Lower Thames Crossing

6.3 Environmental Statement Appendices
Appendix 14.4 Hydromorphology Assessment

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Lower Thames Crossing

Appendix 14.4 Hydromorphology Assessment

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1 Executive summary

1.1.1 This document presents an assessment of the potential for likely significant effects on the hydromorphology of watercourses during the construction and operational phases of the A122 Lower Thames Crossing (the Project).

1.1.2 The assessment has been undertaken with reference to the guidance provided in the Design Manual for Roads and Bridges (DMRB) LA 113 Road Drainage and the Water Environment (Highways England, 2020b). The study area includes watercourses and floodplains within the Order Limits and up to 1km up and downstream.

1.1.3 Baseline information to characterise the hydromorphology of watercourses has been collected from a desk-based study and site walkover surveys. Hydraulic modelling of the watercourses with the potential to be most impacted has also been undertaken.

1.1.4 Watercourses in the study area are of low to medium sensitivity with regard to their existing hydromorphology. The watercourses have generally been extensively modified (for example by culverting, impoundment, addition of bank protection, or to perform a flood defence or drainage function). They have limited morphological diversity and uniform flow, bed and bank profiles.

1.1.5 The Project's design ethos, described in Design Principles (Application Document 7.5), of using open, clear span crossings wherever practicable and adopting best practice where culverting and diversions cannot be avoided, limits the significance of residual effects to no more than slight adverse, and spatially limits any impacts to the reach scale. Effects are therefore considered to be not significant in the context of the Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 (EIA Regulations).

1.1.6 It is concluded that the Project would not cause deterioration, at the water body scale, of the hydromorphology supporting element of the Water Framework Directive (WFD) status of the watercourses assessed in this study, nor compromise attainment of future WFD objectives for these water bodies.

2 Introduction

2.1 Aims and objectives

2.1.1 This document presents an assessment of the potential for likely significant effects on the hydromorphology of watercourses during the construction and operational phases of the A122 Lower Thames Crossing (the Project).

2.1.2 The assessment has been undertaken with reference to the guidance provided in the Design Manual for Roads and Bridges (DMRB) LA 113 Road Drainage and the Water Environment (Highways England, 2020b).

2.1.3 The assessment constitutes a 'simple' assessment in accordance with DMRB LA 113 and has informed Environmental Statement (ES) Chapter 14: Road Drainage and the Water Environment (Application Document 6.1) and ES Appendix 14.7: Water Framework Directive (WFD) Assessment (Application Document 6.3).

2.1.4 The specific objectives of this assessment are to:

a. define baseline characteristics of watercourses and categorise each with a sensitivity classification

b. assess the potential hydromorphology impacts on each watercourse

c. outline measures required to mitigate potential impacts and identify any further investigations or monitoring that may be required

2.2 Study area

2.2.1 The study area for this assessment includes watercourses and floodplains within the Order Limits which could be directly impacted by the Project. Reaches of watercourses up to 1km upstream and downstream of the Order Limits have also been included, where they have the potential to be indirectly affected.

2.2.2 ES Figure 2.1 (Application Document 6.2) provides an overview of the Project extent. A full description of the Project can be found in ES Chapter 2: Project Description (Application Document 6.1).

3 Methodology

3.1 Introduction

3.1.1 The hydromorphology effects of the Project have been determined by assessing the sensitivity of watercourses and the magnitude of the likely impact(s). The classification criteria and the methodology by which they have been applied are outlined below.

3.1.2 To some degree the assessment relies on professional judgement. Baseline information to characterise the hydromorphology of watercourses has been collected from a desk-based study and site walkover surveys. Hydraulic modelling has also been undertaken to qualify the flow regimes of some watercourses within the study area, providing additional information to inform this assessment. The findings of the modelling studies are reported in ES Appendix 14.6: Flood Risk Assessment (Application Document 6.3).

3.2 Desk-based study

3.2.1 A desk-based study within the study area was undertaken to identify current hydromorphological conditions and any historical changes to present-day conditions. Table 3.1 lists the data sources that have informed the desk-based study.

Table 3.1 Desk-based study data sources

Data source	Description
Contemporary aerial photographs	Contextual information including land use, vegetation types and insight into the distribution of fluvial features.
Contemporary Ordnance Survey mapping	Provides an indication of channel gradients and surrounding land topography.
Historical mapping	Determines changes to channel alignments and other fluvial features.
Thames River Basin Management Plan (Environment Agency, 2018)	Identifies which watercourses are classified under the WFD and their relative status.
Geological mapping	Adds to understanding of potential response/stability.
Catchment Data Explorer (Environment Agency, 2020)	Identifies the current morphological status of watercourses in the study area.
Topographical survey of watercourse channel cross-sections	Qualifies channel gradients and form.

3.3 Field study

3.3.1 Water features surveys have been undertaken to record the characteristics of watercourses within the study area. The surveys recorded observations of channel dimensions, flow conditions and bankside/in-channel vegetation, as well as a geo-referenced photo record.

3.3.2 The watercourses that have been modelled to understand their flood flow conveyance (to inform the Project's Flood Risk Assessment (ES Appendix 14.6)) have been subject to topographical survey. This survey has recorded the dimensions of a series of channel cross-sections, as well as any hydraulic structures.

3.4 Impact assessment

3.4.1 DMRB LA 113 (Highways England, 2020b) provides brief guidance on evaluating the hydromorphological impacts of highway schemes. The guidance recommends consideration of the potential impacts on:

a. flow processes

b. channel bed and bank form

c. sediment movement

d. riparian zones and floodplains

e. downstream and wider catchment connectivity

f. setting of the watercourse in the wider catchment

3.4.2 DMRB LA 113 does not provide a prescriptive assessment methodology. This assessment has therefore been undertaken using professional experience and with reference to published literature (Sear *et al*., 2003; Northern Ireland Environment Agency, 2014). The Environment Agency has also been consulted and have provided feedback confirming their satisfaction with the applied assessment methodology, as detailed in Table 14.1 of ES Chapter 14: Road Drainage and the Water Environment (Application Document 6.1).

3.4.3 Watercourses have been classified according to their existing importance, in accordance with the criteria in Table 3.2, which have been derived from information presented in the River Hydromorphology Assessment Technique Training Manual (Northern Ireland Environment Agency, 2014).

Table 3.2 Hydromorphology importance criteria

Importance	Criteria
Very high	• Varied morphological features with no sign of channel modification, displaying natural flow regime and fluvial processes. • Sediment regime that is in equilibrium and provides a diverse mosaic of habitat types suitable for species sensitive to changes in turbidity.
High	• Predominantly natural water feature with a range of morphological features (e.g. varied natural bank profiles, pools, riffles, bars). Limited signs of artificial modifications. • Sediment regime that provides suitable habitat for species sensitive to changes in turbidity (e.g. migratory salmon, freshwater pearl mussel).
Medium	• Water feature with channel cross-section partially modified in places but exhibiting some morphological features (e.g. pools, riffles, depositional bars). Varied flow types but with an obviously impacted natural flow regime. • Sediment regime that provides some physical habitat for species sensitive to changes in turbidity.
Low	• Water feature that has been extensively modified (e.g. by culverting, impoundment, addition of bank protection, or to perform a flood defence or drainage function). Exhibits limited to no morphological diversity, with uniform flow, bed and bank profiles and low energy. • Sediment regime that provides for very limited physical habitat for species sensitive to changes in turbidity.

3.4.4 Similarly to the sensitivity criteria, there is little guidance on the classification of the potential magnitude of hydromorphological impacts. Criteria for assessing the magnitude of impacts are presented in Table 3.3, again compiled with reference to published literature (Sear *et al*, 2003; Northern Ireland Environment Agency, 2014). The matrix used to determine an overall significance of effect is shown in Table 3.4 and is adapted from Table 3.8.1 in DMRB LA 104 (Highways England, 2020a).

Table 3.3 Impact magnitude classification criteria

Magnitude	Criteria
Major adverse	• Significant impacts on the bed, banks and vegetated riparian corridor, resulting in changes to sediment transport, load and turbidity. • Significant alterations to channel planform and/or cross-section. • Significant shift away from baseline conditions at the water body scale.
Moderate adverse	• Some changes to bed, banks and vegetated riparian corridor, resulting in some changes to sediment transport, load and turbidity at the multi-reach scale. • Some alterations to channel planform and/or cross-section. • A shift away from baseline conditions with impacts at the multi-reach scale.
Minor adverse	• Limited impacts on bed, banks and vegetated riparian corridor resulting in limited changes to sediment characteristics. • Small changes to channel planform and/or cross-section and a minimal shift from baseline conditions; localised impacts up to the reach scale.
Negligible	• Minimal or no measurable change from baseline conditions. Any impacts highly localized; no impacts at the reach scale.

Table 3.4 Significance matrix (adapted from DMRB LA 104)

Environmental value (sensitivity)	Magnitude of impact (degree of change)			
	Negligible	**Minor**	**Moderate**	**Major**
Very high	Slight	Moderate or large	Large or very large	Very large
High	Slight	Slight or moderate	Moderate or large	Large or very large
Medium	Neutral or slight	Slight	Moderate	Moderate or large
Low	Neutral or slight	Neutral or slight	Slight	Slight or moderate

3.4.5 Effects of very large, large and moderate adverse significance are considered significant with regard to the EIA Regulations.

3.5 Mitigation

3.5.1 The Project includes a range of environmental commitments. Commitments of relevance to avoiding or mitigating effects on hydromorphology are set out in Section 5.2 under the following categories:

a. Embedded mitigation: measures that form part of the engineering design, developed through the iterative design process.

b. Good practice: standard approaches and actions commonly used on infrastructure development projects to avoid or reduce environmental impacts, typically applicable across the whole Project.

c. Essential mitigation: any additional Project-specific measures needed to avoid, reduce or offset potential impacts that could otherwise result in effects considered significant in the context of the EIA Regulations. Essential mitigation has been identified by environmental topic specialists, considering the embedded and good practice mitigation.

3.5.2 Embedded mitigation is included within the Design Principles (Application Document 7.5), or as features presented on Figure 2.4: Environmental Masterplan (Application Document 6.2). Design Principles relevant to mitigation of effects on the water environment are described in Sections 4 and 5 of this report, each with an alpha-numerical reference code e.g. (SX.X or LSP.XX). Good practice and essential mitigation are included are included in the Register of Environmental Actions and Commitments, which is within ES Appendix 2.2: Code of Construction Practice (Application Document 6.3). Each entry in the REAC has an alpha-numerical reference code (e.g. RDWE0XX) to provide cross reference to the secured commitment. Relevant extracts covering avoidance of hydromorphological effects and mitigation for effects that cannot be avoided, are described below.

3.5.3 Schedule 2 Requirement 4 of the draft DCO (Application Document 3.1) states that no part of the authorised development is to commence until an Environmental Management Plan (Second Iteration) substantially in accordance with the CoCP has been submitted to and approved in writing by the Secretary of State. It further states that the Environmental Management Plan (Second Iteration) must reflect the mitigation measures set out in the REAC.

3.5.4 In addition, a range of secondary consents (from the Environment Agency and Marine Management Organisation) would also need to be secured. Details of these secondary consents are provided in the Consents and Agreements Position Statement (Application Document 3.3).

3.6 Limitations

3.6.1 The field survey data was collected during a Project-wide water features survey, rather than via a targeted and specific fluvial geomorphology audit. The survey focused on water features within the Order Limits, but the survey was prevented in some areas by lack of land access permissions and/or health and safety issues.

3.6.2 Conditions may vary over time/with the seasons, such as land cover, as well as under different flow conditions. Field surveys were generally undertaken during the summer months, under dry conditions.

3.6.3 The Project is subject to further design development, so the precise nature of the hydromorphological impacts on watercourses are potentially subject to change. Therefore, this assessment is based on conservative assumptions, to cover a reasonable worst case and to provide robust conclusions.

3.6.4 For some smaller watercourses, channel gradients have been estimated using available topographical data in the absence of specific ground measurements. This is considered appropriate for assessing hydromorphological effects and does not present a substantial limitation.

4 Baseline

4.1 Screening

4.1.1 To the south of the River Thames, the Project would not directly or indirectly affect any surface water features during the operational phase. During the construction phase, it is proposed to discharge treated rainfall runoff from the southern tunnel entrance compound and the satellite compound associated with construction of the ground improvement tunnel, to a ditch in Filborough Marshes. The ditch (referred to as the Western ditch), and wider interconnected network of watercourses, would convey the runoff to the River Thames via an existing outfall. Construction of an outfall from the compound runoff collection and treatment system to the ditch would be required, but this structure would cause only a very localised and temporary effect on the ditch while being installed. Discharges would be made in accordance with an Environment Agency issued environmental permit, the conditions of which would prevent channel scour/erosion and changes to the hydrological regime, as secured by REAC commitment RDWE033. Therefore, watercourses to the south of the River Thames crossing are screened out from further assessment.

4.1.2 Beneath the River Thames, the crown of the twin-bored tunnel would be at sufficient depth below the riverbed to avoid the need for any works within the river to provide tunnel scour protection (RDWE041). This would avoid any disturbance to the channel banks and bed form, and the existing hydrodynamics and sediment transport regimes.

4.1.3 Construction and operation of a new self-regulating tide gate or equivalent structure on the north bank of the River Thames is proposed at Coalhouse Point. This would function to supply water from the Thames to an area of wetland, comprising a ditch network and scrapes, which would be created by the Project in accordance with Design Principle S9.13. The construction working area needed to install the structure would be small (approximately 50m by 35m) and while the works would result in the temporary loss of inter-tidal habitat, given the scale of the works and the dynamic nature of the tidal regime, any loss would naturally re-establish within a short time scale. Once operational, the footprint of the proposed structure would not extend beyond the footprint of an existing flood bund and therefore the Project would not result in any permanent loss of inter-tidal habitat. In the context of the Thames water body, it is concluded that this element of the Project would not impact the hydromorphological quality, existing hydrodynamics or sediment transport regimes of the river.

4.1.4 A temporary, construction phase discharge to the River Thames is proposed via a new pipeline and outfall. The outfall would drain water arising from dewatering of the tunnel excavations at the North Portal and discharges would be made in accordance with the conditions of an Environment Agency discharge consent. The design of the discharge pipeline and outfall to the River Thames would provide for a subtidal mid-water discharge for effective dilution and dispersal, and to reduce disturbance to the intertidal zone (RDWE028). The preliminary drainage design proposes one permanent discharge to the River Thames, comprising operational drainage from the tunnels. Discharge rates would be low (in the order of 5 litres/s), so works to construct the small new outfall would be very limited in scale and extent. Discharges from the new outfall, which would dbe subject to environmental permitting, would be limited to high water conditions to maximise available dilution and mixing and to prevent scour/erosion of the intertidal zone (RDWE026).

4.1.5 Subject to securing the necessary consents and adopting suitable methods of working, it is considered that these elements of the Project have very limited potential to change baseline conditions. Impacts on the hydromorphology of the River Thames have therefore been screened out from further assessment.

4.1.6 To the north of the River Thames, the Project would interact with numerous watercourses. These drain the catchments of the Mardyke, the West Tilbury Main and the Gobions Sewer at Linford. Table 4.1 provides a list of the watercourses to the north of the River Thames that have been subject to initial screening.

4.1.7 The shaded rows in Table 4.1 highlight the watercourses that were screened out due to not supporting a permanent flow system, with a channel width of less than 1m, and exhibiting no natural features or processes.

Table 4.1 Watercourses subject to screening for hydromorphology effects

ID*	Watercourse	Location	Development interaction
MR-1N07ZZZ1	West Tilbury Main	North Portal	• New crossings (culverts) and works to existing culvert crossings, including removal of blockage in an existing culvert and re-establishing flow in the section of West Tilbury Main running northward from Station Road. • Watercourse diversions. • Construction of flood risk management measures, including a new hydraulic flow control structure and floodplain compensation areas, and drainage attenuation/treatment basins within the catchment. • Receipt of Project runoff during operation.
OW-1N07ZZ10	Ordinary watercourse (OWC) (unnamed)	Tilbury - south of the proposed Project viaduct	• Most of this network would be lost under the proposed Project road embankment. Diverting all the individual watercourses that form this network is not viable. However, part of an existing watercourse to the east of the Project road would be retained and then diverted to take it under the proposed viaduct. The diverted watercourse would discharge to West Tilbury Main. A culvert would need to be constructed to accommodate the diverted watercourse.
OW-1N09ZZZ1	Gobions Sewer	Chadwell St Mary	• New crossing (culvert) and diversion to rationalise the culvert length and accommodate Project earthworks. • Receipt of Project runoff during operation.

ID*	Watercourse	Location	Development interaction
DI-1N09ZZZ1	Ditch (unnamed)	Chadwell St Mary (Muckingford Road)	• New crossing (culvert) and diversion. Replacement of existing culverts with two new culverts and two open channel sections.
MR-1N11ZZZ1	Orsett Fen Sewer	Orsett Fen	• New crossing (viaduct), construction of floodplain compensation areas within the catchment. • Receipt of Project runoff during operation.
OW-1N17ZZZ1	OWC (unnamed)	Orsett Fen	• New crossings (viaduct and culvert) and realignment.
MR-1N17ZZZ2	Golden Bridge Sewer	Orsett Fen	• New crossing (viaduct), construction of a floodplain compensation area and drainage attenuation/treatment basins within the catchment. • Receipt of Project runoff during operation.
MR-1N17ZZZ1	Mardyke	Orsett Fen	• New crossing (viaduct) • Receipt of Project runoff during operation.
OW-1N17ZZZ6	OWC (unnamed)	Orsett Fen	• New crossing (culvert).
OW-1N13ZZZ1	OWC (unnamed)	South Ockendon	• Diversion and culverting - channel split and replacement channel creation.
DI-1N14ZZZ2	Ditch (unnamed)	M25	• New crossings at two locations and diversion including open channel and piped culverts where ground levels are significantly higher than the invert level of the diverted watercourse.
MR-1N17ZZZ4	Mardyke West	M25	• Extension of existing bridge and installation of one new bridge, with a gap to allow for daylight to reach the area beneath the bridge decks. Construction of floodplain compensation areas. • Receipt of Project runoff during operation.

**ID is the unique identification (following the code HE540039-CJV-EWE-ZZZ-) assigned to each water feature surveyed in the Water Features Survey (further details of which are provided in ES Appendix 14.2)*

4.1.8 Several of the watercourses in Table 4.1 would receive discharges of highway runoff from the Project during its operation. However, the potential for these discharges to cause impacts on flow and sediment transport regimes, or the water quality of the receiving watercourses, would be mitigated as described by commitments RDWE011 and RDWE025. To reduce the potential for scour and associated hydromorphological change, highway drainage outfall headwall arrangements would be set back from the banks of the receiving watercourses, and outfall designs would accord with DMRB CD 529 (RDWE011). Drainage design would include attenuation and a range of treatment measures for highway runoff designed in accordance with DMRB CG 501 and CD 532 to meet the requirements specified for each outfall to surface watercourses identified in ES Appendix 14.3: Operational Surface Water Drainage Pollution Risk Assessment (RDWE025).

4.2 Water Framework Directive morphological status

4.2.1 Two of the watercourses screened into the assessment are classified WFD water bodies, namely the Mardyke (water body ID GB106037028200) and the Mardyke West Tributary (GB106037028080).

4.2.2 Both watercourses have a hydromorphological designation of Heavily Modified (by human activity) and neither of the water bodies achieve 'High' status. Further details are provided in ES Appendix 14.7: Water Framework Directive Assessment (Application Document 6.3).

4.3 Geology, topography and land use

4.3.1 The National River Flow Archive (UK Centre for Ecology and Hydrology, 2019) describes the catchment of the Mardyke and its tributaries, draining approximately 90km^2 in total, as underlain by a superficial geology predominantly of London Clay. The topography varies, with the middle and lower catchment less than 10m above ordnance datum (AOD), rising to over 100m AOD in the most northern and westerly parts of the catchment. Land use is dominated by arable farming, with the lowest areas of the catchment covered with fenland.

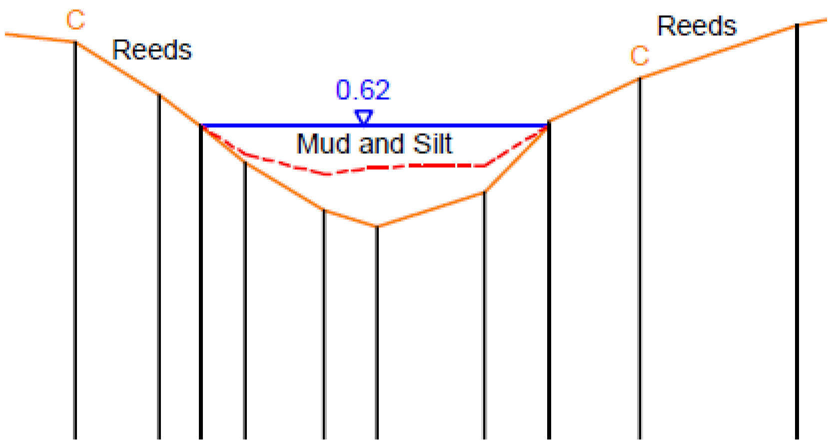
4.3.2 The West Tilbury Main drains a much smaller catchment (just over 3km^2) that is underlain by superficial deposits of Alluvium in its low-lying, flatter parts adjacent to the River Thames. Further north, the catchment has a more varied geology of Head and Gravel Member Deposits. The catchment has a mean altitude of 11m above sea level. The land use is predominantly arable farming. An area in the lower catchment is subject to land remediation to restore a former landfill site to arable land.

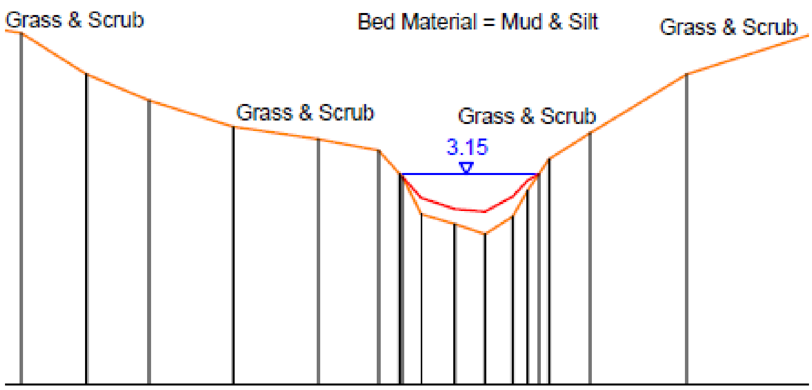
4.3.3 The Gobions Sewer, draining towards Linford, has a catchment area of 11.7km^2. Its superficial geology comprises a mixture of Taplow and Boyn Hill Gravels, with Head Deposits locally. The catchment has a mean altitude of 19m above sea level. The settlements of Chadwell St Mary and Linford/East Tilbury are within the catchment, with the remainder of the land use predominantly agricultural.

4.4 Field observations and survey data

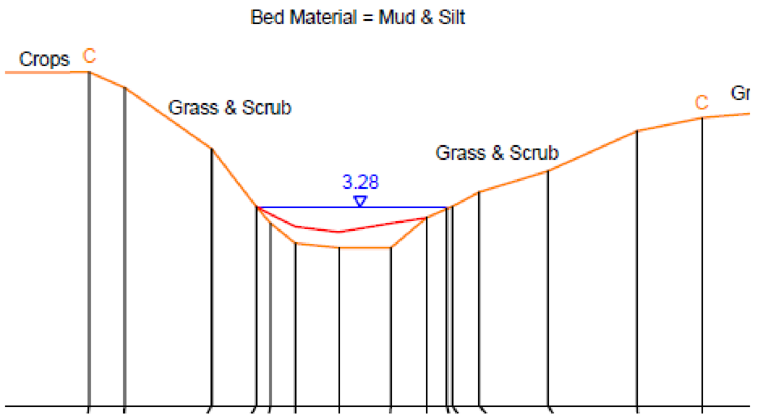
4.4.1 A topographical survey of five of the screened-in watercourses, the West Tilbury Main, Golden Bridge Sewer, Orsett Fen Sewer, Mardyke and Mardyke West Tributary, was undertaken in November and December 2018. The survey collected data on the geometry of the watercourse channels and crossing structures, for use in building hydraulic models. A summary of the data collected is presented in Table 4.2.

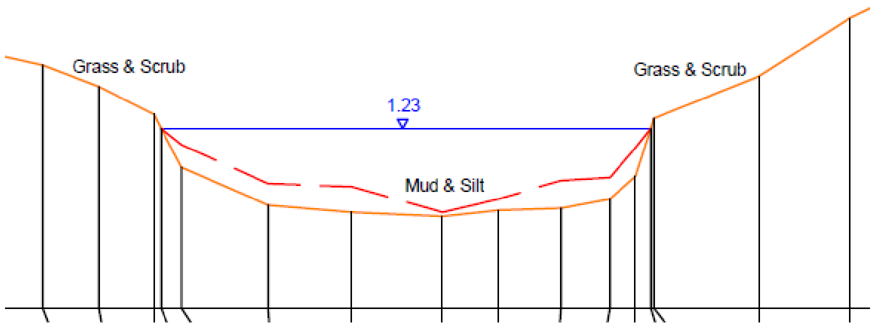
Table 4.2 Watercourse survey data

<table>
<tr><th>ID</th><th>Channel gradient (m/m)</th><th>Typical cross-section parameters</th></tr>
<tr><td>West Tilbury Main
N.B three separate reaches were surveyed</td><td>0.0003 to 0.0006</td><td>

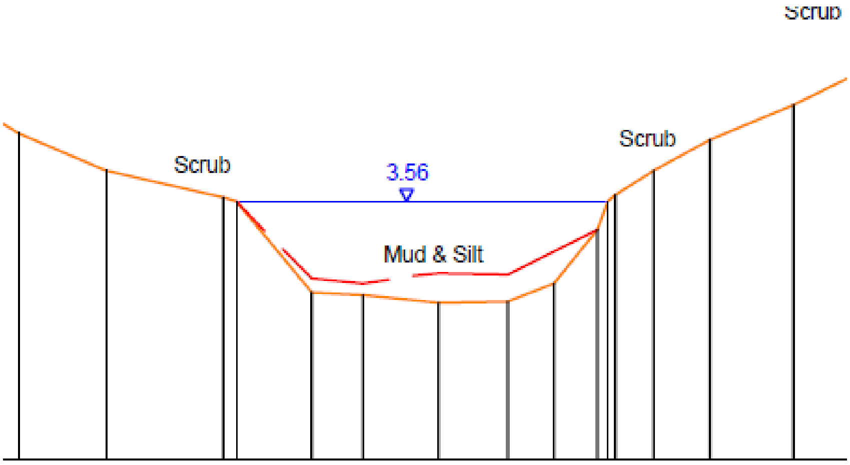
Bed width – 1.85m
Top of bank channel width – 3.69m
Typical depth of silt to hard bed – variable, deposits of 0.4m to 0.5m at some existing culvert inlets
Water level at time of survey – 0.62m AOD
Channel sinuosity – straight reaches with 90-degree bends
Existing structures in surveyed reach – each reach has a section of channel in culvert
</td></tr>
<tr><td>Golden Bridge Sewer</td><td>0.0013
(2,068m reach length surveyed)</td><td>

Bed width – 0.93m
Top of bank channel width – 2.15m
Typical depth of silt to hard bed – 0.16m
Water level at time of survey – 3.15m AOD
Channel sinuosity – largely straight reach with two 90-degree bends
Existing structures in surveyed reach – three footbridges and four access bridges
</td></tr>
</table>

<table>
<tr><th>ID</th><th>Channel gradient (m/m)</th><th>Typical cross-section parameters</th></tr>
<tr><td>Orsett Fen Sewer</td><td>0.0011
(2,907m reach length surveyed)</td><td>


Bed width – 1.1m
Top of bank channel width – 3.05m
Typical depth of silt to hard bed – 0.35m
Water level at time of survey – 3.28m AOD
Channel sinuosity – straight reaches with some 90-degree bends in the channel, following field boundaries
Existing structures in surveyed reach – two footbridges, four access bridges and three culverts
</td></tr>
<tr><td>Mardyke</td><td>0.0007
(representative of a 2,041m reach in the area of interest)</td><td>


Bed width – 4.25m
Top of bank channel width – 6.24m
Water level at time of survey – 1.23m AOD
Typical depth of silt to hard bed – variable, no silt recorded in some sections.
Existing structures in surveyed reach – eight footbridges and nine road bridges, three rail bridges, six pipe crossings, one weir and one sluice gate that is operated for flood defence, excluding tidal ingress from the River Thames.
Note: the Mardyke channel form shows variability along the surveyed reach length. The section shown is typical of the open channel local to where the Project would span the river.
</td></tr>
</table>

ID	Channel gradient (m/m)	Typical cross-section parameters
Mardyke West	0.0008 (1,596m reach length surveyed, from Mardyke confluence upstream)	 • Bed width – 2.4m • Top of bank channel width – 3.77m • Typical depth of silt to hard bed – 0.21m • Water level at time of survey – 3.56m AOD • Channel sinuosity – exhibits some natural sinuosity • Existing structures in surveyed reach – one footbridge, one road bridge

4.4.2 As noted, two of the watercourses, the West Tilbury Main and the Mardyke, have flapped outfalls to the River Thames at their downstream extents and their flow regimes are therefore subject to tide locking. The tributaries of the Mardyke are also affected by this regime.

4.4.3 The ordinary watercourses screened into the assessment have not been topographically surveyed but using Light Detection and Ranging (LiDAR) data, typical channel gradients have been estimated to range from 0.0009m/m to 0.0133m/m. A selection of photographs of the watercourses are presented in Annex A, and further photographs are provided in ES Appendix 14.2: Water Features Survey Factual Report (Application Document 6.3).

4.5 Historical mapping analysis

4.5.1 Landmark web-based historical maps (Landmark, 2019) and aerial photographs have been reviewed.

4.5.2 On the West Tilbury Main, mapping is available from 1898 to date. This shows that the reach of the watercourse that is currently designated as main river has not changed in its alignment since the earliest dated mapping. However, there is a general trend of field enlargement and subsequent ditch infilling, the most notable change between the 1967 and 1975 maps. At the catchment outlet to the River Thames, there is no notable change until the 1938 map when sea walls are marked. On the 1898 map, sluices are shown along the reach draining to the River Thames.

4.5.3 The Gobions Sewer is shown to follow the same general alignment in maps dating back to 1882. On maps post-dating 1958, the watercourse is shown to sink at Hoford Road and issue again further downstream. Mapping pre-1938 shows an open channel watercourse between these two locations. A pumping station on the watercourse at Lower Crescent is shown on all maps back to 1898 but is absent on the map dated 1882. The watercourse corridor has become less vegetated, with earlier maps showing more extensive areas of woodland and marshy grassland. In the catchment downstream of the railway line, there have been changes in the extent of gravel pit workings and a reduction in the density of the ditch network on Muckingford Marshes.

4.5.4 In the Mardyke West catchment, notable changes include construction of the M25 motorway in 1975. A fishery containing a series of fishing lakes on the outskirts of Ockendon opened in 1998, and maps dating to 1975 and 1960 show a sewage treatment works adjacent to the watercourse. There have been no significant watercourse alignment changes dating back to 1872.

4.5.5 The Mardyke, the Golden Bridge Sewer and Orsett Fen Sewer, show similarly stable alignments, with no significant historical changes.

4.5.6 A review of the historical mapping concludes that the subject watercourses have generally been stable in their alignments and form over the last 130 years. Within their catchments, there have been general trends of a reduction in riparian vegetation cover and infilling of drainage channels and ditches where agricultural fields have been enlarged.

4.6 Watercourse importance classification

4.6.1 Based on the desk-based study and field observations described above, a summary of the importance of the screened-in watercourses is presented in Table 4.3. These receptors have been agreed in consultation with the Environment Agency which also provided feedback indicating general satisfaction with the applied assessment methodology.

Table 4.3 Watercourse sensitivity classification

Watercourse name and ID	Importance	Justification
West Tilbury Main MR-1N07ZZZ1	Low	• Watercourse channel extensively modified for land drainage/flood defence. Low-energy, tide-locked flow regime. Exhibits limited hydromorphological diversity.
Gobions Sewer OW-1N09ZZZ1	Medium	• Watercourse with a natural flow regime, with a channel exhibiting limited but some hydromorphological diversity.
Orsett Fen Sewer MR-1N11ZZZ1	Low	• Watercourse with impacted natural flow regime, low energy, no morphological features and very limited hydromorphological diversity observed. No suitable habitat for species sensitive to changes in turbidity.

Watercourse name and ID	Importance	Justification
Golden Bridge Sewer HE540039-MR-1N17ZZZ2	Low	• Watercourse with impacted natural flow regime, low energy, no morphological features and very limited hydromorphological diversity observed. No suitable habitat for species sensitive to changes in turbidity.
Mardyke MR-1N17ZZZ1	Medium	• Watercourse with impacted natural flow regime, channel cross-section modified for land drainage and flood defence in some reaches, but with other reaches exhibiting a more natural regime with limited, but some, hydromorphological diversity. WFD water body with a Heavily Modified hydromorphological status, achieving an overall status of Moderate.
Mardyke West MR-1N17ZZZ4	Medium	• Watercourse with impacted natural flow regime, channel cross-section modified in some reaches, but with other reaches exhibiting a more natural regime with limited, but some, hydromorphological diversity. WFD water body with a Heavily Modified hydromorphological status, achieving an overall status of Moderate.

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5 Assessment of effects

5.1 The Project

5.1.1 To enable construction of the Project, the following activities with the potential for hydromorphological impacts would be required:

a. Watercourse realignment

b. New watercourse crossings

c. Extensions to existing crossings

d. Riparian vegetation clearance

e. Receipt of highway drainage discharges

f. Introduction of hydraulic structures, flood defence embankments/walls and creation of floodplain compensation storage areas

5.1.2 Table 5.1 provides a summary of the works required to each watercourse scoped into this assessment, including details of the approximate reach lengths of watercourses proposed to be culverted, diverted and abandoned. These works have the potential to impact on the flow and sediment transport regimes of the watercourses.

Table 5.1 Summary of Project activities with the magnitude of the potential hydromorphological impact prior to the application of Project mitigation

Watercourse ID	Works description	Magnitude of potential impact and summary
West Tilbury Main MR-1N07ZZZ1	A concrete box culvert of up to 46m in length (H: 2.8m, W: 4m) following the path of the existing watercourse as far as practicable. Diversion required that will eliminate two near 90 degree bends in the channel, creating a more naturalised alignment. Abandonment length – up to 148m of open channel. Diversion length – up to 120m of open channel. Flood protection for the North Portal of the Project comprising walls or bunds each side of the highway. The structural form of protection would be driven by local ground conditions. One new flow control structure would be constructed to manage flood flows. Three existing culverts would be removed, improving channel hydraulics. Approx. 125m of watercourse re-established by unblocking an existing culvert north of Station Road. Receipt of treated road drainage discharges during operation of the Project.	• Minor adverse – one new 46m long culvert created, representing 1.7% of total length of the designated main river reach of the existing watercourse. However, this is offset by culvert removal, channel re-establishment and creation of a more naturalised alignment along open channel diversions.
Gobions Sewer OW-1N09ZZZ1	A concrete box culvert of up to 139m in length (H: 1.7m, W: 1.55m). To rationalise the length of the culvert, the watercourse would also be diverted. Abandonment length – up to 186m (all open channel). Diversion length – up to 284m (145m of open channel and 139m in culvert). Receipt of treated road drainage discharges during operation of the Project.	• Minor adverse – up to 41m of open watercourse channel would be lost compared to existing. • This represents 1% of total length of the existing watercourse.
Orsett Fen Sewer MR-1N11ZZZ1	A viaduct would be built to cross the watercourse channel in a single span, with a minimum lateral clearance of 8m between top of bank and the base of the viaduct revetments and abutments and vertical clearance of 4m between the viaduct deck and riverbank. No realignments are necessary. Floodplain compensation would be created via a shallow scrape on existing agricultural land, ensuring appropriate hydraulic connectivity is maintained and that vegetation is reinstated.	• Negligible – there would be no loss of open watercourse compared to existing. Floodplain connectivity impacts reduced by orientating the crossing to avoid key floodplain flow routes.
Golden Bridge Sewer	A viaduct would be built to cross the watercourse channel in a single span. No realignments necessary. Floodplain	• Negligible – there would be no loss of open watercourse

Watercourse ID	Works description	Magnitude of potential impact and summary
MR-1N17ZZZ2	compensation would be created on existing agricultural land, ensuring appropriate hydraulic connectivity is maintained and that vegetation is reinstated.	compared to existing. Floodplain connectivity impacts reduced by orientating the crossing to avoid key floodplain flow routes.
Mardyke MR-1N17ZZZ1	A viaduct would be built to cross this watercourse in a single, clear span. No realignments are necessary. Receipt of treated road drainage discharges during operation of the Project.	• Negligible – there would be no loss of open watercourse compared to existing. Floodplain connectivity impacts reduced by orientating the crossing to avoid key floodplain flow routes.
Mardyke West MR-1N17ZZZ4	Extension of an existing bridge by up to 52m, matching the existing bridge dimensions. A new 20m long structure to match the dimensions of the existing bridge. Floodplain compensation would be created via a shallow scrape on existing agricultural land, ensuring appropriate hydraulic connectivity is maintained and that vegetation is reinstated. Receipt of treated road drainage discharges during operation of the Project.	• Minor adverse – up to 72m of open channel watercourse would be subject to increased shading and loss of riparian vegetation compared to existing. • This represents just over 1% of total length of the existing watercourse.

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5.1.3 Available information indicates that there is an existing culvert on an ordinary watercourse which flows along the Chadwell St Mary link, near Linford. Subject to landowner agreements and other permissions, this culvert would be broken out and, if practicable, the reach would be reinstated to an open channel. This would represent a net increase in the open channel reach on this watercourse of approximately 500m.

5.1.4 In addition, the West Tilbury Main is in culvert where it crosses Station Road. During a site investigation, it was observed that the culvert was blocked and the section of West Tilbury Main to the north of Station Road was dry. To ensure continued functionality of this flow path, the blockage in the culvert would be cleared and the section of West Tilbury Main running northward from Station Road would be re-established. This is secured by commitment RDWE047.

5.2 Embedded and essential mitigation and good practice

5.2.1 As described in Section 3.5, the Project includes a range of commitments to avoid or reduce effects on the hydromorphology of watercourses, which are summarised below. These include embedded mitigation measures, additional Project-specific measures (essential mitigation) and good practice approaches and actions needed to avoid, reduce, or offset potential impacts that could otherwise result.

Embedded mitigation

5.2.2 Open span (viaduct) crossings have been incorporated into the design where feasible and are included for crossing the Mardyke and its first order tributaries the Orsett Fen and Golden Bridge Sewers, as well as one ordinary watercourse. Regarding these viaducts, the Design Principles (Application Document 7.5) state that they shall be designed to maximise environmental permeability and maintain views (S12.03). The viaducts would be elevated above the design flood level and to allow vehicles to pass safely underneath (S12.05). The viaducts have been designed using information from hydraulic modelling and have been orientated to reduce disruption of key floodplain flow paths, maintain floodplain flow connectivity and reduce afflux. The viaducts would leave the bed and banks of the watercourses undisturbed, and disturbance of existing riparian vegetation and habitats would also be reduced. The Design Principles also commit to restoring suitable wetland habitat and integrating the built structures into the wider fenland landscape through suitable planting (S12.06).

5.2.3 Where watercourses would cross the Project at an oblique angle, the watercourse may need to be realigned to avoid excessive culvert lengths and avoid sharp bends. New channels would be constructed to accommodate baseline flow and sediment regimes. The Design Principles (Application Document 7.5) commit to, where practicable, constructing watercourse diversions that are more naturalised in form and that follow historic ditch patterns (S9.10). As existing channels typically exhibit limited hydromorphological diversity, this design principle provides opportunities for promoting morphological and habitat diversity.

5.2.4 Where baseline or future baseline conditions suggest that watercourses may be used by commuting or foraging mammals, culverts have been designed to allow mammal passage. The Design Principles (S9.10) (Application Document 7.5) specify that mammal ledges would be provided in box culverts, and for pipe culverts a separate dedicated pipe would be installed. The ledges and pipes would be positioned above the flood water level, while maintaining 600mm headroom from the top of the mammal ledge to the soffit of the culvert. Following Essex County Council's (2012) Culvert Policy and the Environment Agency's (2021) Fluvial Design Guide – Section 8.6: Culverting of Watercourses, ledges would be at least 500mm wide and accessible from bank ramps (RDWE044).

Essential mitigation

5.2.5 On the West Tilbury Main (main river), a wide range of crossing options have been investigated. Constraints linked to the topography and presence of ground contamination have discounted several options as impracticable, including an open span crossing. The adopted crossing solution has been selected in consultation with the Environment Agency as representing the 'least worse' option of those practicable. The West Tilbury Main culvert (structure reference X-ERF-2-01) would integrate a fish pass aid designed for eels and elvers, incorporating some form of matrix, such as bristles, to assist their migration by crawling/climbing instead of swimming (RDWE030). The culvert would be submerged at its downstream end to prevent perching and a resting pool for coarse fish would be provided immediately downstream of the culvert, with a minimum depth of 30cm (RDWE031). Bankside vegetation reinstatement and planting at the entrance to the West Tilbury Main culvert would be designed to ensure no sharp light/dark interface, to encourage continued fish passage. This would be achieved by planting with a scrub mix that will include Alder. Root barriers would be installed to protect the structural integrity of the bank as appropriate (RDWE021).

Good practice

5.2.6 Where culverting cannot be avoided, new culverts would be sized to maintain the current land drainage regime, including for climate change resilience, and to convey flood flows without causing any detriment to baseline flood risk. Culvert inverts would be buried below existing bed levels to allow baseline bed levels, slopes and bed materials to be maintained (RDWE013).

5.2.7 Where bank protection is required during construction work, this would take the form of soft or natural riverbank protection, such as coir or other biodegradable geotextiles (RDWE010). Bankside vegetation would be reinstated at culvert entries and exits following the completion of construction works as soon as conditions are suitable for planting (RDWE009).

5.2.8 Where below ground utilities diversions are required, watercourses would be crossed by directional drilling or other trenchless techniques, in order to avoid disturbance to channel form, flow regimes and riparian habitats and species, unless other techniques are agreed with the Environment Agency or Lead Local Flood Authority, where relevant (RWDE008). Alternative techniques are likely to be more appropriate for example, when crossing minor ditches or drains that do not support a permanent flow system.

5.2.9 Highway drainage outfall headwall arrangements would be set back from the banks of the receiving watercourses and outfall designs would accord with DMRB CD 529 (RDWE011).

5.3 Residual significance of effects

5.3.1 Accounting for all the measures described above, the magnitude and residual significance of the hydromorphological effects of the Project have been assessed.

5.3.2 As reported in Table 5.1, the spatial extent of directly impacted reaches represent a very small percentage of the water bodies as a whole, and effects are therefore considered to be limited to the reach scale. Also, the subject watercourses are of low to medium sensitivity to hydromorphological change due to the heavy modifications they have been subject to. The results are reported in Table 5.2.

Table 5.2 Residual effects summary

Watercourse name and ID	Importance	Magnitude	Proposed mitigation	Significance of residual effect
West Tilbury Main MR-1N07ZZZ1	Low	Minor adverse	Design principle: constructing watercourse diversions that are more naturalised in form. Removing two existing culverts and replacing one existing culvert (structure ref X-EFR-2-01A) with a significantly larger (2.8m high by 4m wide) box culvert with a customised cross section. Re-establishing an approx. 125m section by unblocking a culvert. RDWE009 RDWE010 RDWE011 RDWE013 RDWE021 RDWE030 RDWE031	Slight adverse
Gobions Sewer OW-1N09ZZZ1	Medium	Minor adverse	Design principle: constructing watercourse diversions that are more naturalised in form. RDWE009 RDWE010 RDWE011 RDWE013	Slight adverse
Orsett Fen Sewer MR-1N11ZZZ1	Low	Negligible	Design principles: viaducts designed to maximise environmental permeability and integrate into the landscape through suitable planting.	Neutral

Watercourse name and ID	Importance	Magnitude	Proposed mitigation	Significance of residual effect
Golden Bridge Sewer MR-1N17ZZZ2	Low	Negligible	Design principles: viaducts designed to maximise environmental permeability and integrate into the landscape through suitable planting.	Neutral
Mardyke MR-1N17ZZZ1	Medium	Negligible	Design principles: viaducts designed to maximise environmental permeability and integrate into the landscape through suitable planting. RDWE011	Neutral
Mardyke West MR-1N17ZZZ4	Medium	Minor adverse	RDWE009 RDWE010 RDWE011 RDWE013	Slight adverse

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6 Conclusions

6.1.1 As a result of the design ethos of using open, clear span crossings wherever practicable, and of adopting best practice where culverting and diversions cannot be avoided, coupled with the low hydromorphological value of most of the watercourses that the Project would interact with, the significance of residual effects is considered to be no more than slight adverse and spatially limited to the reach scale. Effects are therefore considered to be not significant in the context of the EIA Regulations.

6.1.2 It is concluded that the Project would not cause deterioration, at the water body scale, of the hydromorphology supporting element of the WFD status of the watercourses assessed in this study, nor compromise attainment of future WFD objectives for these water bodies.

6.1.3 However, geomorphological inputs into future design stages will be required to ensure the construction of any realignment or watercourse crossing (including on those more minor watercourses screened out of this assessment) is suitable, accords with the defined Design Principles (Application Document 7.5), and would not result in instability, bank or bed erosion or scour. Geomorphological guidance on the size and retention of substrates through culverts may also be required.

6.1.4 Works would be subject to the necessary consents from the Environment Agency and Lead Local Flood Authorities as appropriate.

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Annex A Photographs

 West Tilbury Main at Goshems Farm, East Tilbury Date: October 2019	 West Tilbury Main at its outfall to the River Thames. South-west view showing the upstream face of Bowater Sluice. Date: October 2019
 Mardyke at Orsett Fen Date: July 2019	 Orsett Fen Sewer – existing footbridge crossing Date: October 2017

	
Golden Bridge Sewer Date: October 2017	Mardyke West – existing culvert beneath the M25. Date: October 2017

Further photographs are provided in ES Appendix 14.2: Water Features Survey Factual Report (Application Document 6.3).

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