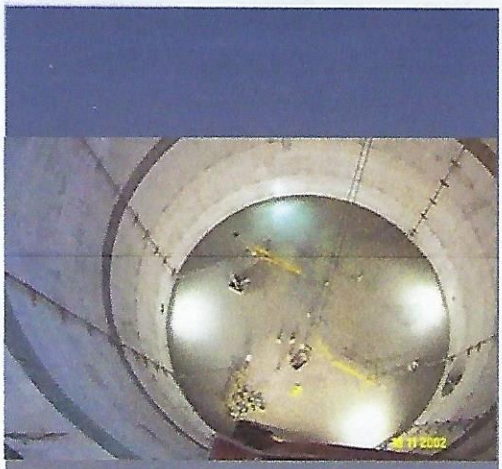
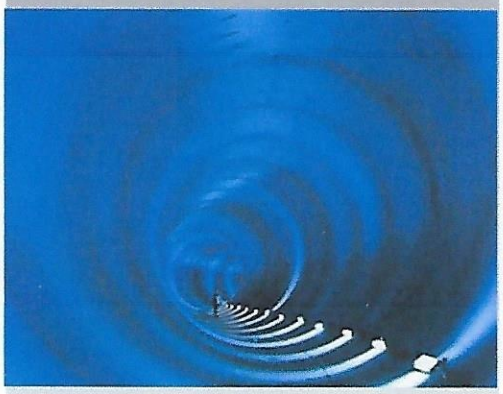
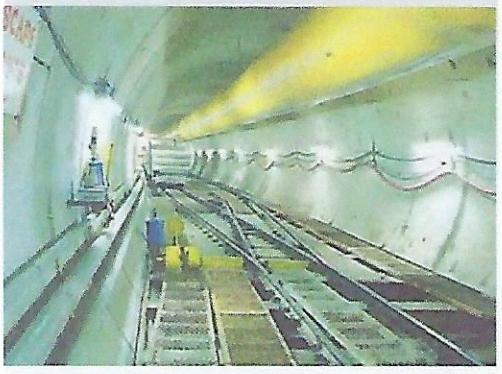


Construction of the deep pumping station

A tunnel boring machine (TBM)



The completed tunnel



The completed tunnel

Singapore Sewerage: No Space to Waste

17 June, 2009 | By Jessica Rowson

Construction of the Deep Tunnel Sewer

Increasing demands on Singapore's constrained sewerage system has seen its water authority radically rethink its strategy. Jessica Rowson reports.

The treatment of wastewater in Singapore steps into the future next week with the opening of phase one of a deep tunnel sewerage system and the Changi water reclamation plant.

The project will be opened on Tuesday by Singapore's prime minister Lee Hsien Loong as the centrepiece for Singapore International Water Week.

The concept for Singapore's deep tunnel sewerage system was first conceived in the late 1990s. At that time, Singapore had in place a comprehensive wastewater system, comprising over 3,000km of sewers and pumping mains, 100 pumping stations and six water reclamation plants serving the tiny 704km² island.

A Bold and Radical Approach

The demands on the system increased in line with population and industrial growth, but the option to continue expanding the treatment capacity of the plants and adding more pumping stations was unsustainable in land-scarce Singapore.

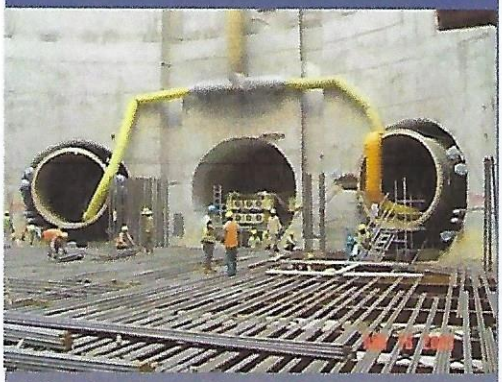
Confronted with these challenges, Singapore's Public Utilities Board (PUB), embarked on a bold and radical approach with the plan to build an entirely new wastewater infrastructure that would take up less space and progressively phase out the existing system.

"One of the drivers was to reduce land take. Singapore has only around 700km² of land."
Yong Wei Hin, Singapore's Public Utilities Board assistant director

A £1.6bn deep tunnel sewerage system is PUB's solution to meet Singapore's wastewater needs for the next 100 years.

"One of the drivers was to reduce land take," says PUB assistant director Yong Wei Hin. "Singapore has only around 700km² of land."

Wastewater is collected in sewers and conveyed to the 48km long deep tunnel sewer which runs 20m to 55m below ground. The deep tunnel sewer takes the water to the centralised Changi Water Reclamation Plant for treatment. The new system depends on gravity – it is graded towards one end so there is no need for intermediate pumping.



The deep tunnels

A tunnel shaft

Construction of the deep tunnel sewer

Pumping station construction

"The new system doesn't take up much space on top," says Wei Hin. "It goes deep underground. Also the new plant takes up less space."

Pumping Station Construction

Minimising the Impact

Eight earth pressure balance tunnel boring machines (TBMs) were used concurrently to drive the 48km long tunnel, which varied between 3.3m and 6m in diameter.

The depth of the tunnel varies between 20m and 55m. In addition, TBMs and pipe jacking were used to create 60km of link sewers between 300mm to 3m in diameter between 10m to 55m below ground.

As the TBMs advanced, the team erected reinforced concrete pre-cast segments, before sealing and bolting them together in rings to provide primary ground support.

"The new system doesn't take up much space on top. It goes deep underground. Also the new plant takes up less space."
Yong Wei Hin, Singapore's Public Utilities Board assistant director

The route of the tunnels was specifically selected to minimise the impact on existing structures.

"We aligned the tunnel along the major expressway and not beneath buildings," says PUB assistant director Yong Wei Hin.

For corrosion protection, concrete cast insitu with 225mm thick lining and 2.5mm thick high density polyethelene (HDPE) membrane were placed inside the bored tunnel.

This project has involved 49 main contractors and consultants, with over 300 subcontractors and suppliers. A joint venture of consultants CH2M HILL and Parsons Brinckerhoff carried out a feasibility study of the deep tunnel sewerage system and designed the 48km long tunnels.

An Efficient New Source

The Changi Water Reclamation Plant is efficient in its land use. The plant has doublestacked treatment tanks and a six-storey building with three storeys of basement that houses the sludge handling facilities.

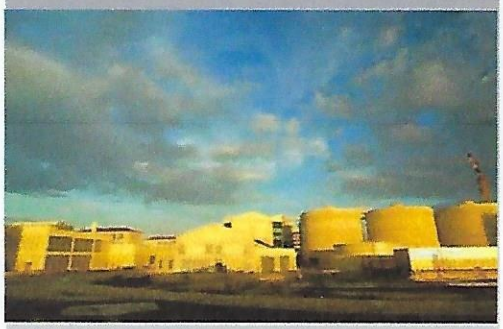
At 32ha, it has taken up only a third of the conventionally designed water reclamation plant's land area, according to PUB.

The treated wastewater is channelled to a processing facility called Changi Newater Factory on the rooftop of the reclamation plant.

Here it is further purified through advanced membrane technologies. The processed water can be consumed by humans and is used in

The completed pumping station

Thickening centrifuges

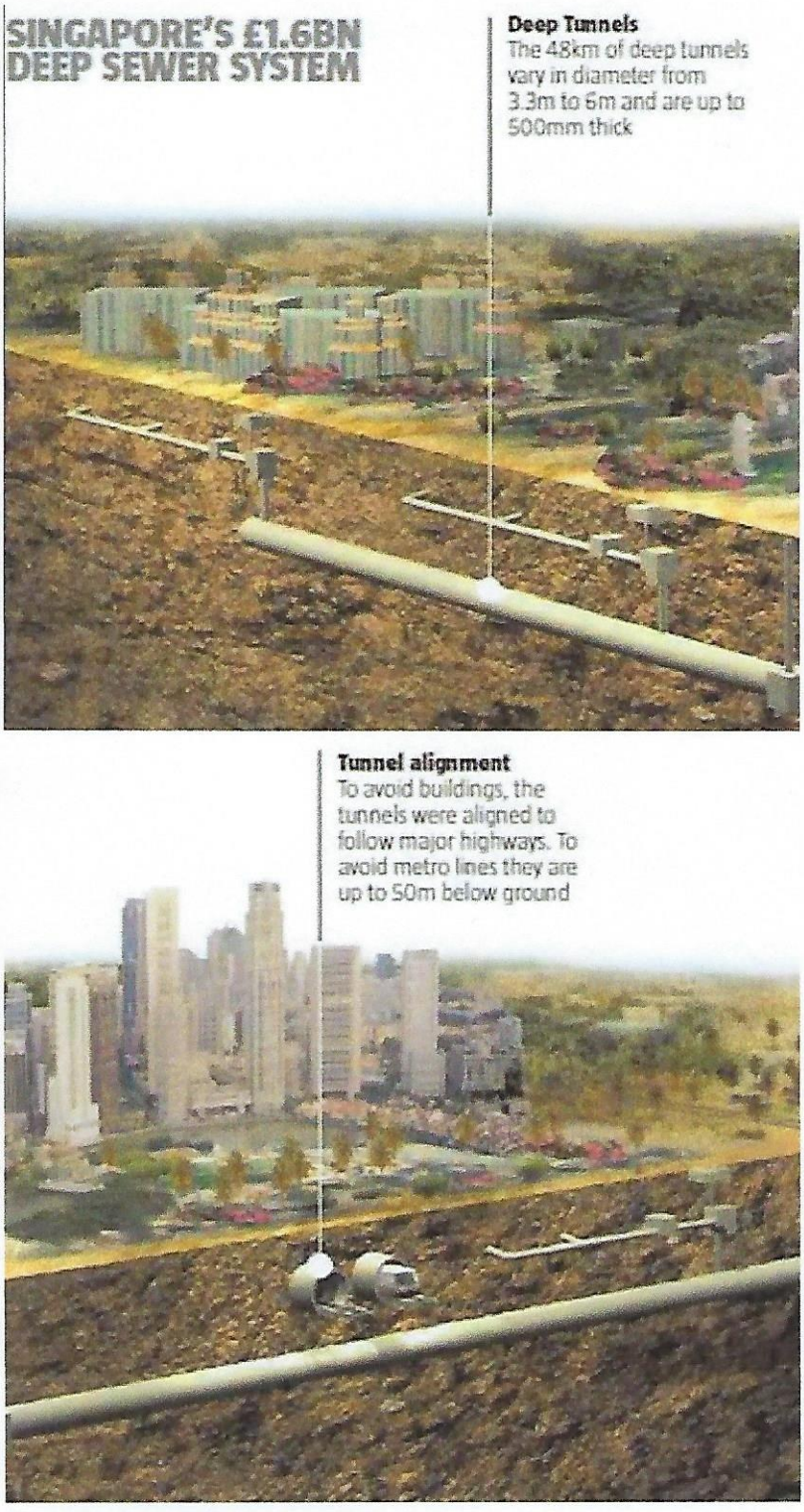


The Changi water reclamation plant at sunset

The Changi water reclamation plant control room

industry where high purity water is required. "It's another source of water for us," says Wei Hin.

Besides being used as feedstock for the new Changi Newater Factory, treated wastewater the new reclamation plant is used for purposes such as tank flushing and for cooling systems in machinery and buildings.

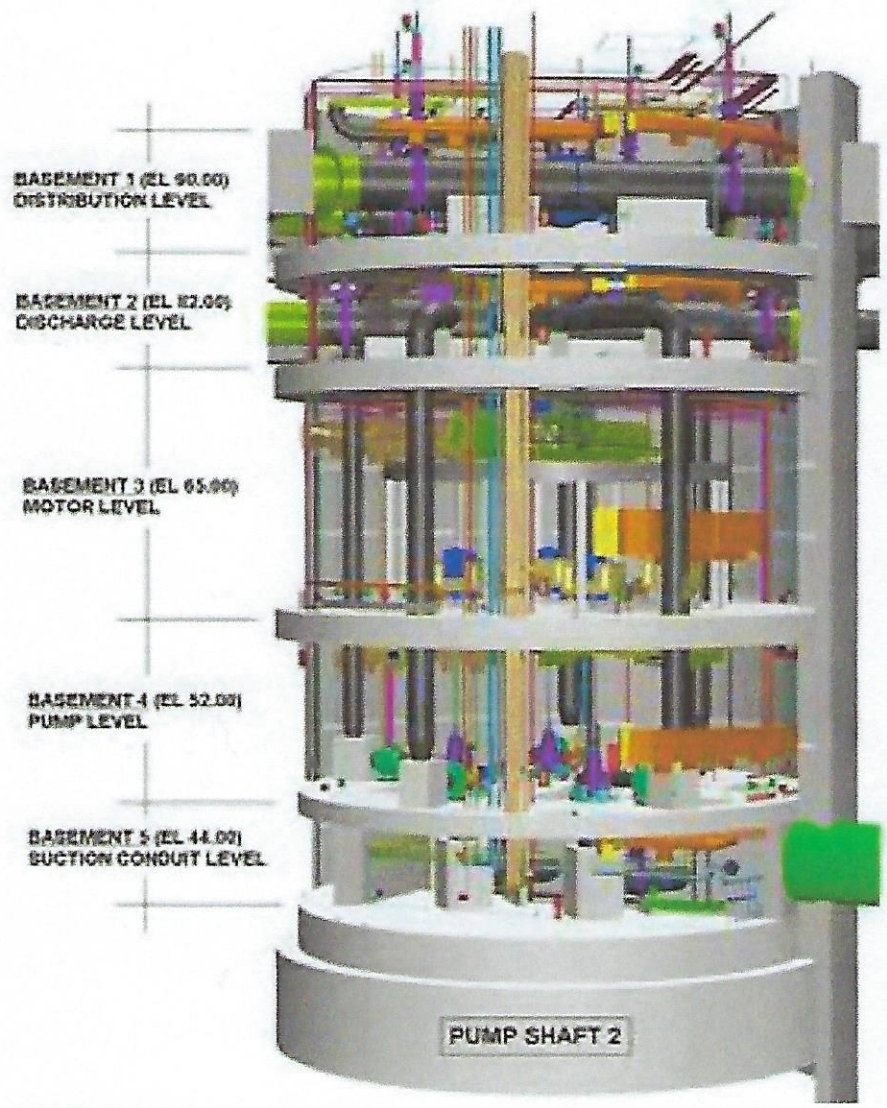


Changi water reclamation plant

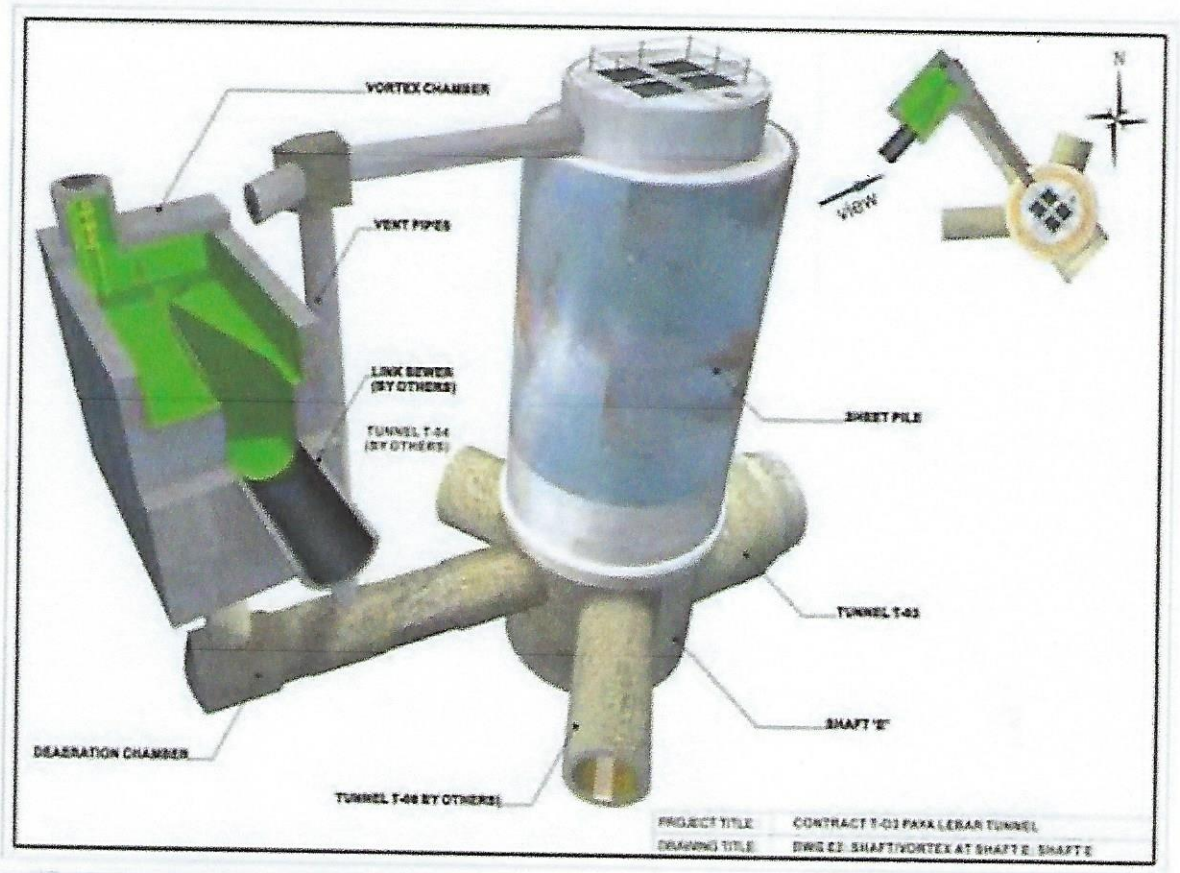
Pumping station
The pumping station consists of one 68.5m deep, 30m diameter coarse screen shaft and two 72.5m deep, 37m diameter pump shafts

Changi water reclamation plant
The plant is designed to treat 800,000m³ of water/day. Its capacity can be tripled to handle 2.4Mm³/day

Sea outfall
The sea outfall is 4.9km long and consists of three 3m diameter pipes, laid in a dredged trench and covered with rock armour



A shaft and vortex


VORTEX CHAMBER
VENT PIPES
LINK SEWER (BY OTHERS)
TUNNEL T-04 (BY OTHERS)
SHEET PILE
TUNNEL T-03
SHAFT 'E'
DEAERATION CHAMBER
TUNNEL T-06 BY OTHERS)
VIEW
N
PROJECT TITLE
CONTRACT T-03 PAYA LEBAR TUNNEL
DRAWING TITLE
DWG E2: SHAFT/VORTEX AT SHAFT E: SHAFT E

A pump shaft