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## **1 INTRODUCTION AND EXECUTIVE SUMMARY**

Metrotidal Lower Thames Pool integrates new flood defences for London with energy storage, a multi-modal tunnel, data storage, utility wayleaves and enabling development for over 250,000 homes with corresponding employment. The integrated infrastructure provides economic growth without an associated increase in carbon audit. This green-growth is achieved through the integration of a flood defence system with a sustainable power plant that generates and stores zero-carbon energy for supply on demand. The sustainable energy offsets the demands of the new transport connectivity, led by rail, and the enabling development. The pool system includes energy-efficient data storage and distribution with an exceptionally low power usage effectiveness (PUE) and new utility wayleaves that serve the enabling development. The proposals also result in the construction of a valuable new deep-water dry dock on the Isle of Grain that is used to cast the Metrotidal Tunnel sections and the subsequent sections for the Sheppey Tunnel c2040.

The result is full-spectrum enabling development in which housing, employment, energy, transport, data, utilities and marine services are co-ordinated to generate green-growth benefits across the Greater Thames Estuary.

## **2 THE METROTIDAL LOWER THAMES POOL AGENDA**

### **2.1 Integration Benefits**

The combination of the separate initiatives into a single, well-integrated infrastructure project reduces the planning overheads, construction costs and environmental impacts while increasing the net economic benefits. Substantial integration benefits are realised by combining separate components for flood defence, sustainable energy storage, multimodal tunnel, data storage and utilities into an orbital network that supports growth across the Greater Thames Estuary region.

## **2.2 Flood defence**

The Metrotidal agenda provides a new system of flood defence to protect London and the Thames Estuary from surge tides through to the 22nd century. The defences are provided in the form of a throttle working in tandem with flood storage capacity to reduce the level of an incoming surge tide. The throttle is located on the shipping channel and the associated flood storage is provided by a pool beside the Hoo Peninsula, with additional emergency capacity across the marshes to the Isle of Grain.

The throttle has a weir with deep-water flood sluices that admit water to the pool during an incoming surge and return it to the sea on the ebb tide. Existing monitoring systems provide over 24 hours' advance-warning of the storm surge. This allows the pool to be drained during the preceding low tide and the flood sluices closed to reserve the maximum flood storage capacity ahead of the surge tide. The variables of the incoming surge waveform and duration are recorded and analysed as the tide advances down the North Sea coast, enabling the most effective use of the available flood storage in the pool to be programmed before the storm surge arrives in the Thames Estuary. The level of the weir and area of the flood sluices are then controlled to suit the programme. If additional flood storage is required in an emergency a weir and flood sluices from the pool allow controlled flooding of the marshes beside the Isle of Grain.

The system is designed to allow the free movement of normal tides while restricting and limiting the incoming storm surge. The throttle and flood storage capacity of the pool then works in tandem with the capacity of the tideway upstream and the existing Thames Barrier to reduce the incoming peak surge. Accordingly, the system protects all the flood risk areas upstream from the throttle including the metropolitan areas and the existing fresh water habitats that remain at risk in the event of a surge tide under the current TE2100 proposals.

The flood defence proposals replace those of the TE2100 programme for which current budget is £1.5bn by 2034. The flood risk to very substantial property, infrastructure and habitat assets upstream is reduced, enabling the Association of British Insurers (ABI) to redirect a proportion of the premia raised under the new Flood Re agreement towards funding the flood storage system, so that government expenditure for the flood defence component will be less than the current £1.5bn budget. The flood storage pool impoundment doubles as a sustainable energy storage system and reduces the construction cost of the multimodal tunnel, consequently increasing the net economic benefits of the integrated system. The resultant net economic benefits are much higher than for the TE2100 investment programme, which addresses only the flood risks.

### **2.3 Sustainable Energy Storage**

The Metrotidal agenda integrates flood storage and tidal power within the same impoundment, enabling the range within the impoundment to be pumped to treble the natural tidal range within the estuary. This allows the tidal power plant to increase peak output when required or store energy in the pool for delivery on demand. The energy for the pumping is provided by solar, wind and tidal power along with the forthcoming option of nuclear power from Bradwell in Essex. The solar energy is provided by floating arrays within the protection of the impoundment that generate up to 50MW per sq.km. The wind energy is provided from the London Array in the outer estuary and the tidal energy from the natural range at the throttle in the Thames generating power through turbines below the flood weir.

The combined solar, wind and tidal pumped-storage system can deliver sufficient energy to offset the energy demands of the multimodal tunnel and new rail systems, leaving surplus energy to be sold to the grid.

## **2.4 Lower Thames Tunnel and Sheppey Tunnel**

The Metrotidal agenda includes a multimodal, D2T2 Lower Thames Tunnel formed from a combination of cut-and-cover and immersed tube tunnel construction techniques. The costs are reduced by maximising the proportion of cut-and-cover and minimising the length of the immersed-tube construction. For a Lower Thames Tunnel running between Leigh-On-Sea in Essex and Allhallows-On-Sea in Kent the pool impoundment reduces the cost of the tunnel by increasing the cut-and-cover approaches and reducing the length of immersed-tube tunnel across the remaining open tideway. The immersed tube tunnel sections are formed in a casting basin on the Isle of Grain, towed into position and sunk into a prepared trench across the open estuary. There is sufficient width in Sea Reach to maintain port operations during the immersed tube tunnel construction. The casting basin subsequently becomes a deep-water dry-dock to service shipping on the Thames and Medway Estuaries and provides the facility to cast the sections for the Sheppey Tunnel 2040.

The multimodal Lower Thames Tunnel completes a Crossrail Plus rail orbital and a highways outer orbital that together provide relief for the M25/Dartford Crossing and serve substantial growth across the Greater Thames Estuary region. On the north bank alternative Crossrail Plus orbitals can be completed via the C2C Basildon Line or the Southend Victoria Line to Crossrail at Shenfield. The rapid growth in population from Central London east along the Thames Estuary places priority on increasing capacity closer to the river hence the C2C route via Basildon is proposed as the initial orbital with the Shenfield orbital a subsequent option c2040.

## **2.5 Lower Thames Tunnel Connections**

### **North Portal Connections**

- new twin tracks alongside the C2C line from Leigh-on-Sea to Upminster, and dualling of the Upminster to Romford line for the extension of Crossrail services from Romford
- a subsequent option of a new connection from South Benfleet to Wickford and new twin tracks alongside the Southend Victoria services to Shenfield for the extension of Crossrail services from Shenfield
- a new passenger and freight chord at Shenfield to the Great Eastern Main Line
- road connection to the A13/A130 at Sadler's Hall Farm
- access to a new Southend Park-and-Ride bus service between Southend Eastern Esplanade and Leigh-On-Sea via the Pier, Western Esplanade, Chalkwell Esplanade and a new Leigh Esplanade that replaces the existing C2C tracks

### **South Portal Connections**

- twin-track rail connection to the Isle of Grain Line, which is dualled from Lower Stoke to Hoo Junction for the extension of Crossrail services from Abbey Wood, with associated line improvements
- a twin-track chord from the Isle of Grain Line to the North Kent Line and Southeastern network services at Strood
- road connection to the A228/A229/A2
- rail connection to Sittingbourne and road connection to the A249 following construction of the Sheppey Tunnel 2040

## **2.6 Data Storage and Utilities**

The Metrotidal Lower Thames Pool system generates and stores energy by moving large volumes of cool seawater between the pool and the sea. Data storage centres require reliable, sustainable energy supplies and efficient cooling systems. Modern Tier 4 centres secure alternative energy supplies for resilience and aim to achieve the lowest power usage effectiveness (PUE: total facility energy divided by the IT equipment energy). Data storage centres also require substantial cooling loads to maintain a steady-state environment for the IT equipment.

The seawater of the Thames Estuary maintains uniform temperatures throughout the year, suitable for providing a steady-state environment for the IT equipment and since the sustainable energy system moves large volumes of sea water this can be used to serve the cooling loads of the data centre, thereby achieving an exceptionally low PUE. The wide range of sustainable energy supplies used for pumping the pool provides additional resilience for the data centre supplies. The transport connections from the tunnel portals provide utility wayleaves for distributing the data across to the enabling developments across the Great Thames Estuary region.

Several existing utilities have key network connections that pass under the estuary not far from the line of the proposed tunnel. The immersed-tube tunnel cross-section includes passages for utilities with the benefit of access for maintenance and renewal. The transport corridors north and south of the tunnel provide routes for extending and connecting existing utility networks across the Greater Thames Estuary region. The utility way leaves (broadband, communications, electricity, gas, mains water and other private-sector services) contribute to tunnel revenues.

The Hoo Peninsula in Kent, one of the driest areas of the country, has a distant fresh water supply, pumped from the Medway Valley. The Lower Thames Tunnel opens a new water

supply grid connection between South Essex and North Kent for a more resilient service with less pumping.

## **2.7 Tunnel Transport Services**

**Crossrail Plus:** (C2C Basildon Branch) The Romford to Upminster single-track LTS Line is dualled and connected to new twin-tracks from Upminster to Leigh-on-Sea alongside the C2C Line, with 4-tracking through the stations at Upminster, West Horndon, Laindon, Basildon, Pitsea and Leigh-on-Sea, to create the Crossrail Plus orbital between Crossrail at Romford through Metrotidal Tunnel to Crossrail at Abbey Wood.

**Crossrail Plus:** (Shenfield Branch) The eastern limb of Crossrail to Shenfield in Essex is extended on a 4-tracked Southend Victoria Line to Wickford and a new twin-track connection to South Benfleet and so on to Leigh-on-Sea to create an alternative Crossrail Plus orbital route on the north bank from 2040, again serving the Greater Thames Estuary and Central London. Both orbital rail routes reconnect populations north and south of the Thames, with the existing and new stations becoming the foci for commercial and residential development.

Crossrail Plus connects with HS1 at Stratford and Ebbsfleet thereby providing convenient connectivity to Northern Europe without requiring access into Central London.

**Crossrail Plus:** (Halling & Peters Village Branch) A branch service of Crossrail Plus from Hoo Junction to Halling on the Medway Valley Line, with two additional platforms at Halling and/or Snodland providing a terminus that serves Peters Village on the east bank of the Medway

**Pitsea-Isle-of-Grain-Strood Shuttle:** A rail shuttle service that links the South Essex conurbation and the Medway Towns, with terminals at Pitsea, the Isle-of-Grain and Strood. The shuttle interconnects with Crossrail Plus at South Benfleet, Leigh-on-Sea, Allhallows-on-Sea, Stoke Harbour, Cliffe and Higham, the C2C services at Pitsea and the Southeastern



Network at Strood, with the option of a branch from the Isle of Grain Line via Hoo Junction and the North Kent Line to Ebbsfleet for access to the Javelin and HS1 services into Central London and the Continent. From 2040 the Isle of Grain line can be connected through the Sheppey Tunnel to extend the shuttle rail services through Queenborough, Swale and Kemsley to Sittingbourne.

**Rail freight services:** A rail-freight bypass to the east of London, via the new chord at Shenfield, opens a new long distance freight route between the Haven Ports, Thames Estuary and the Channel Tunnel. The Sheppey Tunnel opens an alternative freight route between Kent, the Thames Estuary and the Haven Ports.

**Road connections:** A new D2 highway between the A13/A130 at Sadlers Hall Farm and the A228/A289 on the Hoo, followed by a D2 connection to the A249 through a Sheppey Tunnel after 2040. The initial connection serves the enabling development across the Thames estuary region outside the M25 orbital and provides an alternative HGV road-freight route between Dover Docks and the Midlands that avoids the congested M20/M25/Dartford Crossing/M11. The current journey from Dover Docks to the A120/M11 junction northbound lane, via the A20/M20/M25/Dartford Crossing/M11 is 158km. The distance of the alternative route, via the A2/A289/A228/A130/A12/A131/A120/M11 is 179km. After the Sheppey Tunnel opens in 2040 the alternative route from Dover Docks to the Midlands via the A2/A249/A228/A130/A12/A131/A120/M11 is 163km. Improvements to the M2/A249 and A131/A120 junctions can reduce this to 158km, matching the existing journey, again without use of the M20, M25 Dartford Crossing or M11 up to the A120 junction.

**Southend Park-and-Ride:** a new shuttle bus service between Southend Eastern Esplanade and Leigh-on-Sea Station Carpark via the Pier, Western Esplanade, Chalkwell Esplanade and a new Leigh Esplanade that replaces the existing C2C tracks

## 2.8 Enabling Development

**Residential Development:** Growth-zones for over 250,000 homes, including the Shelter Wolfson Prize 2014 Housing Scheme on the Hoo Peninsula and Peters Village on the Medway, served by the stations of the Crossrail Plus orbital, the Pitsea-Isle-of-Grain-Strood Shuttle and the adjoining C2C and Southeastern networks.

**Commercial Development:** Office developments served by the stations of the Crossrail Plus orbital, the Pitsea-Isle-of-Grain-Strood Shuttle and the adjoining C2C and Southeastern networks.

**Industrial Development:** New industrial development on existing sites at the London Gateway Port, Basildon, Canvey Island, Isle-of-Grain, Kingsnorth, Hoo Junction, the Medway City Estate and Strood with convenient employee access provided by the Crossrail Plus orbital, Pitsea-Isle-of-Grain-Strood shuttle and the adjoining C2C and South-eastern networks. Additional connectivity for these sites, the industrial sites at Sheerness and Queenborough on the Isle of Sheppey and for the Swale, Kemsley and Sittingbourne in Kent after 2040 with the opening of the Sheppey Tunnel and the Shenfield chord.

**Benfleet Esplanade:** The existing station and rail tracks through Benfleet are replaced by a new 4-platform station and underpass beneath Benfleet Esplanade accompanied by commercial and residential development that restores South Benfleet to Benfleet-on-Sea.

**Leigh Esplanade:** The existing station and rail tracks through Leigh-on-Sea are replaced by a new 4-platform station and underpass beneath the existing station car park. This becomes the terminus of Leigh Esplanade, which runs on the line of the existing tracks through Leigh-on-Sea to Chalkwell, accompanied by commercial and residential development that restores Leigh to being on-Sea.

**Southend Park-and-Ride:** Mixed use commercial development over the new station and underpass at Leigh-on-Sea to receive visitors arriving via the tunnel and its connections and distribute them to the attractions of the Southend seafront via the Southend-Park-and-Ride service. Along with the enhanced rail access Leigh-on-Sea becomes a principal portal for visitors to the Southend conurbation thereby easing traffic on the notoriously congested A13 and A127 arteries.

The combination of one or more of the proposed East London Rivers Crossings upstream of the Dartford Crossing with the Metrotidal Lower Thames Pool downstream of the Dartford Crossing means that no work is required at the Dartford Crossing. The TE2100 proposals would be cancelled. Consequently, the budgets of £4.3-4.9bn for the Highways England LTC proposals and £1.5bn for the TE2100 to 2034 can be redirected to realising the Metrotidal Lower Thames Pool proposals, resulting in much higher outputs.

## **2.9 Counter-Cyclical Commuting-Capacity**

The proposals enable the trains that would have terminated on the eastern limbs of Crossrail at Shenfield and Abbey Wood to continue around the orbital and return on the opposite sides of the estuary. The present radial configuration of Crossrail is designed to serve the diurnal radial commuting pattern into Central London, with trains running largely empty in the opposite directions during peak hours. The Crossrail Plus orbital system around the Thames estuary provides the same Central London diurnal commuter capacity but will also make full use of the counter-cyclical commuter-capacity to serve growth across the Greater Thames Estuary region. Journeys that would have run empty can now provide the rail capacity to serve settlements around the Thames Estuary without requiring journeys into Central London. Over 250,000 new homes and corresponding new employment across the Greater Thames Estuary region can be accommodated without increasing journeys into Central London.

Furthermore, the new orbital capacity will ease congestion and improve the resilience of existing radials by providing alternative routes into Central London. Basildon and the South Essex conurbation will have the option to travel south to Ebbsfleet and on to St. Pancras, while the Medway Towns can travel via the 4-tracked C2C and Great Eastern mainlines to Liverpool Street and Fenchurch Street.

## **2.10 Environmental Benefits**

The environmental impact of the pool is assessed in terms of the impacts on intertidal and low-lying freshwater habitats. The area of St. Mary's Marshes to be occupied by the pool is already identified for managed retreat by the current TE2100 programme. The impacts on the remaining intertidal area occupied by the pool are offset by the benefits of protecting the intertidal areas upstream from tidal squeeze and from protecting large areas of low-lying freshwater habitat from a storm surge. When the zero-carbon energy generated and stored by the system is taken into account the net environmental benefits are substantial.

## **2.11 Green-Growth**

The integrated infrastructure provides economic growth without an associated increase in carbon audit. This green-growth is achieved through the integration of a flood defence system with a sustainable power plant that generates and stores zero-carbon energy for supply on demand. The sustainable energy offsets the demands of the new transport infrastructure and the enabling development. The sustainable pool system includes energy-efficient data storage and distribution with an exceptionally low power usage effectiveness (PUE) and new utility wayleaves that serve the enabling development. The result is full-spectrum enabling development in which housing, employment, energy, transport, data and utilities are co-ordinated to generate green-growth benefits across the Greater Thames Estuary region.

## **2.12 Agglomeration Benefits**

New transport infrastructure creates an agglomeration benefit if the resulting economy exceeds the sum of the separate economies and the cost of the new transport links. Traditional agglomeration operates radially drawing satellite settlements into an ever-expanding urban nucleus. The Metrotidal Lower Thames Pool generates orbital agglomeration that spreads demand and capacity more uniformly.

The economic history of London can be seen as a series of agglomeration benefits, first from the Roman Bridge agglomerating the trade routes of the Thames Estuary with a radial road network spreading inland, accelerated by development of the regions, expanding sea trade, subsequent bridges, docks, warehouses and offices, all in turn rapidly increasing the urban economy and drawing in yet more investment. After WW2 the relocation of the port and trade from the Thames Estuary led to the contraction and separation of the economies in Essex and Kent. The Thames Estuary, for centuries the main artery of trade uniting the region into a single riparian economy from Central London to the coast, had become a barrier to growth. As a result, there are latent agglomeration benefits to be realised simply by re-uniting the economies north and south of the Thames through improved transport infrastructure. A relatively modest investment in new connectivity provides a large agglomeration benefit across the Greater Thames Estuary region. The Metrotidal Lower Thames Pool provides the new connectivity and enabling development, placing emphasis on orbital connectivity rather than extending existing radials. The congestion of Inner London arteries is avoided while full use is made of the counter-cyclical commuting capacity around the orbital, providing greater transport capacity for lower cost and higher agglomeration benefits.

The integration of the multimodal transport orbitals with flood defence, sustainable energy storage, data distribution, utilities and enabling development provides green-growth across the Great Thames Estuary region.