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Thames Tideway Tunnel: King Edward Memorial Park Foreshore: collaborative major change

1 Ania Gonzalez

Jacobs, Tideway, London UK (corresponding author: ania.gonzalez@tideway.london)

2 Dominic Lovelock

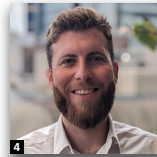
Bachy Soletanche, London, UK

3 John Kinnear

Jacobs, London, UK

4 Thomas Jones

Costain, London, UK



The King Edward Memorial Park Foreshore is one of the Thames Tideway Tunnel project's largest combined sewer overflow (CSO) interception sites, located in east London. This paper reports on the design solutions, construction techniques and methodologies used to deliver the works at this iconic site in the River Thames over 8 years. Key temporary works included a sheet piled cofferdam designed as a temporary working platform and to divert live flows through the site. A significant challenge encountered was the unforeseen geology, which necessitated a large ground improvement scheme, cofferdam redesign, realignment of the main tunnel and turning the CSO drop shaft from on-line to off-line. A 60 m deep shaft was constructed using diaphragm wall techniques. This site now prevents about 782 000 m³ of untreated combined sewage from entering the River Thames in a typical year. The site also provided an extension to the local park with new world-class architectural public realm in the heart of Wapping by reclaiming land from the River Thames. This case study showcases the complexities of large-scale infrastructure, blending engineering excellence with environmental and community benefits, and underscores the transformative impact of the project on London's waterways.

Keywords: cofferdams & caissons; ground movements; soils & ground conditions; UN SDG 3: Good health and well-being; UN SDG 6: Clean water and sanitation; UN SDG 11: Sustainable cities and communities

1. Introduction

The King Edward Memorial Park Foreshore site is one of 17 combined sewer overflow (CSO) interception sites of the Thames Tideway Tunnel project, constructed to reduce untreated combined sewage discharges into the River Thames (Figure 1). The site intercepts the North East Storm Relief (NESR) CSO at what was its river outfall. This was accomplished by constructing a series of underground structures to capture the flow, convey it to a drop shaft and transfer it, through a short connection tunnel, to the main tunnel. All the interception structures were built in reclaimed land, enclosed by a new river wall. The reclaimed foreshore created a new public realm that was landscaped and integrated with the existing park, featuring multi-level walkways designed to reconnect Londoners to the river. Before the CSO was intercepted, it

discharged approximately 782 000 m³ of untreated combined sewage into the River Thames in front of King Edward Memorial Park in a typical year (Thames Water, 2013a).

The nearby 100-year-old Rotherhithe Tunnel, which carries traffic beneath the river, was a key consideration to minimise the impacts of deep excavation and tunnelling. Similar challenges were associated with working around Thames Water's live sewer network, requiring minimised impacts from the construction of a deep drop shaft and underground structures and ensuring robust, watertight connections between the 100-year-old sewer system and the new, high-specification system, designed for a 120-year lifespan.

The contractor that delivered the works was a joint venture of Costain, Vinci Construction Grands Projets and Bachy Soletanche (CVB). Their lead designer was Mott MacDonald.

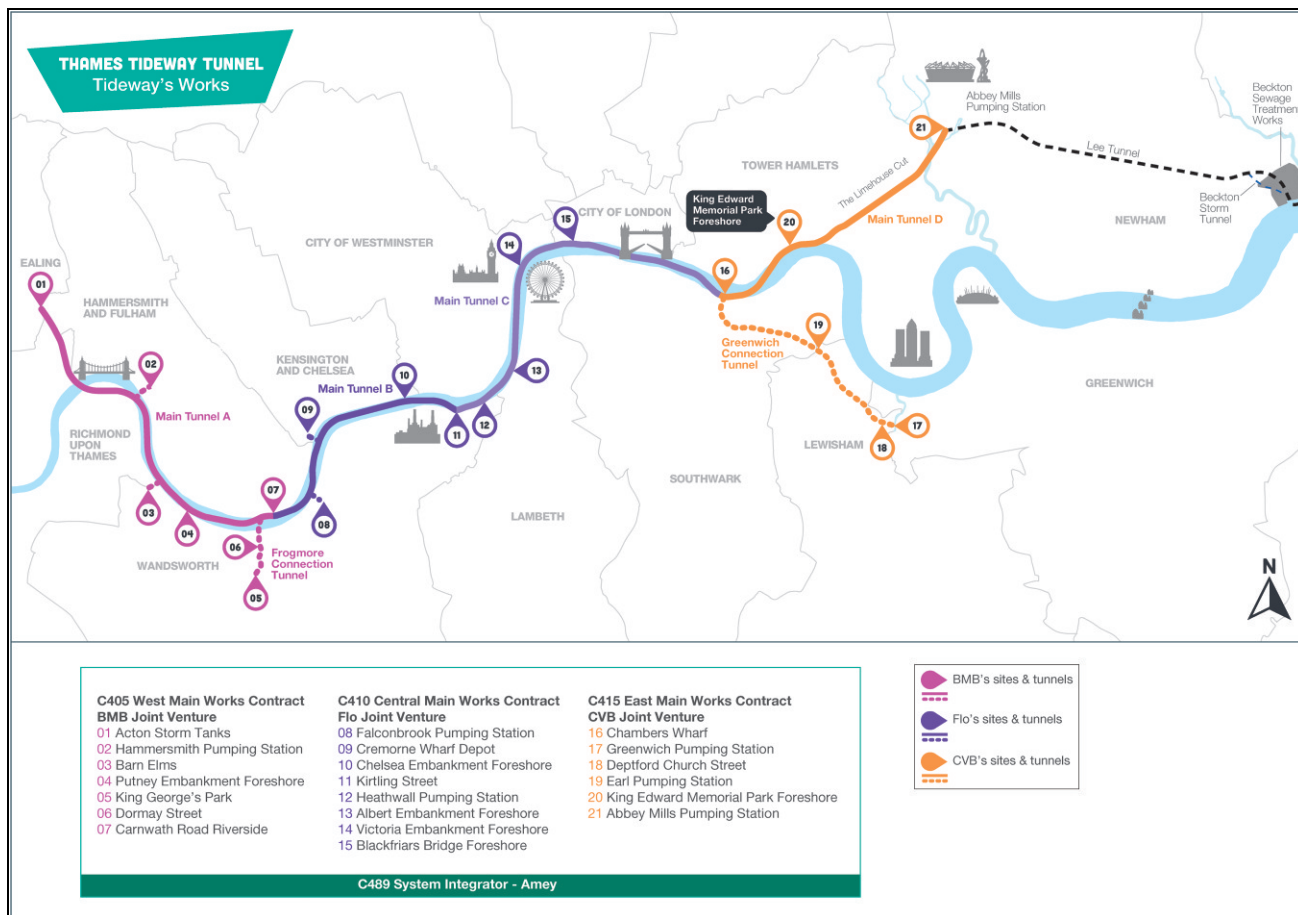


Figure 1. Location of the King Edward Memorial Park Foreshore site, part of the Thames Tideway Tunnel project

2. Scope of works

The new foreshore structure, along with the infrastructure designed to manage flows, was developed through a comprehensive review of multi-disciplinary requirements and constraints. These included hydraulic, civil, structural, marine/maritime and tunnelling considerations, as well as mechanical, electrical, architectural and landscaping factors (Figure 2). The overall design and construction of the works were driven by the need for a design life of 120 years, low maintenance and operational safety.

2.1 Hydraulic requirements

This CSO interception site comprises

- a connection culvert, rerouting the flows from what used to be sewer outfall into the new structure
- a tunnel isolation penstock chamber
- a secondary isolation gate chamber
- a tunnel flap valve chamber
- a tangential vortex intake
- a 3 m dia., 20 mm thick stainless steel lined vortex drop tube inside a 20 m dia., 60 m deep drop shaft

- a short 3.66 m dia. connection tunnel (with sprayed concrete lining (SCL)) to the 7.3 m dia. main tunnel.

There will be occasions when the tunnel system becomes full, so flows will need to overflow into the river. Therefore, there is a river outfall chamber, off the connection culvert, with a double set of river flap valves to protect the infrastructure from tidal inflow.

The hydraulic design of the site was complex and required advanced modelling techniques, including computational fluid dynamics, complimented by a 1:10 scale physical model used to validate the results. These methods were used to develop an optimal solution for a design flow rate of 30 m³/s. The vortex intake and drop pipe directs the flow in a helical pattern, aiding in energy dissipation and air release. The 15 m high perforated baffle wall and weir wall at the base of the shaft, forming the vertical deaeration system, allow air to be released from the flow before it enters the tunnel system. More information on tangential vortex drop and vertical deaeration designs is provided by Fricker *et al.* (2025) in this issue.

2.2 Mechanical, electrical, instrumentation, control and automation (MEICA) and air management

To control the flow entering the tunnel system, the chambers contain mechanical equipment including hydraulically actuated

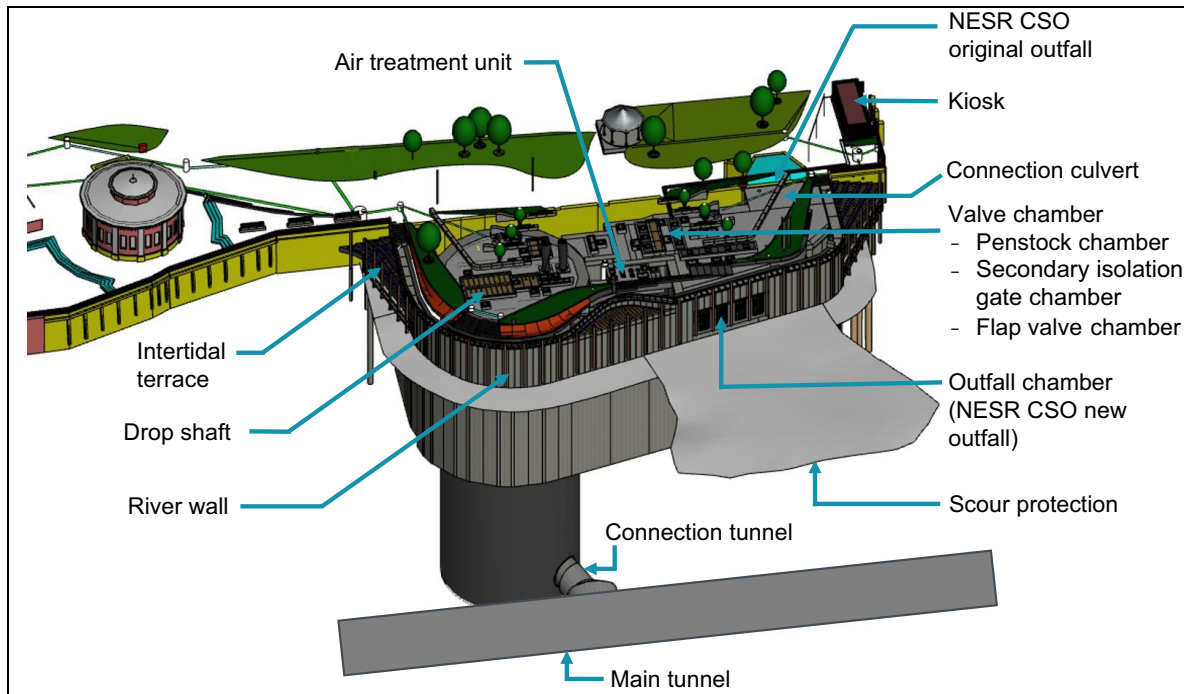


Figure 2. Scope of works for the King Edward Memorial Park Foreshore site

penstocks, flap valves and isolation gates. These components, along with a control system housed in an above-ground kiosk, enable the flow to be directed to the river when the tunnel system is unavailable and they also provide two forms of isolation when maintenance is required inside the tunnels. Air movements generated by the changing combined sewage levels in the tunnels are processed and treated through carbon filters housed in an underground air treatment unit before being released 5.6m above ground through ventilation columns. The shape of the ventilation columns imitates the vortex movement of flows as they descend to the tunnel. The ventilation system, including ducts, dampers and air bridges, is crucial for maintaining internal tunnel air pressures within the design parameters.

2.3 Marine scope

The new river wall alignment and foreshore structure were designed to minimise disruption to the river's fluvial behaviour, reducing scour and accretion. The loss of foreshore was mitigated by the creation of intertidal terraces (suspended platforms designed to support vegetation that thrives in the intertidal zone). The river wall was constructed with a bespoke cladding pattern and ecological fenders were designed to encourage colonisation by aquatic and intertidal organisms, contributing to biodiversity.

The river wall was designed to establish a statutory flood defence and address the requirements of rising flood protection levels over the next century. A significant consideration for the foreshore structure was its potential exposure to ship impacts. A probabilistic ship impact assessment informed the design, ensuring the river wall could withstand a frontal ship impact load of 11.5 MN. The structure is protected from scour, with rip-rap along

the new river wall and grouted mattresses in front of the new river outfall to shield the riverbed from the energy of the flow when the CSO discharges to the river.

2.4 Durability, watertightness and operational requirements

Durability considerations were embedded in every aspect of the design, with attention to exposure conditions during construction and operation. The structures are built to withstand various challenges, including abrasion, cavitation, bio-acid attack and exposure to saline river water and combined sewage. The CSO interception structures were designed in compliance with BS EN 1992-3 standards for watertightness (BSI, 2006). To prevent leakage, construction joints were equipped with external and internal water stops; additional re-injectable grout tubes and hydrophilic strips were also included to increase watertightness. Additionally, all structures were designed for ease of maintenance, catering for a 20 kPa surcharge loading capacity and traffic load over the drop shaft and chambers. The architecture and landscape design (see Figure 3) evolved and incorporated numerous access covers for access to the underground infrastructure. CCTV and instruments openings minimised the need for confined space entry.

2.5 Interface with the existing sewer

Interception of the NESR CSO was achieved by constructing an extension to the old outfall chamber, founded partially on bored piles with a monolithic connection to the new interception structure. This solution avoided any structural loading on the existing sewer. The movement joint was designed to accommodate up to



Figure 3. King Edward Memorial Park Foreshore: (a) 2013 visualisation (@Thames Water); (b) construction nearing completion in 2025 (photo credit: Patricia Rayner)

50 mm of horizontal and vertical movement while ensuring it remained waterproof, using Trelleborg's proprietary Omega seal system.

2.6 Design review and acceptance

The contractor's design and construction proposals were subject to a detailed project manager's review through a series of design submission gates. Designs required Category 2 and independent Category 3 checks and early engagement with Thames Water to capture operational requirements through hazard, operability and maintainability workshops to identify and mitigate hazards in the operational phase. Coordination between the multi-disciplinary teams – covering hydraulic, civil, infrastructure, MEICA, structural, compliance with planning requirements and tunnel design – was essential in developing a cohesive solution. Inter-disciplinary reviews played a key role in achieving an integrated design and ensuring all disciplines were aligned.

3. Construction works

3.1 Temporary works cofferdam

To build the large-scale structures in the river, the first step was to design, secure consent and construct a temporary working platform located on the foreshore. This platform consisted of a 40 m wide by 90 m long cofferdam, formed by seven outer cells enclosing the area for the permanent works. The cells, 11.5 m wide, were constructed from 17.5 m long sheet piles, which were connected using tie rods and filled with compacted material (Figure 4). This arrangement helped retain the ground behind the cofferdam while withstanding up to 100 kPa of pressure generated by the construction plant, providing flood protection and resisting potential accidental ship impacts. The sheet piles were driven into place from the river using a jack-up barge equipped with a Giken unit – a silent piling method to reduce noise pollution. The construction and removal of this temporary structure accounted for approximately 4 years of the overall project timeline due to its complexity

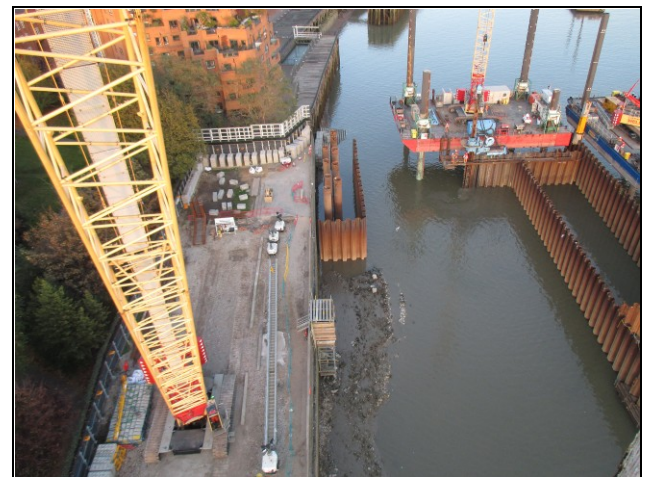


Figure 4. Cofferdam during construction – view over the NESR CSO outfall diversion channel

and the challenges involved in working within the river environment (Figure 5).

3.2 NESR CSO diversion channel

The cofferdam was designed to encapsulate the existing NESR CSO outfall and create a channel that diverted flow through a 90° bend to the river (Figures 4 and 6). To prevent scour of the foreshore and reduce the risk of a 'piping effect' between the sheet piles and the existing river wall, the design included a temporary slab to protect the riverbed from discharge effects while also supporting the sheet pile wall, which acted as a retaining barrier for the tide and CSO discharges. This setup allowed the NESR CSO to continue discharging into the river throughout the construction of the drop shaft and interception structures. The hydraulic performance of the flow diversion was carefully modelled to ensure no adverse impacts on the upstream sewer network. Continuous

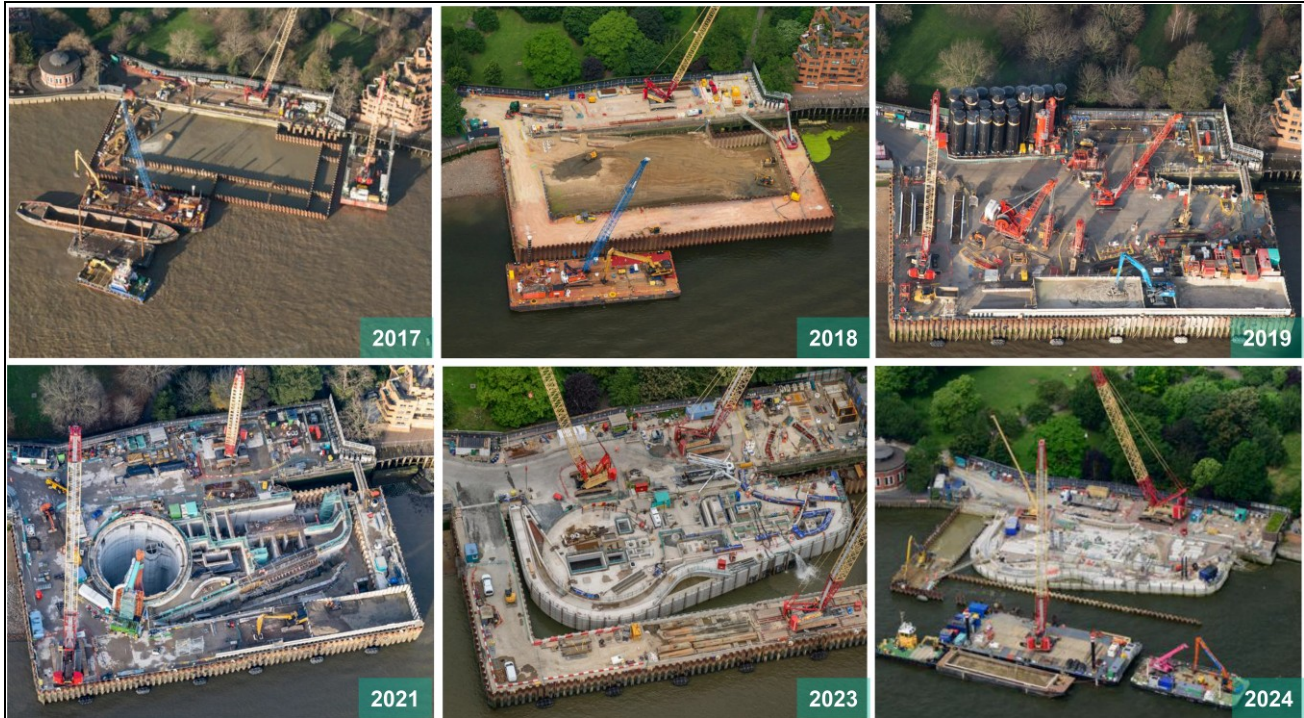


Figure 5. Progress of works from start of cofferdam construction to removal (photo credit: Patricia Rayner)



Figure 6. NESR diversion channel – construction of the final connection with the existing sewer

monitoring of the sheet pile wall was conducted throughout the construction process to ensure the robustness of the flood defence system.

The permanent connection between the old outfall and the new river outfall chamber was completed when the new river outfall chamber was ready to handle flows. This connection was built under tidal and live discharge conditions, and consisted of a piled base slab, in situ walls and a precast roof slab. To mitigate the risk of

contamination from the chloride content in the concrete, cleaning was applied after each discharge. The design for this permanent connection went through multiple iterations, considering several factors: (a) structural capacity to retain CSO discharges, (b) tidal variations and uplift forces, (c) flood defence requirements, (d) the limitations imposed by the size of the plant and its distance from the vulnerable existing sewer and (e) durability requirements for the joints between the discrete precast elements. By monitoring the CSO discharge pattern during construction, the best solution from both a programme and quality standpoint was determined to be a combination of precast elements (base slab and roof) with in situ stitching, connections to the piles, topping slabs and in situ 6.5 m high walls installed in a single pour. One of the biggest challenges to construct the connection was working within a live discharge environment. The safe system of work was developed based on a procedure using a flow monitoring system set up in the Thames Water sewer network upstream of the works, which gave the teams 10 min warning time to evacuate in case of an unexpected discharge event. This procedure combined live weather monitoring and use of Thames Water’s ‘ICM Live’ notification system, which is a near-real-time catchment model using real-time rainfall forecasts and actual data to predict the time of discharges.

3.3 Permanent works

Once the cofferdam and the temporary CSO flow diversion were in place, construction of the drop shaft began using diaphragm walls (D-walls). Each 2.8 m long by 1.5 m wide panel required precise accuracy of greater than 1/200 verticality, which

was directly controlled by the on-board rig's telemetry and then post-excitation proven by 'Koden' testing, which used ultrasonic waves to confirm the panel's geometry, inclination and orientation. The Hydrophraise rig installed 30 panels, each 75 m deep. The reinforcement cages for the D-wall panels were delivered by river as part of the project-wide River Transport Strategy (Tideway, 2023), addressing commitments in the Development Consent Order (DCO) (HMG, 2014) for use of the river to reduce traffic congestion, lower emissions and lower the risk of traffic incidents.

The period of shaft construction coincided with the Covid-19 pandemic, which introduced strict regulations, including a 2 m working distance between operatives. To ensure safety and compliance, the site team used Reactec wristwatches that vibrated and beeped if this distance was not maintained, and exceedance was monitored through the weekly data review. In parallel to the shaft works, the 30 m deep river wall and 20 m deep interception structure panels were also constructed using the D-wall technique with a grab machine. Close coordination was required to ensure a safe interface between these two major activities.

Once the retaining wall construction phase was complete, capping beams were cast, and excavation began. All excavated material was removed from the site by barges. The large base slabs for both the shaft and interception structures were cast in a single pour (Figure 7), with an internal dewatering system left operational until the secondary lining was installed. This lining was designed to meet durability and watertightness requirements and to resist uplift pressures. The final stage of civil works construction involved installing the roof slabs, which were designed with a combination of precast beams, planks and in situ topping slabs (Figure 8).

The use of precast elements was selected in several structures, instead of in situ concrete, to optimise both the programme and quality. Coupled connections for reinforcement were used to avoid post-drill solutions wherever possible to maintain quality control.

To manage risks during the pre-construction and construction phases, the CDM Hazard Register database tool, developed by CVB, was used (HMG, 2015). This tool helped manage risks related to both temporary and permanent designs, and provided a framework for mitigating them during the construction and operational phases.

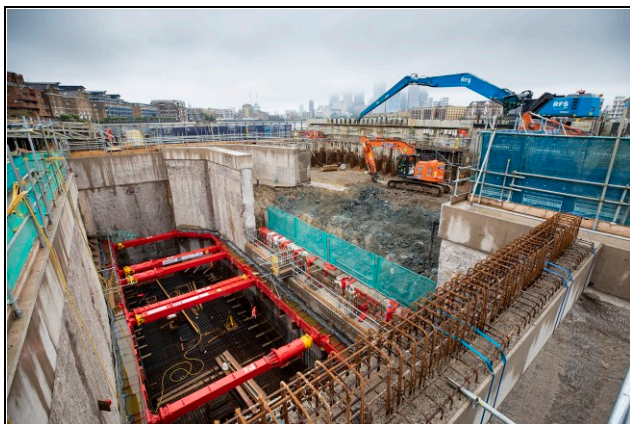


Figure 7. Valve chamber base slab under construction



Figure 8. Drop shaft with completed secondary lining, lined vortex drop tube and roof slab

4. Geotechnical challenges

4.1 Adverse ground conditions

During construction of the cofferdam, it became apparent that the structure was not behaving as anticipated because the filling of the outer cells generated greater than expected movements. This was identified in the routine prescribed daily monitoring and reported to the project team. The monitoring showed greater deflection in the face of the wall (over 500 mm) than the design-prescribed limits (160 mm) (Figure 9). The design was based on geotechnical information derived from an initial ground investigation campaign undertaken in advance of the works. The presence of metal fragments in the foreshore from its historic use as a quay was a key factor in the timing of clearances of unexploded ordnance and further thorough soils investigation. Following the identification of the movement, the team suspended the cofferdam filling work and initiated a programme of more intensive foreshore investigation. The team needed to recover geotechnical samples to

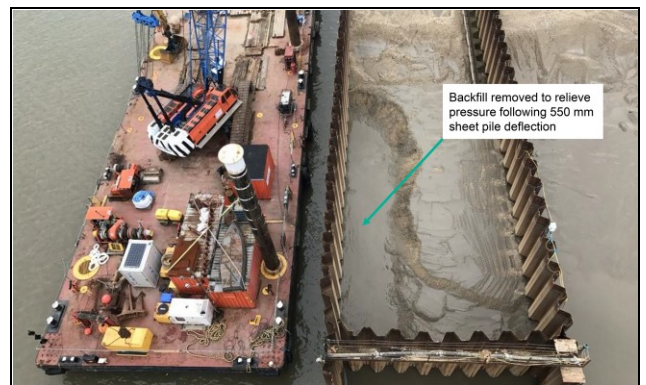


Figure 9. Sheet pile deflection of 550 mm occurred during placement of the backfill material

determine characteristic strength in the shallow foreshore conditions while dealing with a tidal range of 7 m. Use of a Neptune 3000 subsea coiled cone penetration test (CPT) rig enabled shallow depths to be reached and provided sufficient information to continue with the cofferdam filling works. Following the shallow CPTs with Neptune 3000, a further larger campaign of boreholes, deep CPTs and vibrocores was undertaken to profile the foreshore conditions. From this soil investigation, the team was able to identify that there was variability in the foreshore conditions across the site. Specifically

- the foreshore alluvium thickness ranged from 0 to >4 m with extremely low strength (original baseline conditions did not report the presence of alluvium)
- River Terrace Deposits (RTD) ranged from 4 m to 0 (the presence of the RTD was a key design input in the ground model for the construction works)
- peat with varying thickness up to 5.2 m was present along the old river wall.

With the CPT results, it was possible to show that a localised feature was present in the foreshore, which had likely been caused by an old watercourse similar to a ‘lost river’ of London (Barton, 2000), which created these localised soil conditions not visible in the limited pre-contract investigations. The team used this more detailed investigation to confirm the allowable filling sequence of the temporary cofferdam outer cells. However, there was still a concern regarding the permanent structures and the behaviour of the temporary cofferdam when large construction loading would be applied. Therefore, a further nine deep boreholes were implemented from the filled cofferdam to provide a more comprehensive investigation and allow more testing. The results from the boreholes identified that the variability extended beyond the initial layers of the alluvium and RTD and, although the level of the

Reading Formation Upper Mottled Clay (at the top of the Lambeth Group) was relatively consistent across the site, the properties of the clay layer varied, with some results matching the original off-shore investigation but others showing a reduced strength in the underlying clay bedrock. The updated stratigraphy and strength parameters were used to update the cofferdam model and the subsequent results matched the movement that had been observed on site, providing confidence that the variability across the site and the conditions that existed in the foreshore were fully captured (Figure 10). Therefore, the ground model could be reliably used to progress the solutions for the remainder of the temporary and permanent works design.

4.2 Impact on temporary works

The additional geotechnical investigations allowed the cofferdam backfilling works to continue with a number of important adjustments.

- Backfilling was originally to continue up to the sheet pile tie rod level and then the tie rods would be installed using the backfill as a platform to work from. Due to the softer underlying soils, the tie rods had to be installed without the backfill providing this working platform and were suspended on frames. This ensured the sheet piles were restrained from deflecting and allowed for the backfilling to be completed.
- Once backfill was completed within the cofferdam cells, load restrictions were implemented on the top of the cells and within the hinterland until further deep foundations were installed.
- 149 continuous flight auger (CFA) piles (700 mm in dia) were installed 25 m deep within the front cell of the cofferdam to give global stability to the cofferdam and allow for the cofferdam hinterland backfill to be completed by transferring

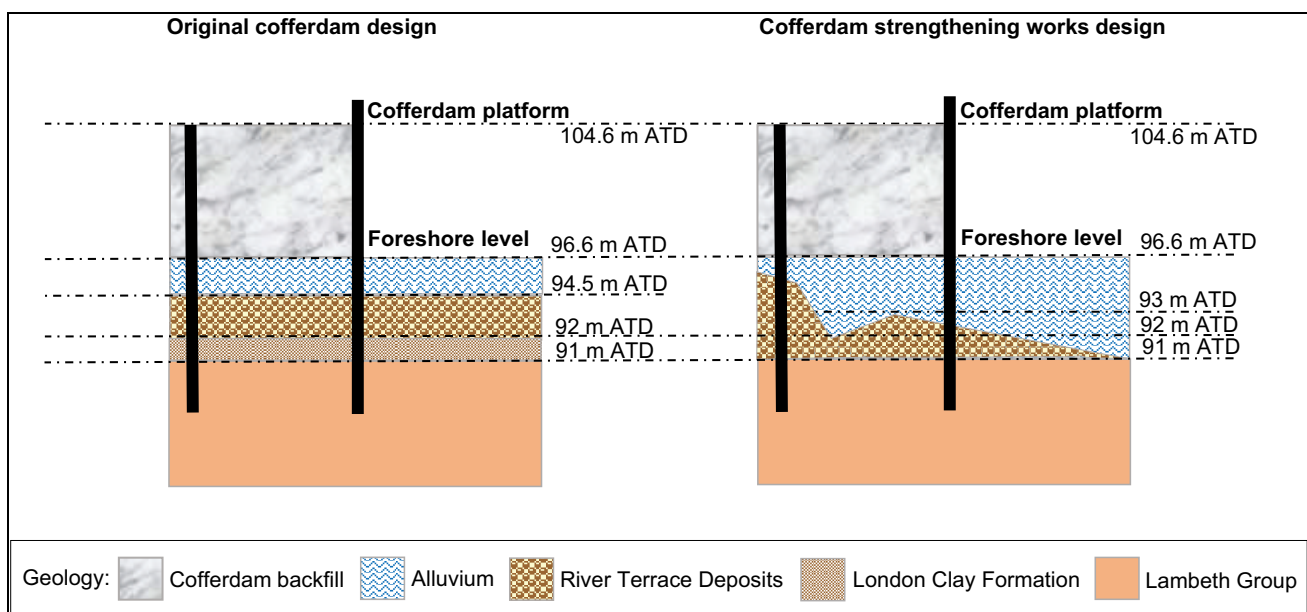


Figure 10. Simplified comparison of the geotechnical model used for the cofferdam design and strengthening works (ATD = above tunnel datum)

the load to the competent strata. Without these additional foundations, the hinterland backfill and construction live loads from the D-wall activities would have caused the cofferdam to experience unacceptable deflections globally. The CFA piles were installed once the cofferdam tie rods had been fitted and the cofferdam fill brought up to a level above the tide. Figure 11 shows the demolition of the cofferdam partially underway, with the piles excavated ready to be cropped 1.2 m below the riverbed. The piles were cut below the riverbed to ensure they do not become hazards for future river users.

4.3 Ground improvements for temporary conditions and permanent works

Due to the differing properties of the soil conditions found on the site, the team needed to develop a scheme to improve the prevailing soil conditions with the aim of reducing platform settlement during the D-wall activities. The performance of this treatment needed to meet a broad set of criteria, as follows.

- Reduce active pressure on the cofferdam, permanent river walls and other retaining walls, because the soil conditions imposed greater load onto these structures due to reduced stiffness and the reduced angle of internal friction.
- Increase the passive resistance on the permanent river walls and other retaining walls, because the reduced internal friction angle reduced the support to the cantilever retaining walls.

- Improve soil properties to limit the possibility of soil collapse into the D-wall excavations, because the reduced soil strengths increased the risk of soil collapse within the excavated D-wall panels.
- Improve the bearing capacity for the temporary live loads from the plant installing the permanent works.
- Reduce the short- and long-term settlement predictions for the permanent works area.

The drop shaft was originally on-line to the main tunnel from Chambers Wharf to Abbey Mills Pumping Station. A delay to drop shaft completion risked delaying critical tunnelling works. Therefore, the team investigated many differing geotechnical techniques to meet these requirements, including:

- TrenchMix™ in a grid-matrix arrangement
- grouting (permeation, compaction or jet grout)
- deep soil mixing (DSM)
- stone columns/vibro concrete columns
- piling (CFA piles or other boring techniques)
- band drains
- consolidation over time.

Only DSM was determined to meet the technical requirements (Table 1) and was also considered faster than other blended methods. The CVB team worked closely with Mott Macdonald to design the final DSM arrangement (Figure 12).

A scheme comprising secant columns arranged in a grillage formation with an embedment of >1 m into the underlying stiff clay

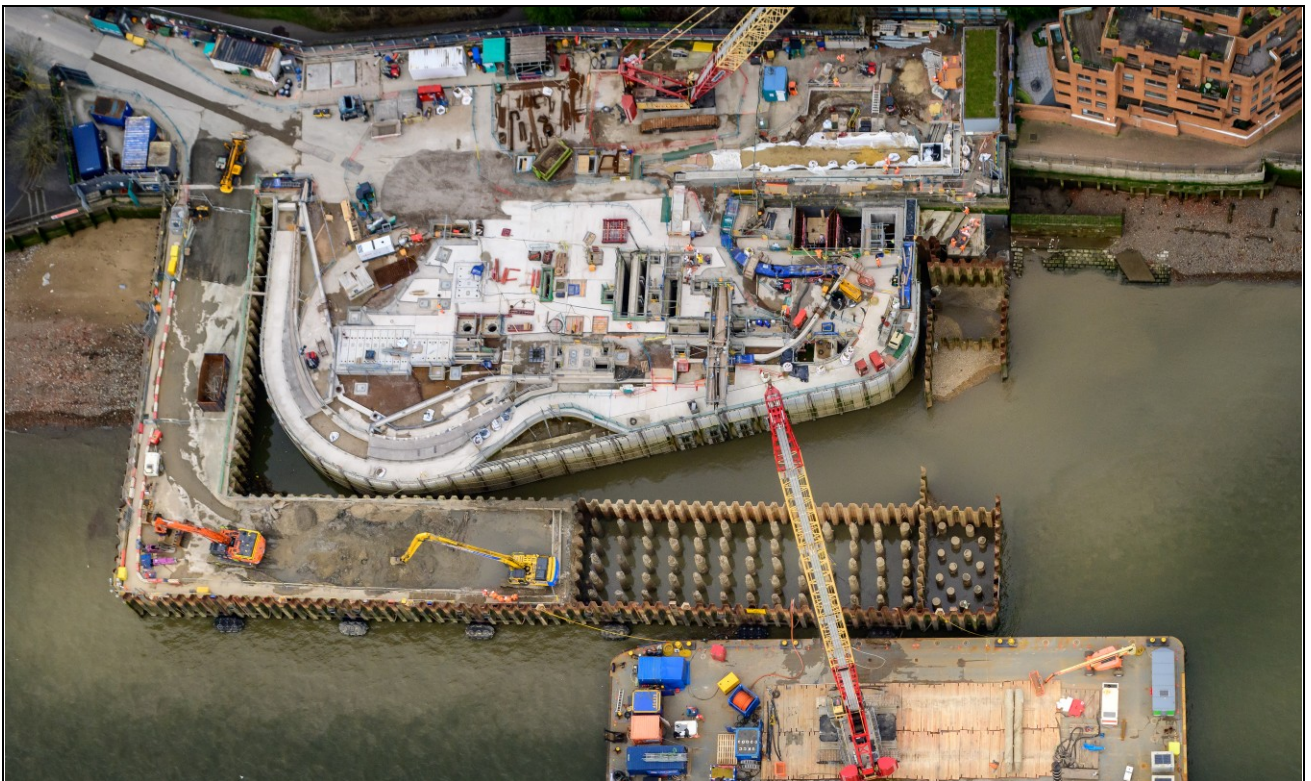


Figure 11. CFA piles in the front cell of the cofferdam exposed during removal (photo credit: Patricia Rayner)

Table 1. Cofferdam ground improvement comparison matrix showing performance criteria of different geotechnical techniques

Performance criteria	Geotechnical technique						
	TrenchMix™ (grid)	DSM	Grouting	Stone columns	Piled columns	Band drains	Consolidation over time
Reduce short-term settlement	✓	✓		✓		✓	✓
Reduce long-term settlement	✓	✓		✓		✓	
Reduce active pressure acting on retaining structures	✓	✓					
Increase passive resistance to support structures	✓	✓					
Reduce local soil collapse for D-walls	✓	✓	✓				
Meet bearing capacity required for temporary live loads		✓			✓		

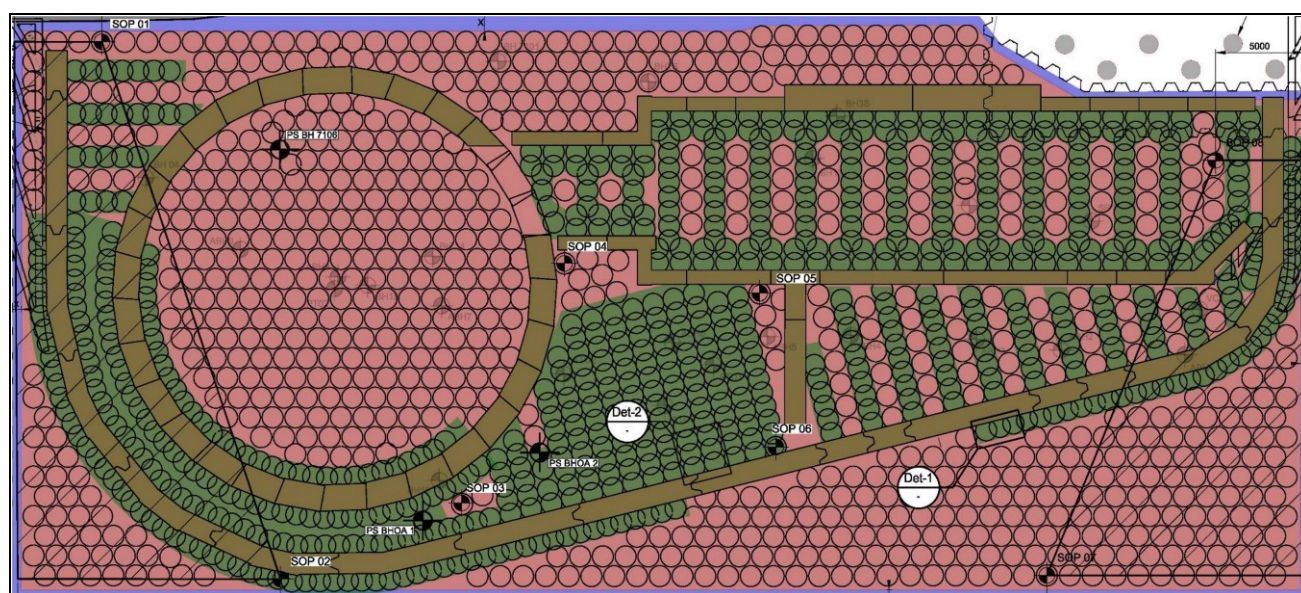


Figure 12. DSM layout showing contiguous (pink) and secanted (green) columns

was proposed. A close column spacing was developed to reduce the applied loads to single columns and effectively meant that the columns acted in panels, which had the additional benefit of restraining adjacent columns, stopping them from detaching and reducing the risk of lateral movement into the D-wall trenches. This had the benefit of reducing active pressure loads acting on the wall, particularly the new cantilever river wall. Where columns provided passive resistance between the interception chamber walls, a similar arrangement was adopted so the row of secanted columns provided an effective ground prop between the interception chamber retaining walls.

The design generally comprised 1.2 m dia. soil mix columns at 1.3 m centre-to-centre spacing, with a secant panel column spacing of 0.9 m. A total of 1425 columns were initially planned (Figure 12). The design unconfined compressive strength (UCS) was 750 kPa, with a requirement that 80% of samples tested exceeded this. The top of the treated columns was intended to vary, consistently penetrating 1 m into the overlying engineered fill.

To ensure the design requirements were met, a campaign of binder dosage trials was implemented, using samples from the ground investigation boreholes drilled in the footprint of the cofferdam. As a result of the ground conditions, two main challenges existed involving the grout mix and the soil mixing process. Firstly, significant pockets of peat and organic clays, which are notoriously difficult to mix, had been found in the borehole campaign across the foreshore. These also had the potential to restrict the compressive strength. Secondly, due to the historical presence of combined sewage discharges in the area, the foreshore contained certain chemical compounds (ammoniacal nitrogen and urea), which could be detrimental to cement strength gain. As a result, 20 different mix design trial specimens were tested for the various soil groups and grout mix combinations by a specialist laboratory (CE Geochem) until the final dosage mix design was determined (Figure 13). The mix was also adjusted across the site where differing soil conditions existed such as in the area where the presence of peat was evident.

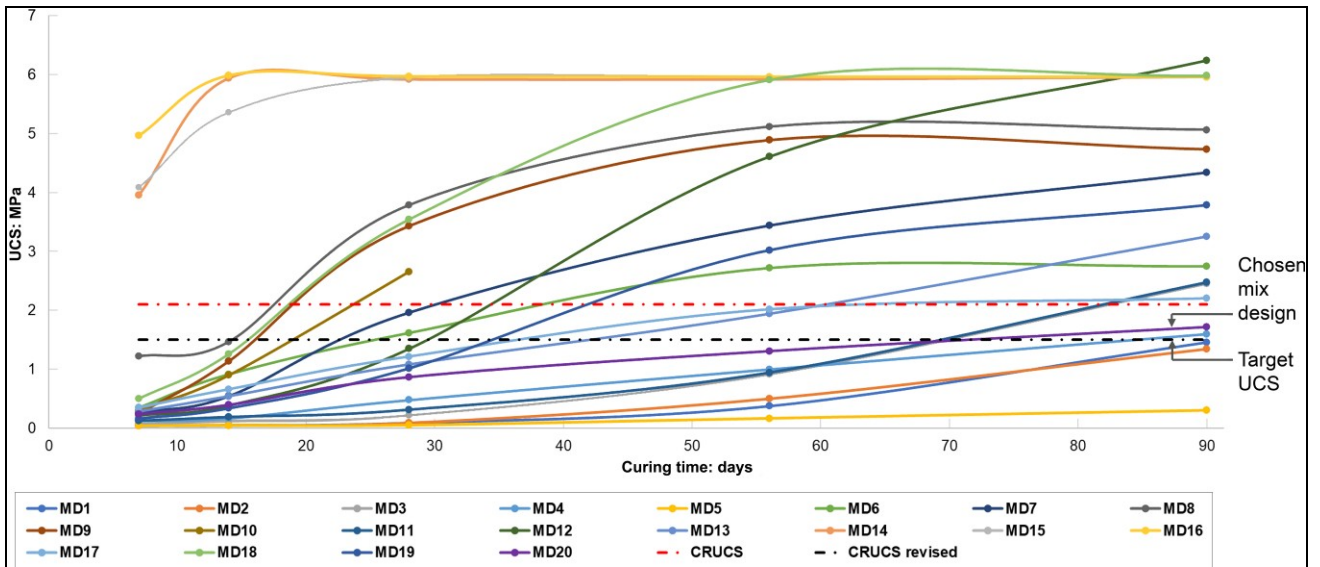


Figure 13. UCSs of different binders used to determine the binder mix design. CRUCS, Critical unconfined compressive strength

Construction began in February 2019 using a Bauer BG28/36 and BG40 rig (Figure 14) and lasted until mid-August 2019. During construction, the number of columns required was rationalised down to 1237. This involved removal of most of the columns within the drop shaft. Due to variations in the binder dosage, depth of treatment and blade rotation number, the drilling equipment was modified to accommodate new automation technology, which meant the parameters of the installation could be predetermined, which ensured a high level of compliance with the design specification. Rigs were fitted with GPS tracking, radio-controlled pumps and automation for rotation speed and penetration rates – this was later identified as an industry first.

During construction of the DSM scheme, the team recovered wet samples from the columns, which were cured and tested to determine if they met the required strength. Initially, the samples showed a higher strength than required, which allowed for the cement ratio in the binder to be reduced. Samples were also taken by coring some of the cured in situ columns. Tests on these samples showed that the required design performance was met by the DSM scheme.



Figure 14. Two piling rigs installing DSM columns working in close proximity

4.4 New connection tunnel as programme mitigation and DCO impact

As the magnitude and complexity of the situation at this site became apparent and potential impacts that the solutions may have on the wider project were recognised, a steering group was established to provide oversight, challenge, support and provide guidance to the team as well as ensuring that the programme leadership team was directly informed. The steering group consisted of representatives from the client, engineering, consents, legal and governance teams.

Early in the process, the CVB team identified that if no other changes were considered in the schedule, then the additional duration required for construction of the cofferdam would result in a tunnelling delay. The tunnel boring machine (TBM) for the main tunnel drive from Chambers Wharf to Abbey Mills Pumping Station would be delayed because the on-line drop shaft at this site would not be ready to receive and relaunch the TBM. Therefore, there would be delay to both CVB's schedule and the overall project's schedule. As the DSM solution developed, it was estimated that the TBM transition at this site would be more than 8 months later than originally planned, with a subsequent delay to the overall project programme by up to 3 months.

To mitigate the time impact, the team initiated a series of studies. A 'drive through' option was considered, where the TBM would transition through the drop shaft at a prior stage in the shaft construction phase than originally planned, which would be prior to construction of the base slab. This would require minimal works to the drop shaft before the TBM passed through the shaft, minimising tunnelling risks. The challenges identified with this solution were excessive stresses on the D-wall that would be difficult to control or mitigate and complex temporary tunnel supports, which would restrict access to the shaft base excavation and construction or cause delay to the tunnelling programme.

Other options were also considered, including (a) pausing the shaft above the tunnel crown and then mining smaller diameter connections to the tunnel, (b) a shorter shaft terminating above tunnel level with a mined lower section and (c) pausing the shaft until after the TBM has passed through.

The drive through option was initially preferred, but Mott MacDonald (the shaft designer) concluded that for the drive through to work, the shaft base slab needed to be in place prior to the TBM transiting the shaft. This resulted in CVB identifying a further alternative option, which, if implemented, would mean that the drop shaft would become an off-line shaft, whereby the shaft would no longer be located on the alignment of the main tunnel. The TBM would pass by the site without impacting the site's cofferdam and drop shaft schedule, thereby mitigating the delay. The off-line shaft option would require the construction of a short connection tunnel between the drop shaft and the main tunnel. The realignment of the main tunnel, away from the drop shaft, would require a non-material amendment to the DCO (HMG, 2014) to change the tunnel's limits of deviation and the order limits.

Understanding the hydraulics for an off-line shaft was critical to confirming if this would be an acceptable solution and these were reviewed for both the immediate location and the wider transient effects (for more information see Plant *et al.* (2020)). It was concluded that there were no significant hydraulic design concerns.

The design for the off-line solution did not identify any significant concerns and there were no new significant effects identified in the Environmental Effects Compliance check that was completed

for the off-line shaft option. Therefore, after stakeholder engagement, the team proceeded with this off-line option, with an application to the Planning Inspectorate and the Secretary of State for the non-material amendment to the DCO (Figure 15). In parallel, separate meetings were held with the project stakeholder's technical advisors and the insurers. This allowed the option to proceed and the project to progress without the risk of a tunnel stoppage at this site.

5. On-line to off-line connection tunnel construction

As part of the redesign of the scheme following the ground condition challenge, the new connection tunnel was designed. A 13 m long and 3.66 m internal diameter SCL and in situ concrete lined tunnel connects the drop shaft to the larger diameter main tunnel.

The primary lining was constructed using SCL techniques, utilising a series of advances and SCL support. Excavation was through very weak to weak, medium dense Seaford Chalk Formation, with all material removed and supplied through the shaft and portal.

The main challenge experienced during construction of the connection tunnel was after the penultimate top heading was completed and the main tunnel extrados was exposed. Movements of the main tunnel exceeded the upper trigger values and the works were therefore paused. A temporary propping scheme was designed and installed to the main tunnel extrados at short notice

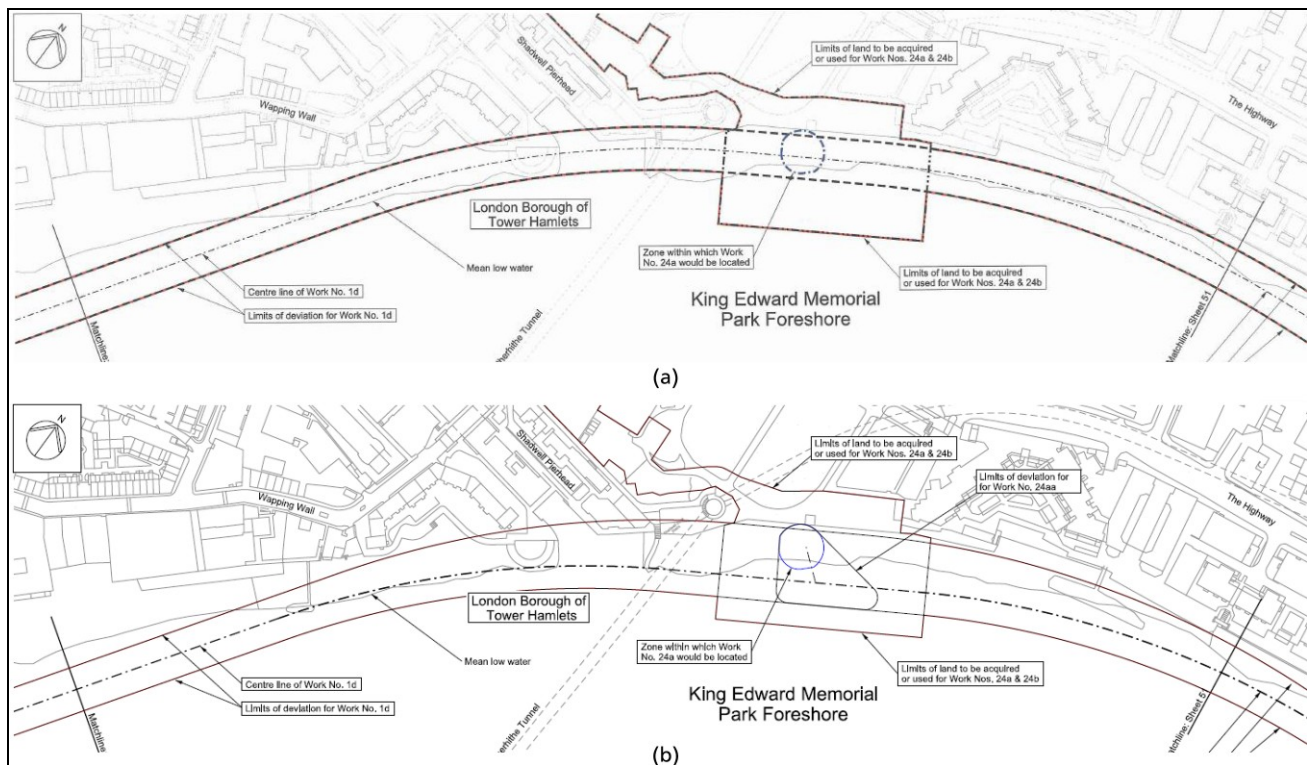


Figure 15. Extracts from the DCO's works plans: (a) main tunnel passing through an on-line shaft (January 2013) (Thames Water, 2013b) (©Thames Water); (b) main tunnel passing to the south east of an off-line shaft (August 2019) (Tideway, 2019)



Figure 16. Connection tunnel – temporary support to the main tunnel segments

(Figure 16). This supplemented the local segment support (additional reinforcement and shear cones); this –coupled with de-pressurisation of groundwater around the main tunnel – prevented further movement.

To maximise the programme opportunity, the sequence was adjusted to allow the section of the secondary lining pours in the drop shaft to be completed ahead of the breakthrough into the main tunnel. To complete the breakthrough, a support frame was erected in the connection tunnel that allowed the cutting and removal of the main tunnel segment sections (weighing up to 4 t) while limiting loading put into both tunnels. A propping frame was also installed in the main tunnel, when the main tunnel TBM drive was completed, to support the opening and the collar pour.

The final secondary lining pour was completed with a modified version of the existing shuttering system, with strict limitations on the pressure that could be applied on the formwork and tunnels. The large mass also led to strict limits on the fresh concrete temperature to prevent damaging heat build-up during curing. To manage this, pressure sensors were installed to the shutters, which allowed the pour rate to be maximised safely, and a piped water-cooling system was designed and cast in, which limited the concrete temperature.

6. Social impacts and improvements

The delivery of works at the King Edward Memorial Park Foreshore brought significant social benefits to the local community and Thames Water's infrastructure. At the planning stage, concerns arose about the potential impact on the historical slipway owned by the Shadwell Basin Outdoor Activity Centre, near the cofferdam. To address safety concerns, Tideway designed and built a modern, safer slipway for the community. Additionally, Tideway invested in the local park's masterplan, supporting its redesign and improvement post-completion. As part of the project, Tideway facilitated the abandonment of disused Thames Water infrastructure in the park and reinforced existing sewers.

Beyond infrastructure, the site team fostered initiatives that shaped the working culture and advanced the construction industry. One such initiative was the creation of the Parents in Construction network, established by joint client and contractor teams on site. The aim of this network was to provide an open, supportive environment for employees managing parenting responsibilities, raise awareness of parental challenges and enhance overall well-being through sharing empowering personal experiences. This supports UN SDG 3: Good health and well-being (UN, 2015).

7. Conclusions

The adoption of standardised components and lessons learnt from other sites contributed significantly to efficiency at the King Edward Memorial Park Foreshore. These practices allowed the site to overcome delays and surpass other sites' delivery programme. Sharing lessons across the joint venture and partner organisations optimised outcomes and reinforced a culture of continuous improvement.

Local improvements – including upgrades to the park, the Shadwell Basin Outdoor Activity Centre and Thames Water's infrastructure – were delivered to bring benefits as part of the works. Initiatives like the Parents in Construction network fostered inclusivity and well-being, leaving a legacy of cultural progress in the construction sector.

The project demonstrated that it is not always possible to fully predict the scope due to limited information during planning. Site investigation was undertaken at the planning stage, but it can be challenging to identify local variations, particularly in tidal foreshore environments. Investing in extensive site investigation in the early stage is essential to manage this risk effectively. The importance of both monitoring the behaviour of structures during construction and reacting to any changes, which may necessitate significant scope changes, should be understood. The requirements for a design life of 120 years and low-maintenance infrastructure influenced the final mitigated design. The principles of collaboration embedded in the NEC3 Contract (NEC, 2013) were instrumental in addressing challenges. The integrated team of client, project manager and contractor and their supply chain working collaboratively enabled swift decision making under time constraints, despite limited information and risk assessments. This approach helped validate the DSM methodologies, adjust tunnel alignments and addressed additional infrastructure needs. Remaining agile and open to making significant changes to methods and the scope of works to generate programme and cost benefits combined with the continuous improvement mindset were the key factors contributing to the success at this site. Having flexibility in planning for such eventualities is a key lesson learnt.

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References

- Barton N (2000) *The Lost Rivers of London*. Historical Publications, London, UK.
- BSI (2006) BS EN 1992-3:2006: Eurocode 2: Design of concrete structures – Liquid retaining and containing structures. BSI, London, UK.
- Fricker S, Lagerberg I, Plant J and Georgaki S (2025) Thames Tideway Tunnel: design responsibilities, phases and system-wide design challenges. *Proceedings of the Institution of Civil Engineers – Civil Engineering*, **10.1680/jcien.25.00054**.
- HMG (Her Majesty's Government) (2014) The Thames Water Utilities Limited (Thames Tideway Tunnel) Order 2014. The Stationery Office, London, UK, Statutory Instrument 2014 No. 2384. See <https://www.legislation.gov.uk/uksi/2014/2384/contents/made> (accessed 26/8/2025).
- HMG (2015) The Construction (Design and Management) Regulations 2015. The Stationery Office, London, UK, Statutory Instrument 2015 No. 51. See <https://www.legislation.gov.uk/uksi/2015/51/contents> (accessed 26/8/2025).
- NEC (2013) *NEC3 Engineering and Construction Contract Option C: Target Contract with Activity Schedule*. Thomas Telford Publishing, London, UK.
- Plant J, Georgaki S, Hon A and Baur R (2020) Mitigating programme critical challenges during deep tunnel construction: Can nimble management and modelling save the day(s)? In *Proceedings of WEFTEC, New Orleans, LA, USA*.
- Thames Water (2013a) Thames Tideway Tunnel Planning Statement, Appendix T. See <https://www.tideway.london/media/2005/701-planning-statement-appendix-t-planning-assessment-king-edward-memorial-park-foreshore.pdf> (accessed 05/09/2025).
- Thames Water (2013b) Works Plan and Section. Main Tunnel Sheet 49, DCO-WP-000-ZZZ-010050. See https://www.tideway.london/media/4193/201_works_plans_and_sections.pdf (accessed 05/09/2025).
- Tideway (2019) Works Plan and Section, Main Tunnel Sheet 49, DCO-WP-000-ZZZ-010050-Rev 1. See https://www.tideway.london/media/7166/dco-wp-000-zzzz-010050-rev-1-august-2019__authorised-1.pdf (accessed 05/09/2025).
- Tideway (2023) Thames Tideway Tunnel River Transport Strategy. See <https://www.tideway.london/media/6296/river-transport-strategy.pdf> (accessed 05/09/2025).
- UN (United Nations) (2015) UN Sustainable Development Goals. See <https://sdgs.un.org/goals> (accessed 05/09/2025).

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