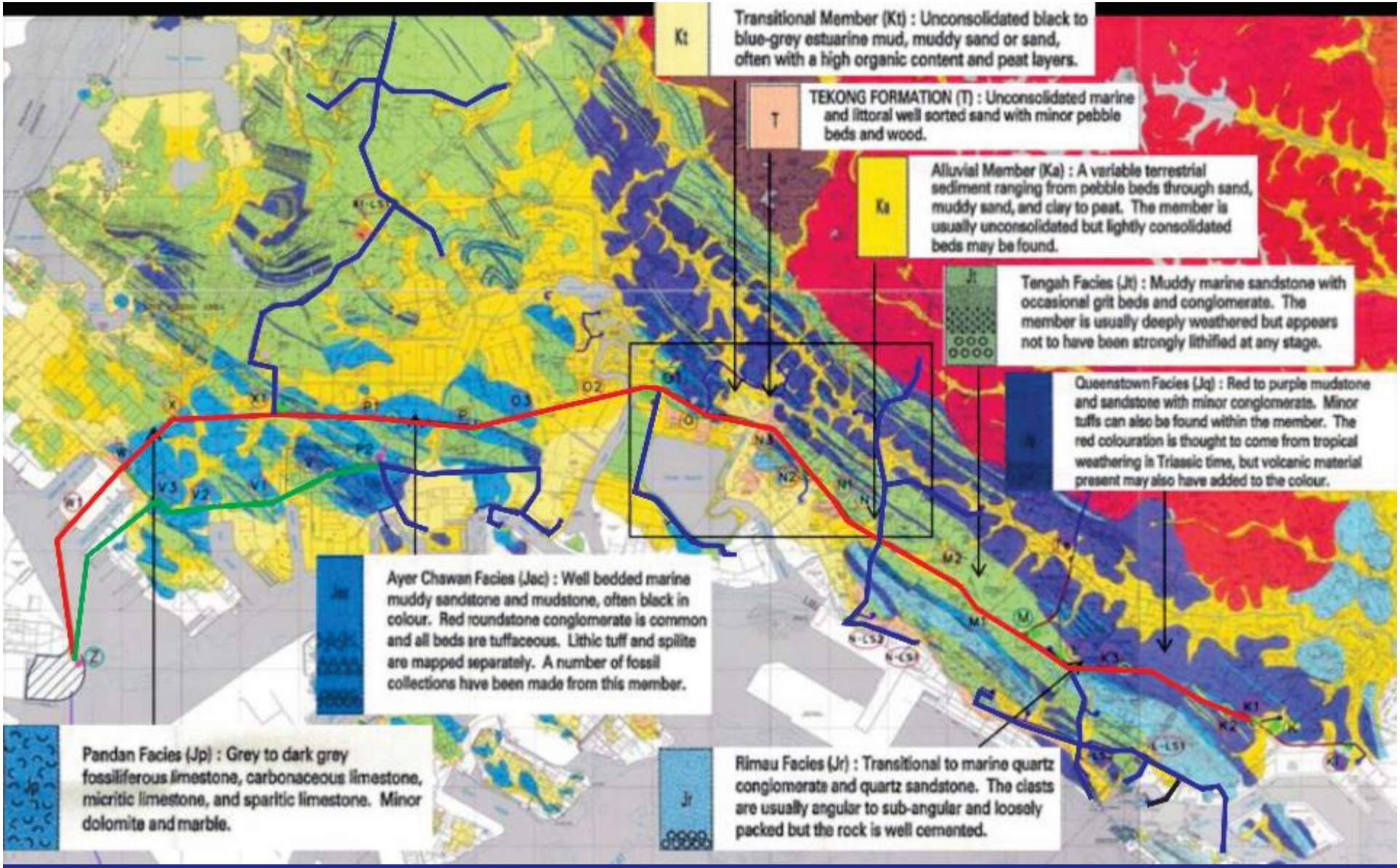


<u>Commentary for Geological Formation: DTSS Ph-1 & Ph-2</u>

This slide shows the Geological Map of Singapore.

While DTSS Phase 1 was constructed mostly in Bukit Timah, Phase 2 is expected to be in Jurong Formation.

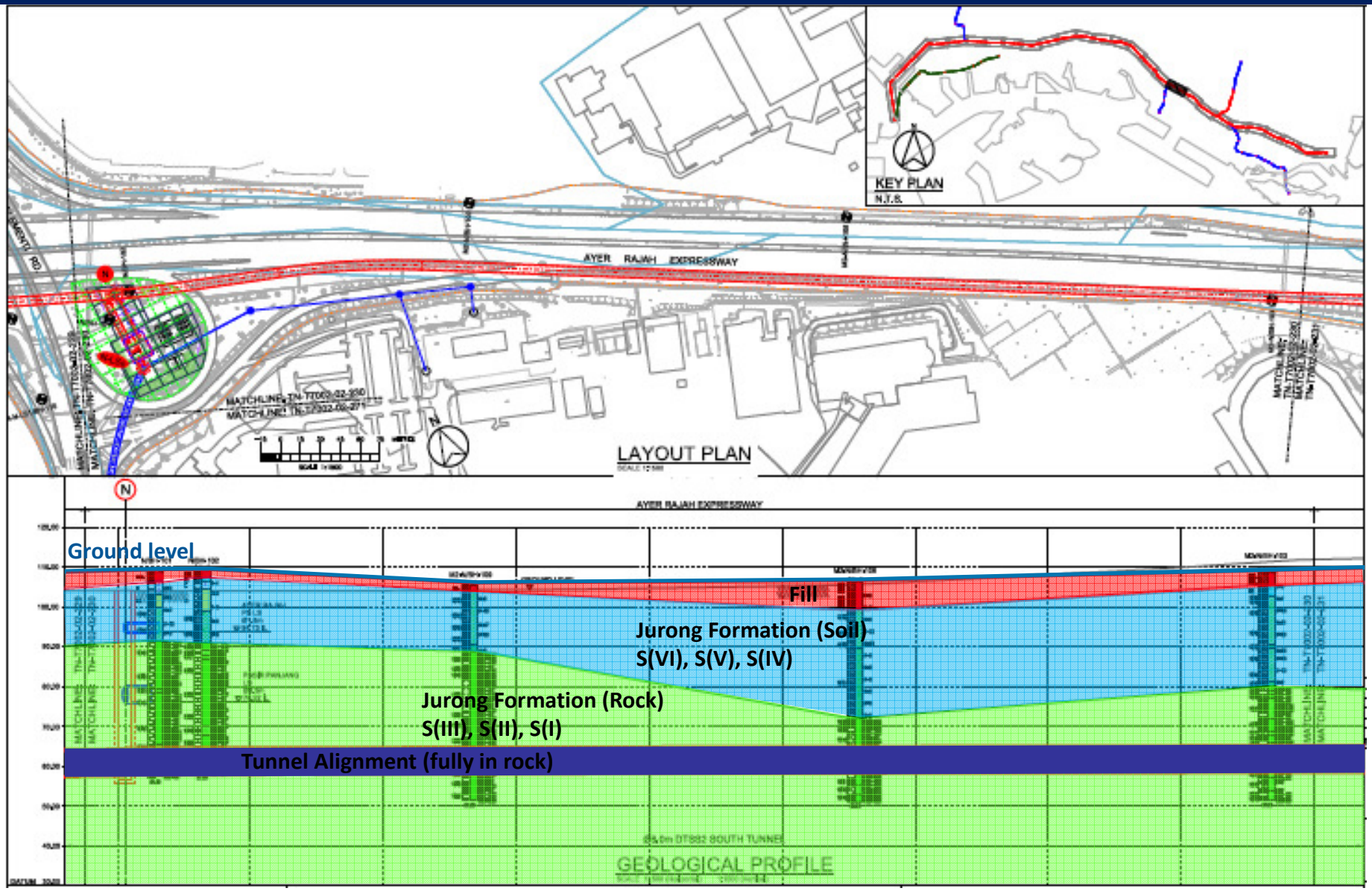
Geological Formation along Proposed Alignment



<u>Commentary for Geological Formation along Proposed Alignment</u>

This slide show the general geological formation expected along the DTSS Phase 2 alignment.

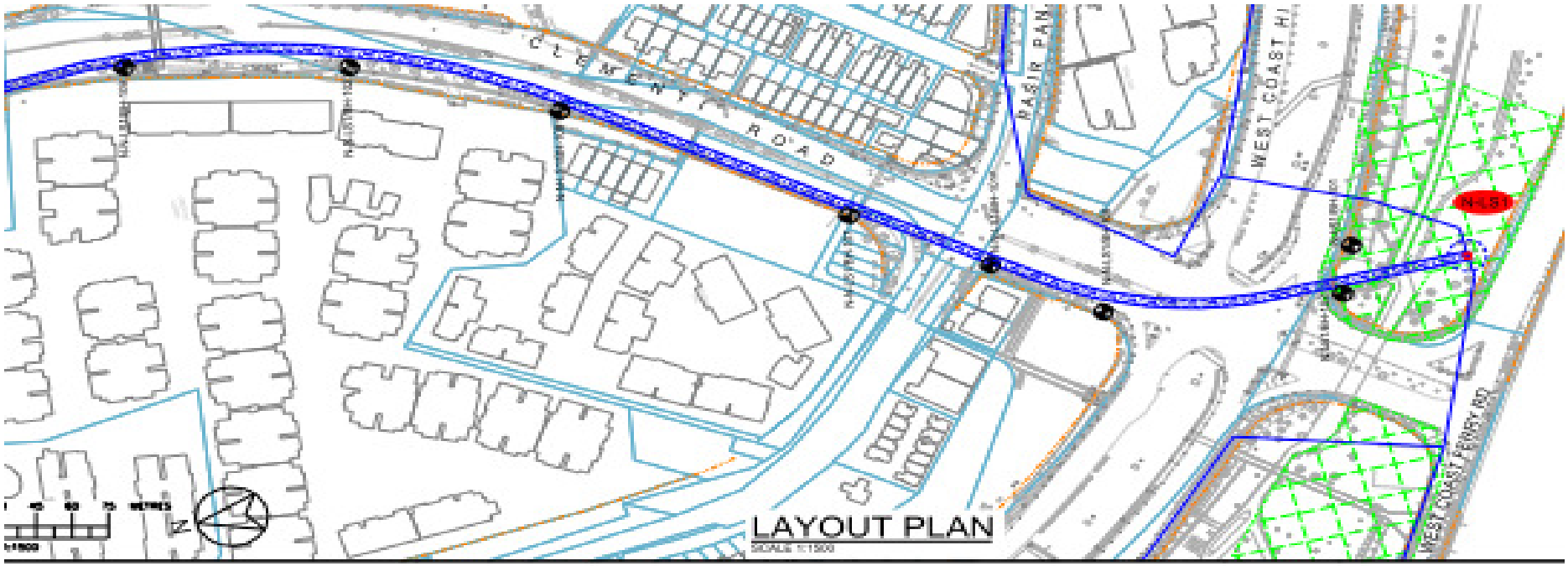
Typical Geological Profile along Tunnel Alignment

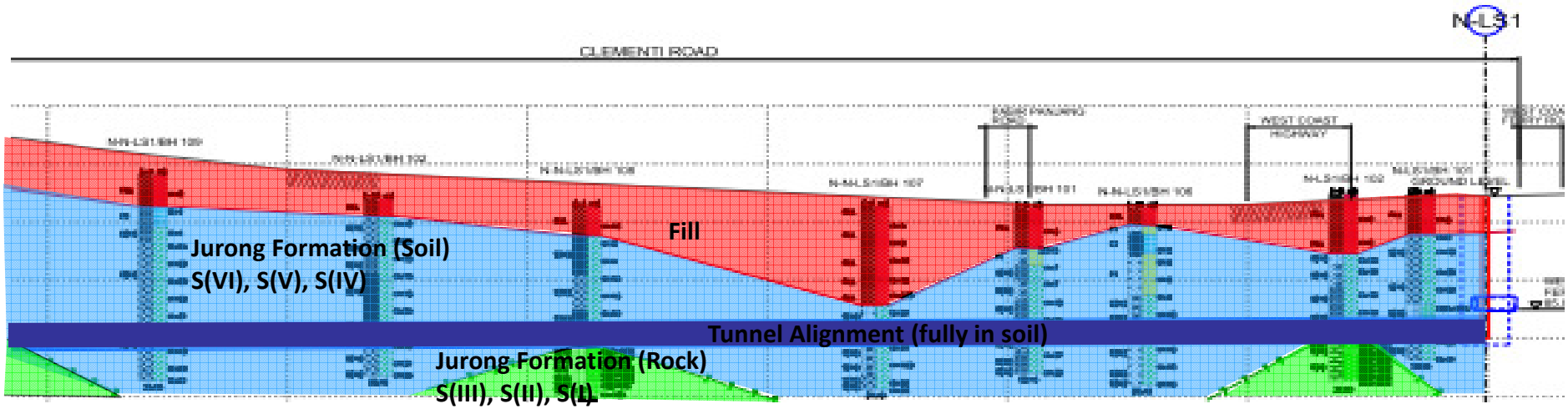


<u>Commentary for Typical Geological Profile along Tunnel Alignment</u>

The DTSS Phase 2 tunnel is expected to go through rock.

Typical Geological Profile along Tunnel Alignment

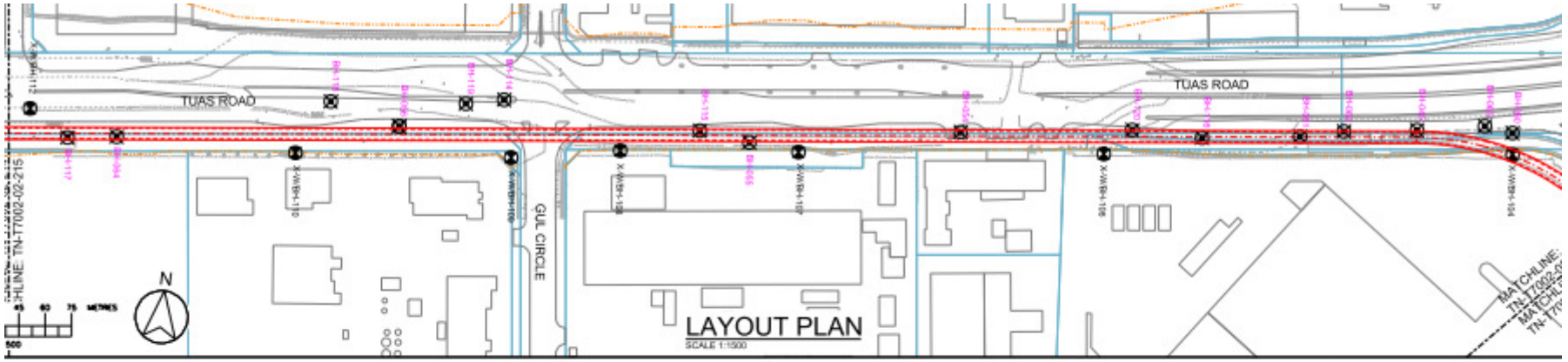


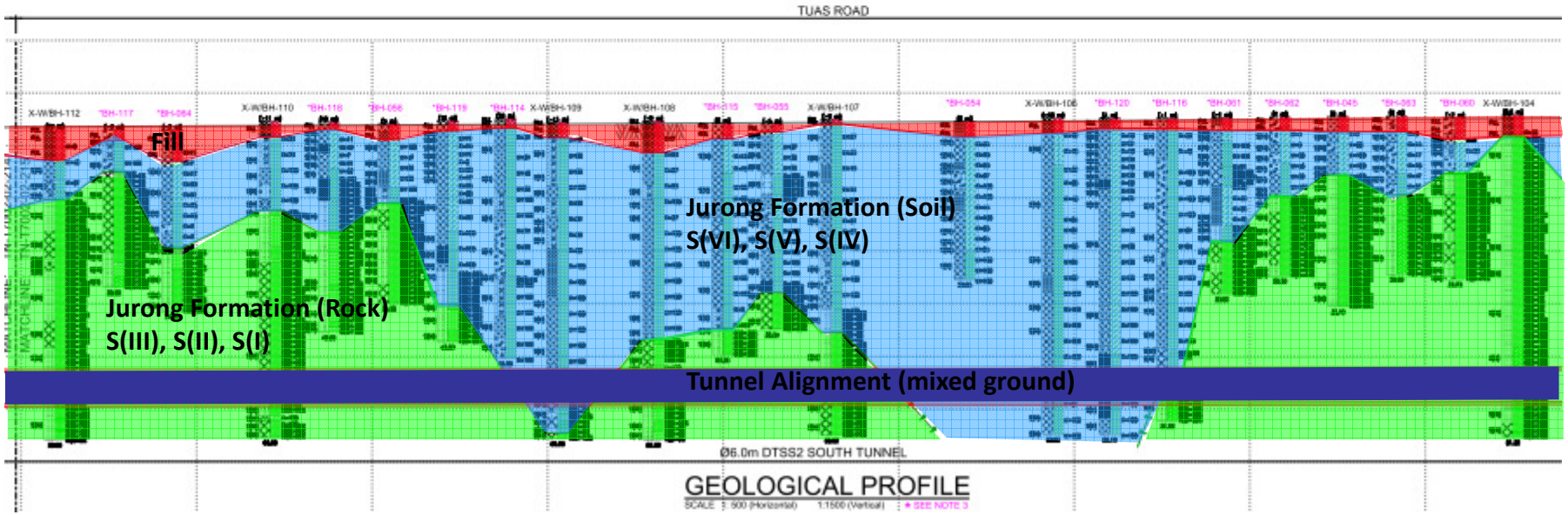


Commentary for Typical Geological Profile along Tunnel Alignment

The DTSS Phase 2 tunnel is also expected to go through soil.

Typical Geological Profile along Tunnel Alignment

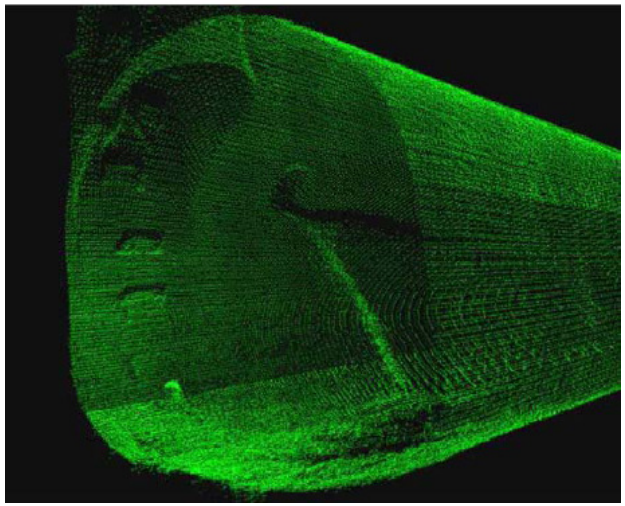




<u>Commentary for Typical Geological Profile along Tunnel Alignment</u>

There will also be many locations where the DTSS Phase 2 tunnel will encounter mixed face conditions.

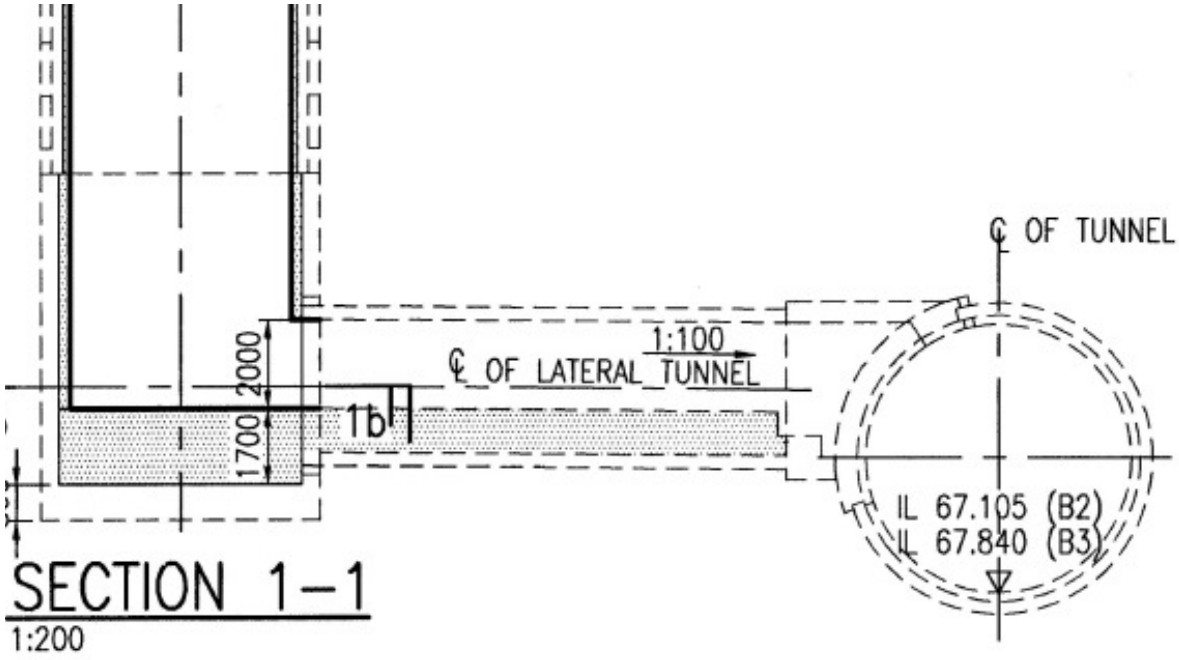
Tunnel Inspection

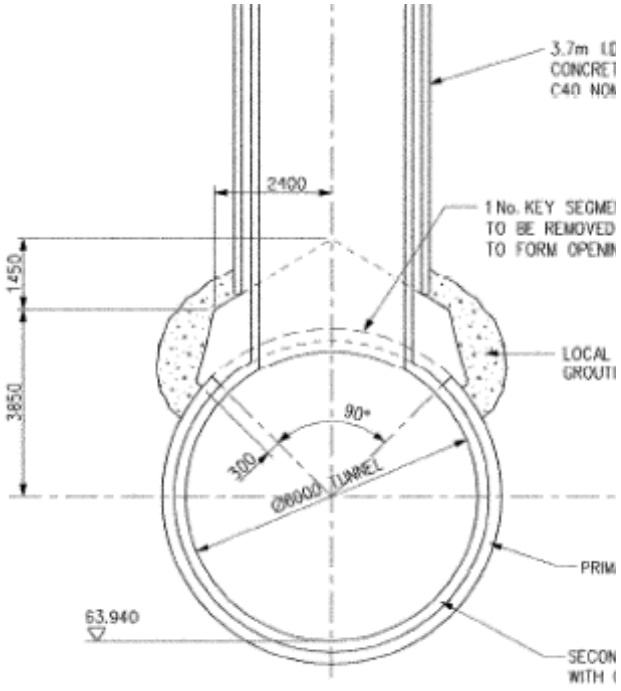


<u>Commentary for Tunnel Inspection</u>

The DTSS Phase 2 Tunnel will be designed with provisions for tunnel inspection by Remotely Operated Vehicles (ROVs).

Shaft – Tunnel Connections





<u>Commentary for Shaft – Tunnel Connections</u>

Previously, in DTSS Phase 1, there were a mixture of off-line and on-line shafts. To facilitate the launching of ROVs, DTSS Phase 2 Tunnels will have only on-line shafts.

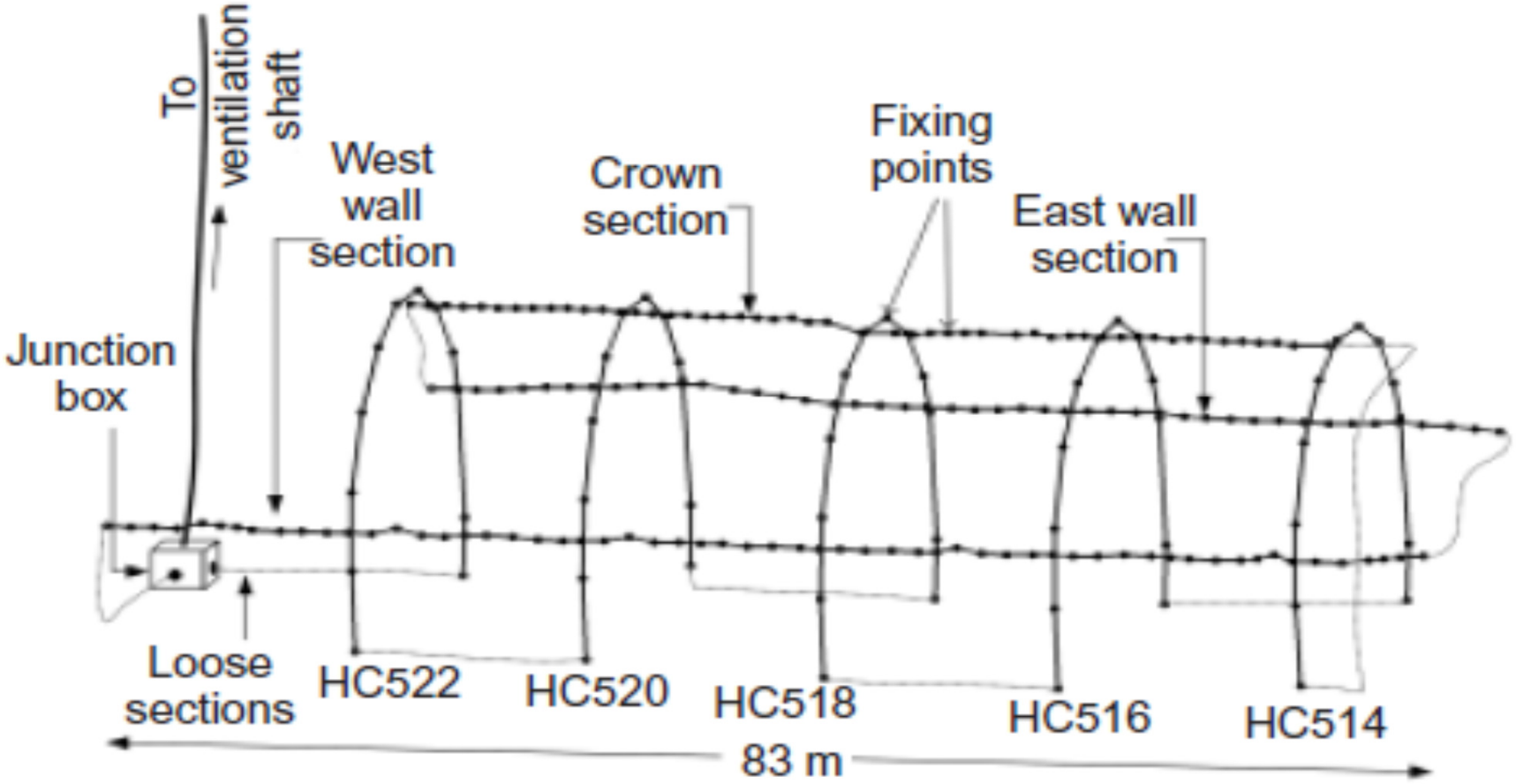
Fibre Optic Strain Monitoring for Structural Integrity

Longitudinal installation :
Fibre optic cables cast directly into CPL during its construction

<u>Commentary for Fibre Optic Strain Monitoring for Structural Integrity</u>

As an added feature, DTSS Phase 2 will also explore the use of fibre optic cables cast into the tunnel lining for structural integrity monitoring.

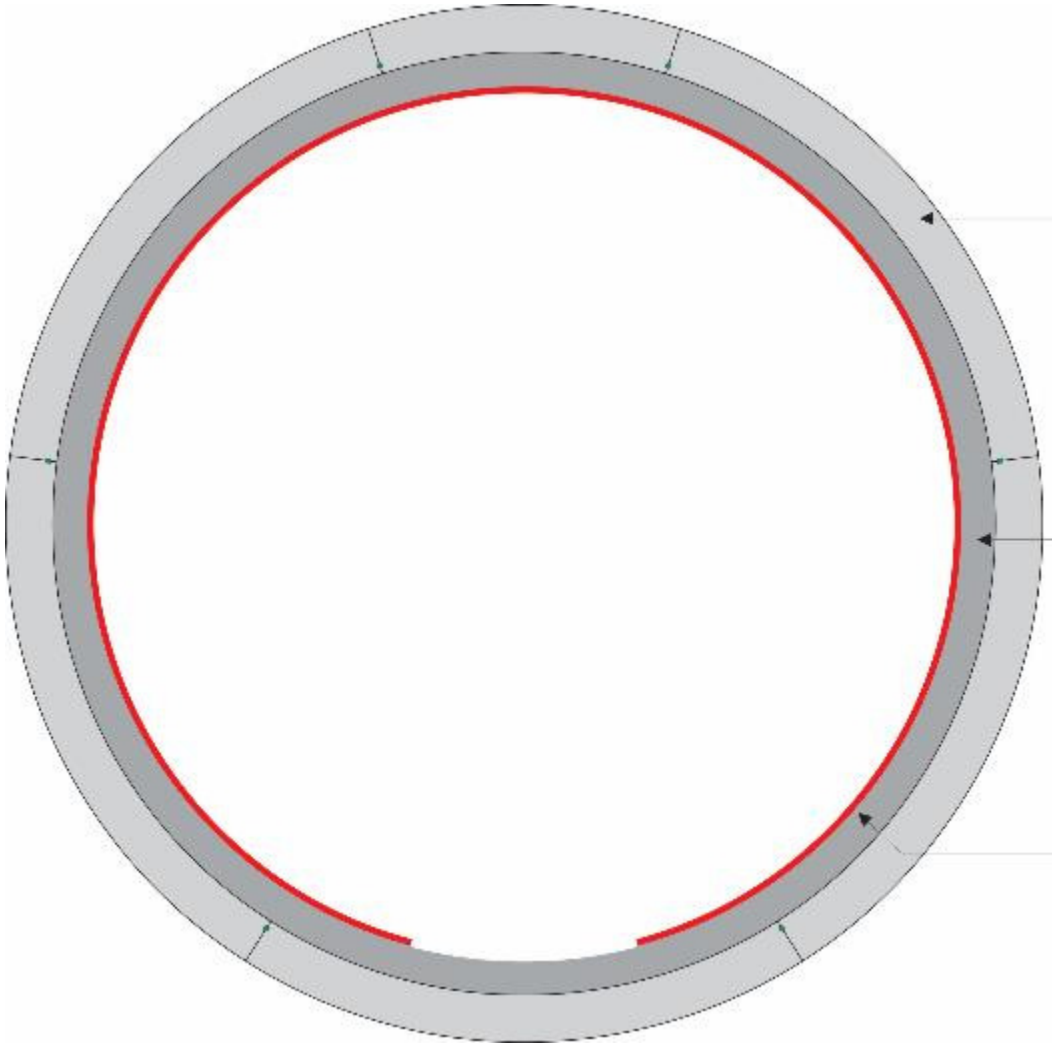
Fibre Optic Strain Monitoring for Structural Integrity



<u>Commentary for Fibre Optic Strain Monitoring for Structural Integrity</u>

This slide shows a typical fibre optic setup to monitor the structural integrity of the tunnel.

Tunnel Cross Section - General



Concrete Segmental Tunnel (Primary Lining)

Inner Secondary Lining **MIC Resistant Concrete**

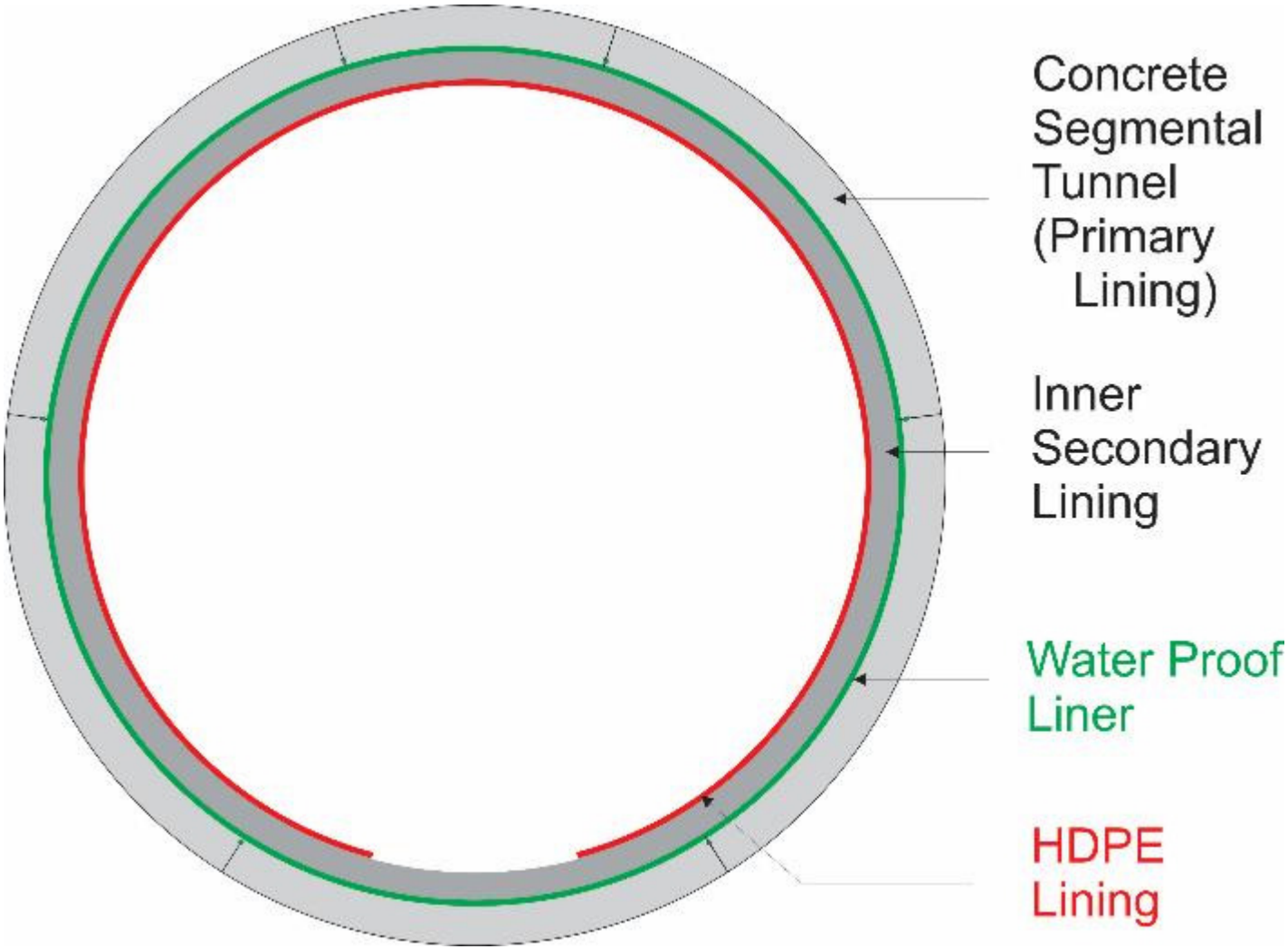
HDPE Lining

MIC - Micro-organism Induced Corrosion

<u>Commentary for Tunnel Cross Section- General</u>

The DTSS Phase 2 Tunnel will feature a secondary lining consisting of MIC resistant concrete with HDPE lining.

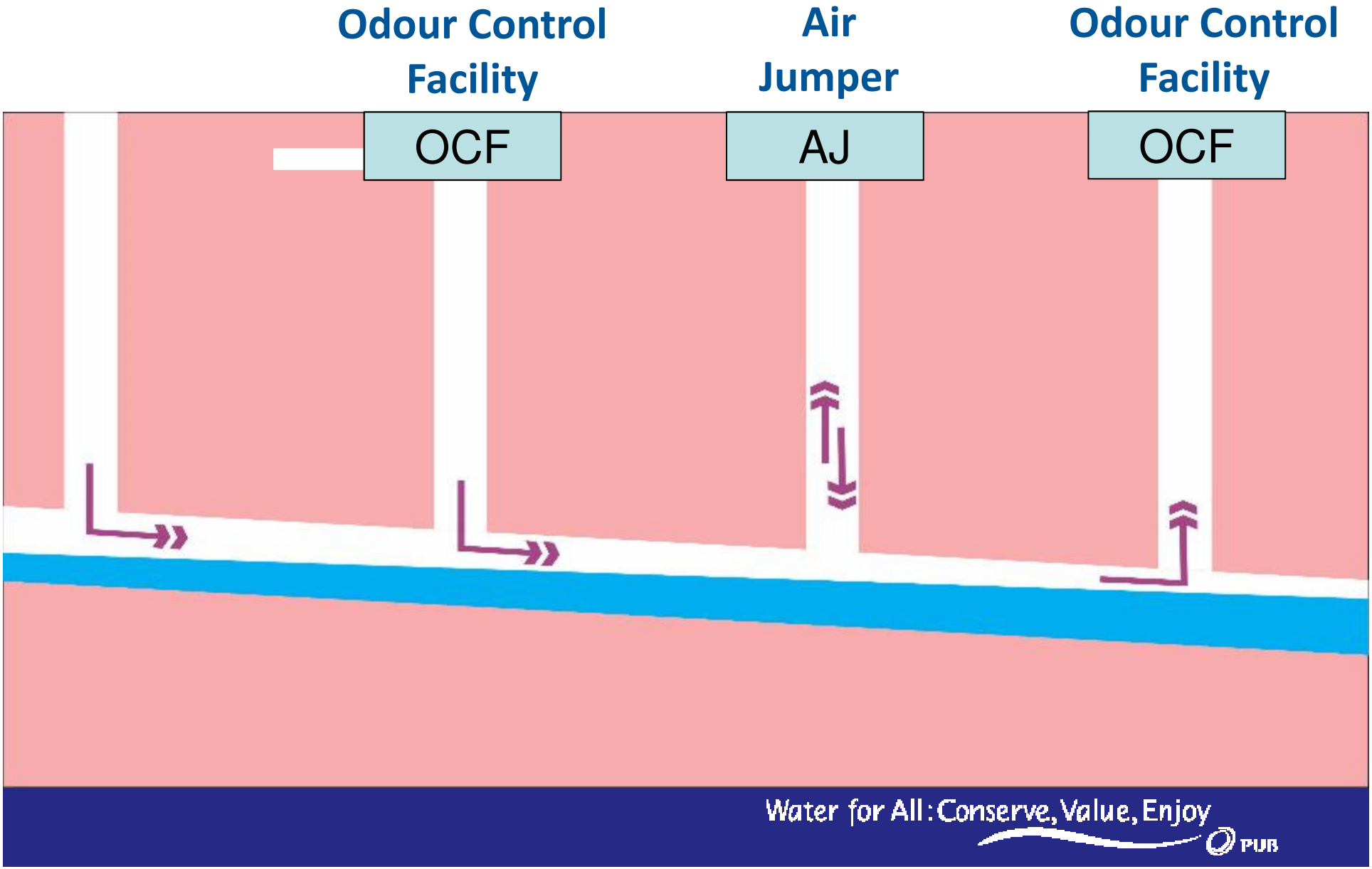
Tunnel Cross Section - Under Sea Crossings



<u>Commentary for Tunnel Cross Section- Under Sea Crossings</u>

For undersea crossings, a waterproof membrane may be incorporated to ensure water-tightness.

Air Flow in Tunnel

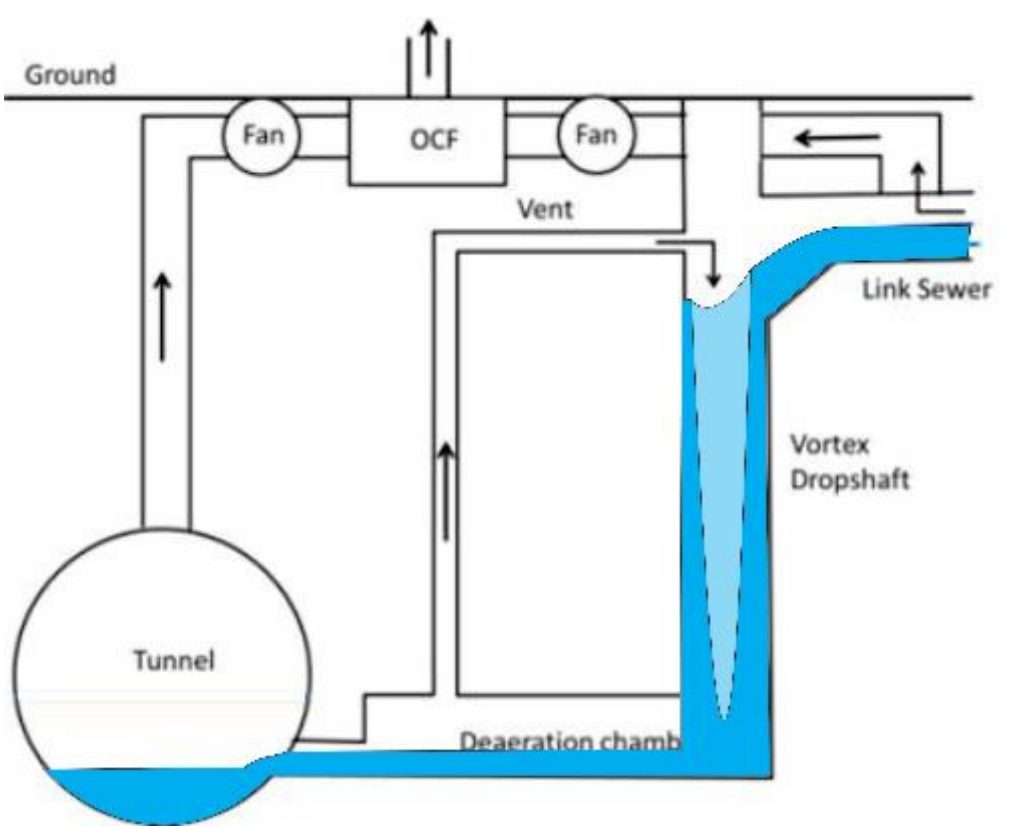


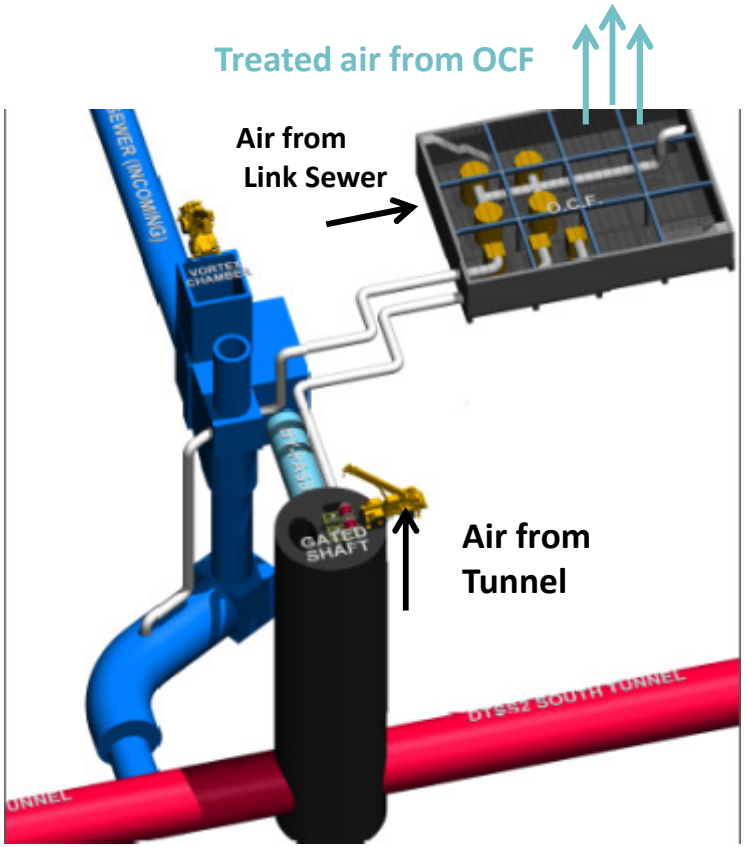
Commentary for Air Flow in Tunnel

The tunnel conveys both used water and air. To control the flow of this air and to prevent any odour nuisance, air management facilities will be installed wherever link sewers connect to the tunnel. These air management facilities consist of both Odour Control Facilities (OCFs) and Air Jumpers (AJs).

Drop Structure & Odour Control Facility

- Withdraws Air from both Link Sewer and Tunnel, Treats & Releases



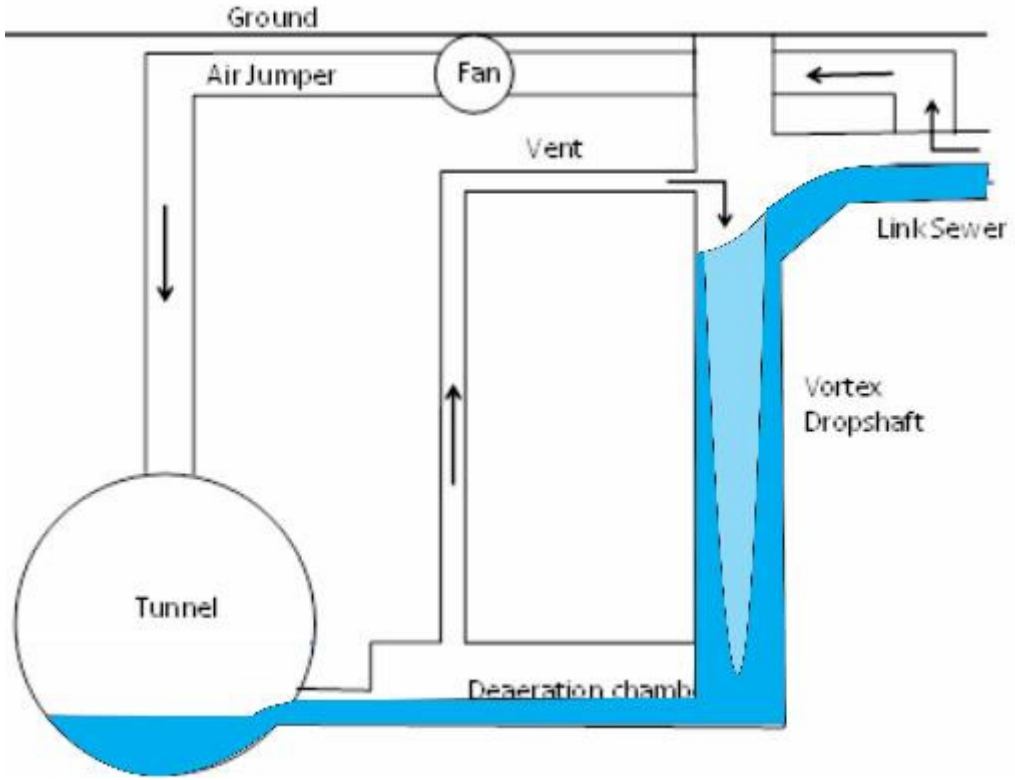


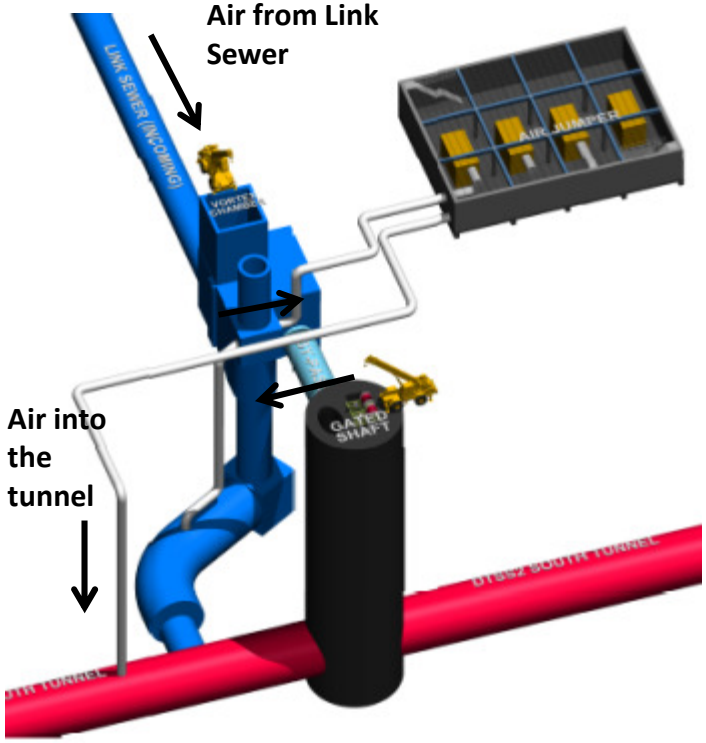
Commentary for Drop Structure & Odour Control Facility

The odour control facility draws air from both link sewer and tunnel and treats the air before releasing it back to the atmosphere.

Drop Structure & Air Jumper

- Negative pressure in tunnel may not be sufficient to pull incoming link sewer air.
- Air Jumper force the air into tunnel

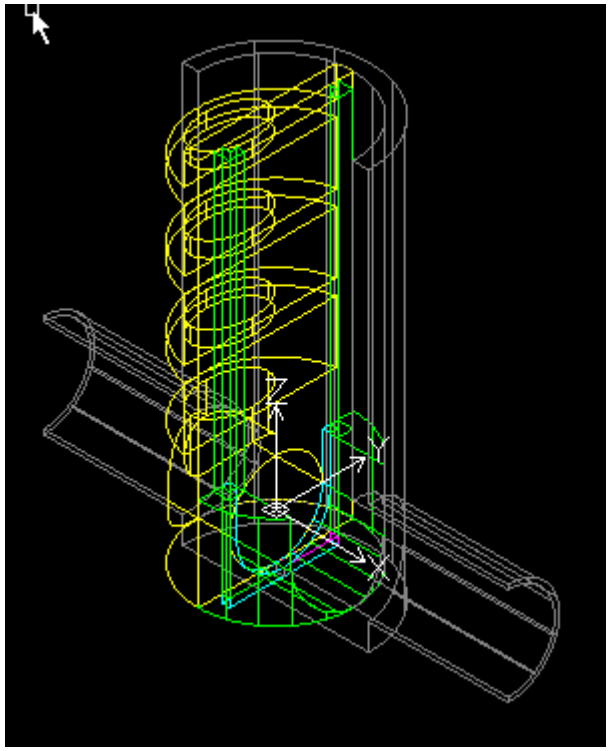


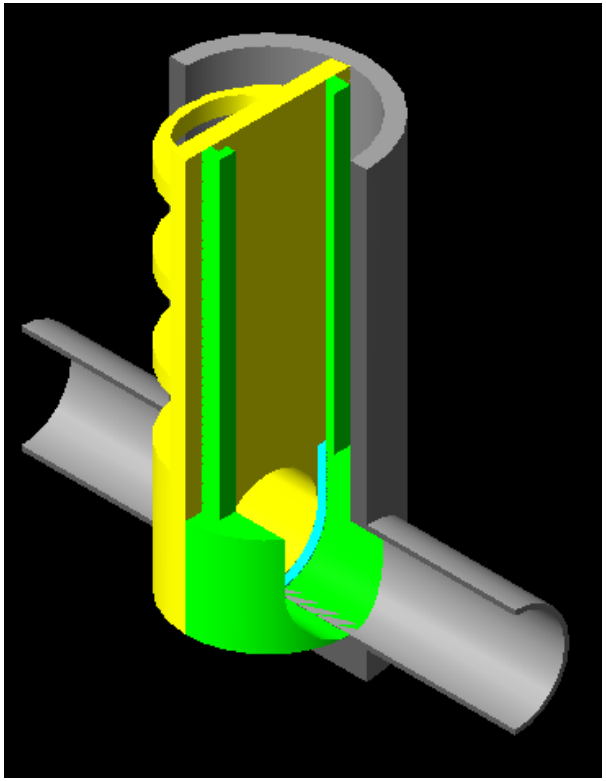


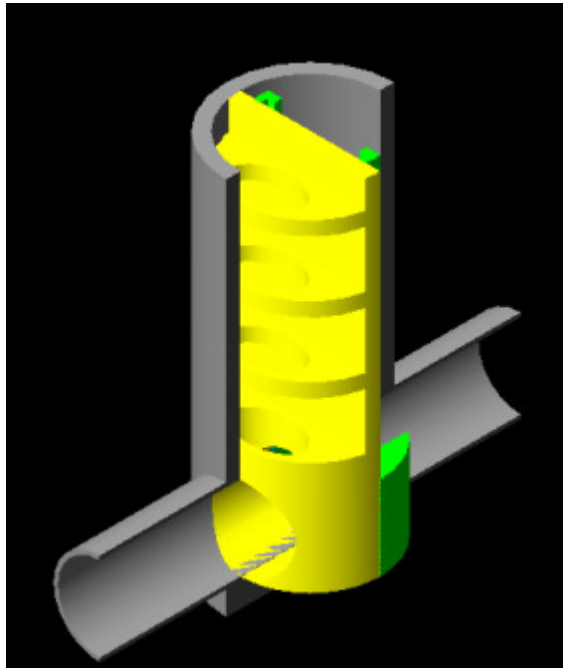
<u>Commentary for Drop Structure & Air Jumper</u>

An Air Jumper serves as forced ventilation to prevent air from the link sewer or tunnel from escaping into the surroundings.

Shafts - Gated



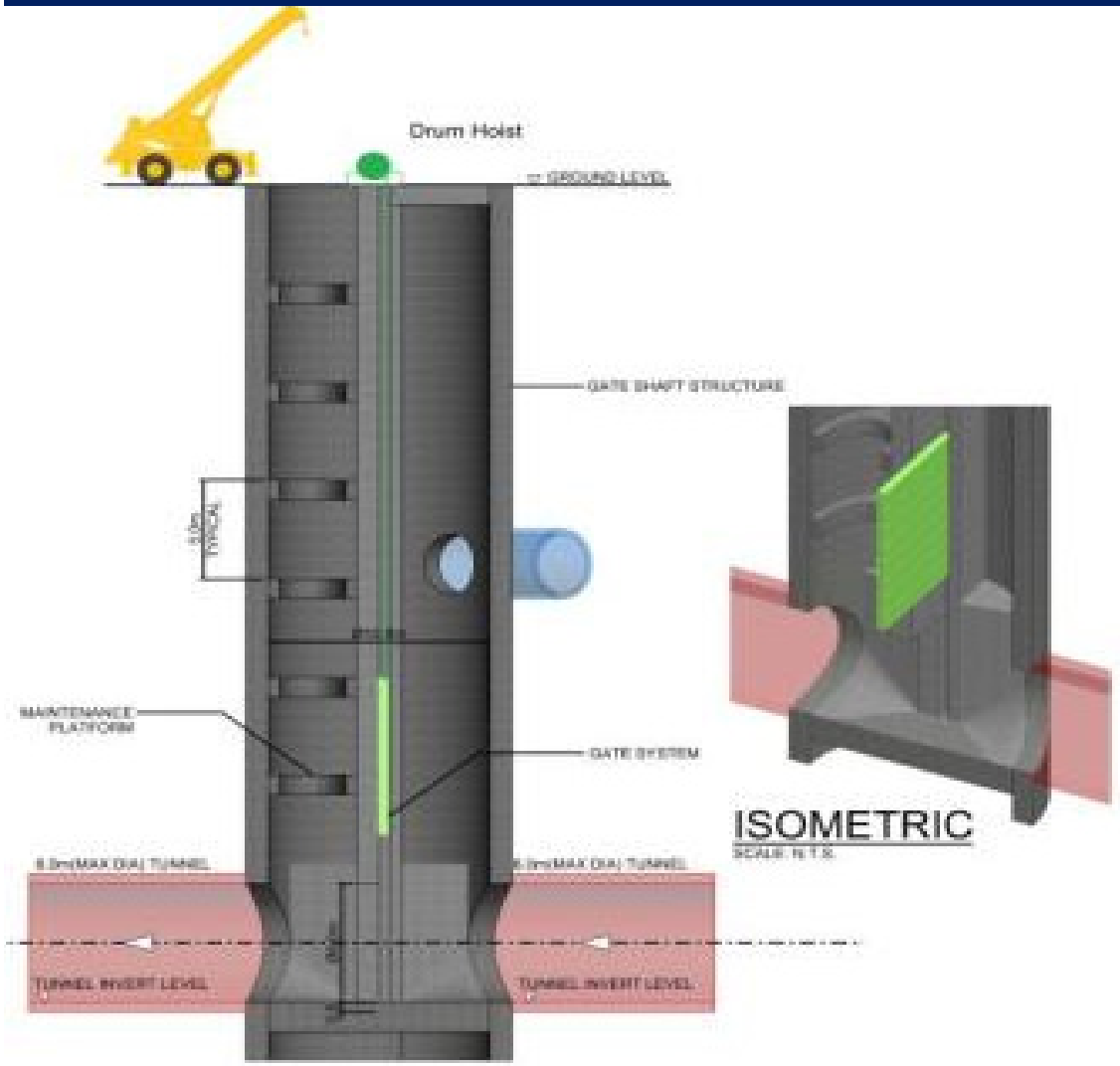




Commentary for Shafts - Gated

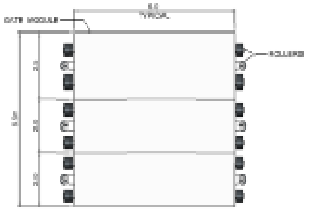
Another new feature in the DTSS Phase 2 tunnel is the ability to isolate sections of the tunnel using gates. This slide shows how a gated shaft will look like.

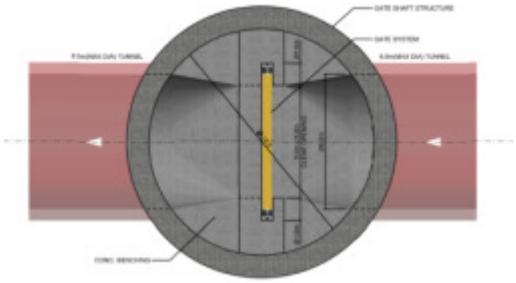
Roller Gates



SHAFT SECTION

ISOMETRIC





Commentary for Roller Gates

A gate can be lowered in the shaft to block flow in the tunnel.

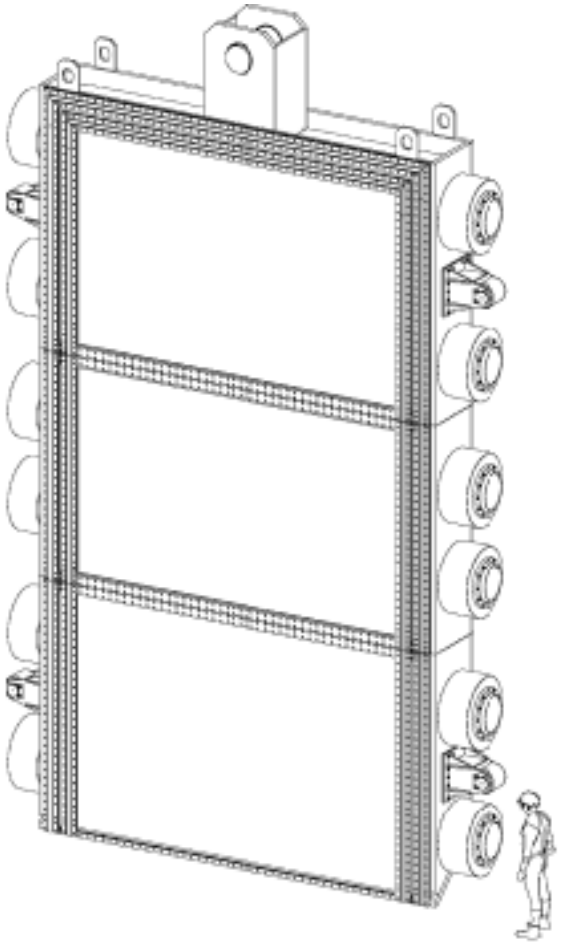
Roller Gates

Commentary for Roller Gates

The gates to be used in the tunnel will be roller gates. This slide shows an example of one such roller gate.

Roller Gates Assembled from 3 Modules

- **Example: Large sectional drop-in gates used for isolation within combined sewer tunnel conveyance system**



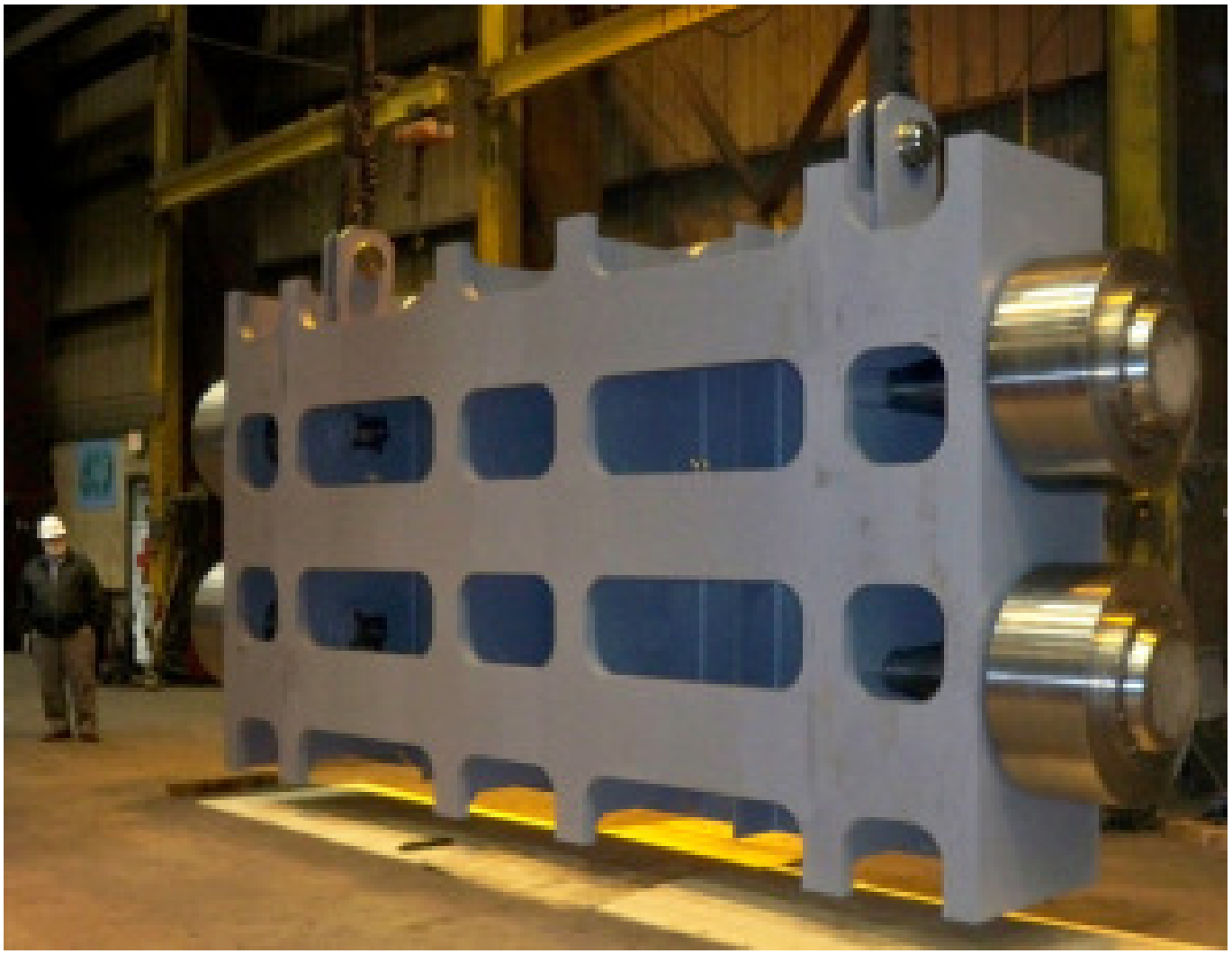
McCook Reservoir Tunnel, Chicago (TARP)

- Twin 9.0 x 7.6m gates
- The shaft depth is approx 90 m.
- Each gate is formed of three panels

Commentary for Roller Gates Assembled from 3 Modules

As the gates may be very large, they will be assembled from several modules. The slide shows an example of such a gate made up of 3 modules.

Roller Gates Assembled from 3 Modules



<u>Commentary for Roller Gates Assembled from 3 Modules</u>
The slide shows how a single module of the gate may look like.

BIM…… BEYOND 3D

DTSS Phase 2 BIM Execution Plan is to Require all Design Consultants to Use a Common "Data Scheme".

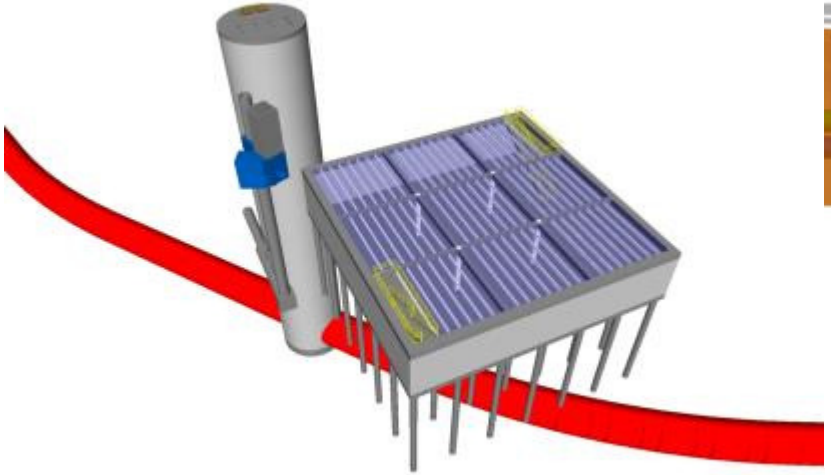
This Scheme Combines Both Uniclass 2015 and COBie Standard Deliverables.

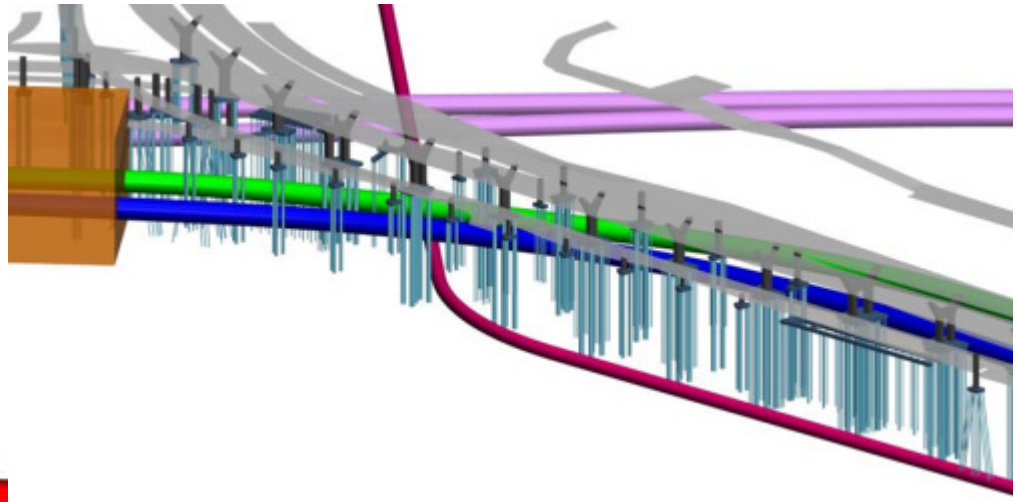
…….ASSET MANAGEMENT

<u>Commentary for BIM Beyond 3D</u>

Building Information Modelling (BIM) will be an mandatory requirement for DTSS Phase 2.

BIM - 3D





<u>Commentary for BIM – 3D</u>

This slide shows an example of 3D BIM used in designing different sections of the DTSS Phase 2 tunnel

Integrated Data Management System (IDMS)

During Construction;

1. **Monitored Instrumentation Data,**
2. **Critical TBM Operational Data,**
3. **Current TBM Location**
4. **Completed Tunnel Rings,**
5. **Shaft Excavation Depth,**
6. **and other information**

are brought on a web based visual platform for all parties to have real time information

<u>Commentary for Integrated Management System (IDMS)</u>

An Integrated Data Management System will also be introduced in the DTSS Phase 2 project for the tracking of construction data so that all parties will be updated with real time information on the progress of the construction and associated instrumentation readings.


THANK YOU

<u>Commentary</u>
End of Presentation

Singapore International Water Week (SIWW)

2016

The Global Platform to Share and Co-Create Innovative Water Solutions

- **Singapore's Water-Energy-Waste Nexus Journey Booth**
  Date: 11 Jul (Mon) – 13 Jul (Wed)
  Venue: The Marina Bay Sands, Basement 2

- **Deep Tunnel Sewerage System Forum**
  Date: 13 Jul (Wed)
  Time: 9.30 am – 12 pm
  Venue: The Marina Bay Sands, Basement 2

Singapore International Water Week

Visit our site for more info on DTSS: http://www.pub.gov.sg/dtss



<u>Commentary for Singapore International Water Week (SIWW)</u>

DTSS Phase 2 project team welcomes contractors/consultants who are interested in participating in our DTSS Phase 2 project to visit the DTSS booth and forum during SIWW from 11 – 13 July 2016.