World Tunnel Congress (WTC) 2009

Planning of Deep Sewage Tunnels in Hong Kong

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CONTENT

Background of Harbour Area Treatment Scheme (HATS)

Rationales for choosing a deep tunnel system

Ground investigation using the specialized technique of horizontal directional coring

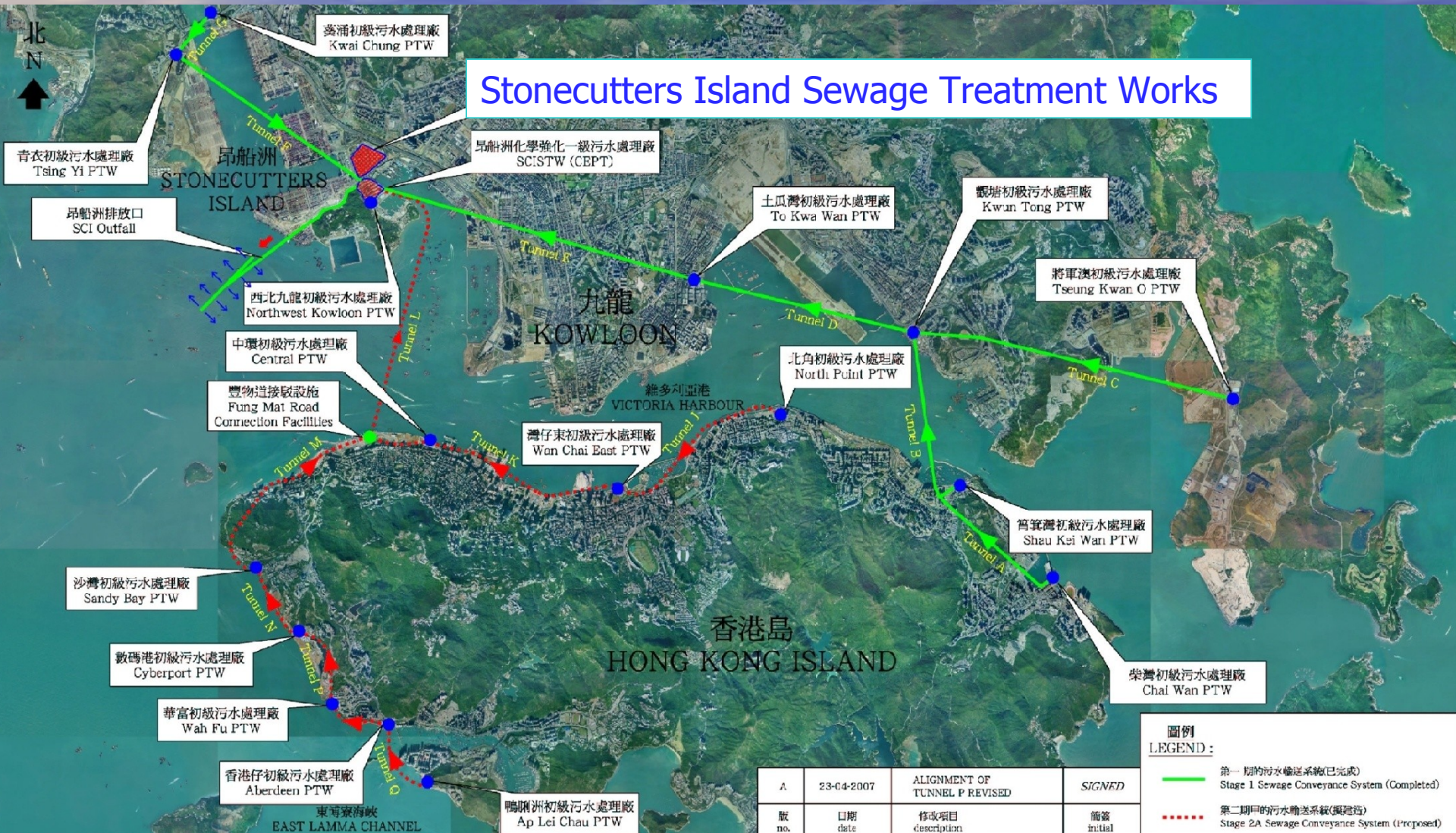
Why we have selected the drill-and-blast construction method instead of TBM

Contract strategy for implementation of the construction works.


Victoria Harbour
a Major Asset for the Hong Kong SAR


Before the implementation of the Harbour Area Treatment Scheme (HATS) Stage 1, sewage discharged into harbour only after screening and degritting.
Rapid development and population increase have led to water pollution problems

Stage 1 tunnels (completed) 24 km
Stage 2 tunnels (being planned) 21 km



HATS - Sewage Conveyance System

Catchment Flow

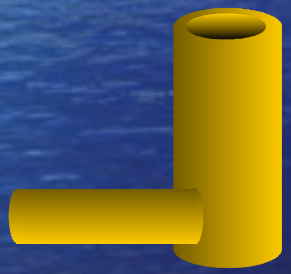
Coarse Screens

Inlet Pumping Station

Fine Screens

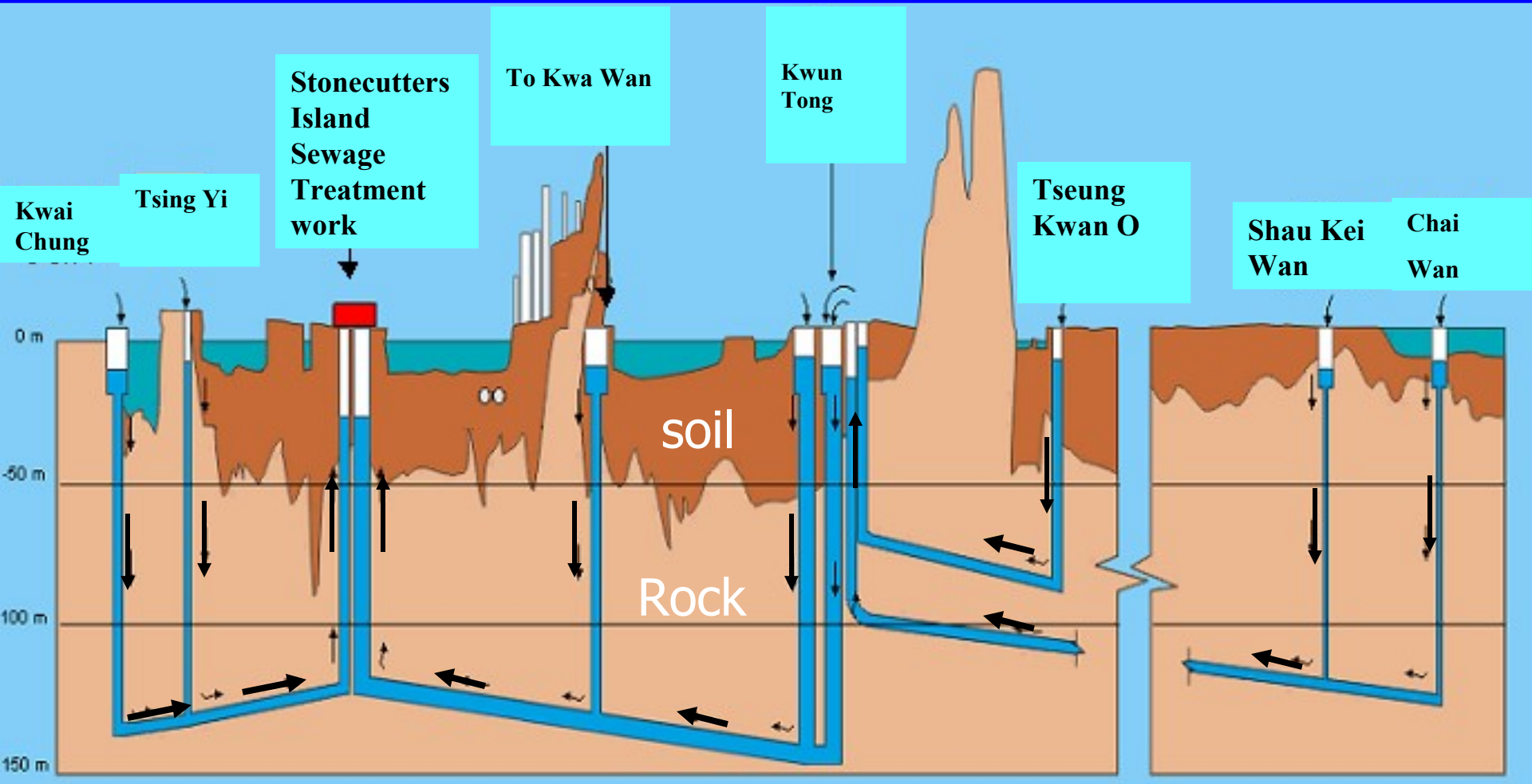
Grit Removal

Discharge to tunnels via shafts



To Sewage Treatment Plant

HATS Stage 1 - Sewage tunnels system – vertical profile



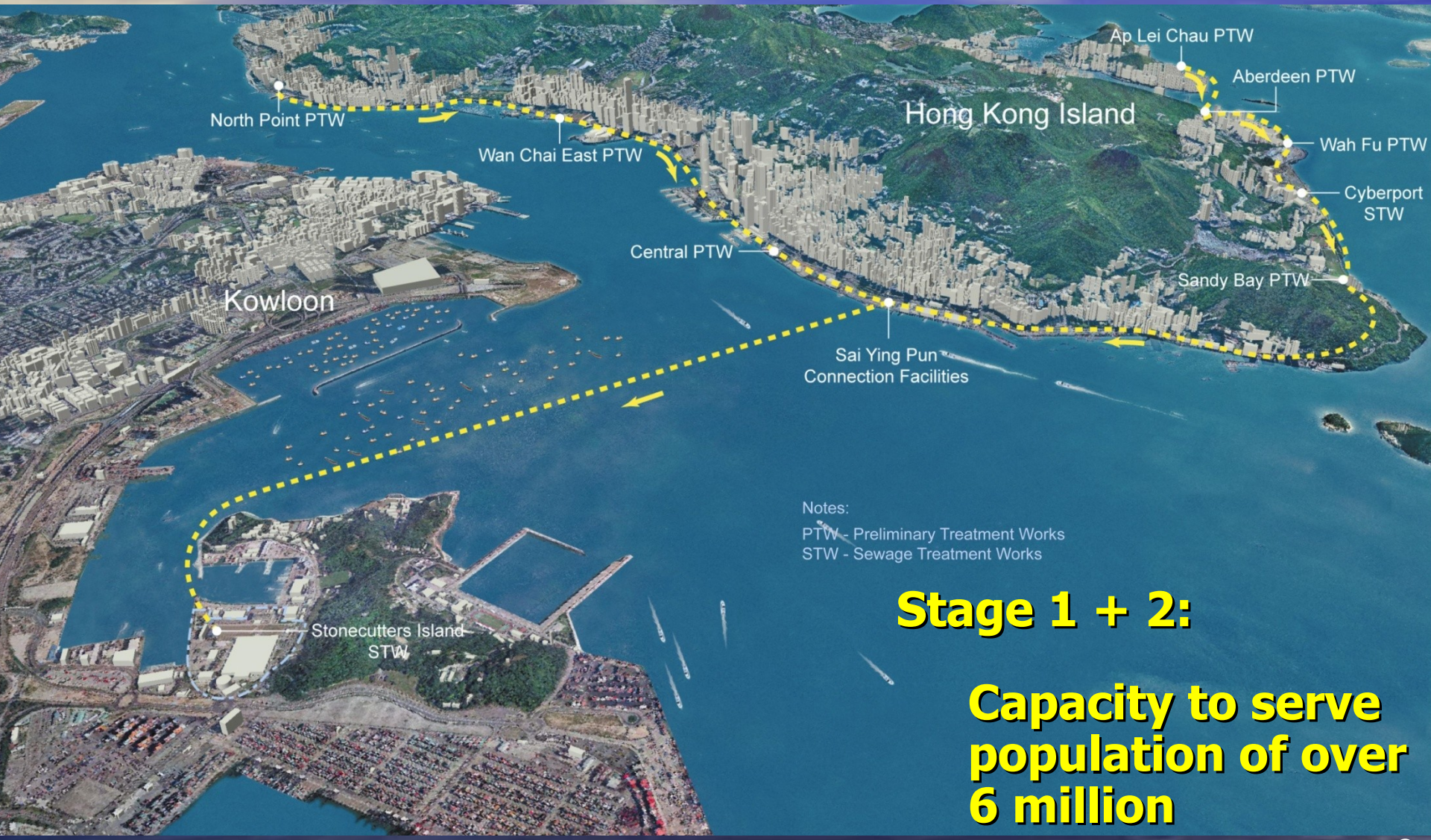
Mostly Inverted siphons

HATS Stage 1 - Stonecutters Island Sewage Treatment Works

Preventing 600 tonnes of sludge from entering into harbour each day

Harbour Area Treatment Scheme Stage 2

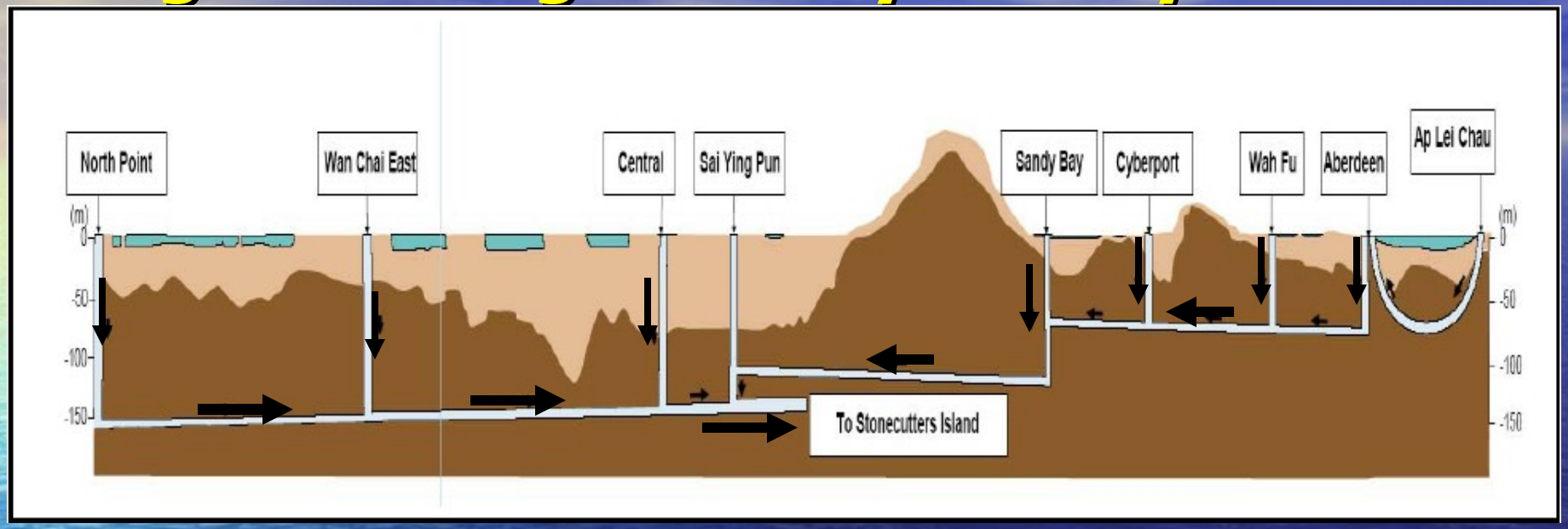
Total tunnel length about 21 km

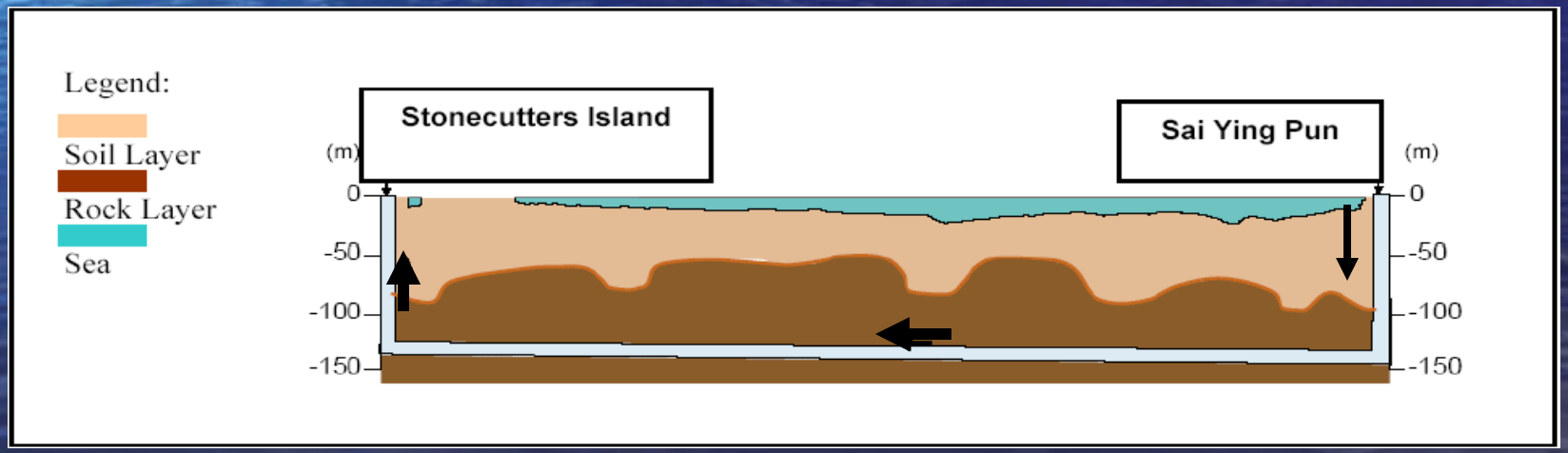


Stage 1 + 2:

Capacity to serve population of over 6 million

Vertical Profile of HATS Stage 2 Sewage Conveyance System





Why use the Deep Tunnel System?

Planning considerations: Options and Evaluations

Options considered:

- **Shallow sewers by open trench method**
- **Shallow sewers by trenchless method: e.g pipe jacking, HDD**
- **Mixed ground tunnelling (20-50m)**
- **Deep hard rock tunnelling by TBM or D&B**

Why use the Deep Tunnel System?

Factors considered in evaluation of options:

- **Constructability**
- **Cost**
- **Environmental and social impact**
- **Programme**
- **Risks**
- **Hydraulic performance**
- **Maintenance**

Why use the Deep Tunnel System?

Open Trench Method for sewers

Why use the Deep Tunnel System?

Evaluation - Open trench method:

- **practically ruled out - unacceptable by the public**
- **difficult and lengthy utility diversions**
- **environmental & traffic impacts difficult to mitigate**
- **strong objections from local bodies and legislature**

Why use the Deep Tunnel System?

Evaluation – trenchless method (pipe jacking):

- Very few possible locations for jacking pits
- Inevitable road opening works -- similar problems as open trench
- costs comparable with mix ground / deep hard rock tunnelling for this project's situation
- Programme risks due to likely strong public objections
- Experience: trunk sewers by pipe jacking in urban areas: "more than 4 years"

Why use the Deep Tunnel System?

Evaluation – mixed ground tunnelling (20 –50m):

- Cost similar to deep hard rock tunnelling
- Ground settlement risks exist as for deep hard tunnel
- Lack of above ground space for support, for e.g. slurry plant, TBM set up.
- Impact on existing/future land development
- Conflicts with existing piles from buildings and existing road and railway tunnels

Why use the Deep Tunnel System?

Deep hard rock tunnelling is selected mainly because:

1. **Disturbance to public is minimized**
2. **Conflicts with existing foundations/utilities minimized**
3. **Acceptance by public**
4. **Cost and programme: comparable/ better than other options**
5. **Future land developments not constrained**

Details of Stage 2 Sewage Tunnels by Drill and Blast

Total Length of tunnels: 20 km

Length of tunnels between shafts: 3.2km to 4.6km

Estimated excavated size of tunnel:

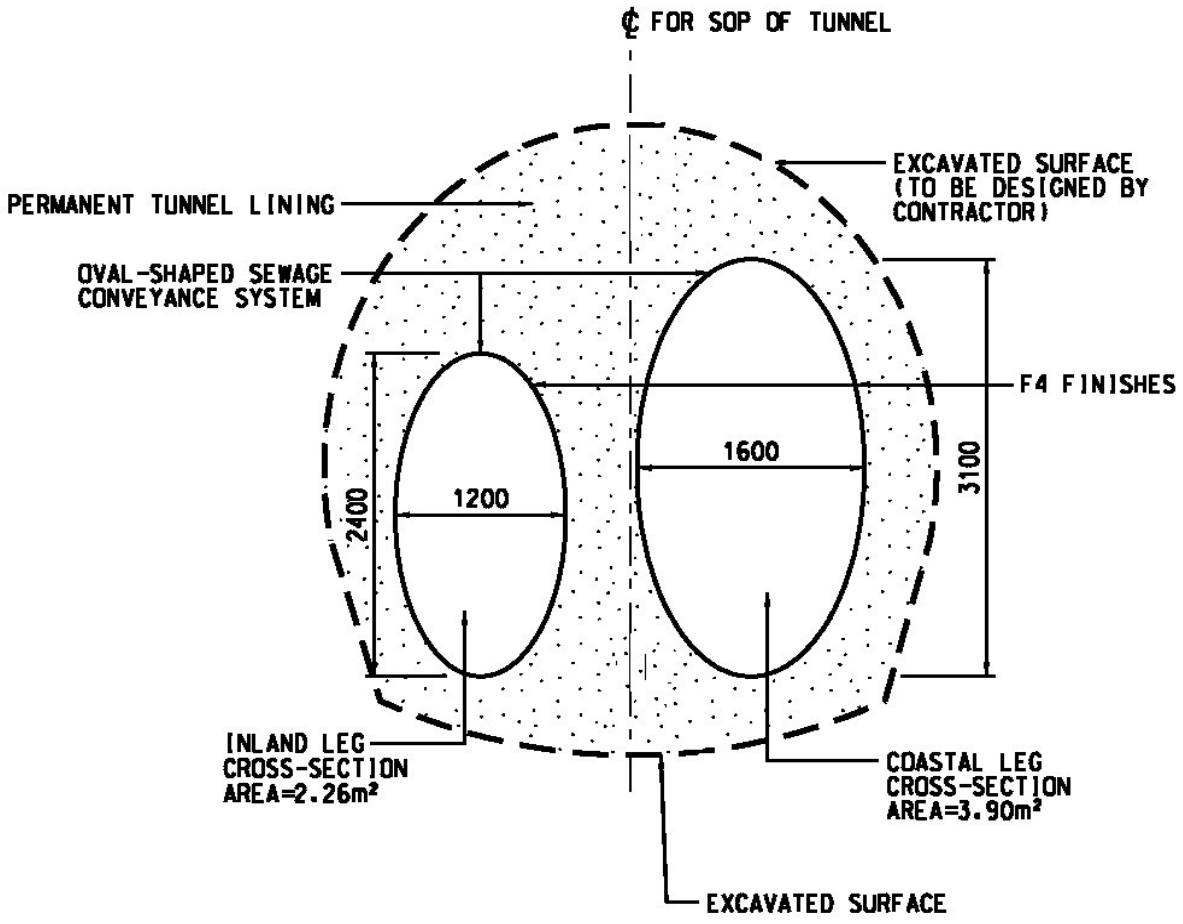
horse-shoe shape

width: 3.5m ~ 4.5m

Height: 3.5m ~ 4.5m

Depth: ~ 75m to 165m below sea level

Cross Section (Oval Conduits) of Sewage Tunnel



TUNNEL K : WAN CHAI EAST TO CENTRAL

Tunnel Construction mostly by Hard Rock TBM in Stage 1

Problems experienced in HATS Stage 1

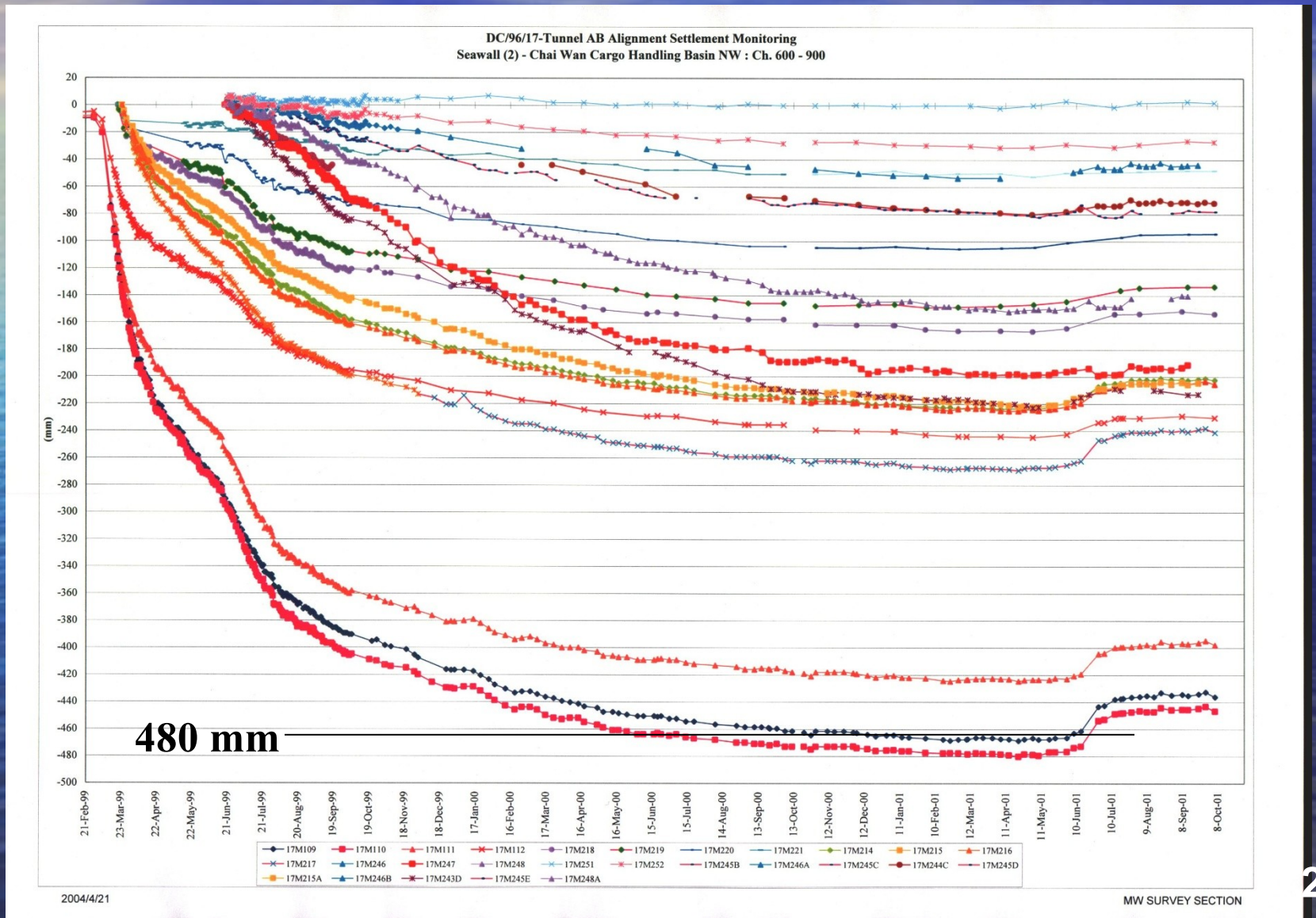
- Water Inflow

Problems experienced in HATS Stage 1

- Water Inflow

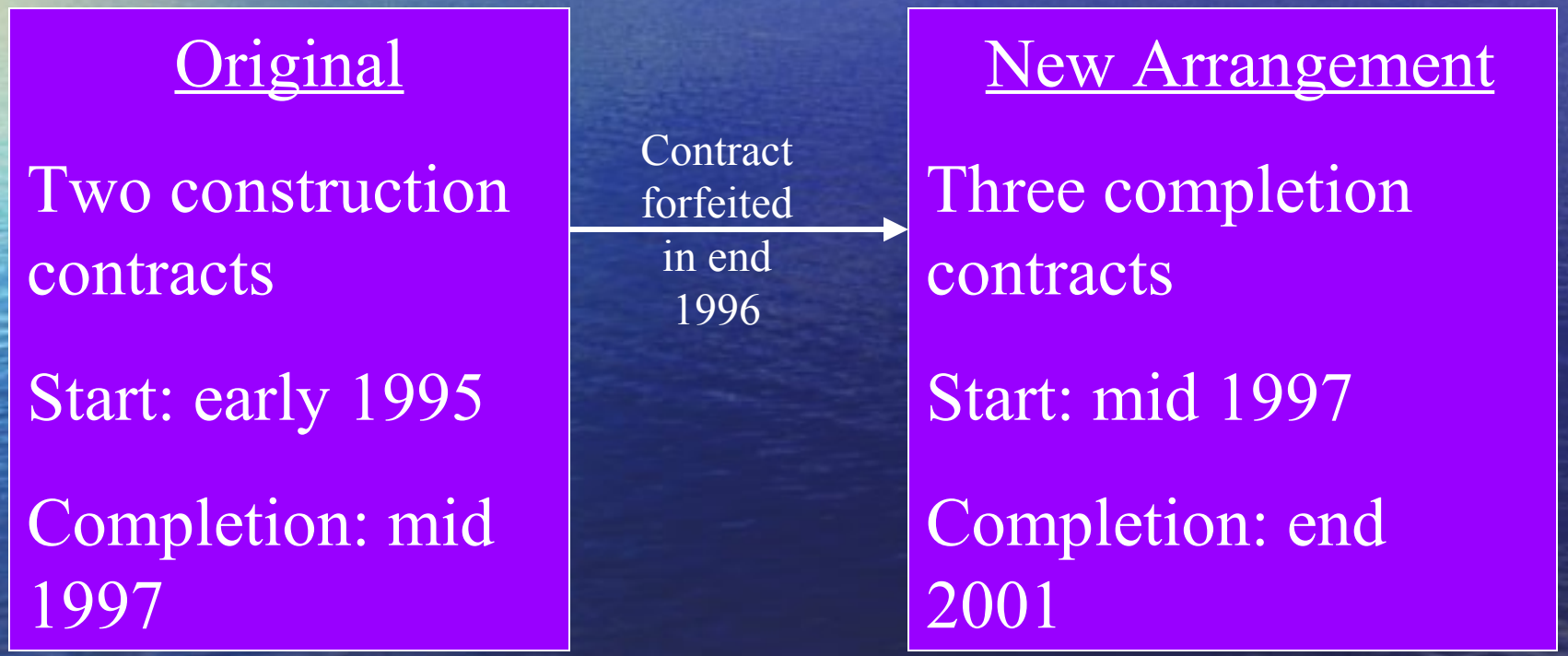
Problems experienced in HATS Stage 1 (Cont.)

- Settlement



Problems experienced in HATS Stage 1 (Cont.)

- Forfeiture of Contract



Measures taken in Stage 2 tunnels:

- Early design input from Experts
- A comprehensive site investigation programme
- Use state-of-the-art site investigation technology : directional coring
- Critical Review of TBM vs Drill-&-Blast
- Contract measures

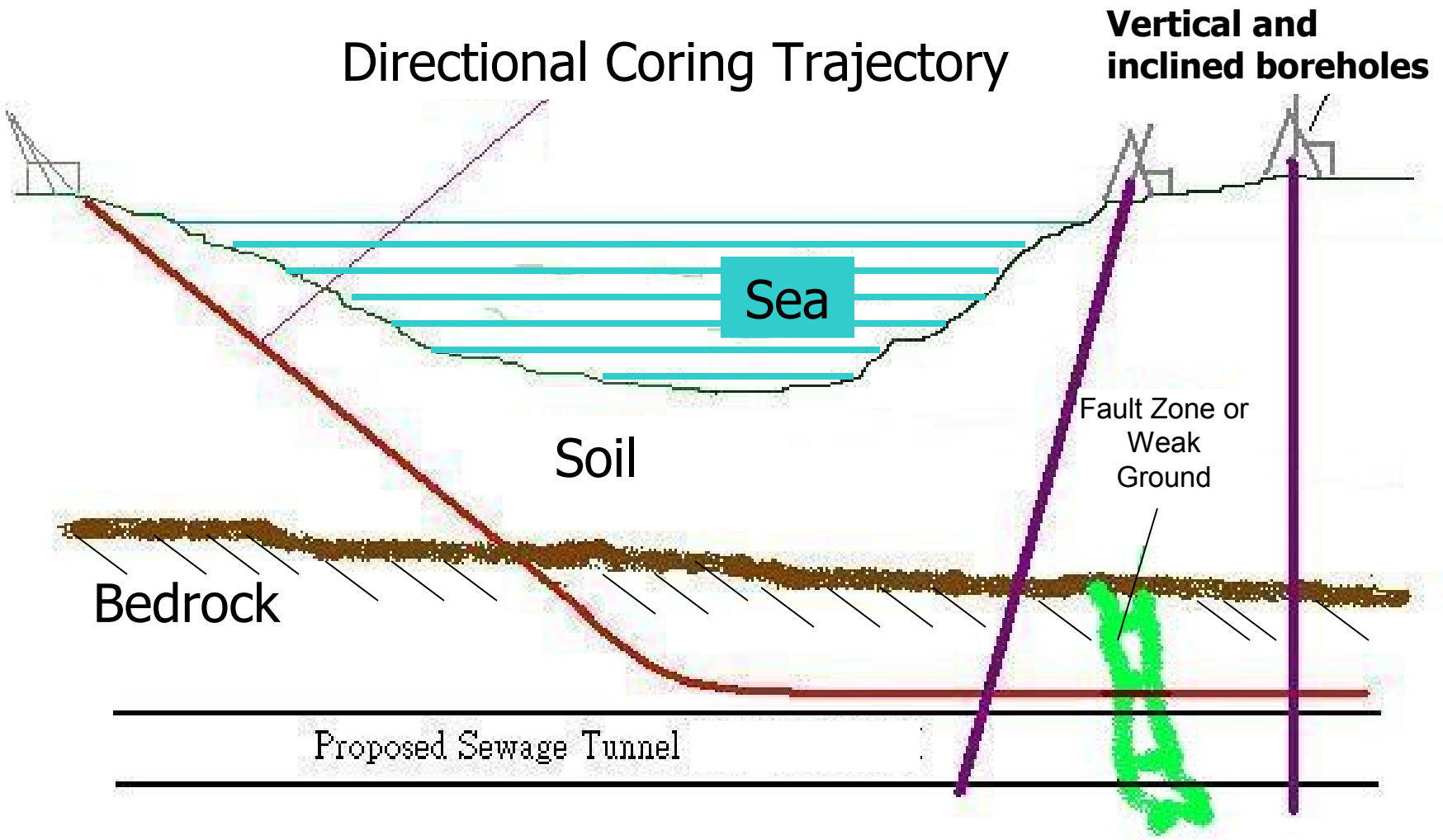
Site Investigation

		Rough costs in Euros (based on 1 Euro = 10 HK$)
Total length of directional coring	about 5 km	4.7 Million
Number of vertical/inclined boreholes	about 150 numbers	5.3 Million
Total length of vertical/inclined boreholes	about 18 km	
Total cost of ground investigation works		10 Million

Horizontal Directional Coring

- **The first use of this technology in obtaining geological information at such depth in Hong Kong**

Horizontal Directional Coring Trajectory

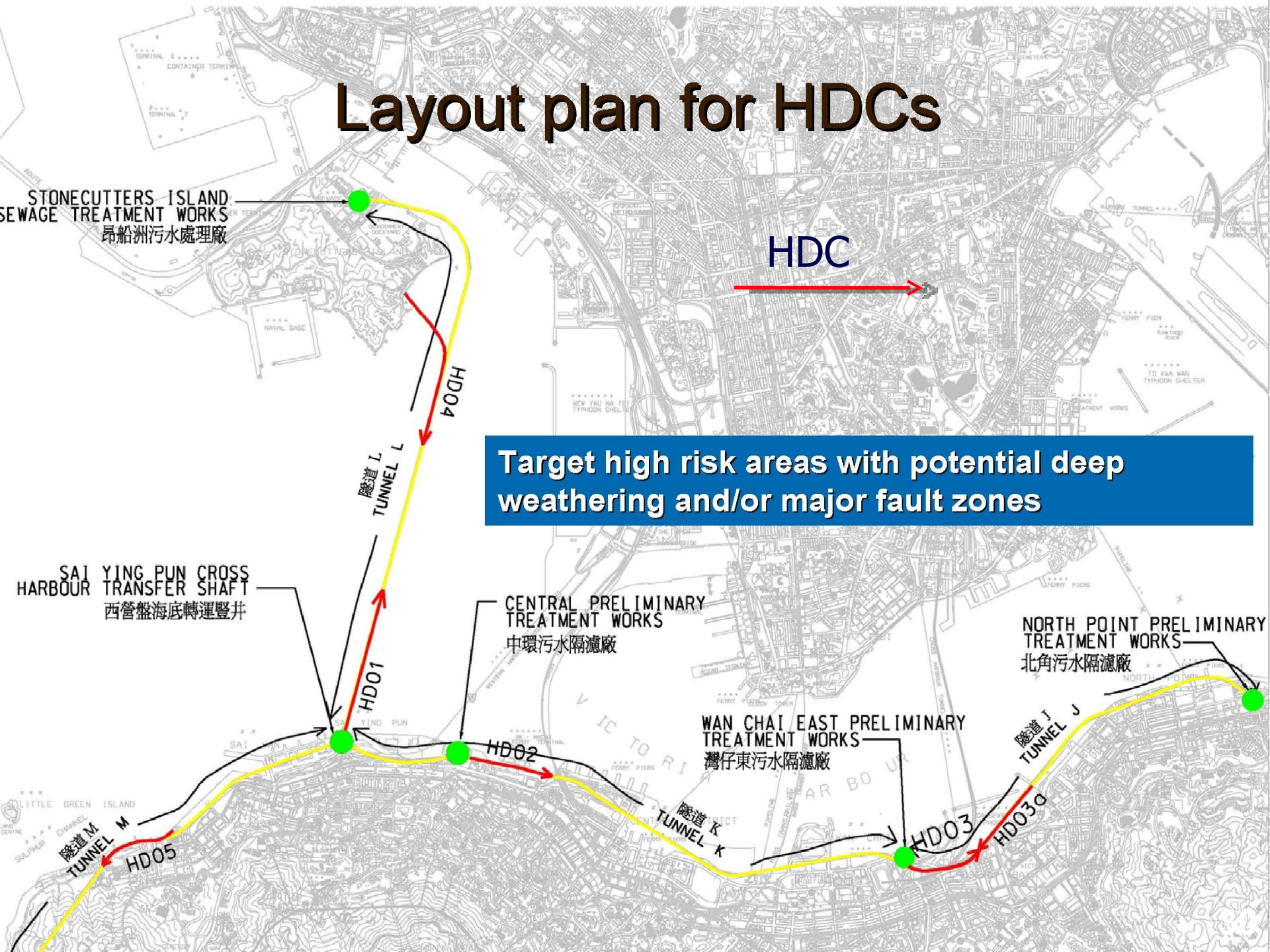


Advantages of using Directional Coring for Site Invetigation

- Continuous geological information at tunnel level can be obtained

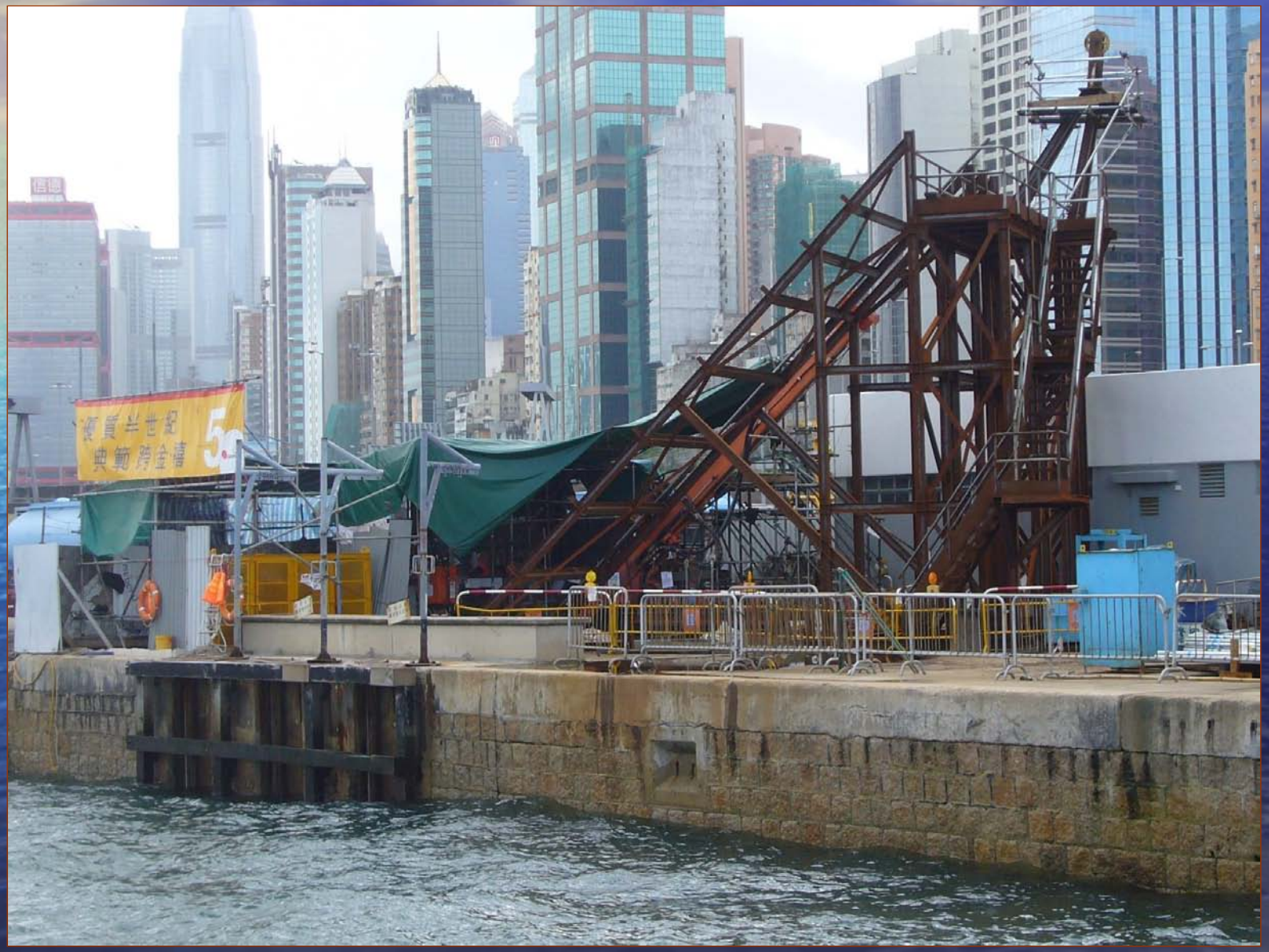
- Tests can be carried out at tunnel level to obtain information for control of groundwater ingress and grouting design

Layout plan for HDCs



Target high risk areas with potential deep weathering and/or major fault zones

Set Up for Directional Coring



DIRECTIONAL BARREL

Rock Cores from Directional Coring

Central PTW 30/07/07 (DV = 32 Ø)

Geological Information

- **Faults and dykes are likely to be encountered at tunnel depth**
- **Deep weathering and/or gouge materials expected at Faults and dykes**
- **Fractured rock in fault zones and areas other than fault zones**
- **Localised weathering in fault zones and dykes**
- **Extensive treatment to limit water inflows and ground supports required**

Critical review on construction method: TBM vs Drill-and-Blast

Why Drill-and-Blast is selected:

- **Variable Geological conditions – extensive grouting and ground support expected; TBM excavation rates more susceptible to adverse ground conditions**

- **Relatively small tunnel sizes for efficient drilling and grouting equipment for TBM. Fully automated drilling jumbo available for size range.**

Why Drill-and-Blast is selected:

- **Extensive grouting to control groundwater inflow**
- **Limited surface works area is available for the use of TBM**
- **Few proven experiences in TBM tunnelling at such depth (-160 mPD)**

Measures taken in Stage 2

- Risk Management Approach
  - A comprehensive risk management plan has now been developed
  - Risks are allocated to the most appropriate parties to deal with

Measures taken in Stage 2

- Contract Strategy to reduce risk
  - Contract Form with Re-measurement of Major Works Items: drilling of probe holes, pre-excavation grouting, shotcreting, rock bolts, steel ribs, etc.
  - Divide into two drill-and-blast contracts with manageable size
  - Restriction that a contractor cannot take both drill-&-blast contracts
  - Requirement for parent company guarantee and a performance bond

Measures taken in Stage 2

- **Mechanism for Selecting the Contractors**
  - Prequalify contractors who are capable (both financially and technically)
  - A marking scheme tailor-made for the tendering exercise is devised and made known to all prequalified tenderers
  - Award based on both technical score and price

Public Consultation

- A continuous public involvement approach
  - Consult the public and stakeholders at various stages of project implementation

HATS Stage 2 Tunnels – Costs

Capital cost of sewage tunnels: ~ 600 million Euros

Project Update

Approval of Environmental Assessment Study	End 2008
Commencement of contracts	2nd half of 2009
Completion of the whole system	2014

Thank you!