Annex B2.7: Navigation Assessment Report

Standard Gate two submission for London Water Recycling SRO

Notice – Position Statement

This document has been produced as the part of the process set out by RAPID for the development of the Strategic Resource Options (SROs). This is a regulatory gated process allowing there to be control and appropriate scrutiny on the activities that are undertaken by the water companies to investigate and develop efficient solutions on behalf of customers to meet future drought resilience challenges.

This report forms part of suite of documents that make up the 'Gate 2 submission.' That submission details all the work undertaken by Thames Water in the ongoing development of the proposed SRO. The intention at this stage is to provide RAPID with an update on the concept design, feasibility, cost estimates and programme for the schemes, allowing decisions to be made on their progress.

Should a scheme be selected and confirmed in the Thames Water final Water Resources Management Plan (WRMP), in most cases it would need to enter a separate process to gain permission to build and run the final solution. That could be through either the Town and Country Planning Act 1990 or the Planning Act 2008 development consent order process. Both options require the designs to be fully appraised and, in most cases, an environmental statement to be produced. Where required that statement sets out the likely environmental impacts and what mitigation is required.

Community and stakeholder engagement is crucial to the development of the SROs. Some high-level activity has been undertaken to date. Much more detailed community engagement and formal consultation is required on all the schemes at the appropriate point. Before applying for permission Thames Water will need to demonstrate that they have presented information about the proposals to the community, gathered feedback and considered the views of stakeholders. We will have regard to that feedback and, where possible, make changes to the designs as a result.

The SROs are at a very early stage of development, despite some options having been considered for several years. The details set out in the Gate 2 documents are still at a formative stage.

Disclaimer

This document has been written in line with the requirements of the RAPID Gate 2 Guidance and to comply with the regulatory process pursuant to Thames Water's statutory duties. The information presented relates to material or data which is still in the course of completion. Should the solutions presented in this document be taken forward, Thames Water will be subject to the statutory duties pursuant to the necessary consenting process, including environmental assessment and consultation as required. This document should be read with those duties in mind.

LONDON EFFLUENT REUSE SRO

Annex B.2.7. Navigation Assessment Report

Report for: Thames Water Utilities Ltd

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1. INTRODUCTION

This report is part of series of Environmental Assessment Reports which catalogue the set of environmental assessments of the London Effluent Reuse Strategic Resource Option (SRO) through RAPID Gate 2: *Detailed feasibility, concept design and multi-solution decision making* and onward to RAPID Gate 3: *Developed design, finalised feasibility, pre-planning investigations and planning applications*. The reports set out the environmental assessments, which will in turn support regulatory assessment requirements proportionate to RAPID Gate 2 and onward to RAPID Gate 3. The scope and approach to the environmental evidence provided in these reports was set out in the Gate 2 Scoping Report and consulted on with the National Appraisal Unit (NAU) in November 2021.

This document has been produced as the part of the process set out by RAPID for the development of the Strategic Resource Options (SROs). This is a regulatory gated process allowing there to be control and appropriate scrutiny on the activities that are undertaken by the water companies to investigate and develop efficient solutions on behalf of customers to meet future drought resilience challenges.

This report forms part of suite of documents that make up the 'Gate 2 submission.' That submission details all the work undertaken by Thames Water (TWUL) in the ongoing development of the proposed SRO. The intention at this stage is to provide RAPID with an update on the concept design, feasibility, cost estimates and programme for the schemes, allowing decisions to be made on their progress.

Should a scheme be selected and confirmed in the TWUL final Water Resources Management Plan (WRMP), in most cases it would need to enter a separate process to gain permission to build and run the final solution. That could be through either the Town and Country Planning Act 1990 or the Planning Act 2008 development consent order process. Both options require the designs to be fully appraised and, in most cases, an environmental statement to be produced. Where required that statement sets out the likely environmental impacts and what mitigation is required.

Community and stakeholder engagement is crucial to the development of the SROs. Some high-level activity has been undertaken to date. Much more detailed community engagement and formal consultation is required on all the schemes at the appropriate point. Before applying for permission TWUL will need to demonstrate that they have presented information about the proposals to the community, gathered feedback and considered the views of stakeholders. We will have regard to that feedback and, where possible, make changes to the designs as a result.

The SROs are at a very early stage of development, despite some options having been considered for several years. The details set out in the Gate 2 documents are still at a formative stage.

1.1 LONDON EFFLUENT REUSE STRATEGIC RESOURCE OPTIONS

For Gate 2, the London Effluent Reuse SRO is set out as four source options and a range of sizes. Three of the options are in west London, utilising crude sewage or final effluent from Mogden sewage treatment works (STW) to a maximum total reduction of 200 Ml/d, with differing London effluent reuse scheme discharge locations in the freshwater River Thames. One option is in east London, utilising final effluent from Beckton STW.

Full details of the conceptual design of the four schemes are provided in the Conceptual Design Reports[1] (CDR) (Annex A). For assessment purposes no specific mitigation is allowed for unless included as part of option design as set out in CDR (other than the Annex B.3. Habitats Regulations Assessment (HRA) Stage 2 and Annex B.5. Initial Environmental Appraisal (IEA)) which has regard for additional mitigation as per the ACWG methodology). A DRA intake would include appropriate fish screening and all new outfalls would include appropriate eel management measures.

High level summaries of each option are provided below.

1.1.1 Beckton water recycling scheme

Final effluent from Beckton STW would be treated at a new advanced water recycling plant (AWRP) within Beckton STW for advanced treatment. Recycled water would be conveyed via a new tunnel from the Beckton

[1] Jacobs (2022) London Reuse Strategic Resource Option, Gate 2 Conceptual Design Reports.

AWRP to Lockwood Pumping Station and then a TLT extension from Lockwood Pumping Station to a proposed new outfall located on a side channel of the freshwater Lee Diversion, known as the Enfield Island Loop, upstream of the existing Thames Water Enfield intake to the King George V Reservoir. Additional abstraction for public water supply on a put/take basis would be through existing intakes in the lower Lee, to supplement the raw water supply to the Lee Valley reservoirs.

The Beckton water recycling scheme has been assessed for Gate 2 independently at 100 Ml/d, 200 Ml/d, 300 Ml/d.

1.1.2 Mogden water recycling scheme

Final effluent from Mogden STW would be pumped in a new pipeline to a new AWRP located at a site near Kempton water treatment works (WTW)) for advanced treatment via a. Recycled water would be transferred in a new pipeline for discharge into the freshwater River Thames at a new outfall upstream of the existing Thames Water Walton intake. Additional abstraction for public water supply on a likely put-take basis would be through existing downstream intakes on the River Thames. AWRP wastewater and reverse osmosis (RO) concentrate would be conveyed back to Mogden STW inlet works via a return pipeline(s). There is an option that the AWRP wastewater could be discharged to the South Sewer for return to Mogden STW, but it is not possible to return the RO concentrate by this means. The option reduces the final effluent at the extant Mogden STW outfall to the estuarine Thames Tideway.

The Mogden water recycling scheme has been assessed for Gate 2 independently at 50 Ml/d, 100 Ml/d, 150 Ml/d and 200 Ml/d.

1.1.3 Mogden South Sewer scheme

Crude sewage would be diverted from the South Sewer of the sewerage catchment of Mogden STW. The South Sewer runs close to Kempton Park WTW and the diverted sewage would be pumped to a new AWRP located at a site near Kempton WTW for advanced treatment. Recycled water would be transferred in a new pipeline for discharge into the freshwater River Thames at an outfall upstream of the existing Thames Water Walton intake, potentially upstream of the Affinity Water Walton intake. Additional abstraction for public water supply on a likely put-take basis would be through existing downstream intakes on the River Thames. Waste streams from the AWRP would be conveyed by a new pipeline and treated at Mogden STW. The scheme reduces the final effluent at the extant Mogden STW outfall to the estuarine Thames Tideway.

The Mogden South Sewer scheme has been assessed for Gate 2 at 50 Ml/d.

During Gate 2, Thames Water took the decision to pause development of the Mogden South Sewer scheme due to limitations on available flow, cost of the scheme and regional modelling not selecting under any water resources planning horizon scenario. The Gate 1 concept design is therefore used in Gate 2, with the exception where scheme elements are shared with the Mogden water recycling scheme (certain conveyance routes, AWRP and discharge location) which have been further developed through Gate 2. Due to the similarities of the Mogden South Sewer scheme with the 50 Ml/d Mogden water recycling scheme (treatment, conveyance, discharge location and discharge volume), the navigation assessment of the Mogden water recycling scheme is considered representative of the Mogden South Sewer scheme. A dedicated navigation assessment of the Mogden South Sewer scheme has not been undertaken.

1.1.4 Teddington DRA scheme

Final effluent from Mogden STW would be subject to further treatment at a tertiary treatment plant (TTP) at Mogden STW. The treated water would be transferred in a new pipe-jacked tunnel for discharge into the freshwater River Thames at a new outfall upstream of the tidal limit at Teddington Weir. Additional abstraction for public water supply on a take-put basis would be through a new intake from the freshwater River Thames, upstream of the new outfall. Abstracted water would be pumped into the nearby Thames-Lee Tunnel for transfer to Lockwood pumping station, part of Thames Water's Lee Valley reservoirs in North London.

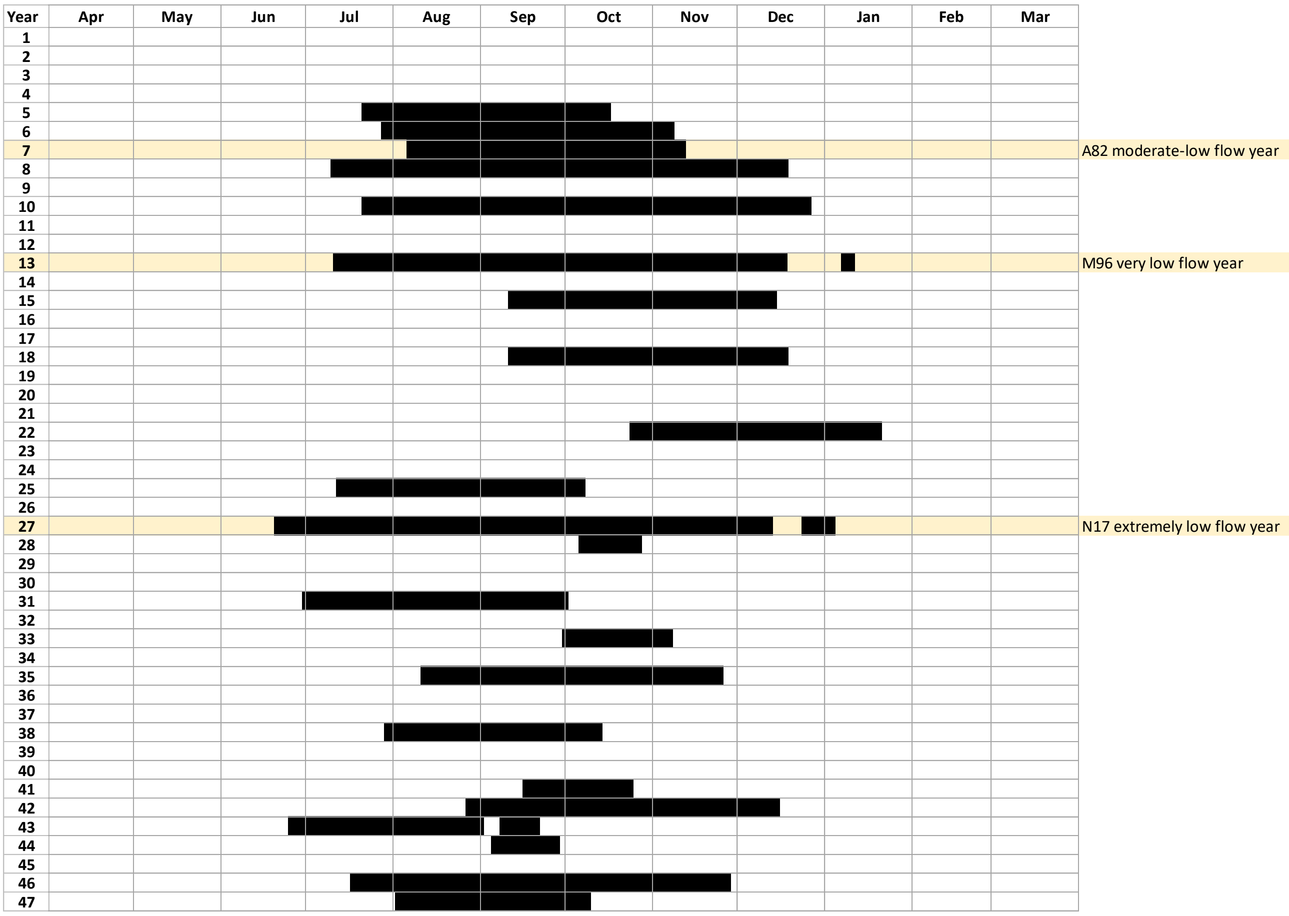
The Teddington DRA scheme has been assessed for Gate 2 independently at 50 Ml/d, 75 Ml/d, 100 Ml/d and 150 Ml/d.

1.2 LONDON EFFLUENT REUSE SRO OPERATING PATTERN

To support the environmental assessments at Gate 2, an indicative operating pattern has been developed. The approach uses the 19,200-year stochastic flow series developed for the River Thames catchment for the

Water Resources South East group (WRSE). The stochastic flow series represent contemporary climate conditions and provide information on the return frequency, or regularity, of both the likely river flow conditions and SRO operation. The stochastic years have been made available as 48-year continuous periods, and one of those has been selected as having representative flow characteristics to inform the environmental assessments. The selected 48-year series[2] includes a suitable range of regular low and moderate low flow periods. It does not include extreme low flows that are considered to be less regular than once every fifty years. It should be noted that this operating pattern is for the SRO solution used on its own for Thames Water, without conjunctive use with other Thames Water SROs (such as SESRO). It also uses the controlling triggers developed by Thames Water for current strategic resource options (such as Thames Gateway Water Treatment Plant) based on lower River Thames flows and Thames Water's total London reservoir storage. The indicative pattern is shown in **Figure 1-1**, noting that outside the normal operating pattern the Gate 2 engineering design for Mogden water recycling and Teddington DRA schemes includes a 25% plant maintenance flow at all times, with the treated water being discharged to the River Thames at Walton Bridge or upstream of Teddington Weir (respectively) but not re-abstracted. Outside the normal operating pattern the Gate 2 engineering design for the Beckton water recycling scheme includes a 15 Ml/d tunnel maintenance flow at all times, with the treated water being discharged to the Enfield Island Loop of the Lee Diversion Channel.

Figure 1-1 Representation of the operational pattern of Beckton water recycling option as used in the Gate 2 environmental assessments



Within these patterns, selected return frequencies have been selected for the detailed assessment including modelling used extensively in the assessments presented for Gate 2. These are a 1:5 return frequency year with moderate-low flows in the River Thames at Teddington with a 1:5 return frequency operating pattern in terms of duration and season (model reference A82). Also a 1:20 return frequency year with very low flow years in the River Thames at Teddington with a 1:20 return frequency operating pattern in terms of duration and season (model reference M96). Noting the scheme would only be used on a 1:2 return frequency, these

[2] Note these are 48 calendar years. The environmental assessment period has been selected as a water resources year (1 April to 31 March) and as such the selected period includes 47 water resources years from the 48 calendar years,

capture a suitable range of circumstances and have been discussed and reviewed with the regulators during Gate 2. In addition, a 1:50 return frequency year of extremely low flows in the River Thames at Teddington and with a 1:20 return frequency operating pattern in terms of duration and season (model reference N17), has been prepared and reviewed for consideration of scheme resilience. Such a low return frequency is outside the regularity of occurrence included in WFD assessments and is not described further in this report.

1.3 THE PURPOSE OF THIS REPORT

The purpose of this series of Assessment Reports is to set out the environmental baseline for each reach of the full study area to identify the source of greatest potential magnitude of change that a London water recycling SRO might cause within that reach, and then assess the potential for change to environmental pathways (physical environment and water quality) and receptors (aquatic ecology). The report identifies where additional data and/or more detailed analysis is required in Gate 3 as the London water recycling SRO designs are developed and operating regimes refined. The findings of these reports provide the evidence base to inform the Annex B.3. HRA, Annex B.4. Water Framework Directive (WFD) and Annex B.5.EA assessments.

This report provides the assessment for the Gate 2 Navigation topic. **Table 1-1** outlines the task and approach to assessment for the navigation assessment for Gate 2 of the London water recycling SRO. It also outlines the evidence base that has been used to undertake the assessment. The estuarine sediment assessment task item is reviewed in more detail within the London water recycling SRO Gate 2 Annex B.2.1. Physical Environment Assessment Report. The scope and approach to this assessment has been developed through consultation with the Port of London Authority (PLA).

Table 1-1 Tasks and assessment approach to the physical environment assessment for London Reuse SRO

Task item	Scope of assessment	Approach to assessment	Evidence Base for Task
Estuarine sediment assessment	• Develop and agree key assessment points to understand any sediment changes in the estuary	• Interrogate modelled sediment dynamics output (estuarine TELEMAC model) to • Describe variability in sediment dynamics during reference conditions and with reuse option scenarios.	• Tideway TELEMAC modelling outputs.
Navigation assessment	• Develop and agree with PLA further tidal navigation assessment scope, including model requirements	• Interrogate estuarine TELEMAC modelling outputs to describe variability in navigation effects during reference conditions and with reuse option scenarios.	• Tideway TELEMAC modelling outputs.

The study area for the London water recycling SRO has been divided into the following watercourses:

- The freshwater River Thames from Shepperton Weir to the tidal limit at Teddington, noting the 1D river model boundary is Cricklade in the upper catchment of the River Thames
- Channels of the freshwater Lee from Newman's Weir on the Enfield Island Loop to the tidal limit at Three Mills Lock
- The estuarine Thames Tideway from the tidal limit at Teddington, including the Richmond Pound, to 3km seawards of Beckton STW outfall, noting the estuarine model boundary is at Southend-on-Sea.
- The estuarine Bow Creek (tidal Lee) from Three Mills Lock to the Thames Tideway.

This report focusses on the estuarine Thames Tideway for the navigation assessments.

The findings of the report are used to support the Annex B.5. IEA of the London Effluent Reuse SRO.

Section 2 of this report provides a high-level overview of the reference conditions for the zone of influence of the London Effluent Reuse SRO sub-options. Sections 3, 4 and 5 provide the navigation assessment for each SRO sub-option included in the Gate 2 submission. Section 6 provides a summary of the additional data and assessment required during Gate 3.

2. REFERENCE CONDITIONS

2.1 INTRODUCTION

In order to inform the assessment for navigation set out in **Table 1-1**, this section establishes the reference conditions as per the relevant study areas.

The Port of London Authority (PLA) has particular concerns about any limitation on the ability of vessels of various draughts to navigate in the upper Tideway around low water when a London water recycling scheme is in operation. This report assesses the navigational impacts of London water recycling SRO at Gate 2 by comparing the baseline conditions to the worst-case scenario for each of the SROs, and assessing the impact that this is expected to have on the ability of vessels to navigate the upper Tideway.

These reference conditions occur during different patterns of river flow and STW final effluent flow (see **Section 1.1**), with a 1:5 return frequency moderate-low flow year; and a 1:20 return frequency very low flow year used as the reference conditions for this assessment.

The 2D/3D Thames Tideway Telemac model has been used to provide the worst-case scenario predictions for each of the London Effluent Reuse SRO options

2.2 SHOAL CONDITIONS IN THE STUDY AREA

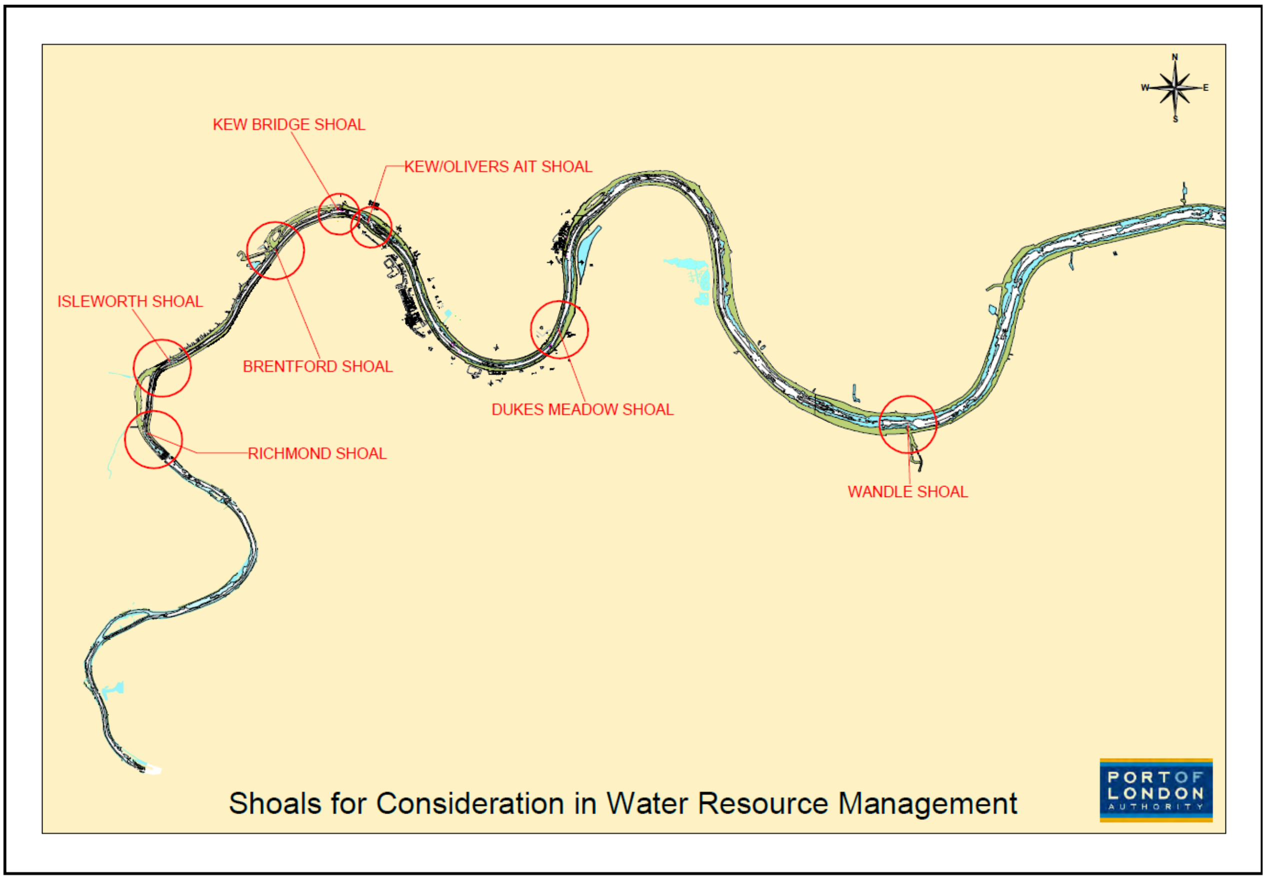
There are seven locations which the PLA has set out for consideration in Water Resource Management that could affect navigation. These shoal locations are shown in **Figure 2-1** and indicate areas where there is a localised shallowing of the water that can restrict the navigation of the estuarine Thames Tideway. The duration of navigational restriction at each of the shoal location has been compared to the baseline conditions at these locations. These shoal locations experience navigation restrictions under existing baseline conditions, which are presented in **Table 2-1** for vessels with 0.5m, 1m, 2m and 3m draughts during average low water under both moderate low and very low flow conditions.

Table 2-1 Baseline average low water navigational restriction duration for vessels of different draughts during a moderate and very low flow year (6 August – 12 November) (all values in HH:MM)

Shoal Location	Vessel Draught (m)	Moderate Low Flow Baseline	Very Low Flow Baseline
Richmond	0.5	00:00	00:00
	1	04:06	04:24
	2	07:02	07:05
	3	08:38	08:39
Isleworth	0.5	00:00	00:00
	1	04:25	04:36
	2	07:05	07:09
	3	08:40	08:42
Brentford	0.5	01:25	02:08
	1	05:14	05:22
	2	07:25	07:27
	3	09:00	09:00
Kew Bridge	0.5	01:00	01:22
	1	04:23	04:28
	2	06:53	06:56
	3	08:35	08:37
Kew/Olivers	0.5	00:00	00:00

Shoal Location	Vessel Draught (m)	Moderate Low Flow Baseline	Very Low Flow Baseline
	1	02:37	02:53
	2	06:14	06:17
	3	08:06	08:07
Dukes Meadow	0.5	00:00	00:00
	1	01:24	01:33
	2	05:28	05:30
	3	07:24	07:25
Wandle	0.5	00:00	00:00
	1	00:53	00:56
	2	03:52	03:55
	3	05:52	05:55

Figure 2-1 Shoal Locations used for Navigation Depth Restriction Analysis

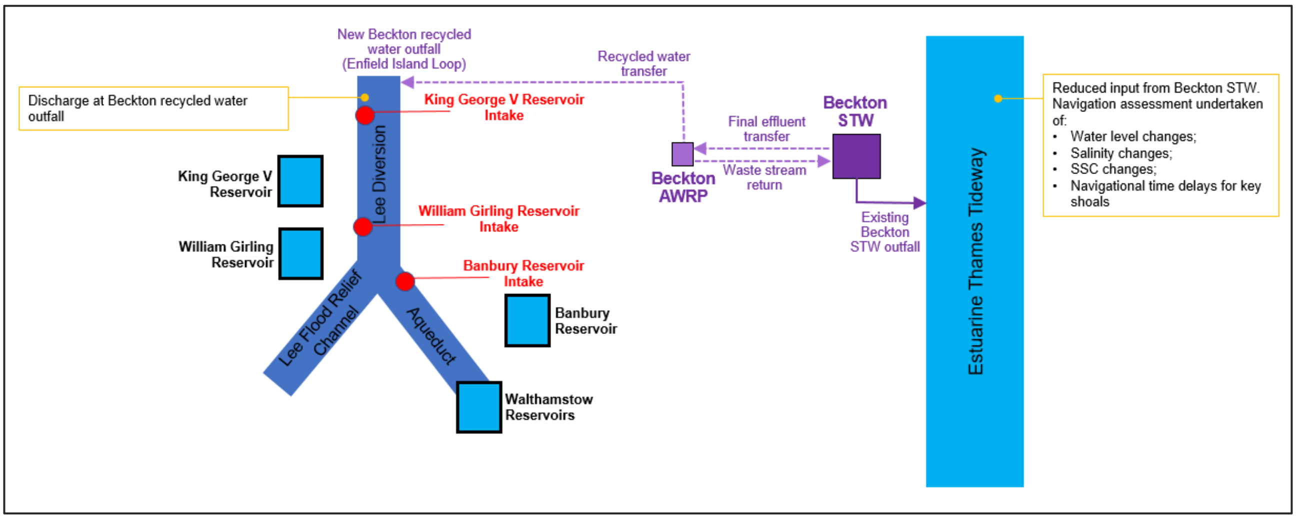


3. NAVIGATION ASSESSMENT OF BECKTON WATER RECYCLING SCHEME

3.1 INTRODUCTION

For the Beckton water recycling scheme, the assessment for navigation set out in **Table 1-1** is detailed in this section. A Beckton water recycling scheme would increase flows in the Enfield Island Loop of the Lee Diversion Channel upstream of Thames Water's Enfield intake by 100-300 Ml/d (dependent on option assessed) when in use for water resources purposes, and at 15 Ml/d at other times. When operational for water resources purposes, flow augmented by a Beckton water recycling option would typically be re-abstracted at Thames Water's Enfield intake to King George V Reservoir or at Thames Water's Chingford South intake to William Girling Reservoir, 3.4 km downstream on the Lee Diversion channel. There may be some operational circumstances where a Beckton water recycling scheme would also enable increased abstraction rates at Thames Water's Chingford Supply Channel intake to the Lower Lee Reservoir's Walthamstow Reservoir Group. Final effluent flows from Beckton STW discharged to the estuarine Thames Tideway at Beckton would reduce by the corresponding amount to the amount transferred to the Enfield Island Loop of the Lee Diversion Channel. This is shown spatially in the conceptualisation of physical environment effects in **Figure 3-1.**

Figure 3-1 Representation of the Beckton water recycling aquatic study area with conceptualisation of navigation effects and listing of assessments undertaken for Gate 2



3.2 BECKTON WATER RECYCLING WATER LEVEL CONDITIONS IN THE STUDY AREA

The option with the maximum final effluent reduction from Beckton STW of 300 Ml/d for the Beckton water recycling scheme was modelled by HR Wallingford to determine the maximum change in the minimum and mean water level along the estuarine Thames tideway while the scheme is operational. **Figure 3-2** shows the modelled minimum water levels along the thalweg (deepest part of a river's cross-section, normally indicating the navigable channel) for a moderate low flow year (A82) for baseline (blue line) and with a 300 Ml/d Beckton water recycling scheme operating (red line), while **Figure 3-3** shows the modelled minimum water levels for a very low flow year (M96) for baseline and with scheme. In each of these scenarios, there is a negligible change in the minimum water level longitudinally along the estuarine Thames Tideway, with no discernible difference between the baseline minimum water level and minimum water level when the 300 Ml/d Beckton water recycling scheme is operational. Consequently, the change in minimum water levels in the estuarine Thames Tideway due to Beckton water recycling is expected to have a **negligible** effect on the vessels ability to navigate along the estuarine Thames Tideway.

Figure 3-2 Minimum water level along thalweg during scheme operation (6 August- 12 November), A82, baseline and B300 scheme, Teddington to QE2 bridge

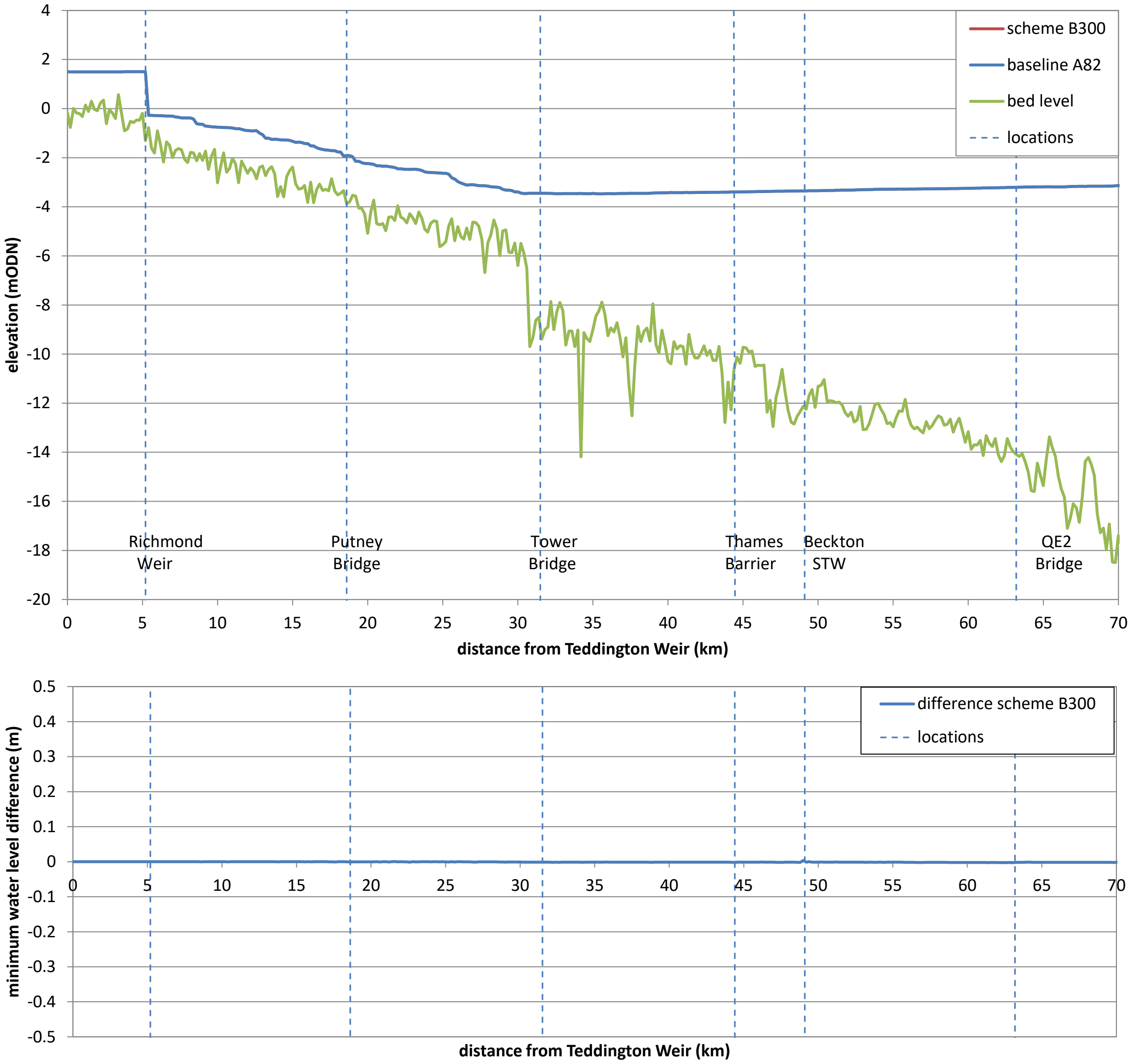


Figure 3-3 Minimum water level along thalweg during scheme operation (6 August- 12 November), M96, baseline and B300 scheme, Teddington to QE2 bridge

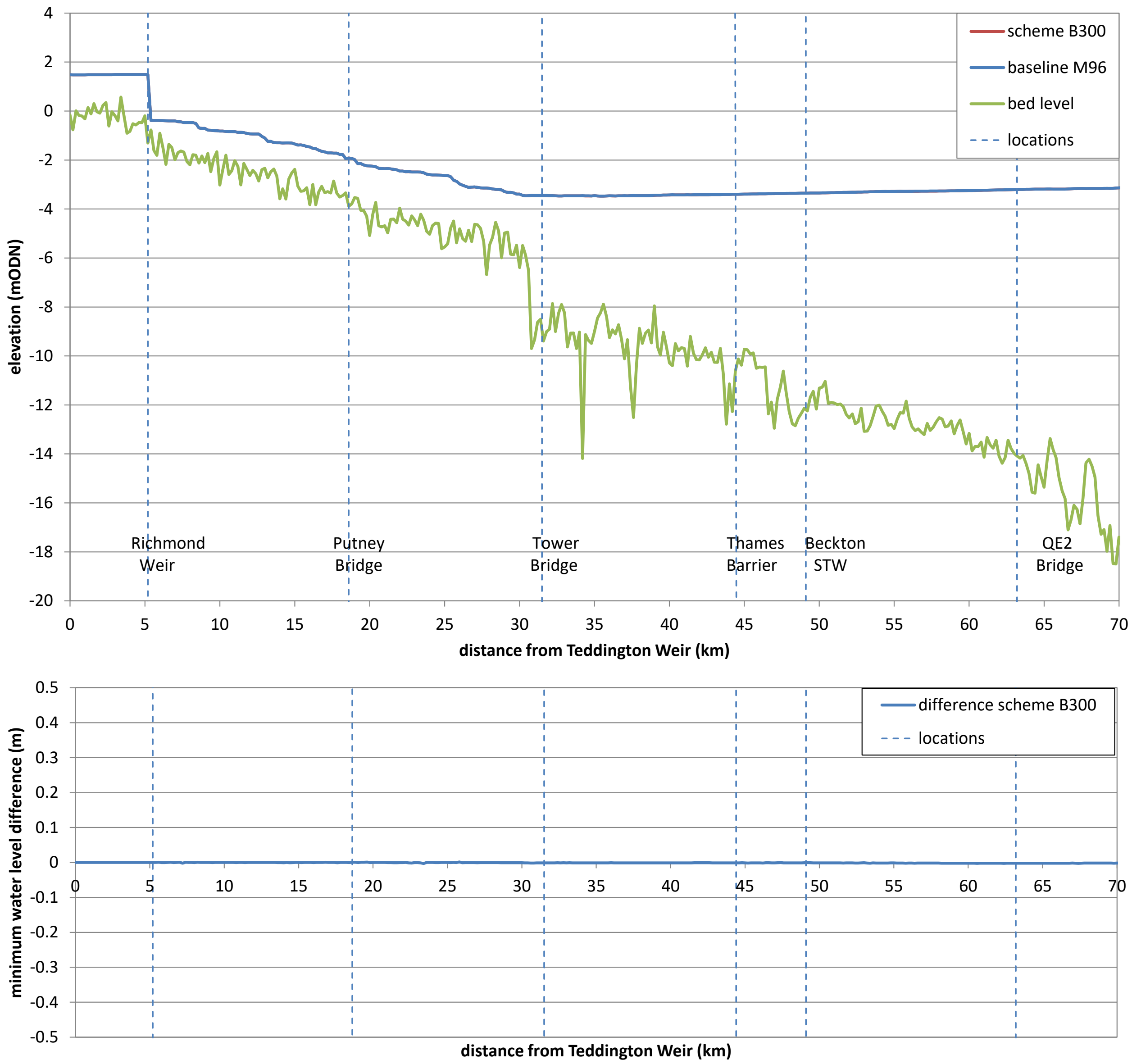
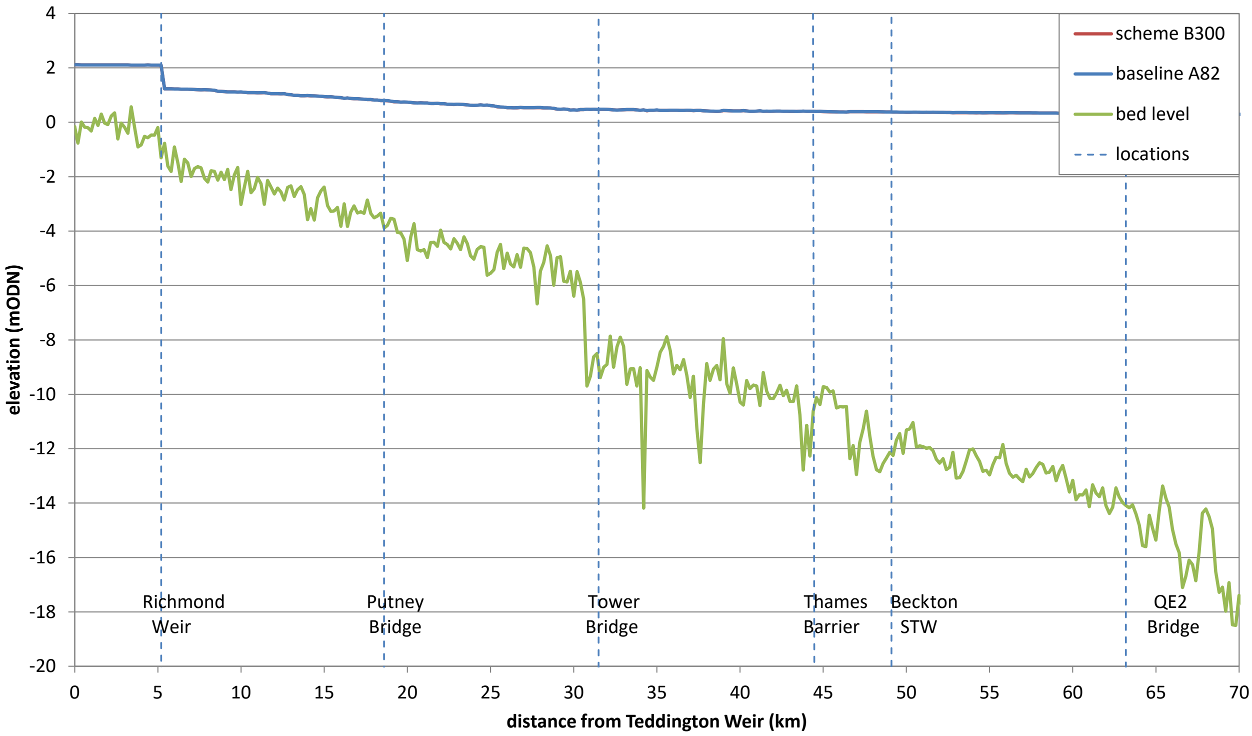


Figure 3-4 shows the modelled mean water levels along the thalweg for a moderate low flow year (A82), while **Figure 3-5** shows the modelled mean water levels for a very low flow year (M96). In each of these scenarios, there is a negligible change in the mean water levels longitudinally along the estuarine Thames Tideway, with no discernible difference between the baseline mean water level and mean water level when the 300Ml/d Beckton water recycling scheme is operational. Consequently, the change in mean water levels in the estuarine Thames Tideway due to a Beckton water recycling scheme is expected to have a **negligible** effect on the vessels ability to navigate along the estuarine Thames Tideway.

Figure 3-4 Mean water level along thalweg during scheme operation (6 August- 12 November), A82, baseline and B300 scheme, Teddington to QE2 bridge



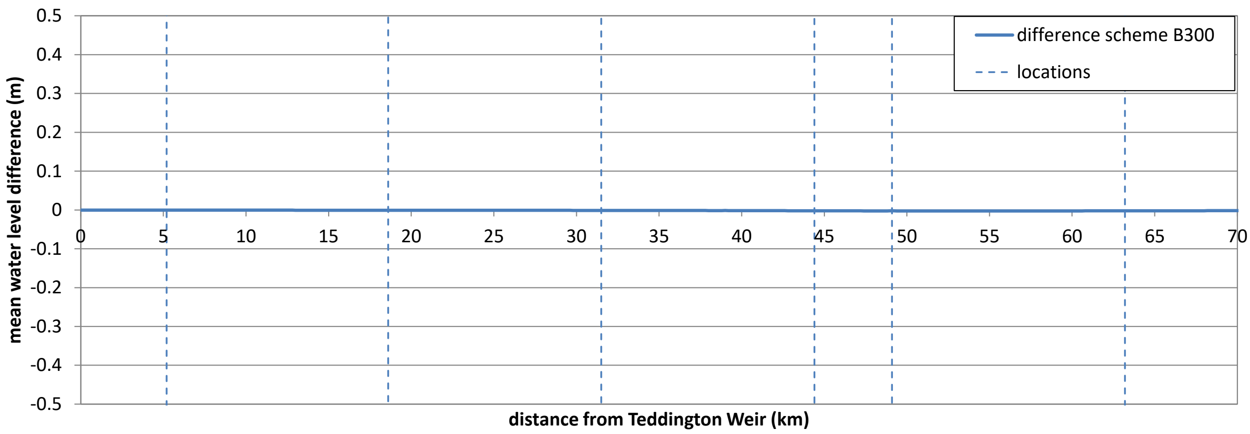
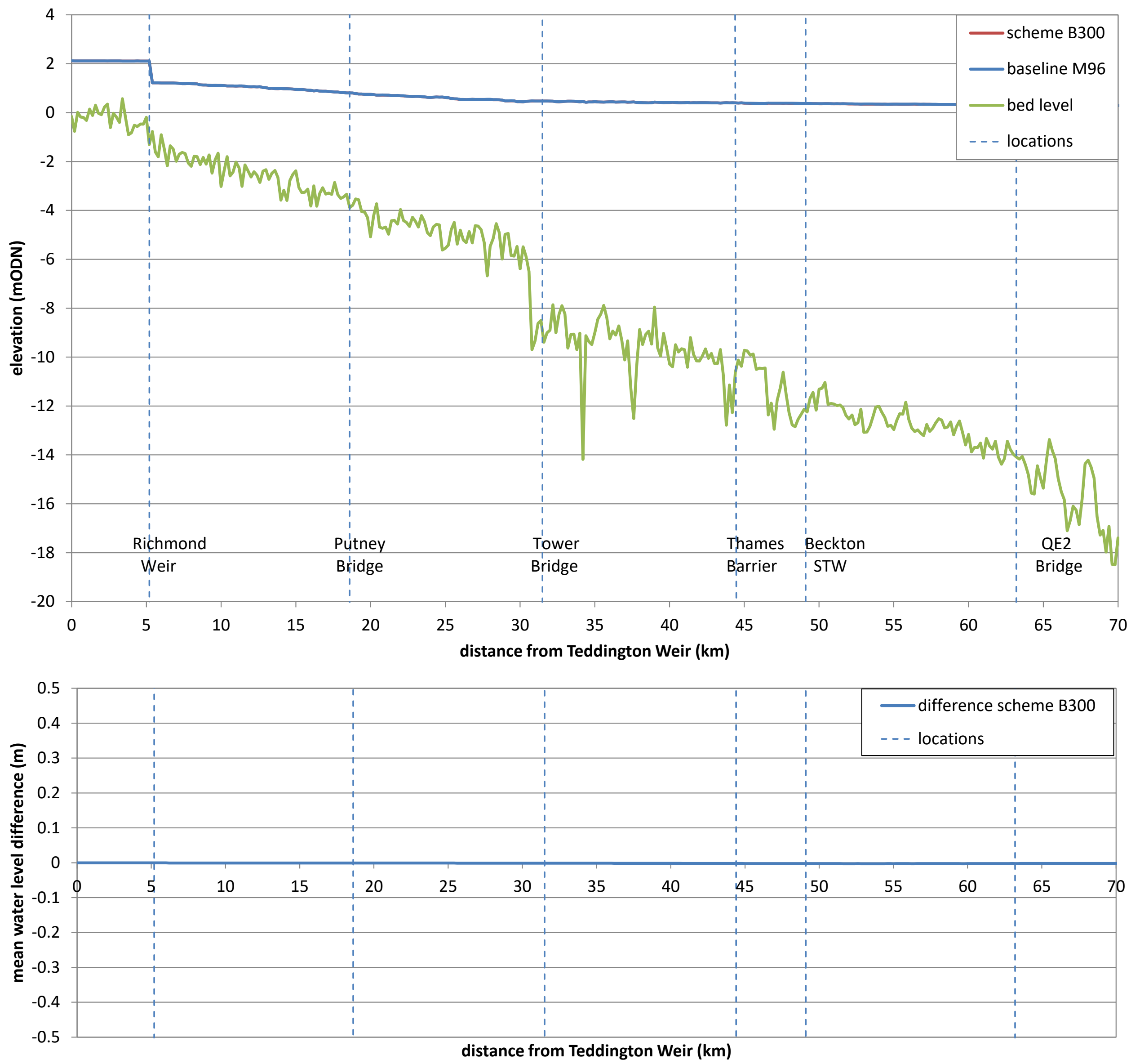


Figure 3-5 Mean water level along thalweg during scheme operation (6 August- 12 November), M96, baseline and B300 scheme, Teddington to QE2 bridge



3.3 TIME DELAYS IN THE STUDY AREA

Model outputs were obtained to estimate the flow changes for the worst-case Beckton water recycling scenario (with a 300 Ml/d reduction of final effluent discharge from Beckton STW into the estuarine Thames Tideway) at each of the shoals for a moderate low flow year (A82) and a very low flow year (M96). The times when navigation will be limited were assessed on various key shoals in the estuarine Thames Tideway for vessels with draughts of 0.5m, 1m, 2m and 3m. The analysis was carried out over the spring-neap cycle in the modelled sequence, and the average limiting period per tide was calculated. This only allows for the limitation by the available water depth and does not include any other limitations of navigation (e.g. during the night).

The results of this assessment found that there were no increases in the duration of low water navigational restrictions at all the shoal locations when the Beckton water recycling scheme is operational during both a moderate low flow year and a very low flow year. Therefore, the Beckton water recycling scheme is expected to have a **negligible** effect on the navigation of vessels around the shoals. No further assessment has been undertaken.

3.4 SEDIMENTATION IN THE STUDY AREA

The PLA has requested that any changes in the sedimentation rate that could affect navigation are assessed. This is particularly important around the entrance to the Royal Docks, as well as Barking Creek, which require dredging to remove the sediment. Barking Creek is located adjacent to Beckton STW, with the Royal Docks located less than 2km upstream of Beckton STW.

Increases in salinity has the potential to cause flocculation and increase the deposition of sediment along the channel perimeter. Therefore, the model has assessed the changes in both the maximum and minimum salinity concentrations and the 95th percentile and mean suspended sediment concentrations (SSC) along the thalweg of the estuarine Thames Tideway due to the interaction between salinity and SSC. This has been used to estimate if there is likely to be an increase in sediment deposition that could restrict navigational operations along the estuarine Thames Tideway.

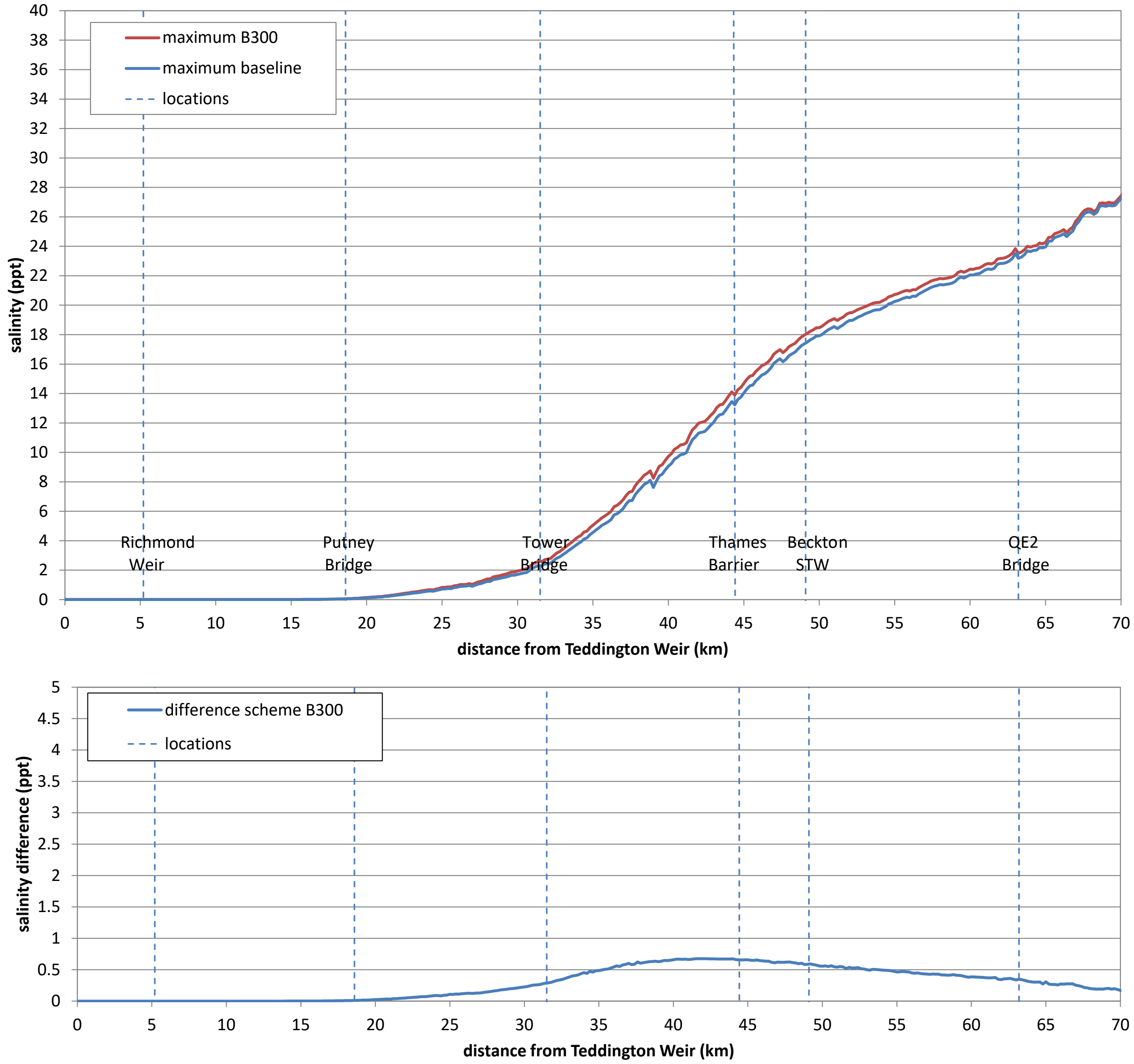
Figure 3-6 shows the effect that the 300 Ml/d flows from the Beckton water recycling scheme will have on the maximum and minimum salinity concentrations along the thalweg of the Thames in a moderate low flow year (A82). For both maximum and minimum salinity, there is a small increase in the salinity concentration when the scheme is operational compared to the baseline. The highest salinity increase when the Beckton water recycling scheme is operational is approximately 0.7 parts per thousand (ppt) above the baseline. For the maximum salinity in the estuarine Thames Tideway, the salinity for the scheme increases above the baseline downstream of Putney Bridge, with the highest salinity increase above the baseline occurring upstream of the Thames Barrier. The difference between the salinity concentrations for Beckton water recycling scheme and the baseline subsequently reduces downstream of the Thames Barrier.

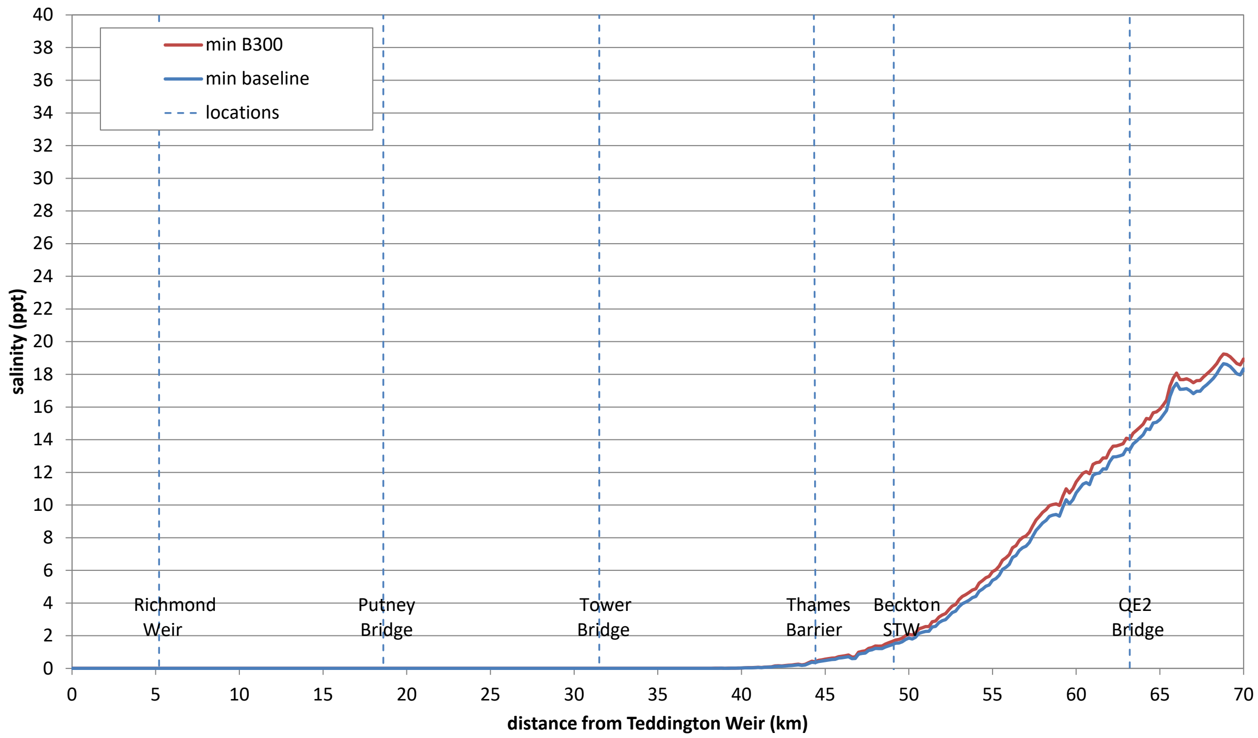
For the minimum salinity concentrations within the estuarine Thames Tideway, the increases in salinity for the scheme compared to the baseline occurs adjacent to the Thames Barrier, with the highest increase in minimum salinity above the baseline occurring upstream of the QE2 bridge. These differences subsequently reduce slightly after the QE2 bridge.

The changes to the 95th percentile and mean SSC in the thalweg of the estuarine Thames Tideway is shown in **Figure 3-7**, while modelled sediment flux over a single spring tide is illustrated in **Figure 3-9** for four transects located along the Tideway (**Figure 3-8**) within the area of greatest change in sediment dynamics indicated by the SSC data. These data show that there are very few changes in the SSC and sediment flux between the baseline values and the 300 Ml/d Beckton water recycling scheme along the estuarine Thames Tideway in a moderate low flow year, with no increase in SSC or change in sediment flux that could cause a higher rate of sediment deposition.

Taken together, it is expected that the scheme would not have a discernible effect on sediment deposition rates during a moderate low river flow year. This would have a **negligible** effect on navigational operations, including at the Royal Docks and Barking Creek.

Figure 3-6 Maximum (top) and minimum (bottom) salinity along thalweg (6 August – 12 November) with A82 flows for the baseline and 300 Ml/d Beckton water recycling scheme




min B300
min baseline
locations
salinity (ppt)
distance from Teddington Weir (km)
Richmond Weir
Putney Bridge
Tower Bridge
Thames Barrier
Beckton STW
QE2 Bridge

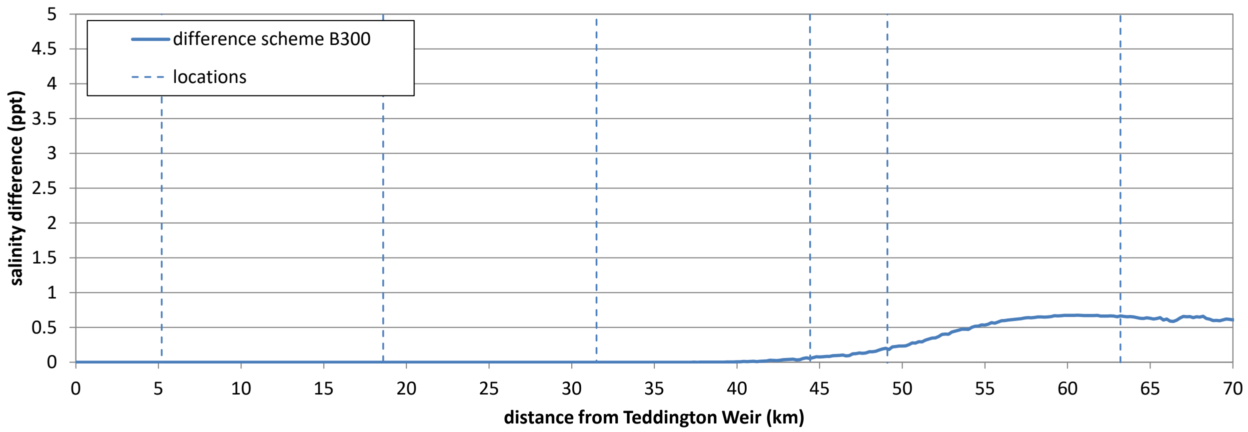
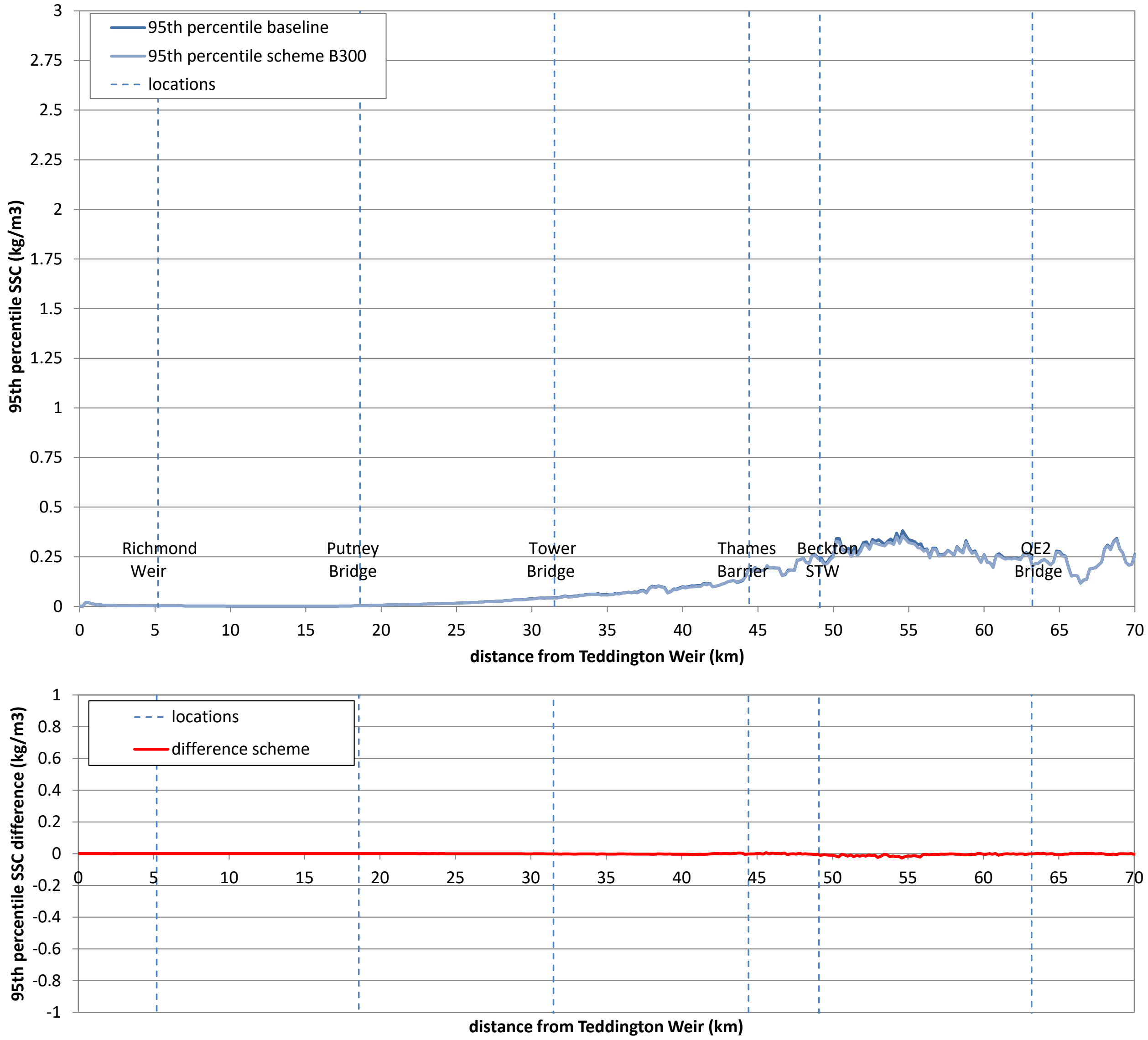

difference scheme B300
locations
salinity difference (ppt)
distance from Teddington Weir (km)

Figure 3-7 95th percentile (top) and mean (bottom) SSC along thalweg (6 August – 12 November), A82, baseline and 300 Ml/d Beckton water recycling scheme



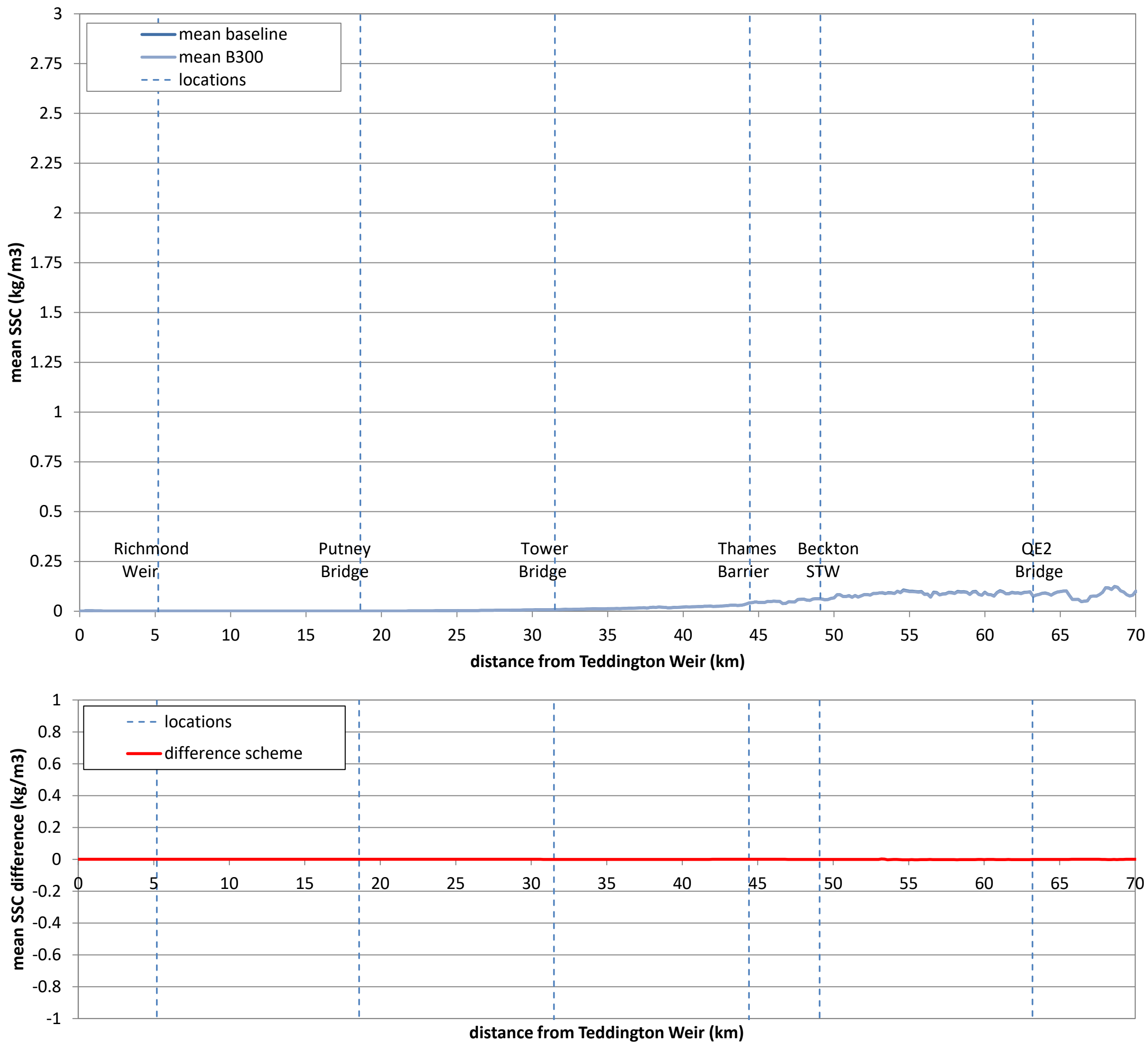


Figure 3-8 Thames Tideway sediment flux transect locations

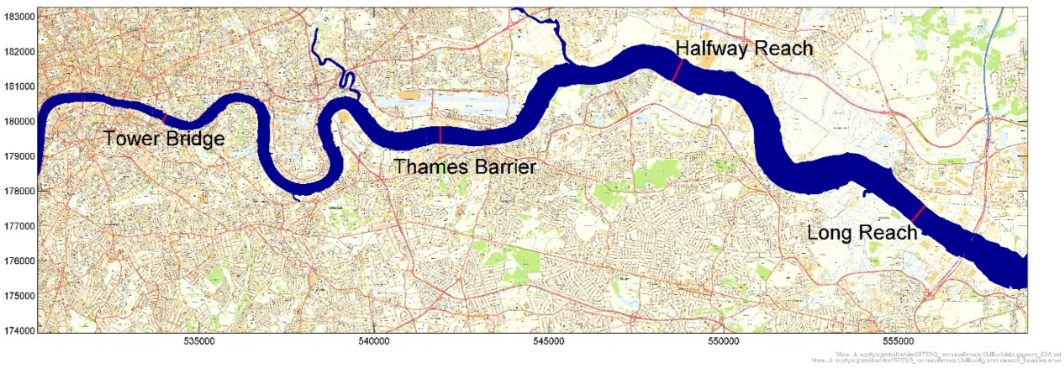
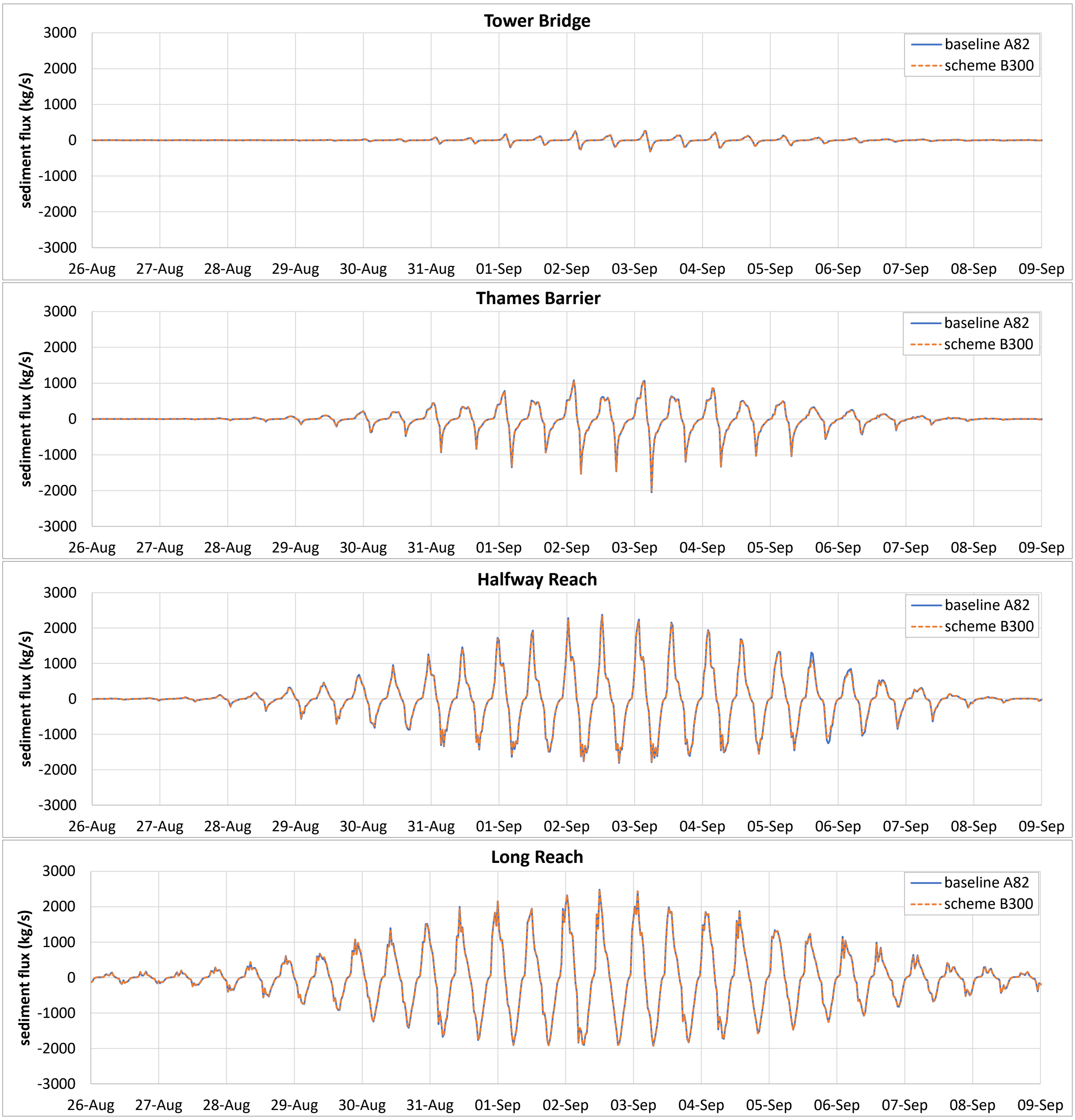


Figure 3-9 Sediment flux at each of the four transects over a spring tide for A82 baseline and 300 Ml/d Beckton water recycling scheme



The effects of the 300 Ml/d Beckton water recycling scheme on sediment deposition and navigation were also assessed during a very low flow year. Taken together, it is expected that the scheme would not have a discernible effect on sediment deposition rates during a very low flow year. This would have a **negligible** effect on navigational operations, including at the Royal Docks and Barking Creek.

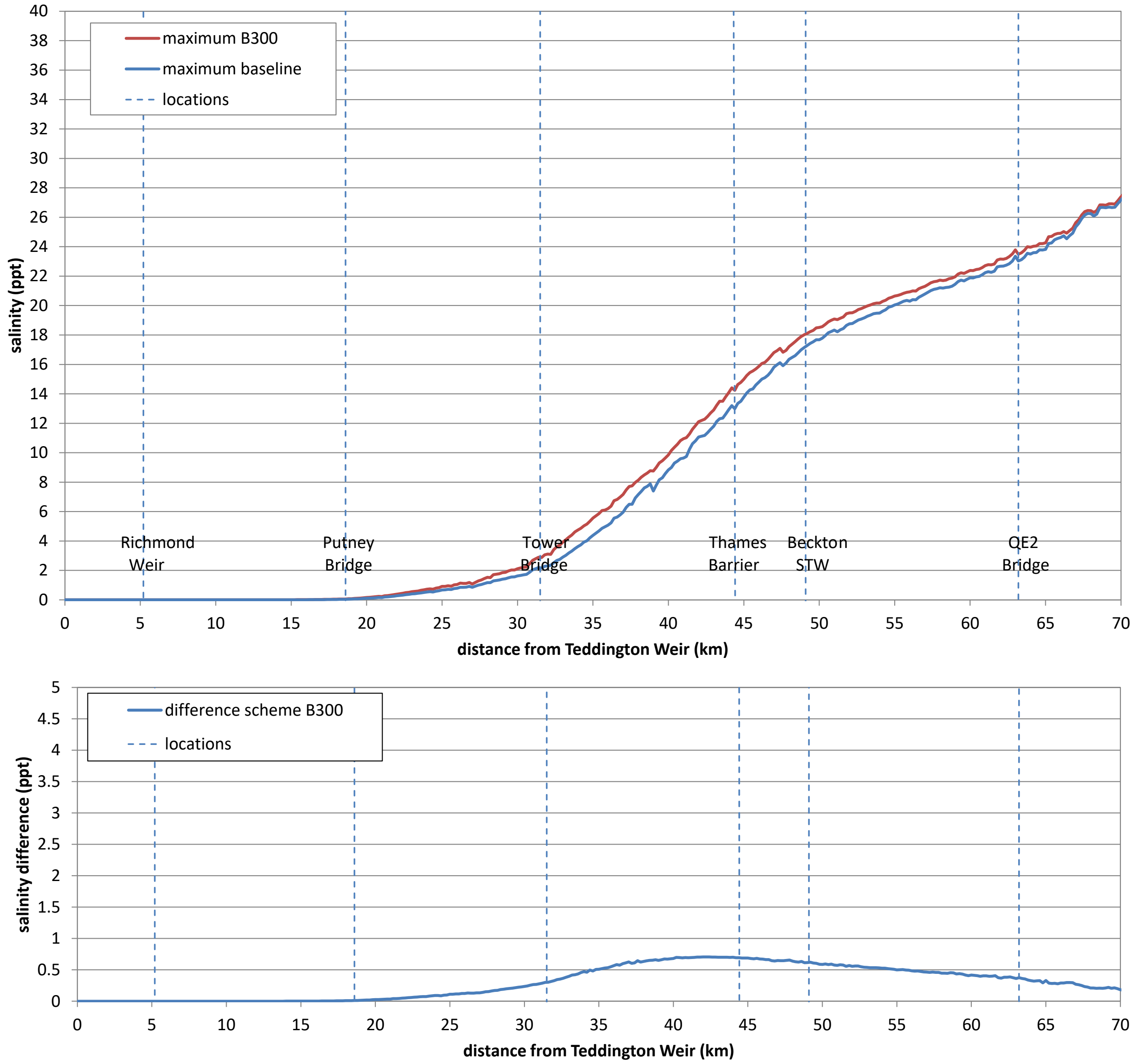
Figure 3-10 shows the effect that the Beckton water recycling scheme will have on the maximum and minimum salinity concentrations along the thalweg of the estuarine Thames Tideway in a very low flow year (M96). For the maximum salinity concentrations in the estuarine Thames Tideway, the salinity when the scheme is operational at 300 Ml/d increase above the baseline conditions approximately 20km after Teddington Weir and this continues to increase up to approximately 0.7ppt above the baseline between Tower Bridge and Thames Barrier, before reducing further downstream.

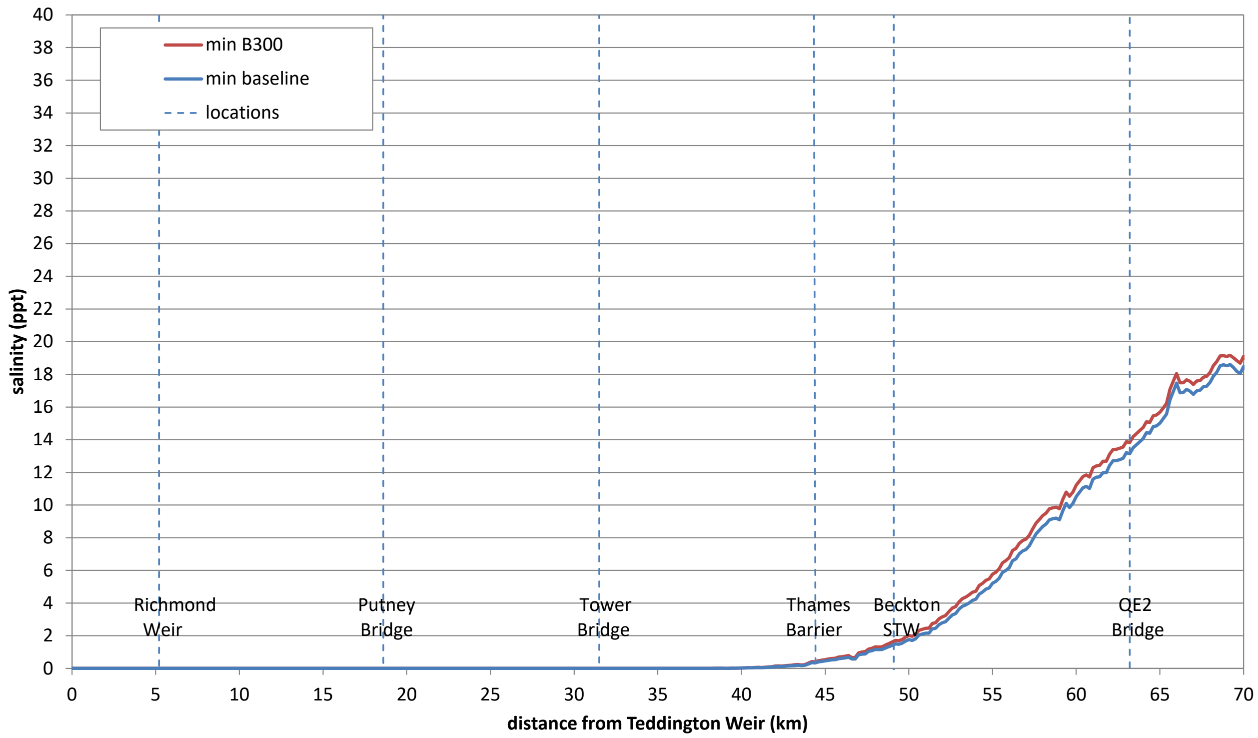
For the minimum salinity concentrations graph, the increases in salinity for the scheme compared to the baseline increases further downstream from Teddington Weir compared to the maximum salinity concentrations. The scheme's salinity concentration increases occur near to the Thames Barrier, with the highest difference between the scheme and the baseline occurring approximately 60km downstream of Teddington Weir.

The changes to the 95th percentile and mean SSC in the thalweg of the estuarine Thames Tideway is shown in **Figure 3-11**, while modelled sediment flux over a single spring tide is illustrated in **Figure 3-12** for four transects. These graphs show that there are very few changes in the SSC and sediment flux between the baseline values and the 300 Ml/d Beckton water recycling scheme along the estuarine Thames Tideway in a very low flow year, with no increase in SSC or change in sediment flux that could cause a higher rate of sediment deposition.

Taken together, it is expected that the scheme would not have a discernible effect on sediment deposition rates during a very low flow year. This would have a **negligible** effect on navigational operations, including at the Royal Docks and Barking Creek.

Figure 3-10 Maximum (top) and minimum salinity (bottom) along thalweg (1 August – 30 November) with M96 flows for the baseline and 300 Ml/d Beckton water recycling scheme




min B300
min baseline
locations
salinity (ppt)
distance from Teddington Weir (km)
Richmond Weir
Putney Bridge
Tower Bridge
Thames Barrier
Beckton STW
QE2 Bridge

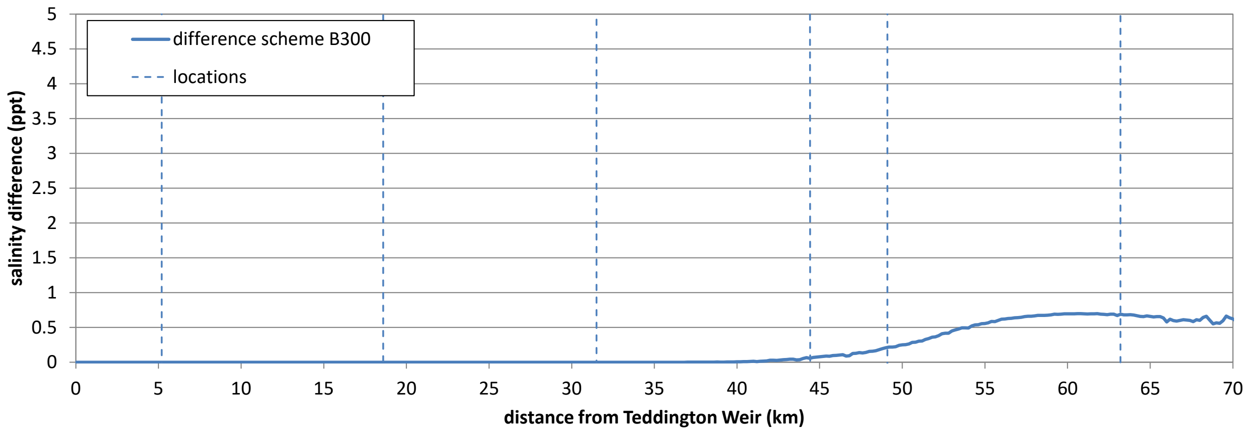
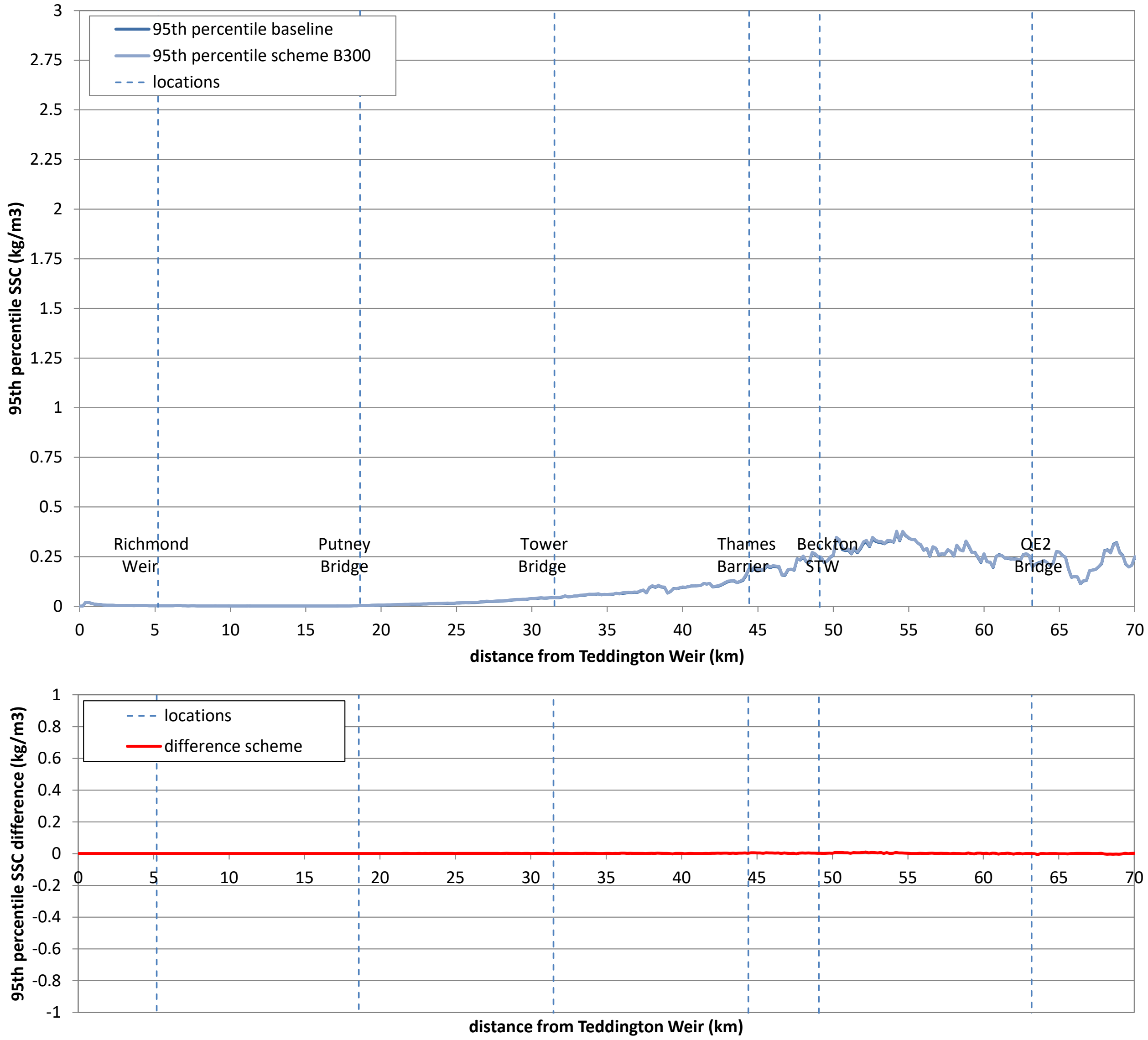
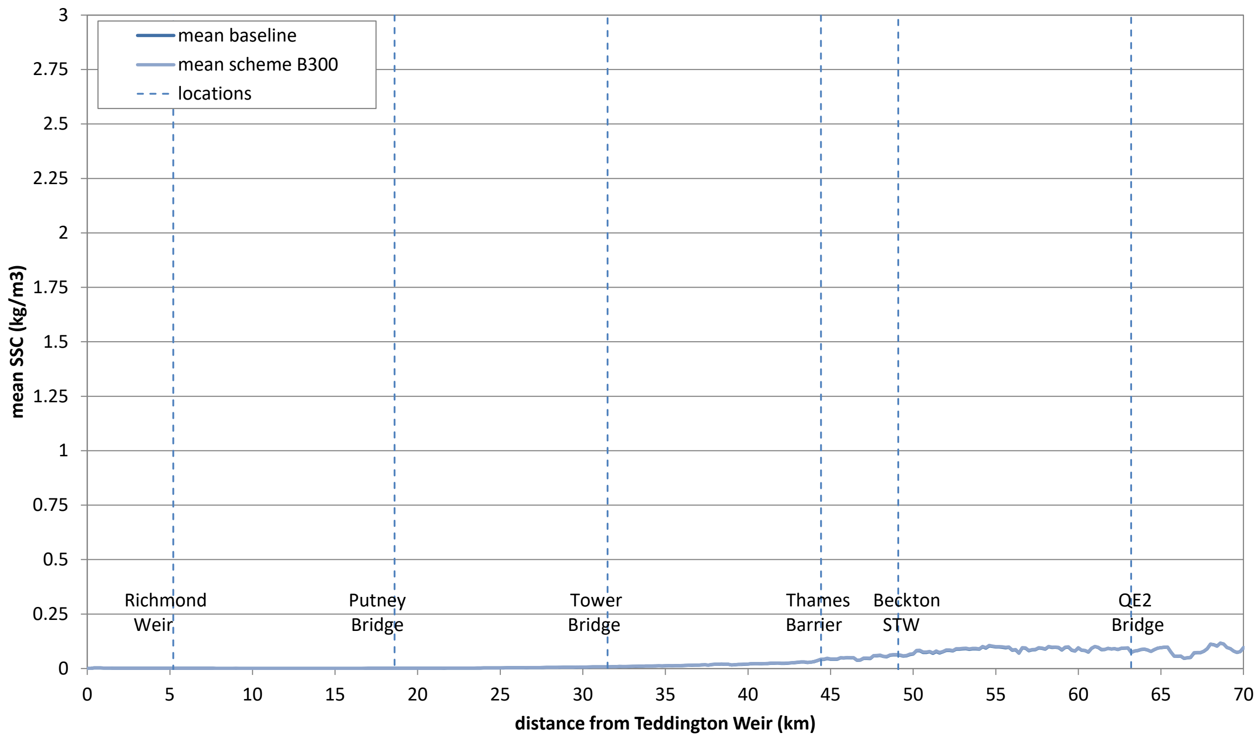
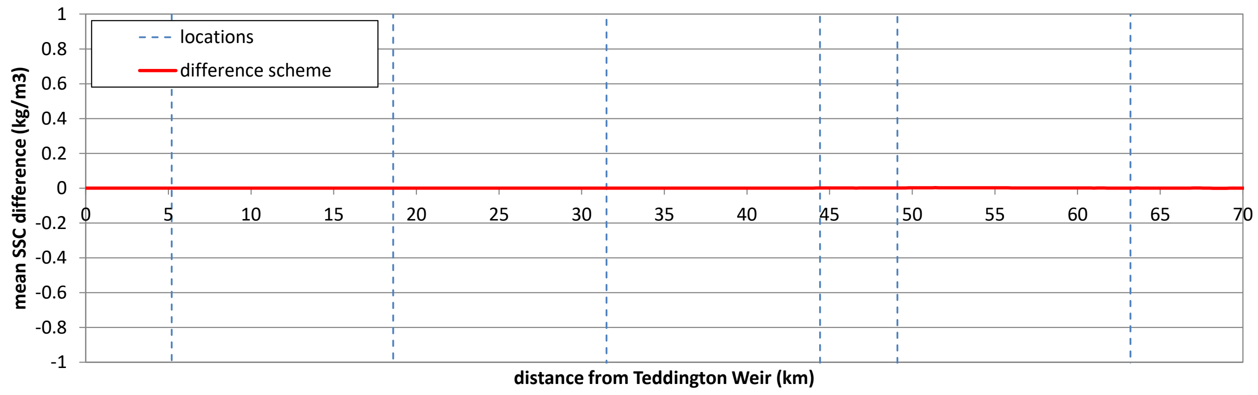

difference scheme B300
locations
salinity difference (ppt)
distance from Teddington Weir (km)

Figure 3-11 95th percentile (top) and mean (bottom) SSC along thalweg (1 August – 30 November), M96, baseline and 300 Ml/d Beckton water recycling scheme



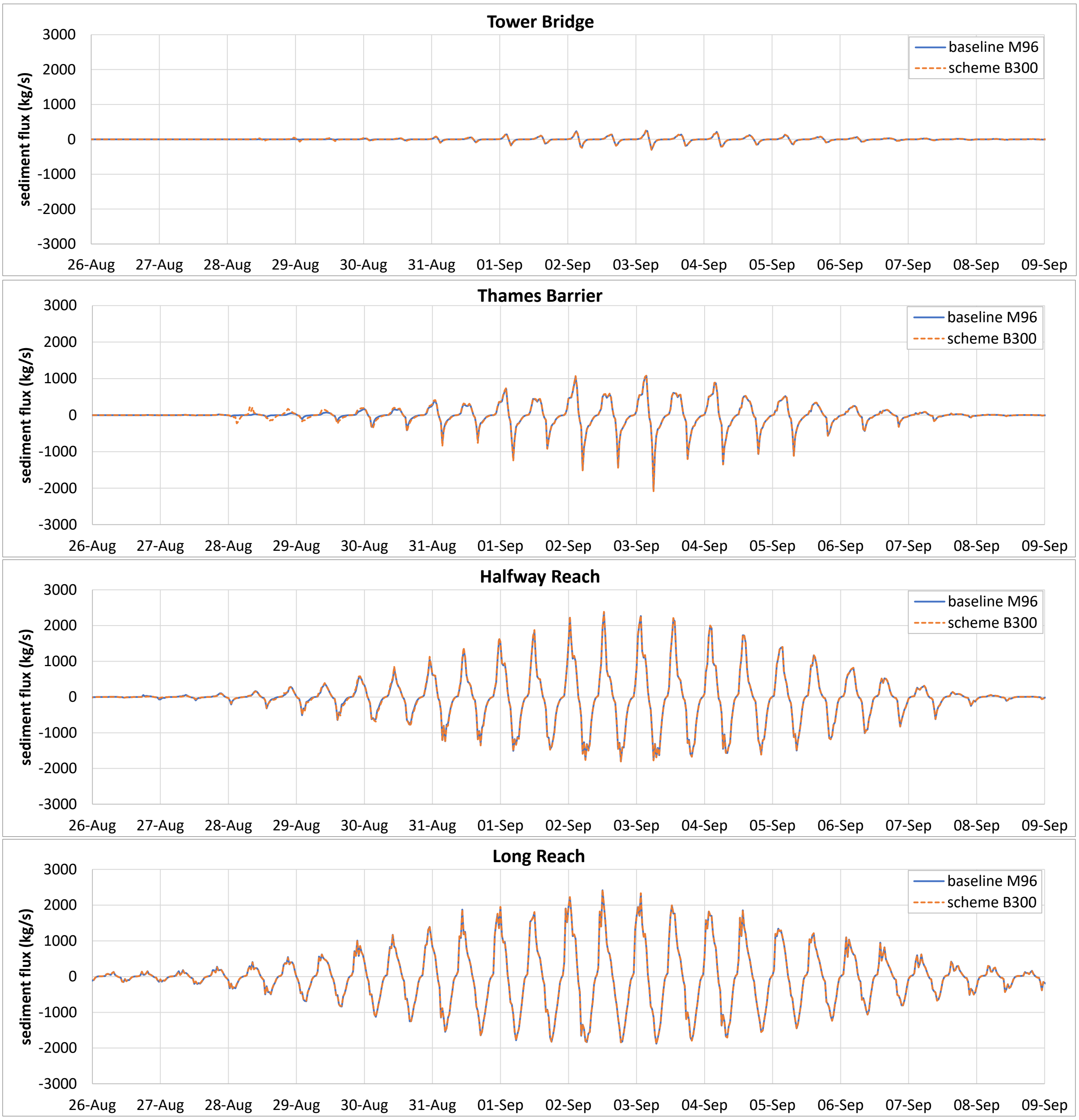


mean baseline
mean scheme B300
locations
mean SSC (kg/m3)
Richmond Weir
Putney Bridge
Tower Bridge
Thames Barrier
Beckton STW
QE2 Bridge
distance from Teddington Weir (km)



locations
difference scheme
mean SSC difference (kg/m3)
distance from Teddington Weir (km)

Figure 3-12 Sediment flux at each of the four transects over a spring tide for M96 baseline and 300Ml/d Beckton water recycling scheme

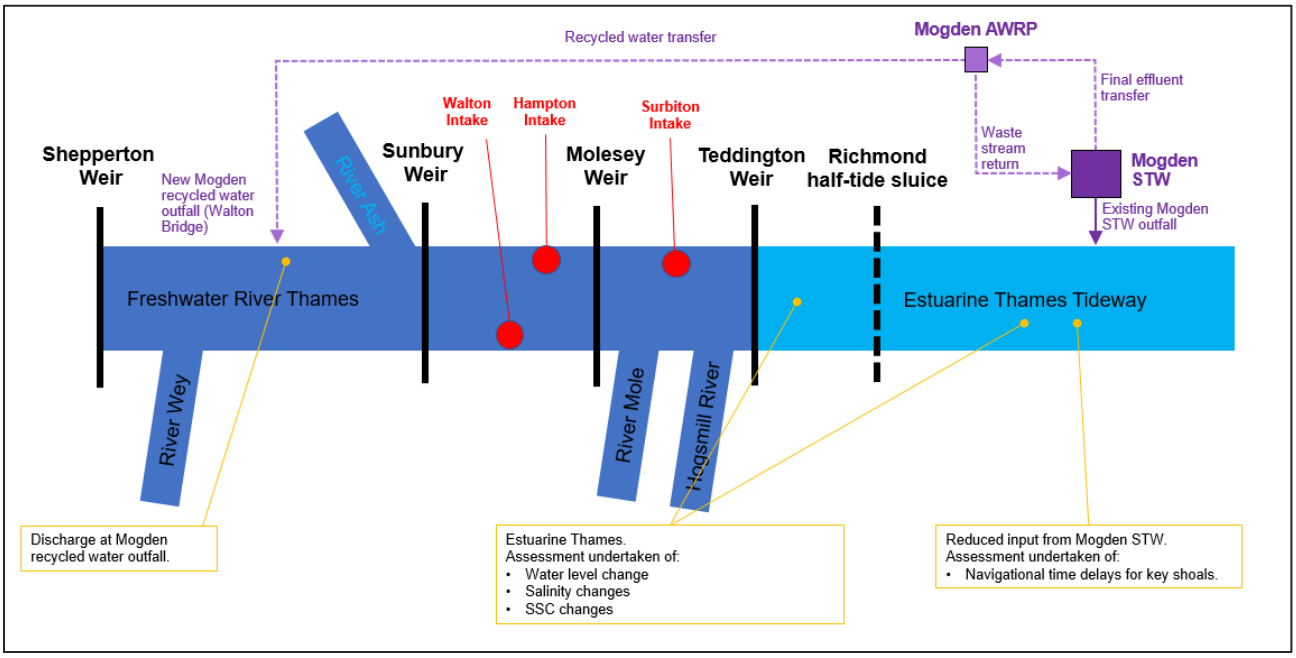


4. NAVIGATION ASSESSMENT OF MOGDEN WATER RECYCLING SCHEME

4.1 INTRODUCTION

For the Mogden water recycling scheme, the assessment for navigation set out in **Table 1-1** is described in this section. This is shown spatially in the conceptualisation of physical environment effects in **Figure 4-1**.

Figure 4-1 Representation of the Mogden water recycling aquatic study area with conceptualisation of navigation effects and listing of assessments undertaken for Gate 2



To support the environmental assessments at Gate 2, an indicative operating pattern has been developed, which is described in Section 1.2.

4.2 WATER LEVEL CONDITIONS IN THE STUDY AREA

The option with the maximum final effluent reduction from Mogden STW of 200 Ml/d for the Mogden water recycling scheme was modelled to determine the largest change in the minimum water level along the estuarine Thames Tideway while the scheme is operational. **Figure 4-2** shows the modelled minimum water levels along the thalweg for a moderate low flow year (A82), while **Figure 4-3** shows the modelled minimum water levels for a very low flow year (M96). In each of the low flow scenarios, there is a reduction in the minimum water level downstream of Richmond Half-tide Sluice where the largest reduction in water levels occur. The minimum water level difference between the baseline and the scheme subsequently decreases further downstream of Richmond Half-tide Sluice. As can be expected, these differences are slightly more pronounced in the very low flow scenario compared to the moderate low flow scenario as less water is available.

Since the bed level is approximately 1-2m below the water level, a difference of less than 0.07m in the minimum water level is likely to have a **negligible** impact on the ability of vessels to navigate the Thames Tideway when the Mogden water recycling scheme is operational.

The changes to the minimum water levels for the key shoals were also assessed. These are shown on each of the graphs, with the exact level changes at these shoals shown in **Table 4-1**. The largest changes to the minimum water levels occur at the Richmond and Isleworth shoals, with a reduction of 0.05m during a moderate low flow year and 0.06m during a very low flow year when the 200 Ml/d Mogden water recycling scheme is operational. This difference reduces at shoals further downstream, from a 0.05m reduction at Brentford during a very low flow year to 0.01m reduction at Wandle for both low flow scenarios. The effects of the water level differences on the low water navigational restrictions at the shoals has been assessed in **Section 4.3**.

Figure 4-2 Minimum water level along thalweg during scheme operation (6 August- 12 November), A82, baseline and 200 Ml/d Mogden water recycling scheme, Teddington to Wandle Shoal

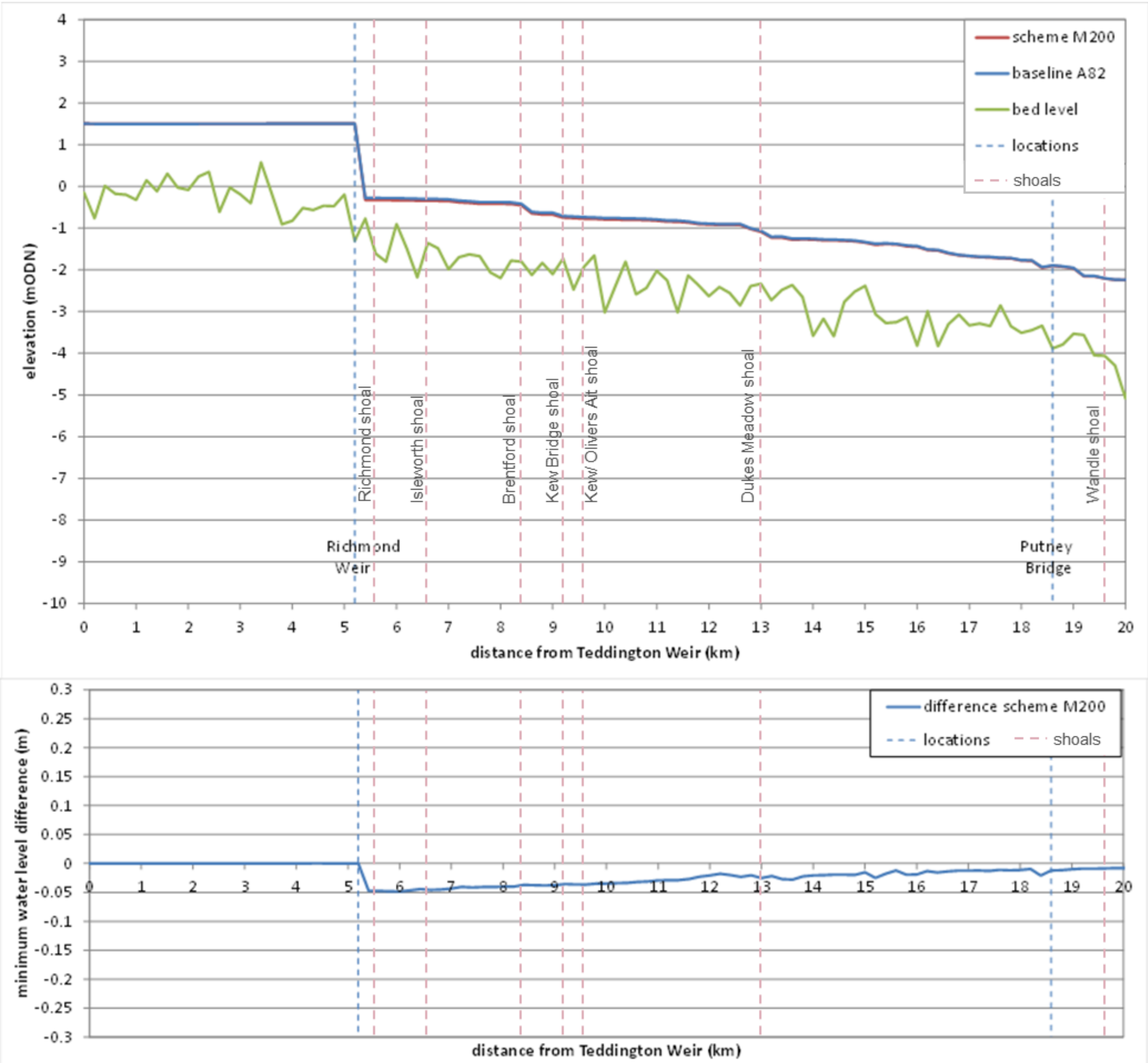


Figure 4-3 Minimum water level along thalweg during scheme operation (1 August- 30 November), M96, baseline and 200 Ml/d Mogden water recycling scheme, Teddington to Wandle Shoal

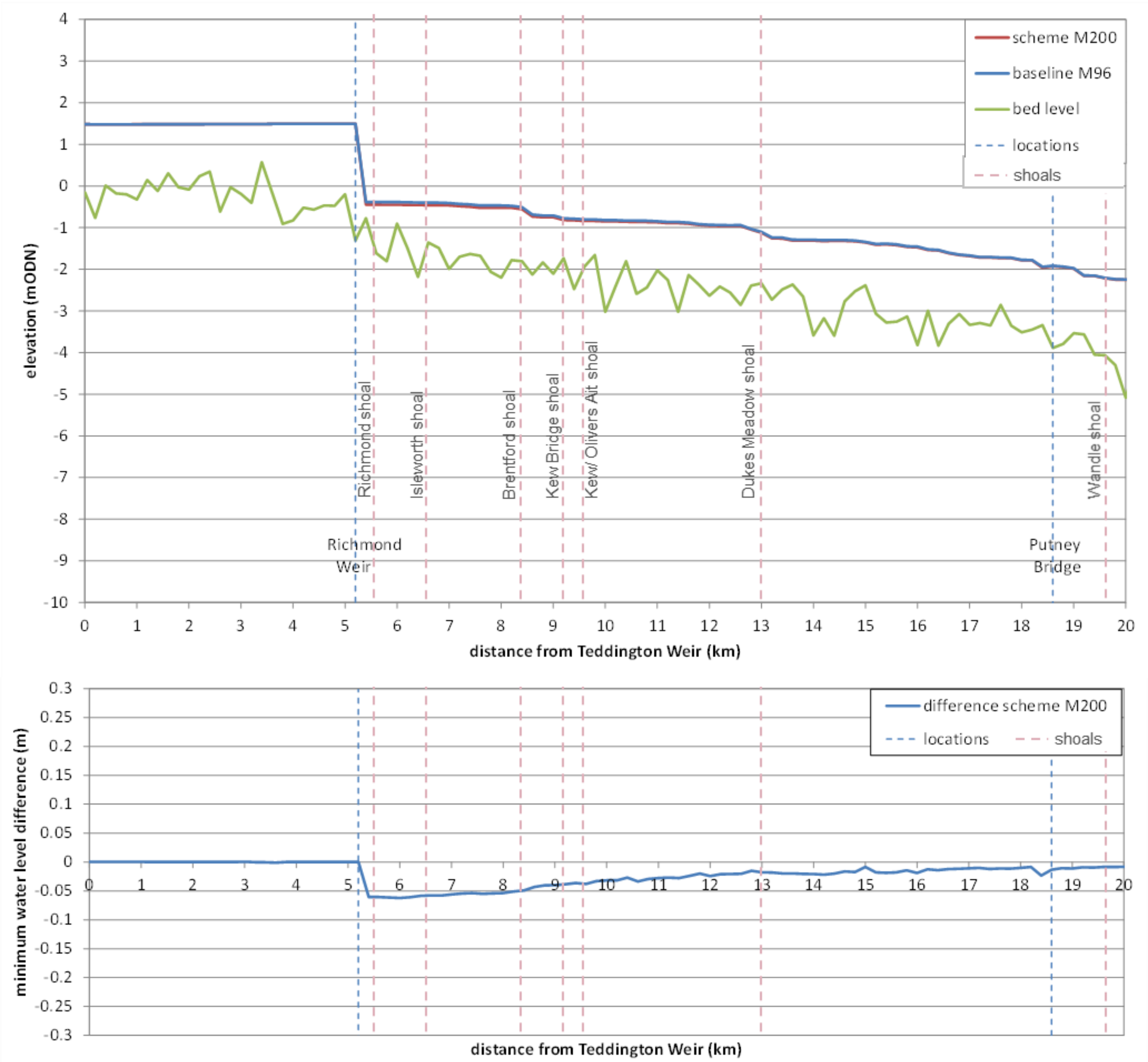


Table 4-1 Change to Baseline Minimum Water Level Depth at Key Shoals for the 200 Ml/d Mogden water recycling scheme

Shoal	Distance from Teddington Weir (km)	Change to Minimum Water Level Depth during a Moderate Low Flow Year (A82) (m)	Change to Minimum Water Level Depth during a Very Low Flow Year (M96) (m)
Richmond	5.60	-0.05	-0.06
Isleworth	6.60	-0.05	-0.06
Brentford	8.40	-0.04	-0.05
Kew Bridge	9.20	-0.04	-0.04
Kew/Olivers	9.60	-0.04	-0.04
Dukes Meadow	13.00	-0.02	-0.02
Wandle	19.60	-0.01	-0.01

4.3 NAVIGATIONAL TIME DELAYS IN THE STUDY AREA

Model outputs were obtained for the estimated flow changes for the 200 Ml/d Mogden water recycling scheme at each of the shoals. The times when navigation will be limited were assessed on various key shoals in the tidal River Thames for vessels with draughts of 0.5m, 1m, 2m and 3m. The analysis was carried out over the spring-neap cycle in the modelled sequence, and the average limiting period per tide was calculated. It only allows for the limitation by the available water depth and does not include any other limitations of navigation (e.g. during the night). As set out in **Section 2**, under current baseline conditions vessels with a 3m draught can already experience delays of up to nine hours during low tide under moderate low flow conditions.

The time delay for each of the shoals when the 200 Ml/d Mogden water recycling scheme is operational during moderate low flow conditions are shown in **Table 4-2**. This shows that there is an increase in the duration of the low water navigational restrictions at each shoal location apart from Wandle, where the modelling indicates that the difference in navigational restrictions are less than a minute for all the vessels. The difference in the navigational restrictions between the baseline and operational scheme depend on the vessel's draught depth. The largest increase in the low water navigational restrictions is 00:49 (HH:MM) for vessels with a draught depth of 0.5m at Brentford. This is caused by the water levels from the spring tide reducing earlier when the Mogden water recycling scheme is operational compared to the baseline levels. This change is demonstrated in **Figure 4-4**.

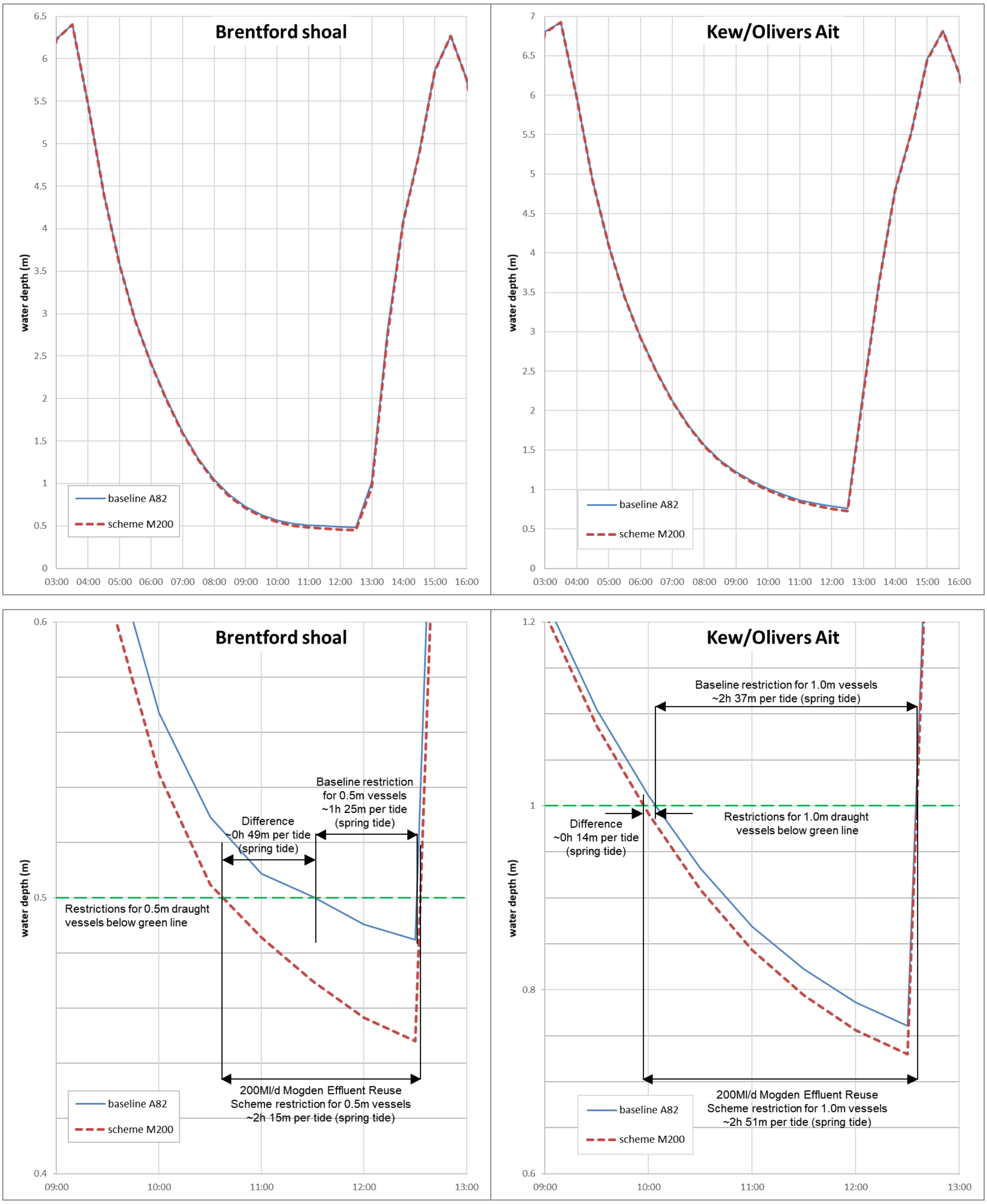
Vessels with the 0.5m draught depth will also be restricted at the Kew Bridge shoals with an increased low water navigational restriction duration of 00:22. At all the other shoals, there are no other increases in duration for the low water navigational restrictions for vessels with a 0.5m draught. For vessels with a draught depth of 1.0m, the modelling indicates that the low water navigational restrictions will increase at each of the shoals apart from Wandle. This ranges from a maximum increase in duration of 00:14 at Kew/Olivers shoal (shown in **Figure 4-4**) to a minimum increase in duration of 00:02 at Brentford.

The vessels with a larger draught of either 2m or 3m are less impacted by the time delays caused by the 200 Ml/d Mogden water recycling scheme. The low water navigational restrictions for vessels with a 2m draught have a maximum increase of 00:02 at Isleworth and Brentford, while the other shoal locations have an increased low water navigation restriction increase of 00:01. For vessels with a 3m draught, the increase in low water navigational restrictions only occurs at four shoal locations (Isleworth, Brentford, Kew/Olivers and Dukes Meadow), each with an increased duration of 00:01. The lower impact on vessels with larger draughts is to be expected due to the fact that they are already constrained by baseline low flow conditions, and the small changes of 0.05m of water depth have a negligible additional effect.

Table 4-2 Average low water navigational restriction duration for vessels of different draughts during a moderate-low flow year (6 August – 12 November) for 200 Ml/d Mogden water recycling (all values in HH:MM)

Shoal Location	Vessel Draught (m)	Baseline	Scheme	Difference
Richmond	0.5	00:00	00:00	00:00
	1	04:06	04:18	+00:11
	2	07:02	07:04	+00:01
	3	08:38	08:39	+00:00
Isleworth	0.5	00:00	00:00	00:00
	1	04:25	04:34	+00:09
	2	07:05	07:08	+00:02
	3	08:40	08:41	+00:01
Brentford	0.5	01:25	02:15	+00:49
	1	05:14	05:17	+00:02
	2	07:25	07:27	+00:02
	3	09:00	09:01	+00:01
Kew Bridge	0.5	01:00	01:22	+00:22
	1	04:23	04:26	+00:03
	2	06:53	06:55	+00:01
	3	08:35	08:36	+00:00
Kew/Olivers	0.5	00:00	00:00	00:00
	1	02:37	02:51	+00:14
	2	06:14	06:16	+00:01
	3	08:06	08:07	+00:01
Dukes Meadow	0.5	00:00	00:00	00:00
	1	01:24	01:29	+00:05
	2	05:28	05:29	+00:01
	3	07:24	07:25	+00:01
Wandle	0.5	00:00	00:00	00:00
	1	00:53	00:54	+00:00
	2	03:52	03:53	+00:00
	3	05:52	05:52	+00:00

Figure 4-4 Water Level effects on the Time Delays for the Brentford Shoal for 0.5m draft vessels (left) and Kew/Oliver Ait Shoal for 1m draft vessels (right) during a moderate low flow year (A82)



The time delay for each of the shoals when the Mogden water recycling scheme is operational for very low flow conditions are shown in **Table 4-3**. There is an increase in the duration of the low water navigational restrictions at each of the shoal locations apart from Wandle, where the modelling indicates that the difference in navigational restrictions are less than a minute for all the vessels. The largest increase in the low water navigational restrictions is 00:31 for vessels with a draught depth of 0.5m at Brentford (**Figure 4-5**). These vessels will also be restricted at the Kew Bridge shoals with an increased low water navigational restriction duration of 00:17. At all the other shoals, there are no increases in duration for the low water navigational restrictions.

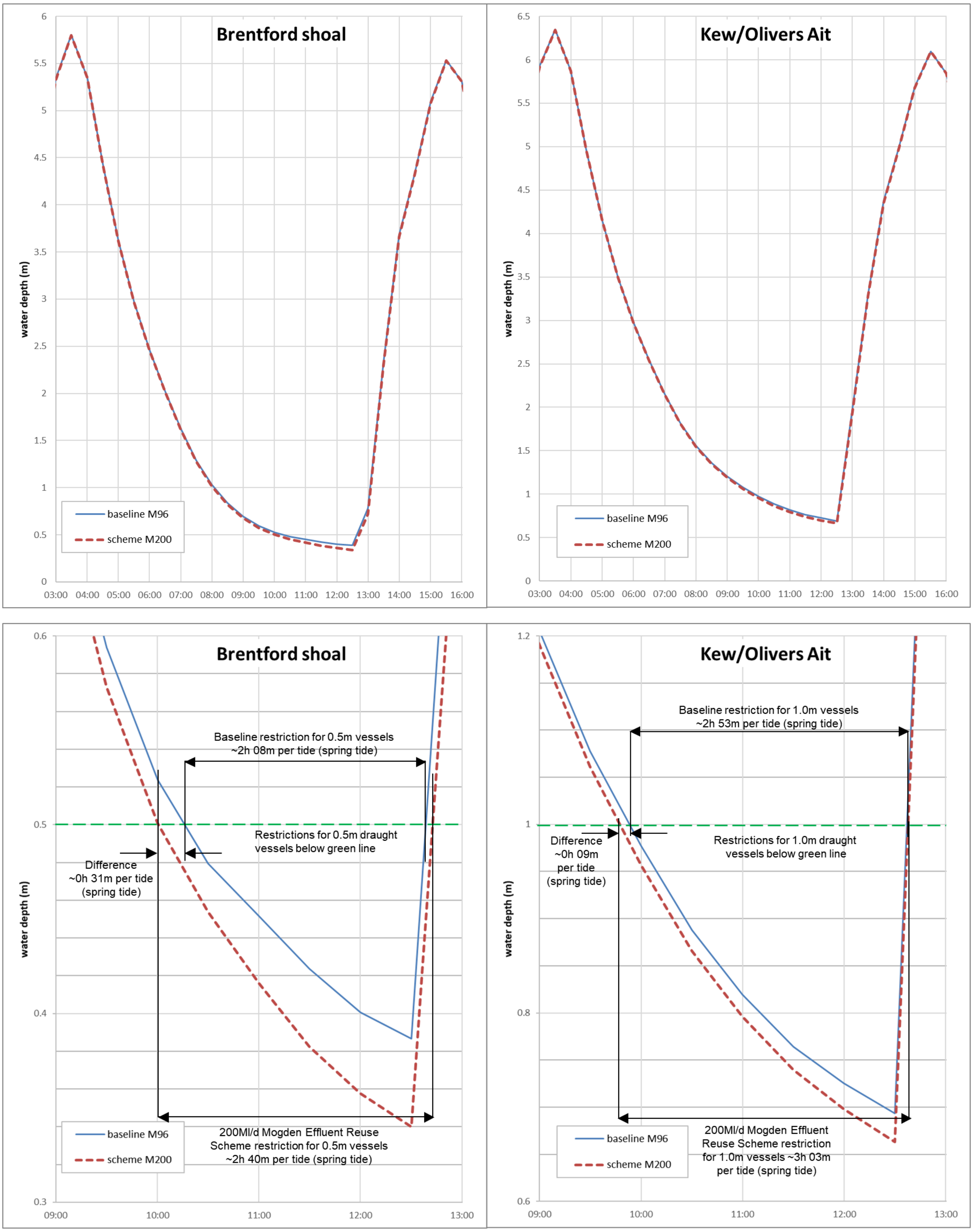
For vessels with a draught depth of 1.0m, the modelling indicates that the low water navigational restrictions will increase at each of the shoals apart from Wandle. This ranges from a maximum increase in duration of 00:12 at Richmond shoal (**Figure 4-5**) to a minimum increase in duration of 00:03 at Kew Bridge. Other vessels with a larger draught of either 2m or 3m are less impacted by the time delays caused by the 200 Ml/d Mogden water recycling scheme. The low water navigational restrictions for vessels with a 2m draught have a maximum increase of 00:02 at Richmond, Isleworth and Brentford, while the other shoal locations have an increased low water navigation restriction increase of 00:01, apart from Dukes Meadow where the increase in navigational restrictions is below 0:01. For vessels with a 3m draught, the increase in low water navigational restrictions only occurs at four shoal locations (Richmond, Isleworth, Brentford, and Dukes Meadow), each with an increased duration of 00:01.

Overall, the impact of the 200 Ml/d Mogden water recycling scheme will have a **minor/negligible** impact on the low water navigational restrictions around the shoals, depending on individual shoals and the draft size of the vessel.

Table 4-3 Average low water navigational restriction duration for vessels of different draughts during a very low flow year (6 August – 12 November) for Mogden water recycling conditions at 200Ml/d (all values in HH:MM)

Shoal Location	Vessel Draught (m)	Baseline	Scheme	Difference
Richmond	0.5	00:00	00:00	00:00
	1	04:24	04:37	+00:12
	2	07:05	07:07	+00:02
	3	08:39	08:40	+00:01
Isleworth	0.5	00:00	00:00	00:00
	1	04:36	04:46	+00:09
	2	07:09	07:11	+00:02
	3	08:42	08:43	+00:01
Brentford	0.5	02:08	02:40	+00:31
	1	05:22	05:25	+00:03
	2	07:27	07:29	+00:02
	3	09:00	09:01	+00:01
Kew Bridge	0.5	01:22	01:39	+00:17
	1	04:28	04:31	+00:03
	2	06:56	06:57	+00:01
	3	08:37	08:37	+00:00
Kew/Olivers	0.5	00:00	00:00	00:00
	1	02:53	03:03	+00:09
	2	06:17	06:18	+00:01
	3	08:07	08:07	+00:00
Dukes Meadow	0.5	00:00	00:00	00:00
	1	01:33	01:40	+00:07
	2	05:30	05:31	+00:00
	3	07:25	07:26	+00:01
Wandle	0.5	00:00	00:00	00:00
	1	00:56	00:57	+00:00
	2	03:55	03:56	+00:00
	3	05:55	05:55	+00:00

Figure 4-5 Water Level effects on the Time Delays for the Brentford Shoal for 0.5m draft vessels (left) and Kew/Oliver Ait Shoal for 1m draft vessels (right) during a very low flow year (M96)



4.4 SEDIMENTATION IN THE STUDY AREA

The PLA has requested that any changes in the sedimentation rate that could affect navigation are assessed. This is particularly important around the entrance to the Royal Docks, as well as Barking Creek, which require dredging to remove the sediment. Barking Creek is located adjacent to Beckton STW, with the Royal Docks located less than 2km upstream of Beckton STW.

Increases in salinity has the potential to cause flocculation and increase the deposition of sediment along the channel perimeter. Therefore, the model has assessed the changes in both the maximum and minimum salinity concentrations and the 95th percentile and mean SSC along the thalweg of the estuarine Thames Tideway due to the interaction between salinity and SSC. This has been used to estimate if there is likely to be an increase in sediment deposition that could restrict navigational operations along the Thames Tideway.

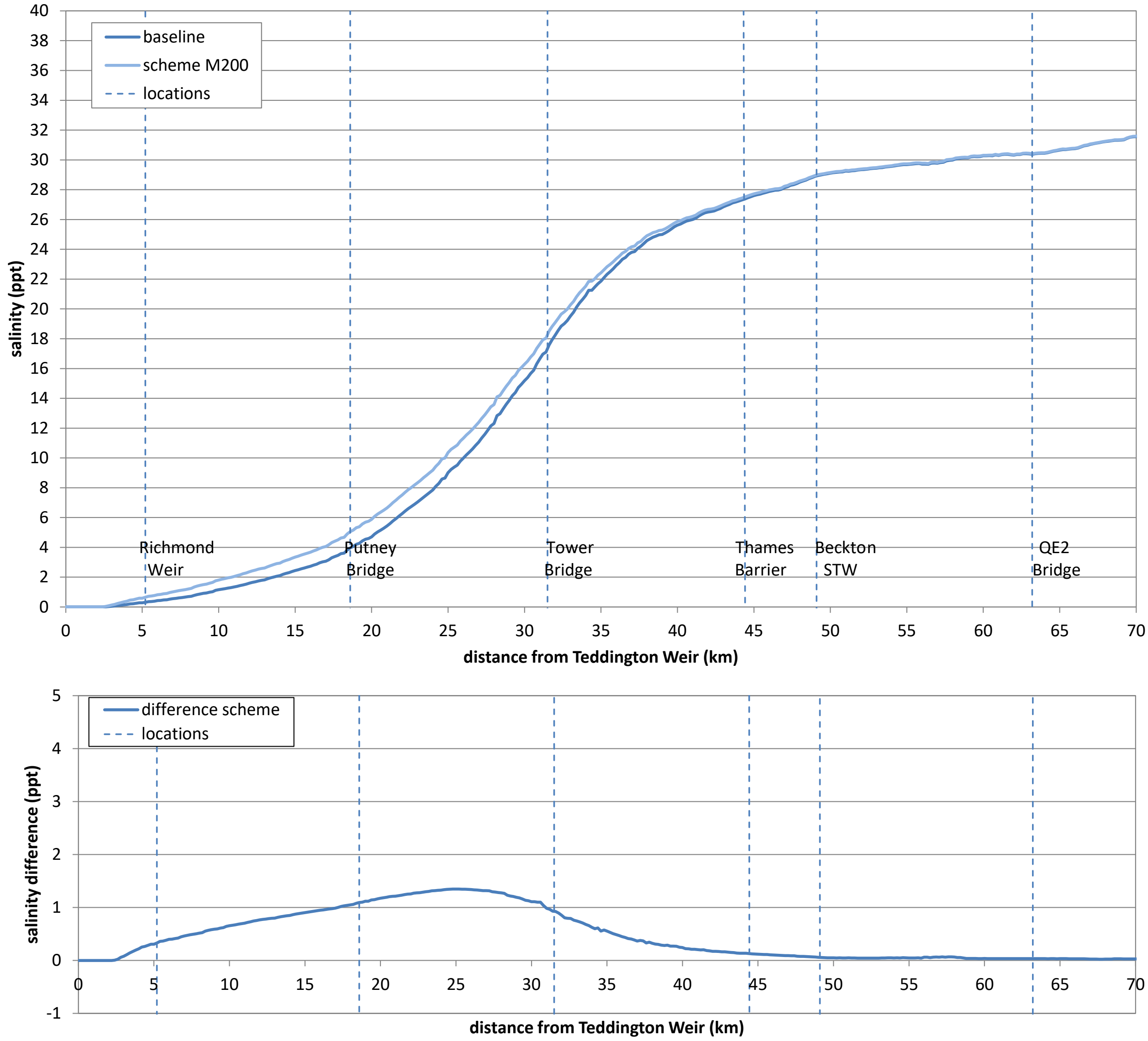
Figure 4-6 shows the effect that the 200 Ml/d reduction in final effluent discharges from Mogden STW from the Mogden water recycling scheme will have on the maximum and minimum salinity concentrations along the thalweg of the estuarine Thames Tideway in a very low flow year. For both maximum and minimum salinity, there is a small increase in the salinity concentration when the scheme is operational compared to the baseline. The highest salinity increase when the Mogden water recycling scheme is operational is approximately 1.5 parts per thousand (ppt) above the baseline for the maximum salinity concentration. For this salinity concentration, the salinity difference increases approximately 3km after Teddington Weir and continues to increase up to the highest salinity difference between Putney Bridge and Tower Bridge. The salinity difference subsequently reduces, with only a small difference occurring downstream from Beckton STW.

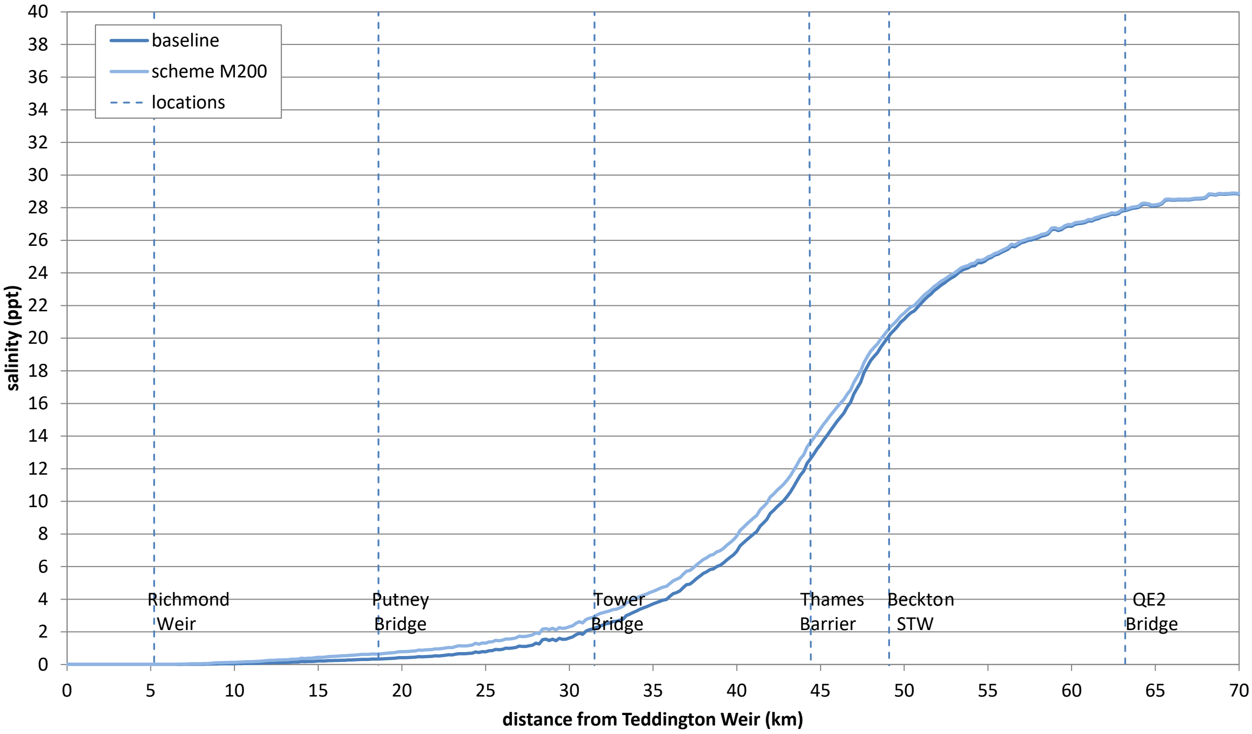
For the minimum salinity concentrations within the estuarine Thames Tideway, the differences in salinity between the scheme and the baseline increases slower longitudinally compared to the maximum salinity concentrations. The highest difference in the minimum salinity between the scheme and the baseline occurs at the Thames Barrier at 1ppt, which subsequently reduces to no difference a few km after the QE2 Bridge.

The changes to the 95th percentile and mean SSC in the thalweg of the estuarine Thames Tideway is shown in **Figure 4-7**. These graphs show that there are very few changes in the SSC between the baseline values and the 200 Ml/d Mogden water recycling scheme along the estuarine Thames Tideway in a very low flow year, with no increase in SSC that could cause a higher rate of sediment deposition.

Taken together, it is expected that the scheme would not have a discernible effect on sediment deposition rates during a moderate low river flow year. This would have a **negligible** effect on navigational operations, including at the Royal Docks and Barking Creek.

Figure 4-6 Maximum (top) and minimum (bottom) salinity along thalweg (24 July – 31 July) with M96 flows for the baseline and 200 Ml/d Mogden water recycling scheme




baseline
scheme M200
locations
salinity (ppt)
Richmond Weir
Putney Bridge
Tower Bridge
Thames Barrier
Beckton STW
QE2 Bridge
distance from Teddington Weir (km)

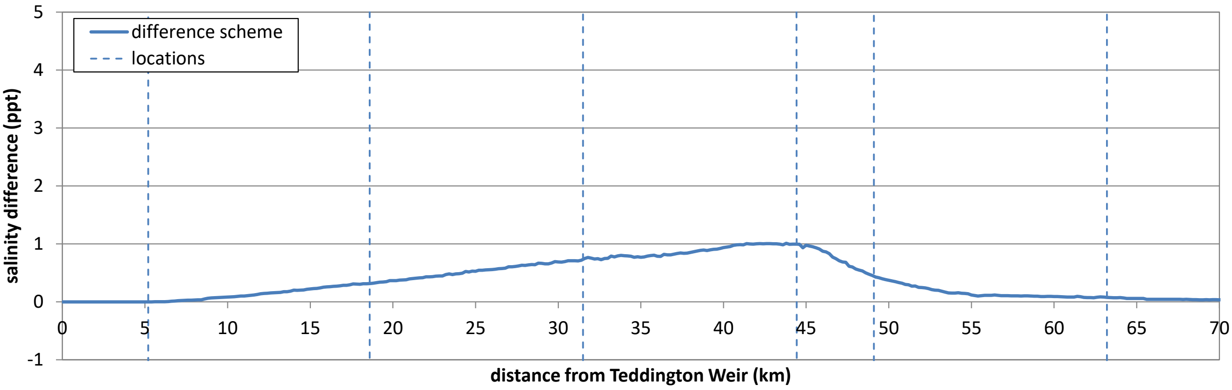
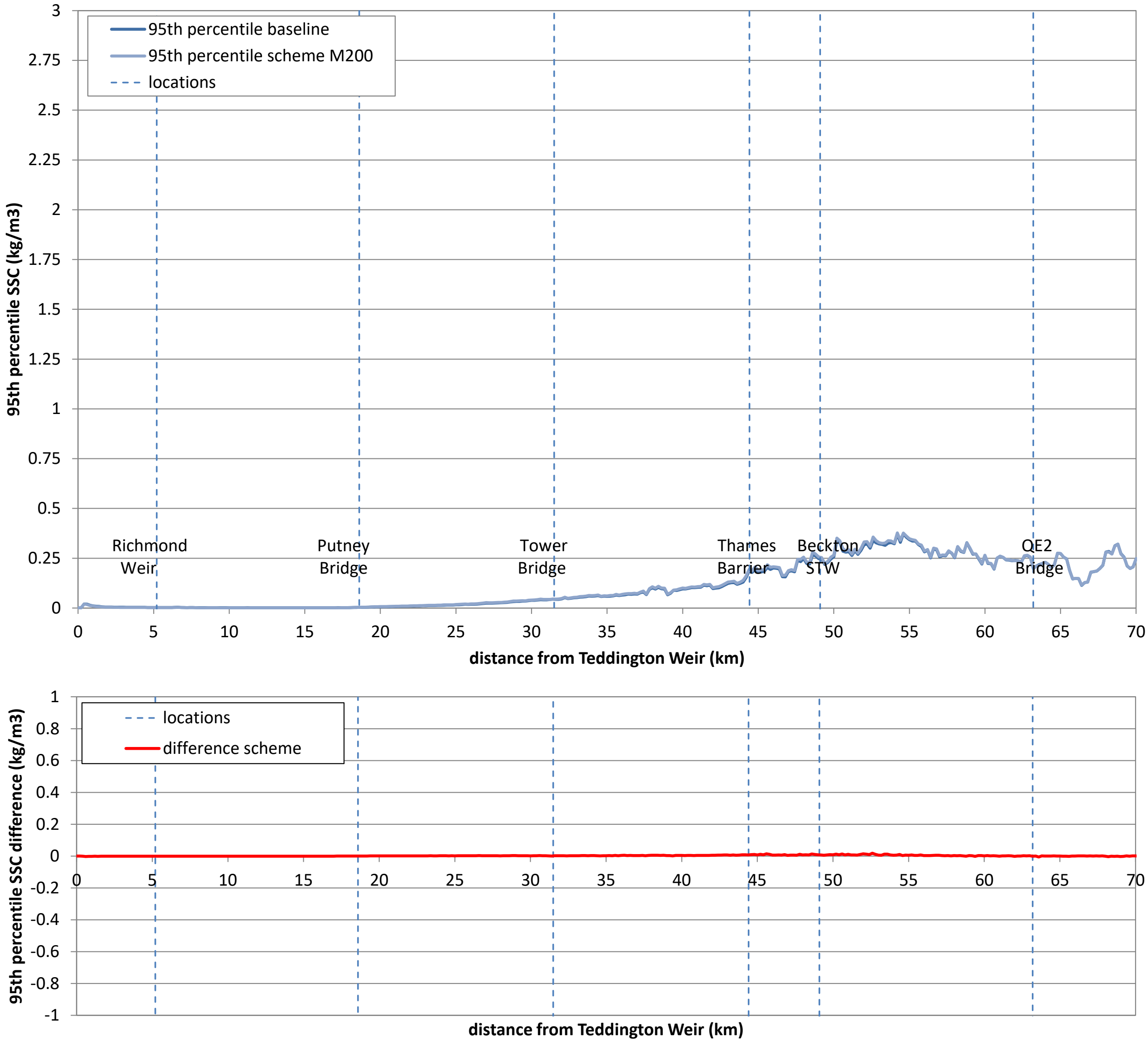
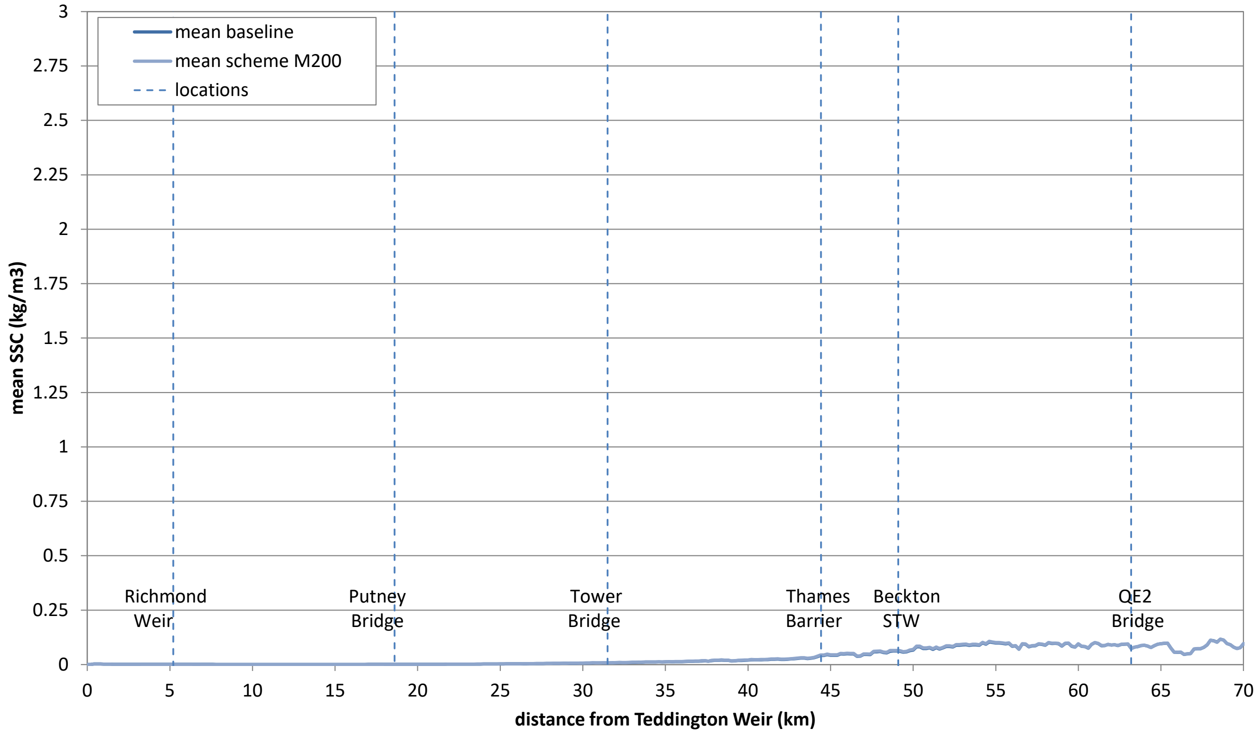
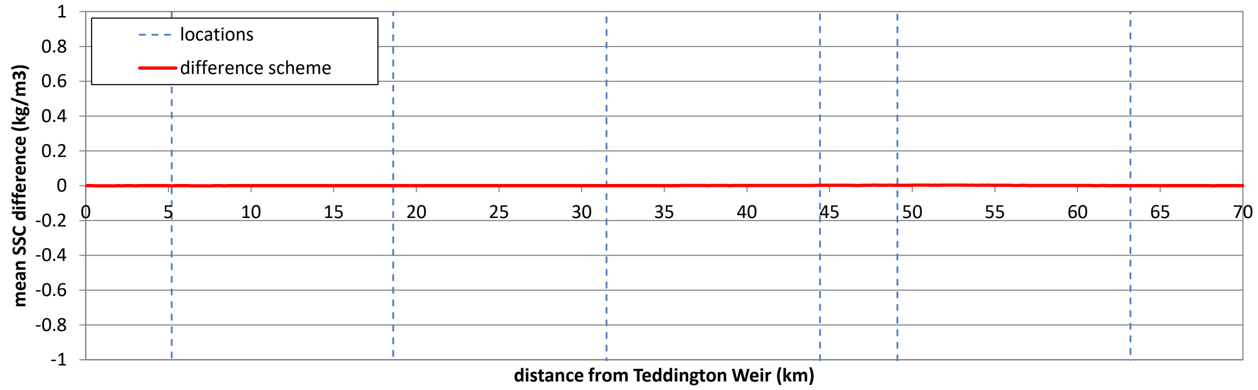

difference scheme
locations
salinity difference (ppt)
distance from Teddington Weir (km)

Figure 4-7 95th percentile (top) and mean (bottom) SSC along thalweg (1 August – 30 November), M96, baseline and 200 Ml/d Mogden water recycling scheme




mean baseline
mean scheme M200
locations
mean SSC (kg/m3)
3
2.75
2.5
2.25
2
1.75
1.5
1.25
1
0.75
0.5
0.25
0
Richmond Weir
Putney Bridge
Tower Bridge
Thames Barrier
Beckton STW
QE2 Bridge
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
distance from Teddington Weir (km)

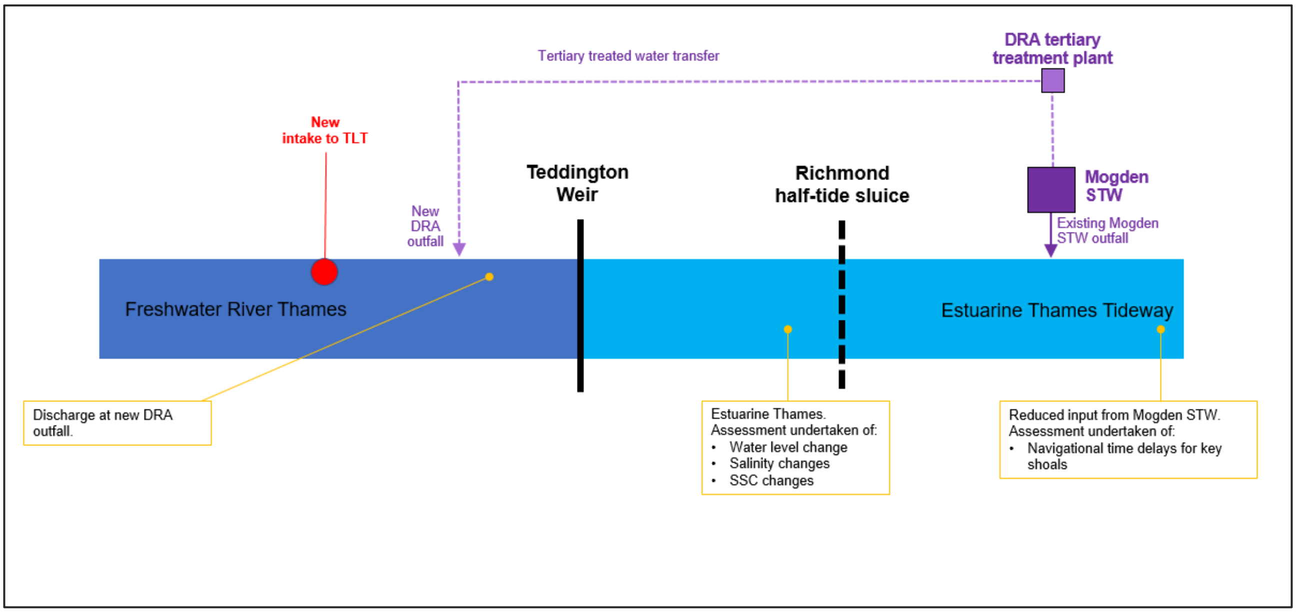

locations
difference scheme
mean SSC difference (kg/m3)
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
distance from Teddington Weir (km)

5. NAVIGATION ASSESSMENT OF TEDDINGTON DRA SCHEME

5.1 INTRODUCTION

For the Teddington DRA scheme, the assessment for navigation set out **Table 1-1** is described in this section. This is shown spatially in the conceptualisation of physical environment effects in **Figure 5-1.**

Figure 5-1 Representation of the Teddington DRA aquatic study area with conceptualisation of navigation effects and listing of assessments undertaken for Gate 2



5.2 NAVIGATION ASSESSMENTS

No bespoke modelling has been undertaken for the Teddington DRA scheme. The modelling undertaken for the Mogden water recycling scheme presents a scenario with a greater impact than this option, as lower flow changes will occur for the Teddington DRA options (max size of up to 150 Ml/d, compared to the 200 Ml/d modelled for the Mogden Reuse Scheme. Therefore, the Mogden water recycling navigation assessment should be referred to as a proxy for the worst-case navigation impacts of the Teddington DRA scheme. This shows that the scheme will have a **negligible** effect on water level changes impacting navigation, a **minor/negligible** impact on the low water navigational restrictions around the shoals, and a **negligible** effect on the sedimentation effects on navigation.

6. FUTURE INVESTIGATIONS AT GATE 3

As the engineering design and operational triggers of the London Effluent Reuse schemes are progressed in Gate 3, further specificity can be added to the Gate 2 assessments.

As engineering design progresses, Gate 2 tools can be re-used to assess variants in each of the schemes and the impacts that this would have on navigation. This would be undertaken with bespoke modelling that incorporates any additional information that have arisen as the options progress to Gate 3. The impact of the flow changes for each option will be undertaken, instead of solely modelling the worst-case scenarios.

Further scenario modelling at Gate 3 could also include for potential future developments, such as an upgraded/ replacement Thames Barrier; and the inclusion of future climate scenarios. Future climate scenarios would account for sea level change, changes in river flows and changes in London Effluent Reuse schemes' operating pattern.

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